HASAN KALYONCU UNIVERSITY
GRADUATE SCHOOL OF
NATURAL AND APPLIED SCIENCES

SUPPLYING WATER FROM TIGRES RIVER TO ELAZIĞ IN ORDER TO MEET 2050 WATER DEMAND

M.Sc. THESIS
IN
CIVIL ENGINEERING

BY
İBRAHİM HALİL IŞIK

GAZİANTEP 2020

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M.Sc. Thesis
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Civil Engineering
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Supervisor
Asst. Prof. Dr. Hüseyin Çağan KILINÇ

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İbrahim Halil IŞIK

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İBRAHİM HALİL IŞIK

ABSTRACT

SUPPLYING WATER FROM TIGRES RIVER TO ELAZIĞ IN ORDER TO MEET 2050 WATER DEMAND
IŞIK, İbrahim Halil
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Population projections are significant for managing and planning the research area. Today, due to the increasing population and the increasing use of water, proper management of water has great importance. Elazığ province, which is the confluence of the Tigris and Euphrates rivers, is one of the provinces that may experience water shortages in the future with its growing population and developing industry. For this case, new water resources needed to meet the water needs of the growing population and the burgeoning industry. In this study, the method of supplying water from the Hamza Bey Dam, a tributary of the Murat River, evaluated to meet the water needs of the calculated population in 2050 examined by using population forecasting methods and exponential regression analysis. The calculated population for the year 2050 estimated roundly 926964 and the total water requirement for this population calculated as 51513758 m^3. Also, the total water capacity of Hamza Bey Dam determined by using geographical information systems and hydrological modelling. According to this result, 53590000 m^3 of water could be supplied in an area of 3366824 m^2 determined at an altitude of 1140 m.

Keywords: Geographic information system, Water supply, Elazıg province, Regression analysis.

ÖZET

ELAZIĞ İLİ 2050 YILI SU İHTİYACININ KARŞILANMASI AMACIYLA DİCLE HAVZASINDAN SU TEMİNİ

IŞIK, İbrahim Halil

Yüksek lisans, İnşaat Mühendisliği Bölümü

Danışman: Dr. Öğr. Üyesi Hüseyin Çağan KILINÇ

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Nüfus projeksiyonları araştırma alanını yönetmek ve planlamak için önemlidir. Günümüzde artan nüfus ve artan su kullanımı nedeniyle, suyun uygun şekilde yönetilmesi büyük önem taşımaktadır. Dicle ve Fırat nehirlerinin birleştiği Elazığ ili, artan nüfusu ve gelişen sanayisi ile gelecekte su kıtlığı yaşayabilecek illerden biridir. Bu durumda, büyüyen nüfusun ve gelişen endüstrinin su ihtiyaçlarını karşılamak için yeni su kaynaklarına ihtiyaç duyuldu. Bu çalışmada, Murat Nehri'nin bir kolu olan Hamza Bey Barajı'ndan su sağlama yöntemi, nüfus tahmin yöntemleri ve üstel regresyon analizi kullanılarak incelenmiş ve 2050 yılında hesaplanan nüfusun su ihtiyaçlarını karşılamak için değerlendirilmiştir. 2050 yılı için hesaplanan nüfus yaklaşık 926964 olarak tahmin edilmiştir ve bu nüfus için toplam su ihtiyacı 51513758 m^3 olarak hesaplanmıştır. Ayrıca Hamza Bey Barajı'nın toplam su kapasitesi coğrafi bilgi sistemleri ve hidrolojik modelleme kullanılarak belirlenmiştir. Bu sonuca göre, 1140 m kotunda belirlenen 3366824 m^2'lik bir alana 53590000 m^3 su tedarik edildiği gözlemlenmiştir.

Anahtar Kelimeler: Coğrafi bilgi sistemleri, Su temini, Elazığ, Regresyon analizi.

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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, √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). Human beings have several basic needs to fulfill their living conditions since the day they were born. If these needs are mentioned, housing, heating, nutrition, transportation are some of the important parts of these needs. Water is vital to the survival of living things and is the most important element that maintains and maintains all biological life and all human activities, from the smallest organism to the largest living being (Küçükali, 2013). These mentioned and non-mentioned substances have a great and important common point. It is the most fundamental need that affects the living standards and sustainability of human beings and all living things on earth. Water is a liquid compound, which is colorless and odorless. It is a liquid consisting of two hydrogen atoms and one oxygen atom. Water is a liquid provides the biological life and activities of all living things. Water constitutes close to 75% of the earth's surface. There is a major classification of water in the world. If mention this distribution, 97% of the water resources are salt water and 3% are fresh water. Since the source of interest for human beings is fresh water, we look at the 3% water source. 67%, of the 3%, glaciers form fresh water source and 32% is groundwater and the 87% of the remaining 1% is composed of lakes, 11% is marshes and 2% is rivers. Water, which is the basic need, is so important that the human being gets warmed up, fed and so on is the largest resource in such cases. If we talk about the greatest source of human beings like water, you can imagine that people exist with it, clean it up, have fun with it, but when there is no water, you will have to face serious problems. It is not wrong to say that water is an indispensable need of living things. Therefore, it is the most valuable resource and need for human beings in their lives. Water and human beings directly affected by each other. To give an example to this situation, air, water and soil pollution mentioned in the last few years with the development of industry and measures have been taken about them. Water resources are directly or indirectly confronted with a number of bad conditions, such as the aforementioned situation. If it needs to be mentioned, water resources around the world are constantly trying to remain the same. As this cycle does not provide continuity over time, water resources decrease over time. In times of climate change, global warming and volcanic eruptions, this cycle cannot provide continuity. The total amount of water in the world does not change over time. The water cycle is a closed system. Water changes state, is in constant motion, and its level changes constantly. However, the amount does not increase or decrease. Except for small amounts of water added to the atmosphere by volcanic eruption and meteorites, global warming and climate change, the total amount of water in the world does not change. In fact, the world today uses water that existed millions of years ago. The same water; from the seas and oceans to the atmosphere, from there to the earth and below, from there to the atmosphere in an endless cycle. If we talk about this water cycle, there is a continuous cycle in which liquid water in the earth passes into the atmosphere by evaporation into the gas by evaporation, condensation falls in the atmosphere and falls to the earth as rainfall, some of which flows into the ground water and flows back to the earth. Plants also transmit gaseous water to the atmosphere through sweating and contribute to the water cycle. This cycle is called the water cycle. You can easily estimate and see the increasing demand for water in proportion to the increasing population in recent years. With the increasing demands, the scarcity of water resources that can be used, and the increasing industrial and agricultural mobility that are rapidly increasing day by day, are in serious need of water resources and for the same reasons, they are decreasing rapidly. Water resources are increasingly affecting all countries in the world (Figure 1.1).

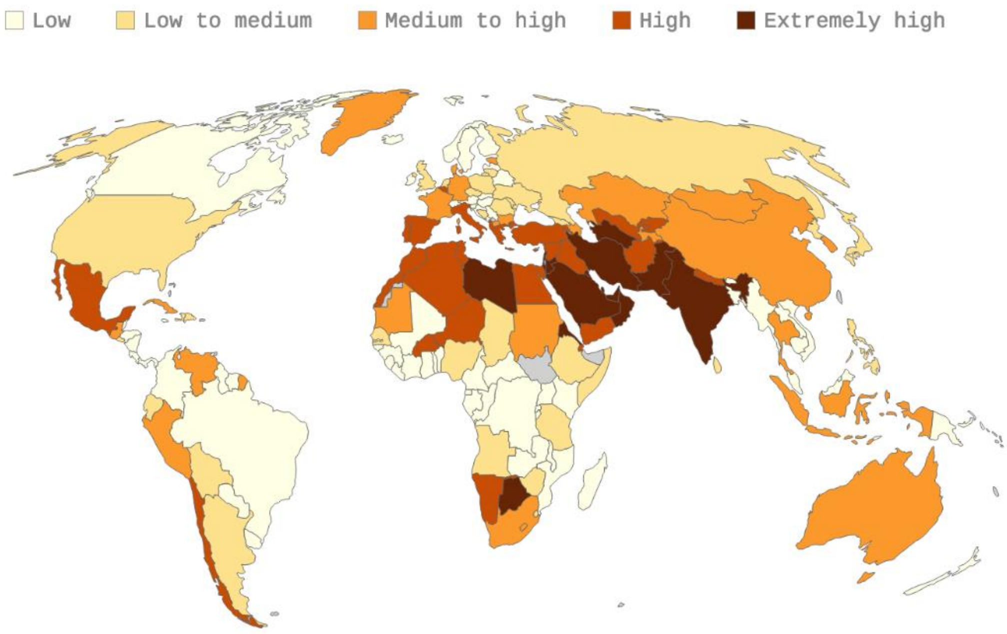

Figure 1.1 Water Distribution of World

In particular, for developing countries, this distress will lead to more severe impacts. It is estimated that 60% of developing countries will experience water shortage by 2020 (Türkyılmaz, 2010). As the population increases in the urbanization process, the need for water increases. It is also known that the daily water requirement per person (liters / person / day) varies regionally. The most important reasons for this difference; habits of communities, living conditions, economic conditions and the availability of water resources (Karakaya and Gönenç 2005). Dams are being constructed in order to protect water resources and meet water needs. The water obtained from the dams can be used as irrigation water or drinking water after being treated and reaching the desired quality. In Elazıg, 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). One of the most important water resources to meet water needs is the urban water wells. Elazıg is located in the Eastern Anatolia Region. The province of Elazığ has a surface area of 9151 km² including the total surface area of the water. Elazığ was established at the junction of Peri Suyu and Murat River and there are plains in the province. As it can be understood from the examples mentioned, the existence of efficient Elazığ Plain and Uluova have played a large role in the establishment and development of Elazığ city. The establishment of industrial branches such as cement, sugar, yarn, plastic pipes and Doğuçelik factories and organized industries increased the volume of employment. Thus, with the increase of these facilities, Elazığ became a lively and vibrant business center of the Eastern Anatolia Region (Mor and Çitçi 2002). There are multiple water sources in the city and its districts. If these water sources are mentioned, there are Keban Dam Lake, Cip Dam Lake, Kalecik Dam Lake, Hazar Lake, Kepektaş Pond, Işıktepe Pond, Tadım Pond, Keban Dam and Lake, Karakaya Dam Lake, Kalecik Dam Lake, Özlüce Dam Lake. As mentioned above, there are major water resources that Elazığ covers. The distribution of these water resources over the Elazığ area shown in (Table 1.1).

Table 1.1 Distribution of water resources in Elazığ

Water resources	**Area**
Total Surface Water Resources Potential	22246.9 hm3/year
Total Groundwater Resources Potential	22380.40 hm3/year
Total Surface of Natural Lakes	8256 ha
Total Reservoir Surface of Dam	53135 ha
Pond Reservoir Total Surface	16 ha

Today, due to the ever-growing population and increasing water usage, the crisis is increasing day by day especially for countries with water problems. In 2050, it is envisaged that one out of every four people will not have access to adequate water. Among emerging countries, Turkey, although it is a very rich country in terms of clean water resources, it is seen that there is a shortage of water in terms of the amount of usable water per capita (Topal and Topal, 2015). Once the water distribution in the world analyzed, it is predicted that some parts will experience a serious water crisis. The main source of the water crisis is the steady supply of resources in response to increasing demand. The main reasons for the increase in water demand are industrialization, increase in agricultural irrigation requirement and population increase (Mengü and Akkuzu, 2008). In parallel with the rapid increase in population in Elazığ, the water demand of the city is increasing rapidly (Mor and Çitçi, 2002). New water resources are needed to meet the water needs of the growing population. In addition to the need for water, it is important to predict for an increasing population. Different population projection methods are used to estimate future water need. This study examined the water demand of Elazig province in 2050 by using different population projection methods.

1.2 Geographic Information System

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). 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. There is a system established throughout the world. This system is called a geographic information system. This system is a system that collects the information available in the world for a specific purpose, processes and processes data into the computer and enters and stores the data, updates, controls, analyzes and displays. Looking at the history of this system, according to research, it began in 1832 by Charles Picquet mapping the outbreak of cholera in 48 districts of Paris. In 1854, the British in order to illustrate the increasing deaths of John Snow due to the spread of cholera in London, he created a map of the same logic and principle. On top of these situations, CBS was first introduced, researched and developed all over the world in the first months of 1960. Roger Tomlinson used computers to combine all the natural data found in Canada. It was precisely the situation that allowed Canada to begin its national land use management program, which created an automated information system to store and process large amounts of data. This system, called GIS. His computerized studies in Canada resulted in GIS assistance in 1963. GIS system consists of five separate parts. Respectively, hardware, human, software, data and purpose. It is possible to call technological devices such as computers, tablets, GPS in order to use GIS systems.

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 1.2 Example of a DEM (Maidment, 2002).

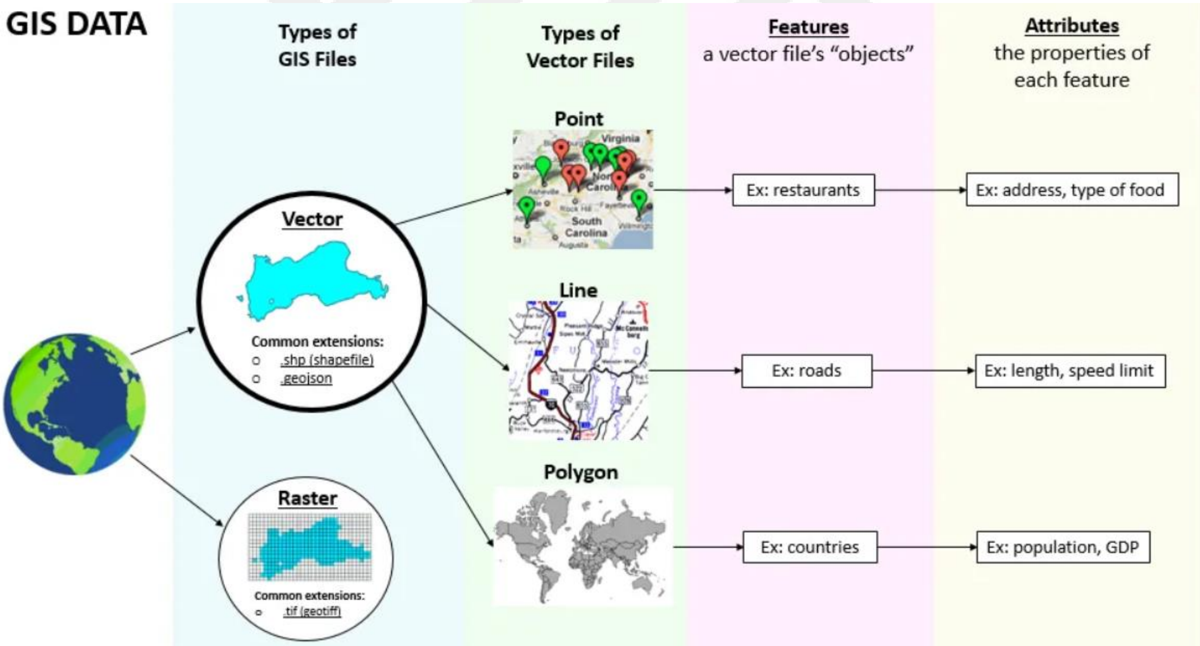

Figure 1.3 Representation of raster-vector data model (Defence Mapping School)

1.3 Aim of Study

In this study Murat river basin hydrological analysis was examined. The main objective of this study is to determine the hydrologic characteristics of Murat river basin and estimate the reservoir capacity of the HamzaBey dam, considered to supply water to Elazığ province, located in Murat river basin. ArcGIS V.10.6 and ArcHydro 10.6 were utilized and sold by Environmental Systems Research Institute, Inc. (ESRI) were used in this study for finding the hydrologic parameters of the Murat River basin. Data layers for all of the Murat 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. 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.

CHAPTER 2

LITERATURE REVIEW

Water is a natural resource of great importance to all civilizations for centuries, and all great civilizations are gathered on the water's edge. With the advancement of technology, the methods and rates of utilization of water resources increase, the development of water resources for many areas such as drinking water, irrigation water, energy production play an important role in the economic development of countries (Akkaya et al., 2017). Increasing water requirement with the world population day by day makes it necessary to use the available water resources in the most economical way. Therefore, the need for water resources engineering and the science of hydrology that will form a basis for this is inevitable. Hydrology; it is a basic and applied science that examines the cycle, distribution, physical and chemical properties of water on earth, underground and in the atmosphere. At the same time, it is important to project and operate water structures. When a water structure is being projected, hydrological studies are carried out first and then the structure is sized. In this way, the water cycle is formed. The waters in the world move in a hydrological cycle with the help of solar energy. Living creatures on the earth meet the water they need for their many activities from this hydrological cycle and then return the water back to the same cycle. In order to sustain vital activities in ecological balance, the sufficient amount and quality of water needed by living things must be provided from this hydrological cycle. Planning for the conservation, development and sustainable use of our country's water resources needs to be done at the basin level (Yüksek, 2004). In order to meet the increasing water needs in the following years, the importance of water management increases even more. Problems with water management; physical infrastructure deficiency, deterioration of water quality, water pollution, lack of water transmission-distribution systems and management problems can be listed as (Çakmak et al.,2006). It is known that there will be nothing artificial to replace water in the future and paying more attention than ever helps to use resources wisely with new strategies (Mengü and Akkuzu, 2008).

The permeable pavement is effective green infrastructure that can improve stormwater hydrology and mitigate urban inundation. However, performance can be effectively weakened when used in the area of high water table and low permeability soil. An innovative porous pavement (IPP) is proposed, where capillary columns and an internal water storage zone consisting of a high density polyethylene liner are installed (Liu et. al., 2020). Hydrology of forest wetlands is critical for ecosystem functions and services of forests. However, the understanding of the hydrology of these wetlands is likely to be very limited due to the tediousness and costs of tracking scattered small wetlands with traditional methods. There was no significant effect of temperature or humidity on the isotopic signatures of the rains (Bugna at al., 2020). Recently, new concepts and ideas about how to approach water resources management more holistically have been discussed. Using approaches to how well social sciences are integrated with hydrological research, it is concluded that interdisciplinarity in water resource research is on a promising path, but it may need to mature further (Seidl and Barthel, 2017).

Hydraulic modeling studies; provides scientific support to water resources management for the analysis and solution of the current and potential problems of the system. Thanks to the hydrological models, the surface flow, ground flow, groundwater flow, evaporation and sweating amounts that make up the water budget of the system can be calculated. Possible effects of factors such as climate, population, land use, crop pattern, irrigation practices for the current situation and the future can be analyzed through various scenarios. While a system is being modeled, the model to be installed must represent the reality as much as possible. In this respect, the data analysis phase is very important. In the analysis stage, taking into account the scale of the study area, the data should be evaluated effectively. GIS numerical calculation and spreadsheet programs are used in the integration of data, processing, analysis and visualization of numerical and spatial data (Yaykıran, 2016). In addition, the Observation Data Model (ODM) is a relational database model developed to provide an appropriate format for storing point-based data. After the data is stored, the data are published and recorded in the HIS Plant, using Hydro servers that allow the data to be researched and accessed (Şarlak et al., 2010).

Hydrological models is widely used in studies based on issues such as the impact area and duration of agricultural drought, as they can provide spatial and temporal continuous and stable data from different layers of soil (Bulut et al., 2014). As a hydrological model, it is observed that DSAP model developed by the Stockholm Environment Institute (SEI) and DSİ method in the Sakarya Basin have a certain degree of compliance with the average values for many years using the PGM method included in the WEAP model (Yaykıran, 2016).

Gichamo et al., (2020) by creating Utah Energy Balance and TOPNET models for multiple major water basins in the Colorado River basin, HydroDS assessments show that HydroDS reduces input preparation time according to manual processing. It also removes the requirements for software installation and maintenance by the user, and the Python workflows enhance reproducibility of hydrologic data processing and tracking of provenance. By Wijayarathne and Coulibaly (2020), investigates five hydrological models to identify adequate model(s) for operational flood forecasting at Waterford River watershed. All five models are capable of simulating streamflow reasonably well in both calibration and validation periods. However, due to the good performance of all five models, an ensemble forecasting using continuous, multiple hydrological models is also recommended.

Geography, the events that occur in the natural environment to the human and human life; It is a branch of science that examines the effects of humans on the natural environment (Çukur, 2005). Today, there are software and systems that are used for researching and learning about the natural and cultural changes of the earth, and at the same time, very fast and accurate information can be obtained. These systems, which have very complex structures, obtain periodic data about the earth and data that can be expressed in millions. These data are an important result of technological development. The system that will provide this data organization is Geographical Information Systems (GIS). GIS is a system that helps to determine the most ideal use of natural and cultural land resources and makes land resource planning successfully. Remote Sensing (RS) is an important tool for collecting and obtaining information. Due to the convenience of GIS in providing data, storing, processing and publishing, it has been developing rapidly and offered to the users in the last 10-15 years. The database, which forms the core of this system, aims to provide information to the system while preserving the data in a technical manner and keeping the information ready for a future use (Sönmez and Sarı, 2004). GIS, which started to be implemented with the development of information and computer technology, is used in many professions and business lines for follow-up and planning. GIS collects all kinds of data with each other and their geographical locations, collects them in computer environment and monitors them graphically or in print. Especially since the beginning of the 21st century, geography science, GIS, Global Positioning System, Remote Sensing (RS), computer and internet has provided great opportunities to mankind in almost all areas of life with its superior technology, tools and methods. In this century in which we live the information age, it is extremely important to find new solutions to the problems of the society by gathering information, producing information and obtaining different results. GIS, which enable all geographical information of the world to be transferred to the computer environment, questioned and analyzed, is an important information technology used in every moment of life in order to produce permanent solutions to the problems faced by societies (Kapluhan, 2014). GIS has recently combined computer graphics technology with database structures and spatial analysis techniques. Technology has been growing rapidly since GIS research has become a solution to computing problems (Huxhold, 1991). Hydrology, agriculture, ecology, forest management, meteorology etc. different climate parameters are used in studies conducted in many different disciplines. GIS, which is an indispensable part of spatial database applications, has become inevitable to use in climate studies (Güler and Kara, 2007). By Elidrissi et al., (2020) the geographical distribution of calcrete has been studied by combining Geographical Information Systems (GIS) and statistical analysis we present a qualitative approach that incorporates topographic, geological, hydrogeological and climatic data as well as field observations. The qualitative approach provided a distribution map that predicted possible areas where different superficial forms could occur and allowed it to clarify the degree of impact on the development of environmental factors. The accuracy of this method has been estimated by comparing 52 cross-section data and the approach proved to be successful in the study. Statistical analysis results confirm the results obtained using the GIS method and emphasize the impact of the environmental factors examined on different types of spatial distribution. Population is met with groundwater in cases where surface water resources are inadequate due to increase in economic activities, agricultural irrigation and industrial activities. GIS, which has been used in many areas in recent years, shows an important development in determining the potential and quality of groundwater (Hamidi, 2018). In Neissi et al., (2020) studies; Irrigation systems are determined to have reached a higher diversity since the selection and implementation of an irrigation system in recent years has been based on the physical constraints of the site area, thereby leading to a much more adequate irrigation efficiency. In addition, GIS software is widely used in most studies on water resources. Especially in hydrological model studies, it is obvious that GIS software provides great convenience when considering the land topography and geomorphology. In such studies, detailed data are usually required. However, it is not always possible to obtain model results quickly and realistically due to the complexity of the models and the need for detailed data (Burgan et al., 2015).

It is only possible to prepare projects, implement them and monitor their results, only with sound data / information. GIS is very effectively providing this type of information to the user; it is a technological phenomenon that is increasing its user base rapidly every day in our developing country. Rapid developments in this direction reveal a lot of confusion along with it. In our country, it is only possible to set out the basic goals for using GIS at a high level, by developing and implementing basic GIS policies. GIS policy not only allows the use of country resources more efficiently, but also opens the way for better understanding, dissemination and survival of GIS on an institutional and individual basis (Yomralıoğlu, 2003). The latest innovations in computer technology and geographic information systems offer new ways to provide decision makers with the necessary information. Developments can be viewed and analyzed in two or three dimensional maps and databases. Thus, it will be able to reach the relevant places in an understandable and usable way (Yalçıner, 2013). Finding areas that are suitable for solar farm development is crucial for the economic feasibility of these projects and the sustainable use of land. A GIS-based approach combined with a Multi-Criteria Evaluation methodology is used to create a map which shows a ranking of areas with high potential for solar farm development. The GIS-based methodology is employed in the treatment of the legal and environmental criteria and sub-criteria to delimit the suitable locations. In the Valencian Community the most discriminating criterion, when selecting the best locations, is the intensity of solar radiation, while temperature is the least discriminant (Marques-Perez et al., 2020). Geographic Information Systems includes spatial data processing, data analysis and presentation of results. Maps are necessary for the communication of spatial information that cannot be explained sufficiently only with texts. Maps are also important for GIS 'decision making functions. The results of the GIS analysis are published as a screen map or paper map. For this reason, GIS is a system more advanced than relational database and computer aided design packages. In this context, the importance of maps in the presentation of data and analysis results of GIS is examined (Uluğtekin and Doğru, 2005). Geographic Information Systems and its version, which has been reduced to the city base, offer great opportunities for the solution of the increasing and complicated problems caused by rapid urbanization as a product of information technology (Pektaş, 2009).

Physical planning is an approach based on the fact that natural environment features are guiding in planning studies. In planning studies carried out at different scales for different purposes, it creates important and public interests such as sustainable use of resources, ensuring continuity in use without needing renewal, providing planning and providing social and economic advantages. Physical planning results play a guiding role for local and public administrators in making all kinds of works related to physical space besides planning. Natural environmental characteristics, characteristics of planning targets, collection, storage, analysis, updating, updating, updating, updating, using, transferring, visualizing and visualizing this database for different purposes, and in these jobs, in a short time, in the least economical way, requiring minimal labor, GIS have today's conditions (Turoğlu, 2005). Effective and correct use of resources is an important factor in ensuring development. Today, when the needs are increasing and diversifying, there is a great pressure on resources. Improper land use caused by this pressure causes destruction of land resources and increased poverty and other social problems. In this context, in Turkey, where the population is increasing, it becomes imperative to use the land in accordance with its potential for use. Because the sustainability of the spaces can only be achieved by determining the natural-cultural potential and applying the land use in accordance with the ecological structure. The subject of the best evaluation of the land has been examined by many researchers using various methods and land suitability analyzes have been made. The GIS methodology and the analytical hierarchy process, which is one of the multi-criteria decision making methods, can be used to perform the land use suitability analysis of the Yukari Kara Menderes Basin. In the study, three different land use types, namely agriculture, meadow-pasture and forest, are taken into consideration. At the end of the evaluation, suitability analyzes were made for the mentioned land use types, an optimal land use suitability map was created for the study area and the existing land use situation was compared with the map created. According to the optimal land use map, 75.1% of the study area was proposed to be used as "forest", 15.2% as "agriculture" and 8.5% as "meadow-pasture". When the proposed optimal land use and the current land use situation were compared, it was observed that the agricultural lands were higher than the recommended agricultural lands in the current land use. In addition, forest and meadow-pasture areas were found to be lower. Accordingly, it has been determined that some of the lands in the area of examination are not used in accordance with the potential and some of the land that should be considered as forest or meadow-pasture are agricultural (Akbulak, 2010).

Remote sensing (UA) and GIS are widely used in studies related to natural disasters. These studies are natural events that cause natural disasters such as earthquakes, floods, landslides, fire, volcanism and storms. CBS and RS cover not only the determination of locations of these natural events, their observation and their effects, but also many studies to be done before and after the disaster (Arca, 2012). Sharma et al., (2019) GIS is also of great interest in the field of disaster management, and it is used by field workers to help its employees achieve faster restoration by providing a more efficient emergency response after a disaster with a mobile application with a GIS feature. The findings could serve as a guide for emergency restoration teams in similar disaster management scenarios in the future.

With GIS, it is possible to collect spatial data, to store it in a database, to update and analyze it when requested. Based on the information obtained from the analysis results, it is possible to draw viewable maps and to access the information needed by inquiry. Taking advantage of such facilities and taking into account the positive results from the work done with GIS to date, it is understood that GIS is a useful tool for marketing work, as in other areas. Those who want to make decisions or access various information related to marketing can easily access and use both the data stored in the database of GIS and the information obtained as a result of analysis made with GIS (Fidan, 2009). There are multiple study samples analyzed by GIS. Some of these are given below.

Four main land cover and land use classes are created in determining the event of land use using satellite imagery and GIS in 341 km of eastern longitudes between northern latitudes and 36° 09° 52"-36° 24° 31" of the Central district of Samsun province. The field study was carried out for the control and determination of the classes created and as a result of the controlled classification, agriculture, pasture, forest and non-agricultural areas were defined. This result; remote areas and geographic information systems have important roles in generating accurate and fast data in determining land use, land cover change and monitoring usage trends (Dengiz and Demirağ Turan, 2014). Remote Sensing and GIS techniques were used in the application of the erosion risk determination method to the study area of Çorum. As a result, the erosion risk map was obtained using ArcGIS 9.0 and Erdas Imagine 8.5 software. The risk of erosion was determined in 7% of the study area, low in 13%, moderate in 20%, high in 27%, and very high in 33% (Tombuş, 2005).

In Afyonkarahisar example, after introducing information about geographical information and city information systems, the importance and benefits of systems in terms of city administrations and the problems encountered in preparation and implementation processes are emphasized. It is observed that in the case of Afyonkarahisar province, with its geographical and urban information system applications, it has not been able to provide sufficient development in this regard (Pektaş, 2009)

Holguín and Sternberg (2018) examines the results of a GIS-based drainage network, showing the hypothetical model of the Ulaan Nuur paleo hydrological system in the Gobi Desert of Mongolia. This model has been successfully used in field research, which led to the discovery of four Neolithic period sites and several Neolithic sites along the supposed south edge of the paleo canals and paleo lake. In addition, it can be seen that GIS hydrology modeling can provide a reliable method to identify places in other arid and semi-arid environments and to evaluate the relations with past waterways with the method of examination of paleo hydrological landscapes in the Gobi Desert.

GIS hydrology water quality model LF2000-WQX is predominantly selected in the rural Tamar (UK) basin when applied to predict the concentrations of diklofenak and propranalol in basins. Predicted concentrations are 1 ng / L or less under low flow (90th percentile) conditions. However, in some locations downstream of small sewage treatment plants, concentrations above 25 are estimated as ng / L. This exercise shows that it is relatively simple to estimate the concentrations of new and emerging organic micro contaminants in real basins using existing GIS hydrology water quality models. More testing is needed to ensure its accuracy (Johnson et al., 2007).

It tries to understand the groundwater potential (GP) region in the drought-prone Plio-Pleistocene elevated channel in Bangladesh using CBS and remote sensing (RS) technique. For the current study from different secondary sources, these layers were recorded together, accompanied by ten thematic layers, and the UTM 45 projection and the world geodetic system (WGS) were corrected to the 1984 datum. Thematic layers have a negative effect besides drainage density, slope, geomorphology, soil thickness, groundwater table depth, lineage density, precipitation, infiltration rate. A positive effect is seen with increasing class range values for GP. Surface lithology and land use / land cover depends on porosity and the presence of water bodies to infiltrate into the aquifer. Map lift sensitivity analysis (MRSA) and single parameter sensitivity analysis (SPSA) are also moved to evaluate the effect after removing the effective weight of the thematic layers on a thematic layer and GP map respectively. MRSA results show that groundwater table depth is more susceptible with an average variation index of 8.9%, and that the effective thematic layer is tilting outside SPSA results (weight 29.7%) (Ferozur et al., 2019).

Li et al. (2011) Investigates the risk of water accumulation under high pressure to provide a reference as required by prevention and control measures to ensure project safety of the Xiamen submarine tunnel. With the support of GIS software, a prediction system for the bundle of water in Xiamen submarine tunnel has been researched and developed. The findings of the assessment are seen as the background database updated with real-time geological data and groundwater data during tunnel construction. The forecasting system FLAC 3D simulation tools are examined by the basic platform MAPGIS and VC ++ as the development tool System functions include data input-output, data query, the bundle of water, prediction and result display function. The implementation of this system in the Xiamen submarine tunnel engineering structure shows that the system can provide a relatively accurate engineering guarantee for water detection in safe tunnel excavation.

In Kilis, which has semi-arid climatic conditions, the fact that the precipitation is irregular and torrential, the lithological structure is susceptible to erosion, and the vegetation luster increases the risk of erosion. Erosion risk map of the central district is created in order to take into account the erosion risk in settlements, transportation and agricultural land use or planning studies in Kilis. Erosion risk map created with Multi Criteria Decision Making Method is produced with the help of ArcGIS 10.x. The slope, precipitation, aspect, lithology, altitude, vegetation density, soil depth and shallowness that are effective on erosion are used to create this map. Firstly, GIS class values are assigned according to their impact values, and then their impact degrees are determined according to the GIS weight values at erosion risk. Finally, each of the parameters that are effective in erosion is made Raster, and the process of overlapping with the Raster Calculater option is performed. According to the map made to reveal areas with high erosion risk, 52% of the study area has medium, high and very high risks in terms of erosion. The remaining 48% are found to have low and very low risk values (Sönmez et al.,2013).

Wastewater leakage problem associated with sewage treatment plants deterioration has become prominent. We develop and apply procedures of GIS and direct current resistivity (DCR) techniques to investigate the wastewater seepage appearance in a semiarid urban environment. Notably, the integrated approach allows us to assess geotechnical problems and to propose a suitable location for wastewater discharge management (Attwa and Zamzam, 2020).

Keskiner et al. (2011) using the ANN method in the Seyhan Basin, the 50% probability average temperature map created by the DEM in the GIS environment and the 50% probability average temperature maps obtained by the Multiple Regression Method (CRS) are compared according to the minimum error criteria. In the Seyhan Basin with an area of 21470.3 km²; The average temperature series of 45 meteorology observation stations belonging to the General Directorate of State Meteorological Affairs (DMI) are used as basic materials for many years. Appropriate probability distribution models are determined with the Kolmogorov-Smirnov conformity test at 5% significance level. M.Turc method, 50% probability average temperature value used in surface flow estimation is estimated from the probability distribution model for each station. Estimated 50% probability average temperature maps with Artificial Neural Networks method and Multiple Regression method are compared according to minimum error criteria. In the Seyhan Basin; It is concluded that the temperature estimations made with the Adaptive Linear Element (ADALINE) model are more realistic than the Multiple Regression method.

Domazetović et al. (2019) in order to determine the presence and spatial distribution of gully erosion on the Pag Island (Croatia), a gully erosion susceptibility model was developed using GIS-based multicriteria decision analysis (GIS-MCDA). Developed GAMA method allows easier and faster application of GIS-MCDA methodology in gully erosion susceptibility modelling, as well as in various other research areas.

Wang et al., (2019) building information modelling (BIM) and GIS provide digital representation of architectural and environmental entities. BIM focuses on micro-level representation of buildings themselves, and GIS provide macro-level representation of the external environments of buildings.

GIS can be extensively integrated into hydrology and non-point source (H / NPS) pollution modeling. The impact of GIS data on H / NPS simulation is explored by resampling the initial GIS data to new grid dimensions and grouping existing GIS maps in all possible ways. The impact of GIS inputs has also been studied by the Soil and Water Assessment Tool (SWAT) in the Daning basin in China, while GIS inputs have a limited impact on flow and nitrogen estimates, while sediment and phosphorus simulations are delicately influenced by GIS data. This study also shows that there is a GIS level of analysis where more precise data cannot benefit from SWAT estimation. To reduce estimation uncertainty, the digital height model (DEM) needs to be addressed to determine the resolution at which the model will perform optimally (Shen et al., 2013).

In addition to being a quantitative representation of the land DEM is of great importance for Earth science and hydrological applications. DEM can be generated using photogrammetry, interferometry, ground and laser surveying and other techniques. Some of the DEMs such as ASTER, SRTM, and GTOPO 30 are freely available open source products. Open record DEMs (ASTER and SRTM) and their high record derivatives are evaluated using Cartosat DEM and Indian Survey (SOI) height information. These results can be highly useful for researchers using such products in various modeling exercises (Mukherjee et al.,2013). DEMs that accurately replicate both landscape form and processes are critical to support modelling of environmental processes. Topographic accuracy, methods of preparation and grid size are all important for hydrodynamic models to efficiently replicate flow processes. In remote and data-scarce areas, high-resolution DEMs are not always available, and therefore low-resolution data such as the Shuttle Radar Topography Mission needs to be evaluated. This study highlights the important impact that the quality of the underlying DEM has, and in particular how sensitive hydrodynamic models are to preparation methods and how important vegetation smoothing and hydrological correction of the base topographic data for modelling floods in low-gradient and multi-channel environments (Jarihani et al.,2015). Soliman and Han (2019) DEM, derived from remote sensing data such as satellite images, remotely sensing, shows that the vertical accuracy of DEM affects the number, density and length of the lines that are applied more simply, requiring costly and laborious field work such as lineage. Also, this cost increases with the vertical accuracy of DEM.

Medium-resolution DEMs have limited applicability to flood mapping in large river systems within data sparse regions such as Sub-Saharan Africa. SRTM (30 m) in West Africa offers a new approach to DEM development and an improvement in the topography of the floodplain for the Gambia River. As a result of this approach, it will be beneficial for flood risk modeling applications in sparse regions of data (Ettritch et al., 2018).

Presently, the application of digital elevation or surface models have increasing relevance in all areas of scientific research and in practical engineering applications. The ASTER GDEM and SRTM databases are the most widely used digital surface models, due to their free accessibility and global coverage. The SRTM model was produced using a radar-based technique and the ASTER GDEM was developed using optical stereo image-pairs. Therefore, as all models contain errors (i.e. differences stemming from real surface or vertical biases), errors in these models will also differ (Szabó et al., 2015). Topographic parameters in glacier inventories are of vital importance for several subsequent applications. In combination with DEMs with near global coverage, such parameters can in principle be derived for all digital glacier outlines. The study investigated the compatibility of SR86 DEM and ASTER GDEM for the compilation of seven glacier-specific topographic parameters for the 1786 Swiss glacier samples. The analysis revealed that large differences of the values can occur on individual glaciers, but they average out for larger glacier samples (Frey and Paul, 2012).

CHAPTER 3

STUDY AREA

3.1. General

The city of Elazığ is located between 40^o 21’ and 38^o 30’ eastern longitudes and 38^o 17’and 39^o 11’ northern latitudes. The city has a total area of 9218km^2, corresponding to 0.12% of Turkey. Elazig province is located in the Upper Euphrates Basin, southwest of the Eastern Anatolia Region. The province surrounds the fields of The Provinces of Bingöl from the east, Tunceli through Keban Dam Lake from the north, Malatya through Karakaya Dam Lake from the west and southwest, and from the south to Diyarbakir. When the water resources potential of Elazığ province is examined, the total water potential for surface water (total average current out of the province) 20716.8 hm^3 /year, groundwater (total safe reserve in the province) is 20813.8 hm^3 /year. Among the most important streams of Elazığ province are Murat River, Peri Water, Mineral Tea, Haringet Creek, Ohi Creek, Caro Creek, Kalecik Creek and Fuzzy Creek. The city is dominated by mountainous areas, plateaus and plains. Southeast Taurus Mountains, Meryem Mountain, Mastar Mountain, Hazar Baba Mountain, Hasan Mountains, Cloudy Mountain, Crow Mountain and Kamislik Mountain are located in Elazığ province. The border cities to Elazığ are, Bingöl, Malatya and Diyarbakır. Elazig province also consists of 11 districts, 537 villages and 709 town. The most important river near the city center is Euphrates River. Also Tributary of the Euphrates River, which is called as Murat River, most efficient and highest water potential passing in the city of Elazığ. The mentioned Murat River is also poured into the Keban Dam Lake in the city. Another river is the Tigris River. The Tigris River provides its source from the mountains of the Eastern Anatolia Region and the Caspian Lake. This river is not only one of the most important water resources of an entire Turkey's Elazig province but also the total length of 1/4 passes through the territory of Turkey so that Turkey and also provides a lot of opportunities thanks to this river. Other important water resources, Hazar Lake is a tectonic lake located 30 km far away from the city center. The depth of this lake varies between 220 and 250 meters. Hazar Lake contributes not only to the city and the country in terms of water supply, but also in terms of tourism and economy. Another important resources is Keban Dam is an artificial lake created to supply water and energy to the artificial dam. This reservoir is also referred to as Turkey's largest artificial lake.

The lake, which is another water source, is Cip Dam Lake. This lake is about 15 km away. As you can see from this name, this lake is an artificial dam lake.
The source of the formation of this dam lake is the Murat River and Cip Stream. Thanks to this dam, necessary irrigation resources fed for agricultural activities.

Figure 3.1 Elazığ Location in Turkey

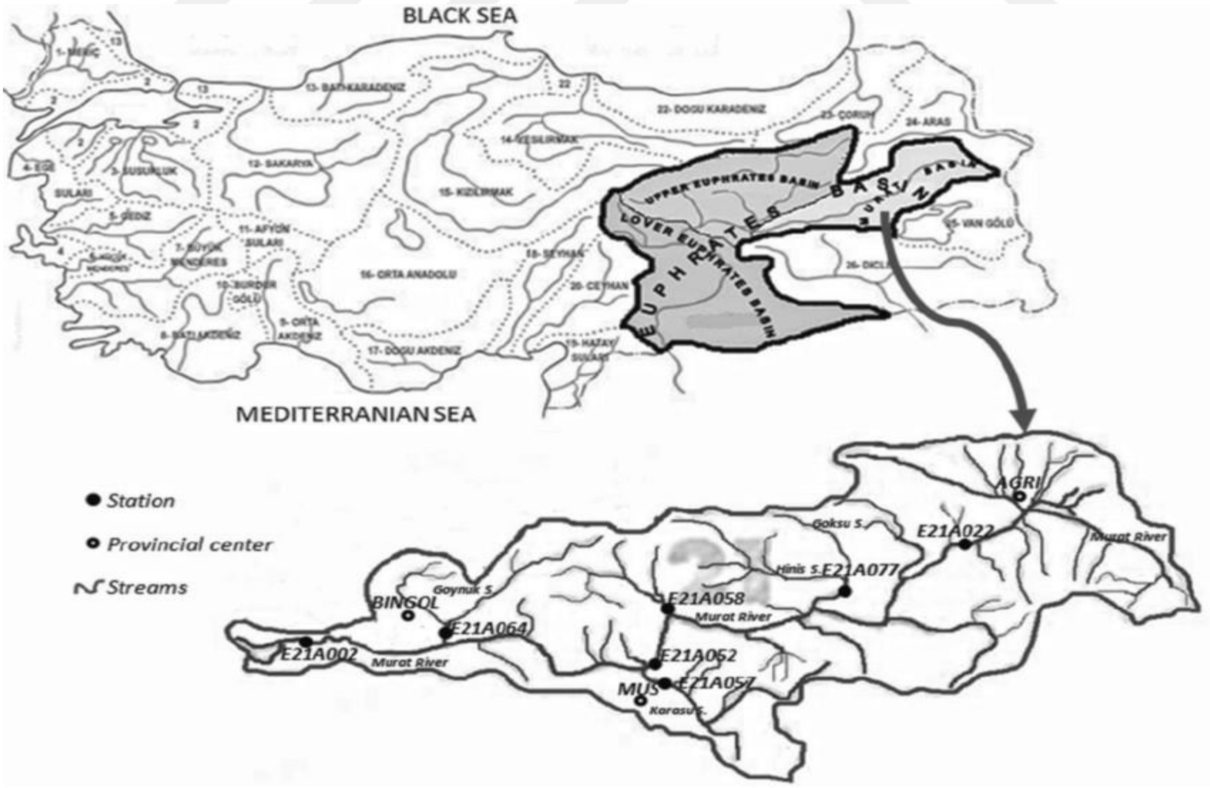

Figure 3.2 General location for study area (Alashan, 2016)

3.2. Geography and Geology

When the geological, tectonic and hydrogeological maps of the Elazig region (Sungurlu et al. 1984; Turan and Bingol, 1991) are examined, general information about the types, ages, distributions, structures and groundwater contents of the rocks in the region can be obtained. Elazığ region has various ages and a wide variety of rocks from paleozoic to today. There are old and metamorphic rocks in Keban, Pertek, Kömürhan and Pütürge, and old and various types of igneous rocks between Baskil-Harput-Kovancılar, Sivrice and Maden. Between the Munzur mountains and Malatya-Sürgü, there are thick and karstic limestones in a wide area, and sedimentary rocks between Ergani and Çermik. Alluvial sediments of current age are found in the plains and large valleys in the region.

Tectonic maps show that Elazig region has a very broken structure. As the largest fractured structure, the part of the Southeastern Anatolia Line between Sürgü and Çüngüş can be specified in the region. The East Anatolian fault passing through Sürgü-Hazar Lake-Palu is a large, alive and left-sided fault line. Apart from these, there are many small fractured structures in the region. Large fault lines in the region also form very rich belts in terms of groundwater.

3.3 Meteorology

The climate of the study area is characterized as continental climate. Annual mean temperature is about 12.4 ºC. According to the data of 36 years the maximum mean temperature is measured to be about 25.9 ºC, which is recorded in July 2000 and the minimum mean temperature is noted to be -1.6 ºC recorded in January. The average annual rainfall is about 534 mm (Figure 3.3, Table 3.1) and the seasonal precipitation regime is winter, spring, autumn and summer.

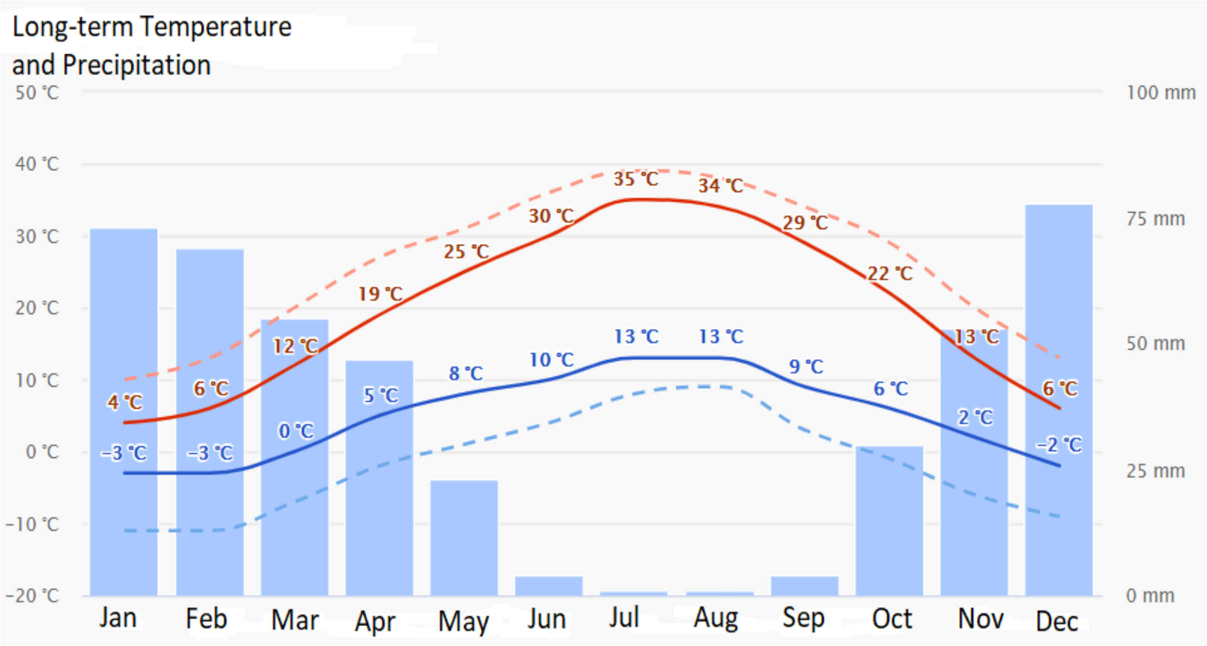

Figure 3.3 Long-term temperature and Precipitation values of Elazığ province

Table 3.1 Weather condition of Elazığ

Ave. temperature	+12.4°C
Maximum temperature	42.2°C
Minumum temperature	-22.6°C
Sunny Days	8.1 hour
Ave. of Humidity	50%
Ave. of Rainy Days	84.5 days
Ave. Rain	534 mm
Ave. Snowy Days	13 days
Ave. Nipping Days	56.5 days
Maximum Snow Elevation	68cm
Wind Direction	Southwest Wind
Ave. Max. Temperature(JULY)	25.9°C
Ave. Min. Temperature(JANUARY)	-1.6°C

Table 3.1 is about weather Condition of Elazığ city with average values. Average maximum temperature is 25.9°C in July and average minimum temperature is -1.6°C in January. Figure 3.3 is about annually average values between 1938 and 2018 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).

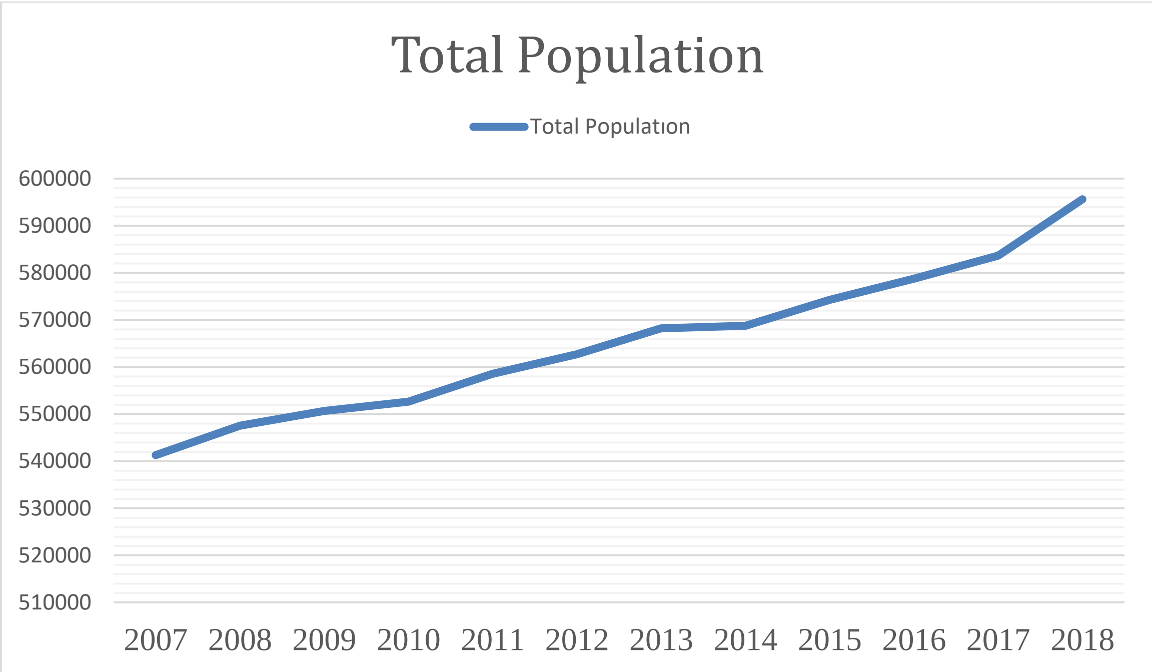

Figure 3.4 Population of Elazığ

Table 3.2 Population of Elazığ province

Years	Population
2007	541.258
2008	547.562
2009	550.667
2010	552.646
2011	558.556
2012	562.703
2013	568.239
2014	568.753
2015	574.304
2016	578.789
2017	583.671
2018	595.638

3.4 History

The city of Elazığ was founded among the skirts of the hill on which the historical Harput Castle was constructed. According to the present historical sources, the most ancient inhabitants of Harput was the Hurrian nation who settled in these parts in c. 2000 (B.C.) Harput and its surrounding region was part of the kingdom of Urartu at the period of its maximum extension. The ancient town and citadel called Kharput (Kharpert), which means "rocky fortress" in Armenian, was built by the first Armenian kings about five km (3.1 miles) from modern Elazığ. However, very little written material about this city reached our day. It is possible that Harput stands on or is near the site of Carcathio-certa in Sophene, reached by Corbulo in A.D. 65. The early Muslim geographers knew it as Ḥiṣn Ziyād, but the Armenian name, Khartabirt or Kharbirt, whence Kharput and Harput, was generally adopted in time.

From its foundation until the end of the World War II, the city's growth was somewhat irregular. While the town probably consisted of 10 to 12,000 inhabitants at the beginning of the World War I, the first census conducted by the Republic of Turkey in 1927 counted 20,052 inhabitants. This figure continued to rise to reach 25,465 in 1945, but the general shortages suffered during the World War II years by the neutral Turkey led to an exodus of population, reducing the population to 23,635. From then onward, the city has gone through uninterrupted growth. Harput, in the meantime, acquired the status of a township separated from Elazığ with a population of about 2,000.

3.5 Current Water Resources of Elazığ Province

Keban Dam is located at 45 km northwest of Elazığ Province and 65 km northeast of Malatya Province. It was built around Keban District 10 km southwest of where the Karasu and Murat rivers meet. The most leather place of the lake is the point where the dam body is located, at which point the maximum depth is 163 m. The main stream of the lake is the Euphrates river. The river is formed by the merger of the Murat and Karasu rivers about 8-10 km north of Keban dam cretine. The water depth of the Euphrates river is around 4-10 m depending on the season. The average discharge is 635 m^3 /s, the minimum daily discharge is 145 m^3/s and the maximum daily discharge is 8.416 m^3/s. Keban Dam Lake is fed by The Euphrates River and its arms (Murat, Karasu, Peri and Munzur waters and Arapkir river). Other important dam lakes are shown at (Table 3.3). On the other hand, as a source of drinking water, deep water wells opened in various parts of city (68 wells) are obtained from the sources and water is provided with a total flow of 1,689 lt/s.

Table 3.3 Rivers located in Elazığ province

Location	District	Average Discharge (m^3/sn)
Cip Creek	Cip Dam Entrance	0,305
Caro Creek	Hamzabey Gardens	1,373
Behramaz Creek	Çevirme Channel	1,336
Harigent Stream	Dedepınarı	0,887
Aliağa Creek	Görgüçler	0,792
Kamışlı Creek	Tatar	0,105
Şorak Creek	Kuşçu	0,316
Söğütlü Stream	Deregezen	0,902
Gökçe Creek	Gökçe	0,063
Tarhana Creek	Arıcak	0,561
Tengila Creek	Kayaönü	0,645
Viran Stream	Keklikpınarı	1,801
Köklüce Creek	Mollik	0,350
Sarni Creek	Altınkuşak	0,150
Murat River	Palu	244,848

3.6. The Flow Measurement and Meteorological Stations at Murat River region

Hamzabey Dam, which is a Drinking Water project in Elazığ Province, is planned to be built on Caro lake, which is located about 75 km away from Elazığ city center and located about 4 kilometers southeast of Palu district. According to the flow discharge measurements obtained from the flow measurement Station (FMS) numbered D21A179, the river is able to provide an average annual water amount of around 56.65 million m^3 with an average discharge of 3.26 m^3/s. FMS is located at 38°40'43’’N 39°57'31’’E. FMS actively involved in running from the year of the 1982 and located on M 38 numbered map and from this day-measured on a instant maximum flow rate 68.6 m^3/s measured at (16.05.1991). For many years, monthly average values taken into consideration annual average flow rate 12.87 m^3/s flow means about 403 million m^3 water passes pear year.

3.7 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 1983-2015 (Table 5.3).

3.8 Geographic Information Systems (GIS)

Geographical information system, is a tool consisting of data entered by a computer developed by humans to track objects, materials and some movements on the world, to examine, to analyze and to pour them into the map system within the studied area. This technology is a tool integrated with the widely used maps developed for statistical analysis of research on a purpose. Considering the use of the Geographic Information System on the world, it is a computer-based system developed by humans to investigate and analyze the earth and its mobility. The program used in the computer, the data to be entered into the programs and what will use this system is also human. This system is not different from the excel program on the computer. Geographic Information System is used for entering data, storing, making analyzes, creating graphics, creating tables, etc. Furthermore, Geographic Information System is a program used to process and analyze data in different ways. In GIS, each data is kept in the system depending on its location in the real world and displayed on the map. Data in each different character put on the map is processed as a different layer and under the section shown. Here, all kinds of data in GIS are kept in the tables belonging to the character seen on the map, and multi-dimensional applications can be performed on one, several or all of them if desired (Armutcu, 2013). Geographical Information System consists of 4 different stages. These stages are digitization, database creation, and correlation with spatial information, analysis and reporting stages. The digitization process is transferring the obtained data to the program created in the computer system. The data can be estimated from classical maps, satellite imagery, field studies and other digital data. With the Geographical Information System, the data is transferred to the digital environment easily. A topology system is created by making necessary studies on the entered data. This topology system will make the first coding by introducing the digitized data to the system in a way that will relate the information to be used in the next stages.

Another step is to create a database as mentioned. In the logical relationships to be established within the framework of the database determined according to the desired results, the necessary information will be entered into the system by the system and the database connection will be made with the spatial information. Four different models have developed for the information of the database. These models defined as relational, network structure, hierarchical, object oriented models. In the continuation of these two phases, the usage and analysis phase is being developed. Necessary calculations are the stage of finalizing new data with the help of researches. This stage called as usage and analysis. It enables the queries need to be made within the framework of the needs of the users. Necessary segmentation, reclassification, registration and many other analyzes are carried out.

The name of the stage known as the last stage is the imaging stage. This stage developed as two models; vector model and the other as a random model. The vector model is defined in three types of information, coordinates and related information. There are three different types as Point, Line and Polygon. The polygon, one of these three different types, represents two-dimensional geographic information that defines the enclosed area on the map. On the other hand, the line represents the matching geographical information defined by its single length or direction. Point represents wells and traffic lights in the city.

To mention the Raster Model, this modeled information recorded in the cells identified by the precision of the study scale. Different data encoded by assigning a data entry to each cell. The Raster Model obtained from data obtained directly in raster format, such as remote sensing, by converting from vector to gray (Uğurel, 2010).

Apart from this, advantages of vector model, precise graphic calculation, clearer and higher quality imaging can be provided. It is possible to organize in line and received information in a comfortable, healthy and easier way. If the disadvantages mentioned, the complex data structures, serious and excessive prices, the appearance provided by the system are very high quality, there are difficulties in overlapping different areas of application, and unfortunately, some calculations needed cannot be done with the vector model. To mention the advantages of the raster model, it has a simple data structure, minimal space on the system, a cheaper supply and cheaper technology, raster modeling applied in different areas, making easy, comfortable and healthy overlaps, spatial data information. Besides providing sensitivity, modeling the images obtained by the result of the entered data, providing effective and comfortable access and communication opportunities, it also has disadvantages. These are based on the cell size when compared to the vector model, and a poorer mapping and unfortunately a difficult-to-perceive topology.

CHAPTER 4

METHODOLOGY

4.1 Exponential Regression Analysis

The future population of the city was estimated by using exponential regression method. 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 (4.1) and (4.2).

$$R^2 = \frac{\sum_{t=1}^{N}[Nreal - Navr.]^2}{\sum_{t=1}^{N}[[Nreal - Nmet.]^2} \tag{4.1}$$

$$RMSE = \sqrt{(1/n)\sum_{t=1}^{N}[Nreal - Nmet.]^2} \tag{4.2}$$

4.1.1. 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.

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 has 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 (Figure 4.1).

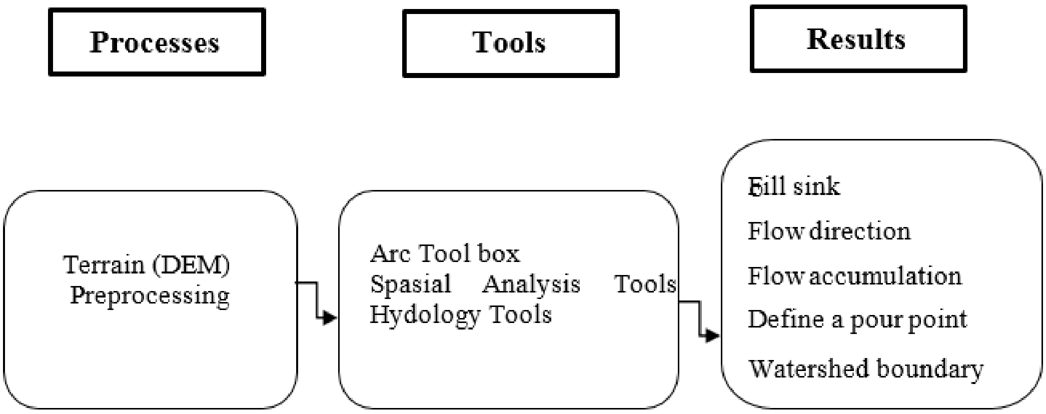

Figure 4.1 Methodology for the GIS processes

4.2.1. Software

ArcGIS software components, which were used in this study to generate sets of digital maps for selected study area, the Murat 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.

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).

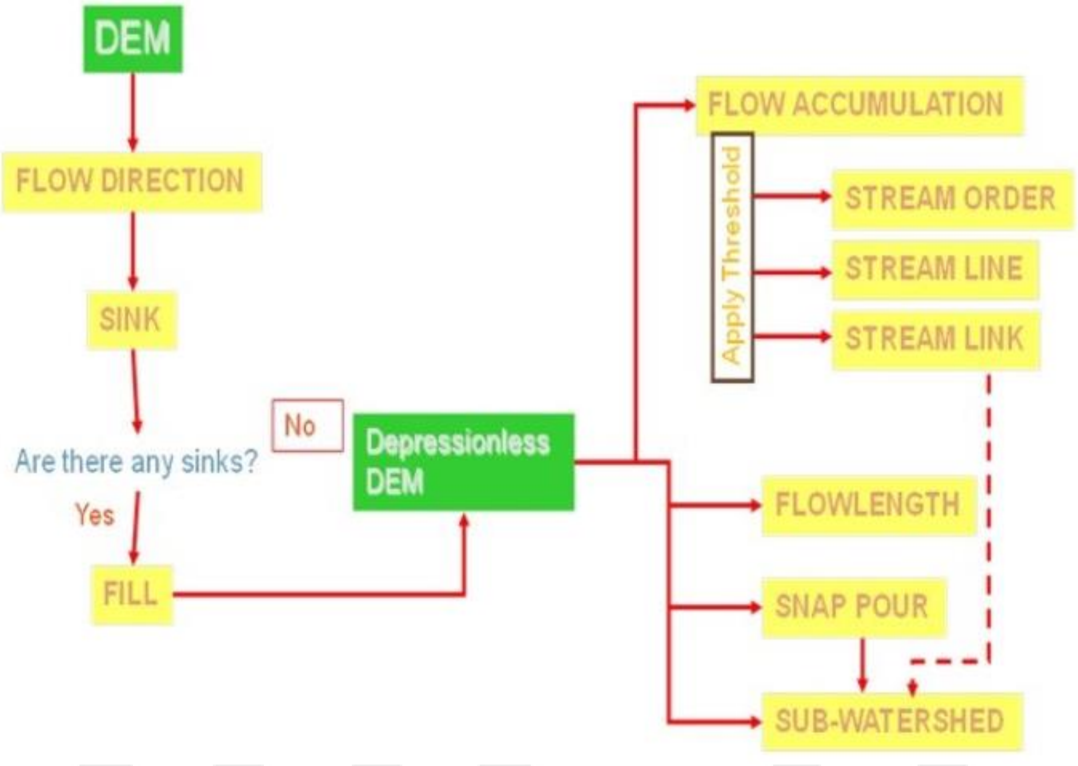

Figure 4.2 Flow chart for delineation of watershed by ArcGIS

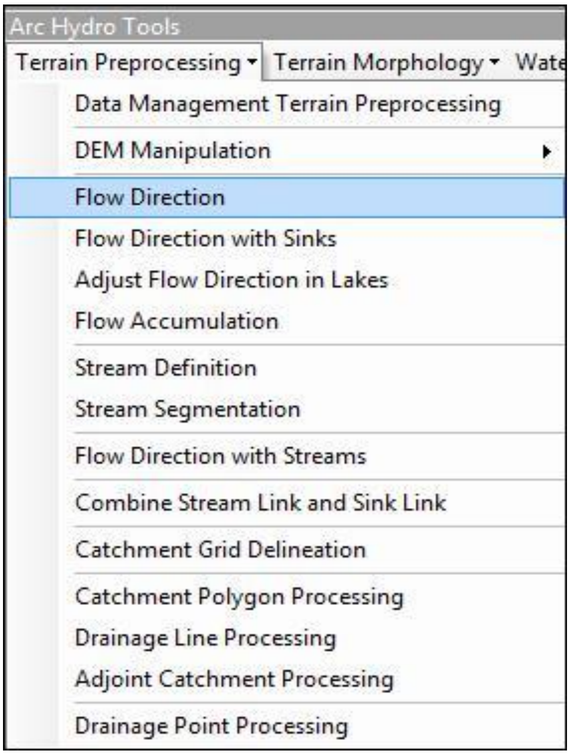

Figure 4.3 Steps of functions in hydrology tools

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 model helpful for estimating sinks, flow direction, flow accumulation, delineate watersheds, and create stream networks. The image below is of a resulting stream network derived from an elevation model. By this process firstly, watershed boundary must be delineating by determining stream direction, calculating flow accumulation and some other necessary steps for example area, slope, flow length and stream network density.

4.2.4.1. Model processing by ArcHydro

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).

Figure 4.4 Filling sinks in ArcHydro

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).

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).

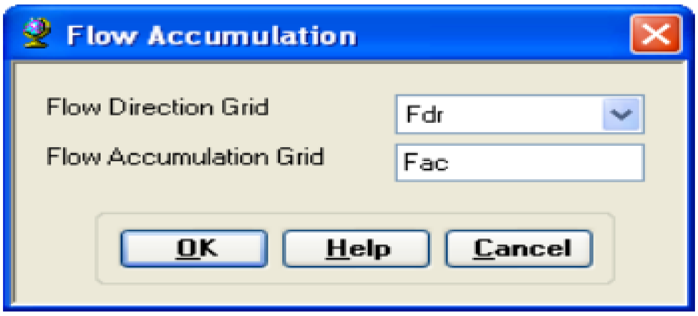

Figure 4.6 Flow accumulation step in ArcHydro

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.

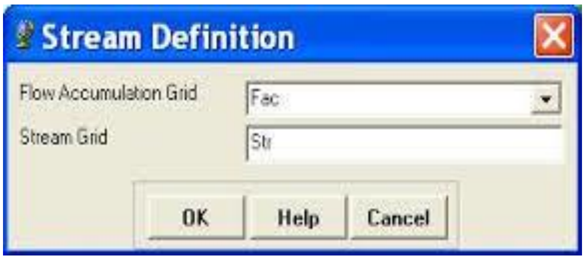

Figure 4.7 Stream definition step in ArcHydro

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).

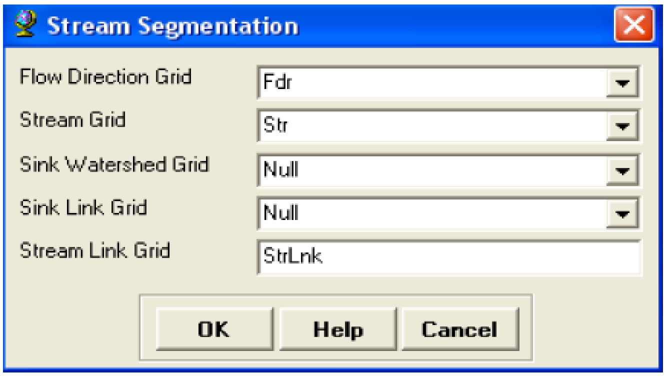

Figure 4.8 Stream segmentation step in ArcHydro

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).

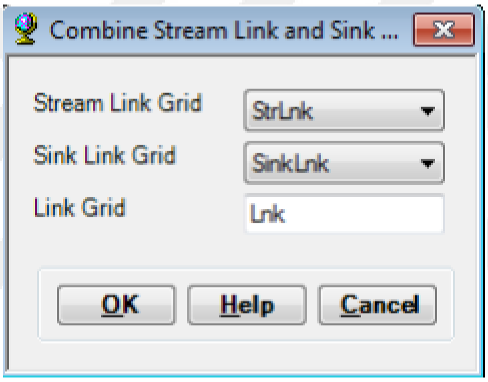

Figure 4.9 Combine stream link and sink link step in ArcHydro

The stream segment or sink link that drains that area, defined in the input stream segment link grid (Stream 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).

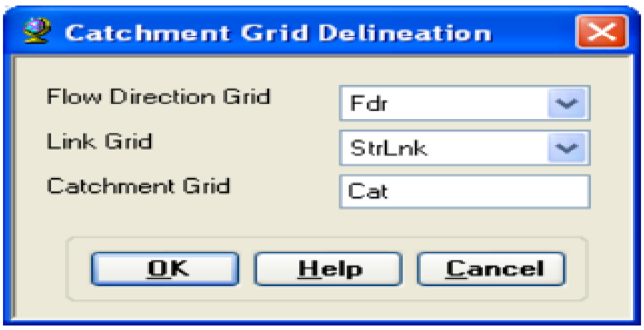

Figure 4.10 Catchment grid delineation step in ArcHydro

Next step is Catchment Polygon Processing; this function converts a catchment grid it into a catchment polygon feature class 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 (Figure 4.11).

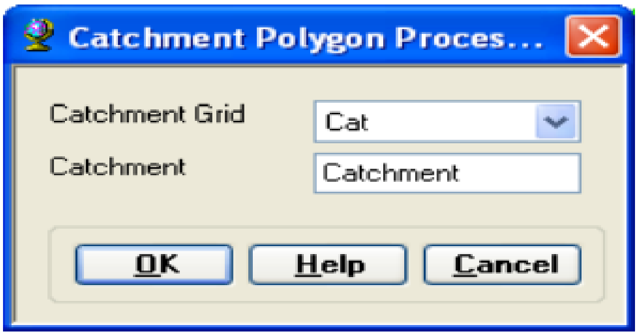

Figure 4.11 Catchment polygon processing

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).

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).

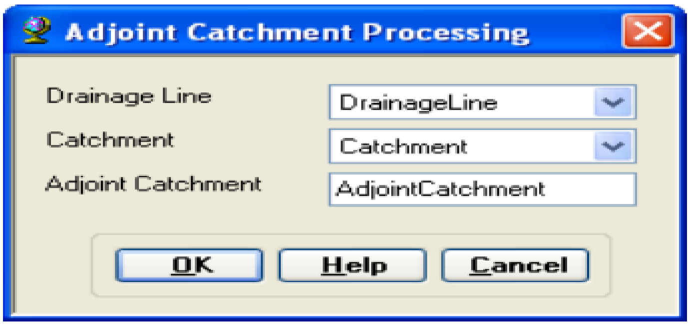

Figure 4.13 Adjoint catchment processing

The next step is Drainage Point Processing. By this function it is easy to create the drainage points to the catchment. The output is Drainage Point, having the default name "Drainage-_Point" that can be overwritten (Figure 4.14).

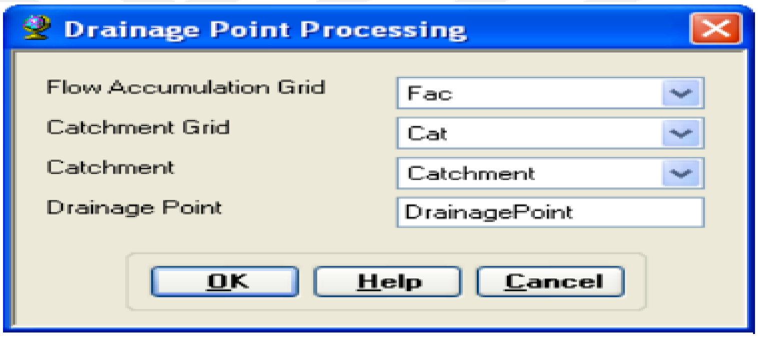

Figure 4.14 Drainage point processing

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).

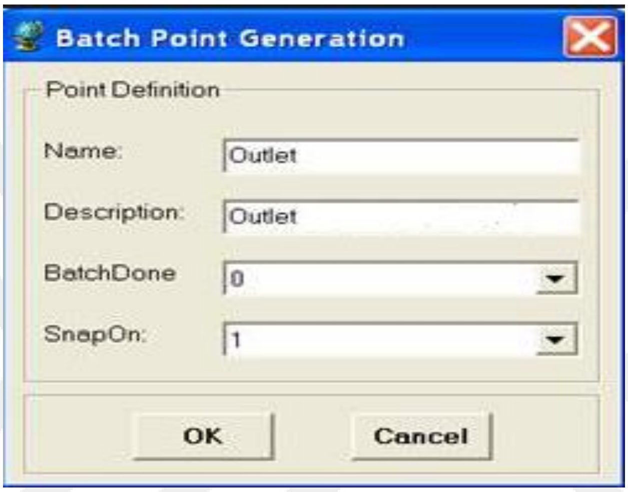

Figure 4.15 Batch point generation

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).

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.

CHAPTER 5

RESULTS & DISCUSSION

5.1 Population Projection and Water Requirement for Elazığ

Table 5.1 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	-		
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	0.9958	26.504
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		

According to the R^2 and RMSE values made and obtained for the past years, the most appropriate population estimation method for Elazığ was found to be the exponential regression analysis method and this method was used for future population estimates (Figure 5.1). The total amount of water consumed and reached for Elazig province in 2019 was 35,000,000 m3 and it was noticed that it was 35,000,000 / 595,638 (Population) / 365 (Day) = 160.98 lt / k / g to meet the water demand per capita (Table 5.2).

Table 5.2 Total amount of water consumed and reached for Elazig

Years	Estimated Population by Exponential Regression Analysis	Estimated Water Requirement (m^3)
2020	496337	29150365
2021	506780	29778392
2022	517443	30404950
2023	528330	31044670
2024	539446	31697846
2025	550796	32364772
2026	562385	33045742
2027	574218	33741049
2028	586300	34450988
2029	598636	35175851
2030	611231	35915933
2031	624092	36671654
2032	637223	37443223
2033	650630	32831018
2034	664319	39035384
2035	678297	39856731
2036	692568	40695295
2037	707140	41551546
2038	722019	42425836
2039	737210	43318459
2040	752721	44229885
2041	768559	45160526
2042	784729	46110676
2043	801240	47080862
2044	818098	48071436
2045	835311	49082874
2046	852887	50115640

2047	870832	51170088
2048	889154	52246689
2049	907862	53345971
2050	926964	54468404

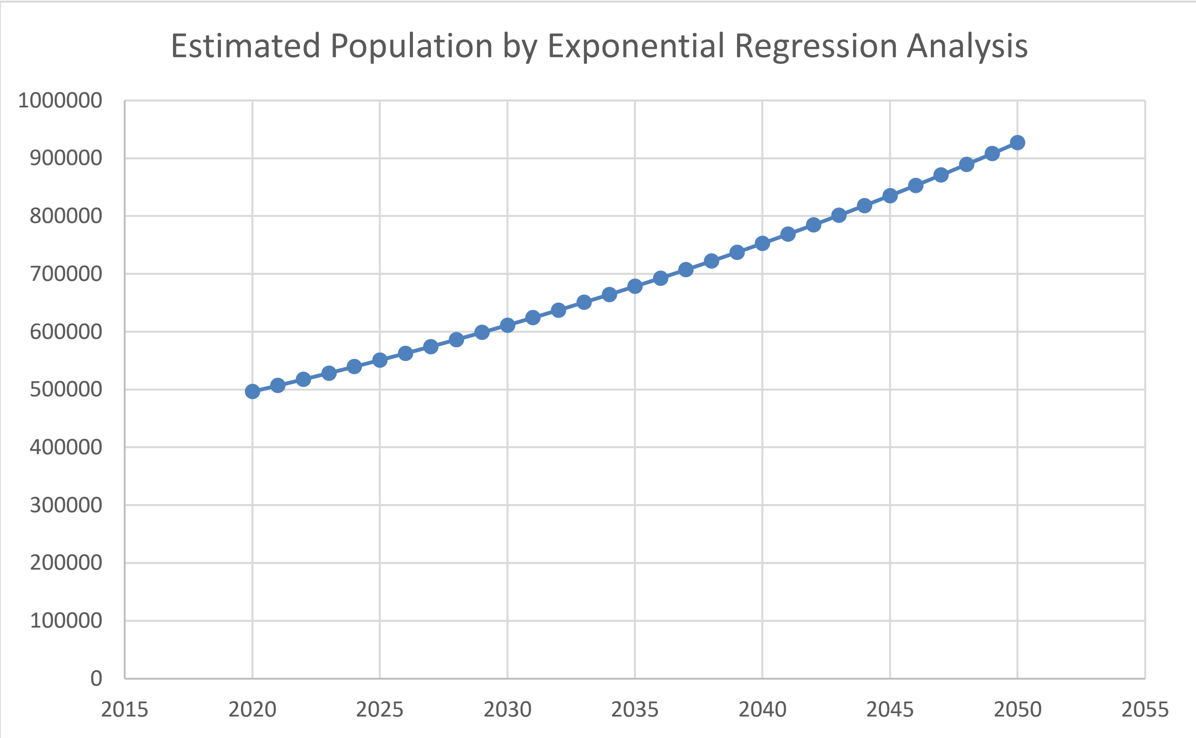

Figure 5.1 Estimated population by Exponential Regression Analysis

5.2 Hamzabey Dam Water Capacity

The Hamzabey Dam was established by DSI on the 26.5 km long Caro Creek, a branch of the Murat River, 5 km south of Palu District, 75 km east of Elazig Province, in order to meet the long-term drinking and utility water needs of Elazig Province. It is a dam constructed at a height of 70 meters from the foundation and also produced in sand-gravel filling type with a body filling of 1.82 million m3, maximum water code 1133 meters and 56.65 million m^3 water accumulation capacity and volume. It was put into operation on October 15, 2018. In order to determine the amount of water to be drawn from the dam, water needs calculated according to the population estimate were taken into account. For the water capacity estimation of the dam, long-term flow data from the D21A179-Caro Stream Current Observation Station operated on the caro creek membrane was used. According to long-term discharge, the average was found about 3.26 m^3/s.

Table 5.3 The Long-Term discharges of D21A179

YEAR	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEPT.	AVE.
1983	0,456	0,617	0,777	1,48	1,4	7,01	7,74	6,99	1,68	0,807	0,437	0,415	2,484
1984	0,696	3,03	3,99	4,82	3,5	9,89	7,83	6,27	1,46	0,661	0,442	0,334	3,577
1985	0,494	1,08	0,96	1,26	2,47	4,98	7,82	2,33	0,862	0,351	0,237	0,158	1,917
1986	1,06	1,43	2,94	5,55	5,31	5,75	4,33	3,41	1,4	0,49	0,25	0,241	2,680
1987	1,18	5,12	3,76	5,83	8,58	13,8	14,2	10	2,4	0,821	0,333	0,311	5,528
1988	2,1	3,7	10,5	8,33	11,4	14,7	12,1	9,05	2,89	1,11	0,358	0,238	6,373
1989	2,29	1,97	2,22	1,8	1,01	3,16	1,57	0,76	0,375	0,04	0,009	0,121	1,277
1990	2,42	11,6	15,6	6,7	12,9	12,6	10,5	6,94	0,971	0,371	0,178	0,116	6,741
1991	0,384	0,612	0,529	0,257	1,19	10,1	6,92	9,06	1,51	0,827	0,65	0,237	2,690
1992	1,22	0,838	2,66	3,52	2,91	7,18	13,5	10,4	3,33	0,829	0,472	0,67	3,961
1993	0,754	5,15	0,41	2,05	4,85	6,36	14,7	14,1	3,5	1,49	0,901	0,488	4,563
1994	0,32	2,67	0,56	2,15	3,12	4,96	6,54	7,54	3,3	1,58	0,89	0,467	2,841
1995	1,15	4,65	0,42	1,89	4,89	5,65	8,32	10,78	2,88	1,6	0,76	0,462	3,621
1996	1,91	1,7	6,98	7,47	5,43	10,2	11,4	6,28	1,13	0,605	0,319	0,328	4,479
1997	0,539	0,54	3,24	3,57	1,61	3,28	20,6	6,43	1,65	0,606	0,362	0,396	3,569
1998	--	--	--	--	--	--	--	--	--	--	--	--	--
1999	--	--	--	--	--	--	--	--	--	--	--	--	--
2000	0,354	0,48	2,78	3,12	1,24	2,87	9,1	4,33	1,34	0,465	0,38	0,334	2,233
2001	0,567	0,54	2,64	3,34	1,3	2,56	12,5	4,12	1,26	0,469	0,41	0,36	2,506
2002	0,107	0,554	1,66	7,47	7,81	6,18	7,02	4,84	0,828	0,152	0,24	1,09	3,163
2003	0,265	0,452	1,68	5,45	6,42	5,69	6,43	4,34	1,11	0,642	0,45	0,32	2,771
2004	0,342	0,54	1,46	6,44	6,5	5,34	5,92	4,32	0,97	0,88	0,54	0,41	2,805
2005	0,452	0,38	1,36	4,87	5,64	5,22	5,87	4,87	1,12	0,98	0,62	0,47	2,654
2006	0,393	4,1	5,28	2,1	6,06	6,44	8,02	5,13	1,27	0,274	0,128	0,04	3,270
2007	0,528	4,32	1,44	1,27	2,68	8,2	6,76	4,54	1,33	0,401	0,117	0,104	2,641
2008	0,227	0,577	1,29	1,15	2,96	8,01	4,89	2,88	0,429	0,14	0,092	0,106	1,896
2009	0,258	0,585	1,2	1,15	3,33	7,09	7,96	2,26	0,761	0,37	0,124	0,238	2,111
2010	0,465	2,32	3,86	24,1	12,8	9,66	4,74	3,72	1,22	0,175	0,064	0,067	5,266
2011	0,302	0,289	1,01	0,82	2,16	5,19	8,96	5,41	1,94	0,469	0,238	0,17	2,247
2012	0,129	1,02	1,26	2,34	2,05	5,39	17,8	6,38	1,78	0,64	0,185	0,131	3,259
2013	0,292	1,32	6,67	6,57	5,78	7,81	6,2	2,83	0,716	0,234	0,064	0,097	3,215
2014	0,193	0,508	0,573	2,1	1,66	3,43	2,61	1,49	0,546	0,126	0,138	0,554	1,161
2015	0,539	1,3	2,59	5,22	5,26	9,92	11,9	4,11	1,14	0,489	0,138	0,083	3,557
Ave.													3,26

Maximum average flow rate was recorded as 6,741 m^3 / s in 1990 and minimum flow rate was recorded as 1,161 m^3 / s in 2014. The current amount of water supplied to the city is 1.11 m^3 / s flow (35000000 m^3 / year) and the actual water requirement of the city is 24.850.000 m^3. Currently, the rate of loss leakage is considered to be approximately 29%. When Hamzabey Dam comes into operation, the flow rate of the transmission line is 5,472 m^3 / s and 77.956.992 m^3 of water can be taken annually. The amount of water planned to be taken from the dam is given in the (Table 5.4).

Table 5.4 The amount of water planned to be taken from the dam

YEAR	Estimated Water Requirement (m^3)	Water From Existing Water Sources (m^3)	Estimated Amount of Water to be Taken From the Dam (m^3)
2020	40888490	24850000	16038490
2021	41748790	24850000	16898790
2022	42627213	24850000	17777213
2023	43524090	24850000	18674090
2024	44439831	24850000	19589831
2025	45374850	24850000	20524850
2026	46329557	24850000	21479557
2027	47304366	24850000	22454366
2028	48299687	24850000	23449687
2029	49315933	24850000	24465933
2030	50353515	24850000	25503515
2031	51413011	24850000	26563011
2032	52494749	24850000	27644749
2033	53599225	24850000	28749225
2034	54726931	24850000	29876931
2035	55878446	24850000	31028446
2036	57054098	24850000	32204098
2037	58254547	24850000	33404547
2038	59480286	24850000	34630286
2039	60731728	24850000	35881728
2040	62009532	24850000	37159532
2041	63314275	24850000	38464275
2042	64646367	24850000	39796367
2043	66006552	24850000	41159552
2044	67395322	24850000	42545322
2045	68813338	24850000	43963338
2046	70261258	24850000	45411258
2047	71739576	24850000	46889576

2048	73248951	24850000	48398951
2049	74790125	24850000	49940125
2050	76363758	24850000	51513758

5.3 Reservoir Estimation

River catchments are the geographical 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.

5.3.1. Reservoir Capacity of Hamza bey Dam

Table 5.5 Area-Volume table due to different elevations

Elevation (m)	Area (m^2)	Volume (m^3)
1080	1009476	40350000
1100	1500334	45280000
1120	2198477	48010000
1140	3366824	53590000

According to different elevations of dam reservoir, minimum reservoir capacity estimated about 40 million m^3 and maximum reservoir capacity estimated as roundly 53.5 million m^3 (Table 5.5).

CONCLUSIONS

Water is the greatest need throughout human life. To say that human beings are in need of water is actually no wrong sentence. While a living can spend a long time without eating, it can close its eyes within a few hours without meeting the water requirement. Based on the aforementioned situation, the world suffers from the same situation. As it is known in an adult, water constitutes 75% of its body. One-quarter of the bones, two-fifths of the fat in the body, three-quarters of the skin, nine-tenths of the blood consists of water. Apart from this information, water has more than one important functions in the living body. If it is necessary to mention these, it balances the body temperature, eliminates toxins in the body, balances the beating of the heart, makes the skin and most importantly helps people or creatures to provide all their activities. As is known, water is the most important substance that keeps the ecological system on earth alive. There is a problem that 70% of the world is composed of waters, but only 0.3% of the creatures are used. Unfortunately, many countries in the world face certain problems in terms of drinking water. These countries work in different ways to eliminate water shortages according to their country. For example, in the United Arab Emirates, they turn the shortage of drinking water into drinking water for serious money. On the other hand, the Turkish Republic of Northern Cyprus is to supply drinking water from Turkey. Turkey much trouble even drinking water almost useless in terms of lives from climate-induced water shortages in some regions and seasons change. These problems are met by the dams by creating dams and drinking and utility water from the dams. Drinking and potable water facilities are generally sized to meet the 20-30 year water need. Because while human beings are consuming their daily needs, the municipality or administrators have to ensure the continuity of this situation. For this, along with the necessary planning, the need of the region for water is planned and met for a long time. By this planning, human beings should use water resources more cleanly, while avoiding the need for consumption, known as waste. In the mentioned water planning, besides the project period, the amount of water consumed per capita and the population of the settlement are the most important sources for this planning in order to determine the water need. Population projection follows any population trend line and predictions are made about the population, and these estimates should be in the maximum state that they should be, so that water resources should be used comfortably without distress. In the general subject of the thesis, Elazığ Province faces serious water need due to the increase in its needs in irrigation of the agricultural areas in agricultural lands, compared to the supply-demand relationship in drinking and utility water.

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