DOKUZ EYLÜL UNIVERSITY
GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

MODELING OF WATER LEVEL IN MOGAN LAKE (ANKARA) USING GIS AND REGRESSION ANALYSIS

by

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October, 2012

İZMİR

MODELING OF WATER LEVEL IN MOGAN LAKE (ANKARA) USING GIS AND REGRESSION ANALYSIS

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M.Sc THESIS EXAMINATION RESULT FORM

We have read the thesis entitled **"MODELING OF WATER LEVEL IN MOGAN LAKE (ANKARA) USING GIS AND REGRESSION ANALYSIS"** completed by **MELİH ALTINEL** under supervision of **ASSOCIATE PROFESSOR K. MERT ÇUBUKÇU** and we certify that in our opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Science.

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MODELING OF WATER LEVEL IN MOGAN LAKE (ANKARA) USING GIS AND REGRESSION ANALYSIS

ABSTRACT

There are several global and local analysis methods applied to manage lake water and its environs. The main purpose of these studies is to determine convection capacity of lakes and to calculate water levels' proximity to convection capacity annually to see how it can approach or deviate. In this study, the purpose was to calculate possible changes in the water level with statistical model by using data taken from the Mogan Lake and to perform analysis for the data by Geographical Information Systems (GIS) methods.

In this study, volume values of the Mogan Lake were calculated for the period of 2000-2010; and its 3D map was prepared by means of the GIS. In addition to the volume calculation, its water capacity for each elevation level was calculated to investigate the capacity of each elevation level in case of possible increase in the water level. Monthly changes in the water volume were modeled meteorological independent variables and regression analysis based on data generated from the organized maps to reveal the actual relationship among the parameters.

As a result of analysis, it was observed that the monthly change in the water level can be explained by following variables: number of windy days, pressure, humidity, temperature values and precipitation amounts. All independent variables were found significant on the 0.10 level. Through the regression analysis, variance of the monthly change in the water level can be explained by 56%. Of the variables, while amount of precipitation has positive effect the water level, other variables have negative effect on it.

Keywords: GIS, regression analysis, Mogan Lake, meteorological data, water level changes, basin management.

MOGAN GÖLÜ (ANKARA) SU SEVİYESİNİN CBS VE REGRESYON ANALİZİYLE MODELLENMESİ

ÖZ

Dünyada ve ülkemizde göl suyu ve etki alanın yönetilebilmesi için çeşitli analiz yöntemleri uygulanmaktadır. Bu çalışmalardaki temel amaç gölün taşıma kapasitesinin belirlenmesi ve yıllara göre su seviyelerinin taşıma kapasitesine artı ve eksi yönlerde ne kadar yaklaşıp, uzaklaşabileceğinin hesaplanmasıdır. Bu çalışmada da Mogan Gölüne ait veriler kullanılarak göl su seviyesinde gerçekleşecek olası değişimlerin istatistiki modelleme ile hesaplanması ve coğrafi bilgi sistemleri yöntemleriyle verilere yönelik analizlerin oluşturulması gerçekleştirilmiştir.

Çalışma kapsamında, CBS programı yardımıyla 3d haritası oluşturulan Mogan Gölü'nün yine CBS teknikleri kullanılarak 2000-2010 yılları arasında hacim değerleri bulunmuş ve her kot için su hacmi hesaplanmıştır. Hacim hesabının yanı sıra her kot değerinin su kapasitesi hesaplanarak olası bir yükselme durumunda her kotun ne kadar su taşıyabileceği gibi durumlar incelenmiştir. Oluşturulan haritalardan üretilen analiz verileri yardımıyla, parametreler arasında gerçekte var olan ilişkinin ortaya konması amacı ile su kütlesindeki aylık değişimler meterolojik bağımsız değişkenler ile regresyon analizi kullanılarak modellenmiştir.

Analiz sonucunda, su seviyesindeki aylık değişimin; rüzgarlı gün sayısı, basınç, nemlilik oranı, sıcaklık değerleri ve yağış miktarı değişkenleri ile açıklanabildiği görülmüştür. Tüm bağımsız değişkenler 0.10 düzeyinde istatistiksel açıdan anlamlı bulunmuştur. Regrasyon analizi ile su seviyesindeki aylık değişimin varyansının %56'sı açıklanabilmektedir. Değişkenlerden, yağış miktarı, su seviyesine pozitif yönde etki ederken, diğer değişkenler negatif yönde etki ettiği tespit edilmiştir.

Anahtar sözcükler: CBS, regresyon analizi, Mogan Gölü, meteorolojik veriler, su seviye değişimleri, havza yönetimi.

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CHAPTER ONE
INTRODUCTION

Lake water levels change with evaporation, wind, humidity, temperature, and precipitation. The changes in the lake water level do not only cause environmental damages around the lake and economical losses, but also present danger for the residential areas surrounding these lakes. Fluctuations in lake water level may lead to floods in urban areas such as residences, official buildings and commercial buildings; blockage and failure in transportation, sewer networks, and transmission lines. Fluctuations in water level also cause indirect effects: formation of marshy grounds around lake, convection of solid wastes due to water flows and increase in the population of mosquito and insects based on aforesaid changes. To determine the reasons for these changes in lake water levels, material convections in lake fields and surrounding areas must be investigated first.

Since lakes receive drainage water from substantially wide land areas, there is continuous material convection between lake and its surrounding areas. Ground and underground runoffs enters and exits lakes. These runoffs carry several physical, chemical and biologic components, organic matters, residues and many other materials with them. Flow rate of these runoffs present variations according to geographical structure of lakes, climate and seasonal conditions (Ünlü et al., 2008).

Analysis and management studies regarding these fields must be formed after consideration of effects of several specifications such as local condition, natural resources consumption on water levels.

Forecasting the changes in water levels of lakes has significant importance in terms of planning in lake basins and sensitive areas within the environs; and of taking required precautions timely. Thus, possible damages and effects to ecological areas and residential areas within the basin can be minimized. At this point, determination of factors affecting lakes' water levels, collection of quantitative data and constructing a forecasting method based on these data will facilitate to make planning for a lake environs and contribute to formation of scenarios for possible results and to sustainable management of these areas.

The essential purpose of water resources management is to plan the area affected by a water source and to save current values by taking the current and future needs into account before occurrence of irreversible damages and without harming function of hydrologic sequence (Meriç, 2004).

There are several global and local analysis methods applied to manage lake water and its environs. The main purpose of these studies is to determine convection capacity of lakes and to calculate water levels' proximity to convection capacity annually to see how it can approach or deviate.

In this study, the purpose was to calculate possible changes in the water level with statistical model by using data taken from the Mogan Lake and Geographical Information Systems (GIS). In the applied statistical model, the relation between the observed changes in water level and meteorological factors is assessed.

For the holistic consideration of the study, concepts such as development and management of water sources; usage of sustainable basin and lake areas and hydrologic recycling must be associated with the subject; and its position and function within the system must be comprehended.

Within the hydrologic recycle, while majority of the precipitation evaporates and returns back to the atmosphere, part of them drains to form ground and underground runoffs. However, ground runoffs do not commence simultaneously with precipitation. As precipitation starts, first the soil is fed until its full satisfaction which is followed by runoffs.

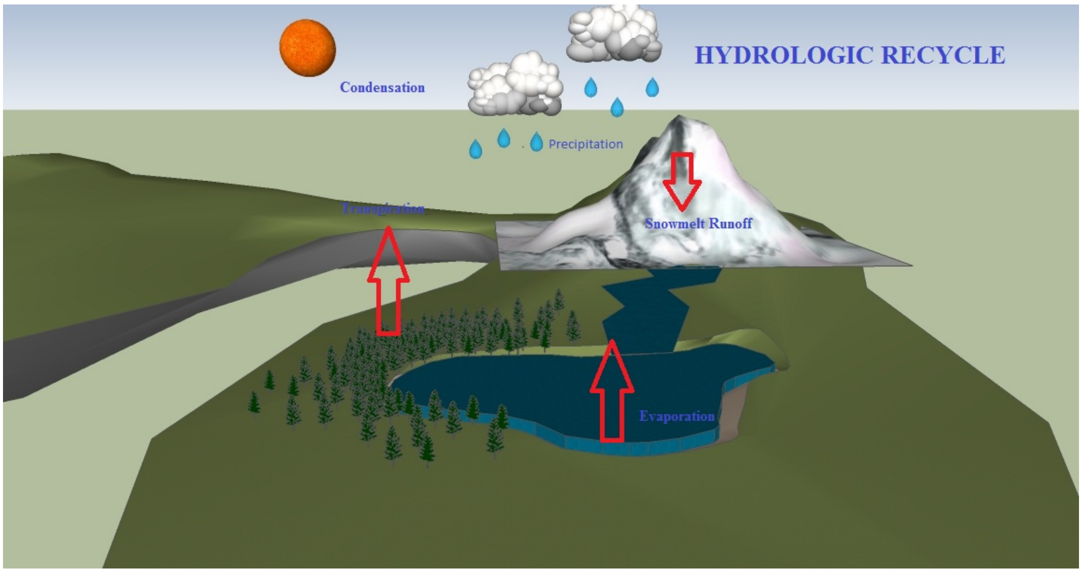

Figure 1.1 Three-dimensional work representing the hydrologic recycle

The water which exists under different conditions and forms (solid, liquid and gas) within the nature follows continuous cycling (Figure 1.1). All of the paths that the water follows within the nature are called "hydrologic recycle". We can start to observe the hydrologic recycle from any point of this recycle.

For instance, if we start from the atmosphere, we observe following processes respectively: water in vapor form in the atmosphere condenses and reaches to the earth as precipitation. 60-75% of this water evaporates or sweats over plants returns back to the atmosphere. While some of precipitation is being hold by plants, some leaks and drains to join underground runoffs. The rest reaches to running waters, lakes and seas as ground runoffs. The water heading to subsurface runoffs reaches ground as underground water and join to the surface runoffs. The water portion heading to sea and lakes evaporates and returns back to atmosphere. Thus, the recycle is completed. The required energy for this circulation is supplied by solar and gravity sources (Bayazıt, 1999).

When we consider the hydrologic recycle in terms of the study, it is understood that water volume of the lake shows variation due to climate conditions, anthropological effects and runoffs that occur at different times. This condition suggests the idea that water volume does not present regular behavior and thus, it is not possible to establish a water level forecast system based on linear equations. Thus, the model in this study focuses on the differences in water volume of the lake, instead of the water volume in total.

It will be beneficent while establishing management plan for specified regions if these effects are synchronized with a forecast system that is synthesized and defined and carried toward future. The defined system will provide logical land use based on current status and the requirement of the lake and prevent possible environmental damages.

Lake eco-systems are subject to changes due to the external effects such as human activities, agriculture, mining, tourism and industry along with the self-renovation process of the nature. The most effective way to take precaution against the changes that may occur in water resources is to create water resources management plans along with the determined priorities and successfully application of them.

When we investigate in the sense of study, the increase or decrease in the lake water levels affects level of soil, urban occupation, infrastructure and ecosystem aggregately. Therefore, a significant relationship among the parameters and water level will provide an opportunity to forecast water level through meteorological data in the future.

Within the scope of the study, an area must be selected so that the data can be obtained completely and reliably. Along with this point, the Mogan Lake was preferred since it has several characteristics such as sensitive ecosystem and the urban stress is being felt at the same time.

In the sense of specified characteristics, the Mogan Lake requires several tools such as protection, management and sustainability. From this point of view, the study area has a structure in which these tools can be applied. Upon the selection of the study area, data pertaining to the study area must be acquired. Data was basically categorized into two sections as spatial and statistical. While in terms of spatial data, bathymetric map and cross-sections from the lake level are obtained. In terms of quantitative data, meteorological data including total monthly precipitation, monthly average humidity, temperature, pressure, wind velocity, and evaporation regarding the period between 2000 and 2010 were collected. Moreover, observed data on the Mogan Lake's water level for the period between 1996 and 2010 was derived. All acquired quantitative data was arranged as required variables for the regression analysis.

In the second chapter of the study, a literature review, investigation of supportive materials, was conducted so as to establish connection between the study and other disciplines; and determination of the applied method. In the third chapter, there is "material and data" chapter consisted of the information regarding collection method for required data and their characteristics. In the material part of this chapter, information on the reasons for selection of study area and its characteristics were presented.

In the forth chapter, "analysis and method", analyses and techniques which ensures that we will reach to the result along with investigated method-techniques, determined foundations and acquired data, was included. Finally, "result and conclusion" chapter evaluates and concludes the study.

CHAPTER TWO
LITERATURE REVIEW

This chapter reviews the past research on the topics dealt in this study. Reviewed literature will shed light on the facts that which techniques should be followed during the study; and how can the essential method and foundation for this study be reflected on our hypotheses. Since it was desired to reveal the relationship between the lake water level and the meteorological observation data, the studies concerning the changes in the water level were initially included. Moreover, as this is a multi-disciplinary study, the studies on water levels are presented under two headings; "Statistical Analysis Studies" and "Geographical Information Systems Aided Studies". In the next stage, "Limnology and Bathymetric Measurement Studies", in which structure and hydrologic characteristics of the lake are investigated, were included to create material and data section of the study. To obtain general information about the study area and to investigate previous studies about the study area, "Several Studies that has been made in the Mogan Lake" are reviewed and added into this section. Finally, "Studies to Reduce the Effects of Water Level Changes" part was included in this chapter in which there are researches to determine what sort of benefits may arise from which subjects.

2.1 Studies Investigating Changes in Water Level

Many researches from several disciplines have developed statistical methods on water level measurement and height calculations; and multi-purpose visualization, assessment techniques and hydrological modeling by employing computer technology. In this part of the literature search chapter, investigation and evaluation of the statistical methods used in measurement of water level and Geographical Information System Aided modeling were included.

2.1.1 Statistical Analysis Studies

Cengiz and Kahya (2006) investigated water level data of the 25 lakes in Turkey with non-parametric Mann-Kendall test; additionally lake water levels' seasonal and regional variation were investigated through harmonic analysis in their study. They conducted the tendency analysis for annual average lake water levels of 25 lakes; and they determined that 20 out of the lake water level data from the 25 stations have high internal dependency value at α=5% significance level. These lake water levels belong to following lakes: İznik, Tuz, Bafa, Beyşehir, Uzungöl, Eğridir, Van, Eber, Akşehir, Ladik, Timraş Obruğu, Çavuşçu, Azaplı, Gölbaşı, Haçlı, Gölhisar, Efteni, Obruk, Sapanca and Burdur. It was stated that the found internal dependency affects the results that might be found in the tendency tests; and thus, several approaches were suggested to reduce this internal dependency in the time series. In this study, the internal dependency effect was tried to be reduced by the pre-whiten operation. In the tendency analyses conducted for the evaluation of the lake water levels at 25 stations, there is tendency found at 9 stations' lake water levels at 5% significance level. It was determined that almost half of the observed tendencies have presented decrease; and that while lake water levels in the country's northeast part have presented increase, the ones in the southwest have shown decrease. Increasing tendencies were determined on the lake water levels of Van, Uzungöl, Ladik, Efteni, Ladik lakes. Decreasing tendencies were determined on the lake levels of Akşehir, Eber, Konya Obruk, Timraş Obruğu, Gölhisar lakes. While decreasing lake water levels have been observed in the southwest and middle-west part of Turkey; increasing lake water levels have been observed in the northern and eastern part of the country. The found trends of the lake water levels were seen quite consistent with the previous trends of runoffs, precipitation and temperature variables. It was stated that conducted lake water level, precipitation, runoff, temperature trend studies in Turkey have revealed that they are totally consistent with each other and that they have complementary structure for each other. It was thought that observed same trends in the same regions as a result of these performed hydro-climatologic parameters points out the existence of the climate change and thus extensive studies must be carried out in this subject. As a result of the harmonic analysis which was conducted to determine the geographical scale of the seasonal variation of the lake water levels in Turkey and to have an understanding lake regimes, variance percentages explained by the first harmonics appeared quite high (Cengiz and Kahya, 2006).

Internal dependency variables included in the Cengiz and Kahya's (2006) study were essential climate and hydrologic variables such as temperature, precipitation, evaporation, runoff and lake water level.

If we consider the internal dependency concept relevant with the subject, it is required to investigate the linear dependency among the dual descriptive variables in a linear regression model. If there is linear dependency among more than two descriptive variables, there may not be appropriate scale found. Therefore, if there is more complicated condition exists among the descriptive variables than dual linear relationship, this will not be sufficient scale in determination of internal relationship (Ertaş, 2011).

As another study focused on the lake water levels' trend, Yurtcu (2006) tried to determine the changes in the Eber Lake's water level through fuzzy logic method. In this study, monthly average data from the five observation stations located in and around the Eber Lake for the period between 1990 and 1996 was used. While precipitation, runoff and evaporation factors were chosen as independent variables in the study, lake water level changes as a dependent variable was modeled through fuzzy logic method. As a result of the study, it was revealed that lake water level difference between the region with highest and lowest rain fall is 45 cm; and that a 35 cm-increase occurs in case of highest precipitation and runoff. The author stated that the essential water source that is feeding the Eber Lake were creeks running to the lake; and that in case if these creeks are interrupted or prevented, the lake water level will eventually reduce and aridification will be present due to evaporation even if there is high amount of rain fall is experienced. In the mentioned study about the determination of change in the Eber Lake's water level through fuzzy logic approach, it was stated that the results obtained through fuzzy logic approach and average monthly values were close to each other; and that the change in the lake water level can be modeled by using the stations' long term monthly average data due to 6% deviation of the error and the acceptable determination coefficient (Yurtcu, 2006).

In his study, Demirkesen (2003) investigated Digital Elevation Model (DEM) which is thought to be helpful for the urban and rural planning and constructed from the satellite images taken from the areas that are considered to be planned; and he conducted hydrologic surface analysis. In the hydrologic surface analysis study, it was determined that which areas will be exposed to flood when there is certain amount of rain fall. A geographical information system software, RiverTools Software package for analysis of digital height models was exploited. Data set was consisted of DEM subset from the Cumberland Basin in Kentucky State of the U.S. and then an analysis conducted over this experimental data set. Limits of the flood areas were determined due to the lake water level; and for this data set, Landsat-5 Thematic Mapper images with 30m-resolution were used. It was stated that although results were affected adversely from the quality, resolution of DEM and from the calculation techniques, there were concrete results about determination of risky flood areas when excessive rain fall is experienced; and also it was explained that which disciplines and studies can benefit from these results. Moreover, emphasis points for the success of these sorts of studies were explained in their study (Demirkesen 2003).

Şener and Morova (2011) developed a fuzzy logic model to forecast the change in the water level of the Burdur Lake; and they constructed a model equation by means of one of the well-known methods, a multi-linear regression analysis. While precipitation and evaporation were used as independent variables; change in the water level of the Burdur Lake was taken as a dependent variable. Data set was composed of annual average data taken from the observation stations in and around the Burdur Lake for a period between 1975 and 2004. Reliability of the constructed models was tested by comparing values estimated through the regression equation obtained by means of the fuzzy logic model and the values obtained from the observation stations (Şener and Morova, 2011).

2.1.2 Geographical Information System Aided Studies

Spatial and temporal changes in parameters supply data for GIS and other modeling tools. GIS is an important tool which can use spatial data in different disciplines (Şeker et al., 2009). While GIS outputs constitute input data during modeling studies, they are also widely applied during visualization of the results obtained from modeling (Ertürk et al., 2004).

Ekercin and Örmeci (2008) investigated the reduction in the water level of the Tuz Lake and its eventual effect on the areas covered by salt crystals. Researchers determined that there has been decrease in the water reserves of the lake lately because the underground waters surrounding the Tuz Lake have been used for irrigation purposes (uncontrolled) for many years and there has been drop observed in precipitation. In the first part of their study, they investigated the changes in the temperature and precipitation between 1970 and 2005 based on the data collected from the 9 meteorological stations. In the second part of the study, satellite images taken from the area were processed (WGS 84, Strip 36). Later on, to make the satellite images that are perceived multi-time comparable, radiometric adjustment process was applied. In the third part, by means of temporal satellite data, the effect of water level reduction due to the draught observed after 90s in the Tuz Lake and around and its effect on the areas covered with salt were investigated. Satellite images and local measurements that are assessed together show that there has been serious amount of reduction in the salt areas experienced between 1987 and 2005 due to the reduction in the water reserve. It was also determined that desertification started in the middle and western shores of the lake; and the salt conglomeration has been totally stopped in the current (2005) dry areas which were under water between 1975 and 1987. By taking these results into account, it is suggested to follow and investigate the updated satellite images in addition to the local measurements in our study. Thus, it is thought that the acquired output data will be fast, reliable and economic resource (base data) for the future plans (Ekercin and Örmeci, 2008).

Özcan et al., (2009) modeled local studies and different data groups in the Geographical Information System environment within the coverage of their study constructing a risk management through GIS and remote sensing data; and they performed flood risk analysis study in the Down Sakarya Basin. In the modeling stage, Multi-Criterion Decision Making Analysis and Hydrologic Modeling Methods were used; and the methods were compared according to the limit conditions. According to the calculations taking limit conditions of the two methods used in risk analysis studies into account, the authors determined that hydrologic modeling provides more accurate results. According to the result of this model, total possible flood area is 3950 ha which is consisted of 620 ha urban and 3330 ha agricultural area. According to the applied risk analysis result, several scenarios were created for the region so as to present acquisitions that are obtained through the application of risk management (Özcan et al., 2009).

2.2 Studies in Limnology and Bathymetric Measurements

Türeli and Norman (1992) investigated bathymetry and base sediments of the Eymir Lake which is interacting with the Mogan Lake. They were stated that the basement of the Eymir Lake, an old river residual, has a flat structure and its borders in a bowl shape, while the deepest part of the lake is 5.5 m and it gradually becoming shallow toward its borders. In the studies about the basement sediments, it was stated that the mud in the basement has 20 cm height and probably it contains sedimentary structures because of the biological activities; and that southwest and northeast ends of the lake a silt layer was dominant at the lake basement. In the studies to construct bathymetric maps, local profile was taken by determining 29 reference station points and by traveling these stations with sonar on a boat to record depth signals among stations. By exploiting these profiles, the depth contours were draw with 1 m intervals and the bathymetric map of the lake was created (Türeli and Norman, 1992).

Verep et al. (2002) intended to present environmental and hydrographic characteristics, morphologic and bathymetric structure and some problems such as filling up the lake with sedimentations by surrounding creeks and covering lake's pace with hygrophilous plants in the Uzungöl Lake which was declared a national preservation area because of its natural beauties. As a result of the study, it was determined that the Uzungöl Lake would lose average volume of 355 m^3 annually. If we consider the volume losses in the last 20 years, it is can be presented this lake would disappear and therefore it may lose its tourism, ecologic and aquaculture potential and may turn into a swamp land. The most valid rehabilitation method was considered as removal of the sediment through mechanical methods (Verep et al., 2002).

2.3 Studies Investigated Mogan Lake

In the Beklioğlu's observation study conducted in the Eymir and Mogan lakes between 1997 and 2001, physical, chemical and biological variables in the lakes and in the creeks running inward toward and outward from the lakes were determined with weekly frequency; and by combining previous studies about the lake, both lakes' ecological structure were determined. Pollutant effects in both lakes and basin were determined; and the Mogan Lake's ecological structure in the past was evaluated as before/after 1974. The author stated that a regulator was built on the exit of the Mogan Lake in the period of 1969-1971 to prevent and flood risk. After the regulator's starting to operation in 1974, he stated that there have been changes in the lake's natural water regime (Beklioğlu, 2001).

Uğur (2009) investigated Mogan Park built around the Mogan Lake which is quite important in terms of ecological dimension so as to present how the ecological criterions were taken into consideration and their possible effects of the applications to the in-lake/shore eco-system. This study investigated the place of the green-belt created around the lake in terms of the urban ecosystem; contribution of this application to the urban ecosystem was determined; and it was probed based on ecological principles. At the same time, he developed suggestions about the ecological sustainability and emphasized the balance of protection-usage of natural reserve areas in urban regions or its surroundings (Uğur, 2009).

Dişli (2007) stated that waste and sewer waters of the industrial plants and the residential areas located in the Gölbaşı county of Ankara city are being directly discharged to the Mogan and Eymir lakes and to the creeks feeding these lakes; and that this situation causes an increasing pollution in the mentioned water sources. Especially, he stated that the pollution occurred in the Mogan Lake affect the quality of the Eymir Lake and the hydrogeological system that is consisted of old quaternary alluvium sediments; and the pollution experienced in the region has started to bring significant risks in terms of water resource quality and human health for today and future. Therefore, he conducted drill, observation, sampling on site to define the hydrogeological structure in the region between the two lakes and to determine physical and chemical parameters controlling the underground water and massive movements; while he was performing experimental studies in laboratory environment. Based on the data obtained as a result of these researches, he introduced mathematical 3-dimensional current and movement model based on the position and time of the pollutants during their movement within the hydrogeological system (Dişli, 2007).

2.4 Studies to Reduce Effects of Changes in Water Level

As it was stated in the introduction part of this study, "Changes in the water level of a lake will cause natural damages around the lake and economical losses. When these changes are forecasted, required precautions are taken, and these regions are planned according to the forecast results, damage and effects can be minimized."

In the their study, Yıldız and Deniz (2005) investigated the effects of the changes occurred in the water level of the Van Lake. The researchers stated that there are wild bird life habitats in the reeds surrounding the Van Lake, and as there have been changes observed on the water level of the Van Lake, these natural life areas have been damaged by these changes. They also stated that there are similar wild bird habitats in the reeds of the Mogan Lake; and that the changes in the water levels of the lake harm the bird nests located in the reed and swamp land, thus they affect the birds' natural area adversely. Moreover, based on the last 58 years' water level measurements, it was determined that the water level of the lake has been gradually increased. Therefore, in the planning for urban or rural areas around lakes, increase trend of the water level of a lake must be taken into consideration and residence area must be limited (all residential activities around lakes up to 1650-1655 meters were banned in 1995 by the ministry cabinet of the Turkish Republic by declaring these areas as a natural disaster area) until certain level of height not to be affected by the possible future floods; all buildings in this area must be evacuated. They think that construction sewer and sewage water refinement facilities that have been damaged by the changes in water levels must be reconstructed and be placed safer places for the urban structure so that the pollution in the lake can be stopped (Yıldız and Deniz, 2005).

Onuşluel and Harmancıoğlu (2002) state that, floods are basically natural circumstances. The reason changing this circumstance into a disaster that causes economical losses or deaths is usually human intervention. Therefore, it is needed to consider flood reasons under two dimensions:

Natural causes: there have been extraordinary precipitations with quite high above the seasonal averages in world lately in many parts of the world; and as a result of these incidents, floods have been experienced in some locations. However, it is not possible to prevent or remove this natural dimension of the floods is not possible. What can be done is to present the flood risks by means of engineering approaches; and to prefer designs and planning resistant to risk in every aspect (Onuşluel and Harmancıoğlu, 2002).

Human interventions: all sorts of human activities with a characteristic that is not accommodating to the nature or with a characteristic like an obstacle to the natural events will increase the amount of losses resulting from floods and turn the flood into a disaster (Onuşluel and Harmancıoğlu, 2002).

In another study, Altınbilek et al. (1995) examined the damages and effects caused by the changes in the lake water levels to environment. It was aimed to calculate the water levels and hydrographs of the floods coming out of the Mogan and Eymir lakes; and at the same time, developing a methodology for these types of basins. In this sense, rainfall penetration for the hurricanes with 100 and 500 years repetition and with 2, 6 and 12 hours duration and their regional distribution were calculated (Altınbilek et al., 1995).

As it is clear from the literature reviewed, natural disasters are the incidents that are affecting and changing human life. It is thought that all planning and applications in a region must include considerations for water level of the lakes. This will allow us to create more healthy and habitable spaces environment; and to minimize the potential losses that may be experienced in the future.

CHAPTER THREE
MATERIALS AND DATA

3.1 Regional Characteristics and Site Selection

The study intends to determine the meteorological factors that affect the water level in lakes. The Mogan Lake was selected as a sample region. The primary reasons to choose the Mogan Lake are that the Mogan Lake hosts endemic species; and this area is located in Gölbaşı Special Environmental Protection Area which is one of the 15 areas under protection in Turkey.

Gölbaşı Special Environmental Protection Area was defined and recognized as an area including the Mogan and Eymir lakes with 273.94 km^2 size upon the publication of relevant law in Government Gazette on 21.11.1990 (Figure 3.1).

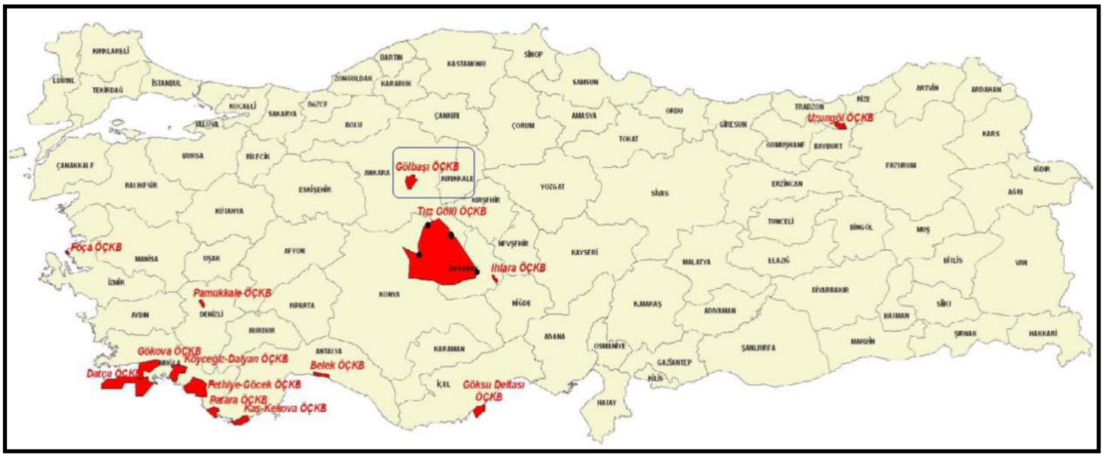

Figure 3.1 The map illustrating Gölbaşı Special Environmental Protection Area among other similar regions in Turkey (Environmental Protection Agency For Special Areas (EPASA) City Status Report, 2008)

In the region, 488 plant and 200 bird species have been reported. 52 of the plant species are endemic species (for instance, *Centaurea tchihatcheffii,* an endemic species, has been symbol of this area) and 22 of the bird species are wild species. The Mogan Lake is a sensitive ecological system that was recognized as a reservation region due to the climate characteristics, ground and soil structure, water resources, biological variety, industrial and residential stresses under the presented issues and Environmental Protection For Special Area criterions (Environmental Protection Agency For Special Areas (EPASA) City Status Report, 2008.).

Therefore, Environmental Protection Agency For Special Areas is implementing research, planning and application projects in subjects of water resources, infrastructure, agricultural pollution, erosion, biodiversity so that they develop protection plan for nature; controlling all hazardous activities against natural values; and protecting biodiversity through coordination and integration with the other relevant government bodies (EPASA City Status Report, 2008.)

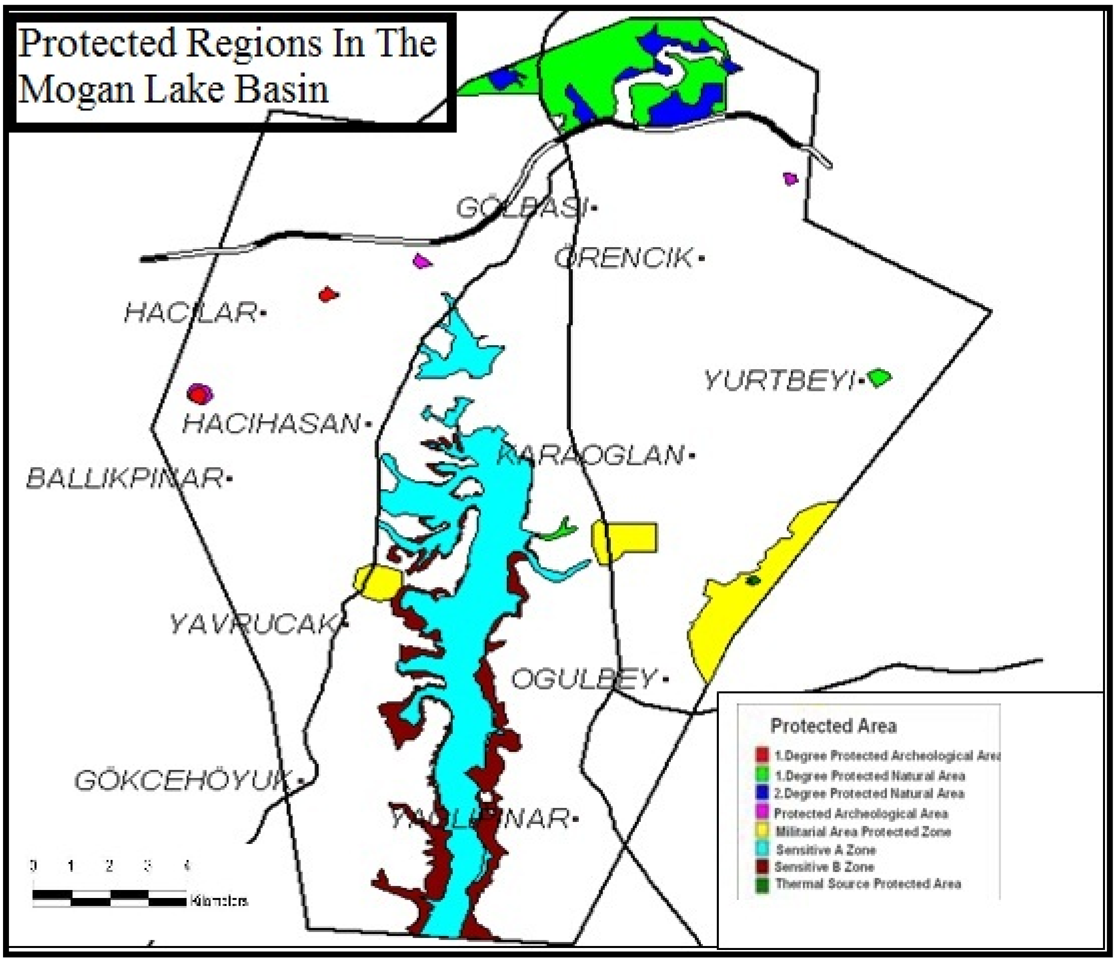

Figure 3.2 Protected regions in the Mogan Lake Basin (EPASA City Status Report, 2008)

As it can be seen on the legend in Figure 3.2, there are 8 different protection areas in the Mogan Lake basin. For the designation of protection area, Environmental Protection Agency For Special Areas Directorship carries out research and observation studies and these studies are marked on maps. All maps and protection-usage provisions designated for the Special Environmental Protection Areas are published in the website of the institution through GIS based on the government's participation, transparency and governance principles.

Other reasons to select the Mogan Lake region are the fact that data which is required to perform this study has been collected regularly from the Mogan Lake by means of several techniques; and the need for the evaluation of the lake's interaction with the urban area through quantified data.

3.1.1 Location of the Mogan Lake and Structural Characteristics

The study area is in the Central Anatolian Region which starts from the Ankara central and extends toward southern Ankara; and it locates in the Mogan-Eymir basin lying on the east side of the Ankara-Konya highway (Figure 3.3). It has an extension area going along with the lake that is 20 km away from Ankara. The width of the lake is approximately 1250m and the length is 4 km long. The lake covers 5 km^2 areas in the region.

Figure 3.3 The map illustrating Mogan-Eymir Basin in Ankara City (EPASA City Status Report, 2008)

The Mogan Lake, which is in the form of sediment cavity surrounded by fresh water clupeid layers, has alluvium set lake characteristic. The Mogan Lake's shores are sinuous. There are very shallow bays on the valley gates opening toward the lake. The Mogan Lake enters into these valley openings. As a result of the conglomeration of the materials (aggregate, sand, clay, mill) on the stream mouths, tiny deltas have been formed. Lake's water has salty character. In the basin region which has a current from south to north, elevation difference is not distributed regularly. In the large portion of the basin, the elevation does not change significantly. On the exit of the Mogan Lake, a channel discharges excessive waters to the Eymir Lake along with the Ankara-Konya state highway by means of a regulator. The Mogan-Eymir lakes positioned in the close proximity of Gölbaşı residency are connected to each other on the surface and underground due to their positions. The Mogan Lake has connection with the Eymir Lake from its northern opening (Anonym, 1995).

3.1.2 Formation of the Mogan Lake and Historical Evolution

According to a DSİ (General Directorate of State Hydraulic Works) (1993) report, sediments have been formed following the tectonic events created a river in the valley. However this river has been weakened because of the aridification in the climate; and the alluviums that were brought from the Elmadağ through creeks with strong current formed the Mogan and Eymir Lakes (DSİ, 1993)

It is thought that region of the Mogan Lake was covering all swamp areas including current residential areas in Gölbaşı at the beginning of 1900s. Maps from 1957 show that the plain toward the Eymir Lake has a characteristic of wetland. From the measurements performed in 1965, it is seen that the depth of the lake was around 5-6 m (1/25000 Environmental Plan Report). Findings reveal that the lake area has been shrank since its formation in 1900s; its depth has reduced; the rate pollution has increased; and its marshiness and shoaling have been observed (EPASA, 1/25000 Gölbaşı Environmental Plan Report).

3.1.3 The Mogan Lake's Climatologic Characteristics

Continental climate prevails in the study area as it is common in the Inner Anatolia Region. In the region with 972 meters elevation above the sea level, it is dry and hot in summers and winters are cold and low in precipitation. During the December and January, the region takes the highest amount of precipitation, while summer season and following September and October months are the most arid periods. The average annual precipitation of the region is about 500 millimeters. In terms of precipitation regime, the region presents semi-arid characteristic. Since rhe underground water level is close to the surface, marshiness can be observed on the lake area and in its proximity during the winter season. The recorded average annual temperatures are the lowest -5^{o} C on January-February; and the highest 25^{o} C on July-August. Therefore, the region is covered with steppe plant texture (EPASA City Status Report, 2008).

3.1.4 Geological Structure of the Mogan Lake and Land Use

In the peripheral area of the Mogan Lake, an alluvium layer is observed that is transported and conglomerated by means of current (Figure 3.4). A sandstone basement that is composing large portion of the valley basin is observed in the later parts after the alluvium around the lake. Again, according to the illustration in Figure 3.4, it is understood that underground waters around the lake is close to the surface.

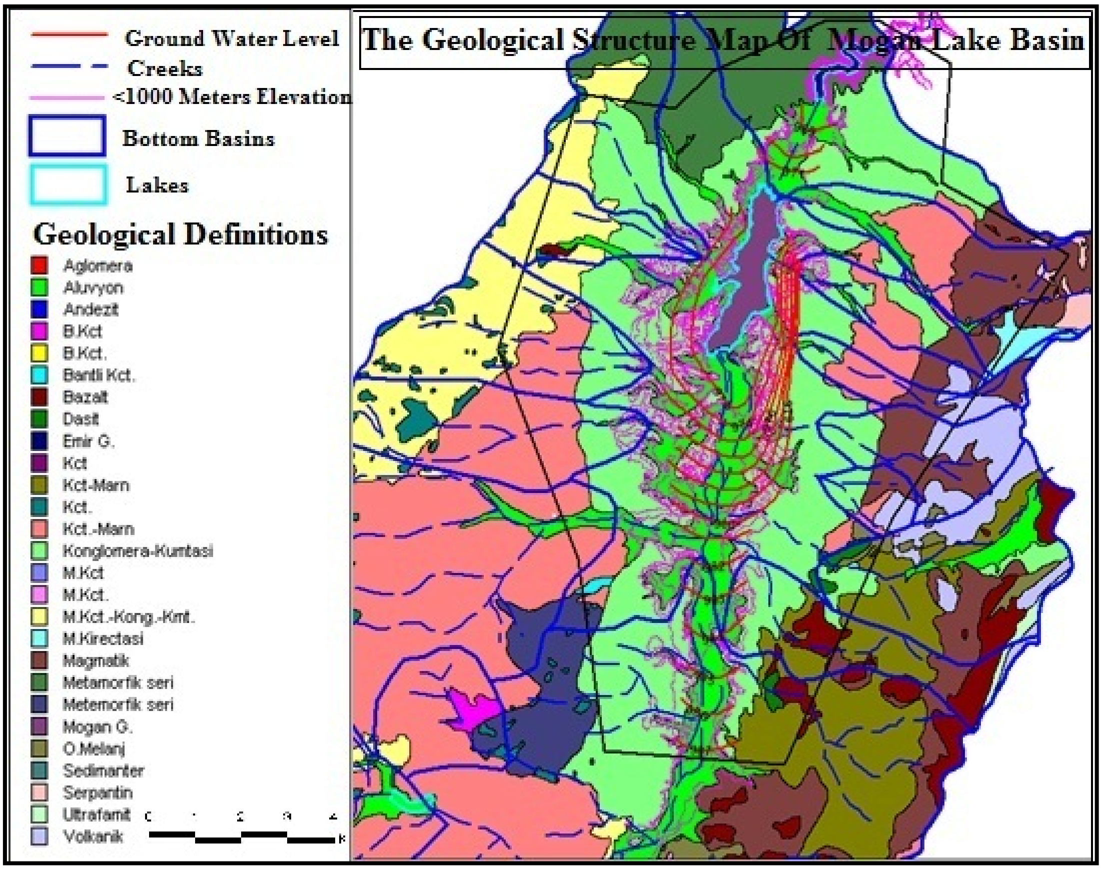

Figure 3.4 The geological structure map of Mogan-Eymir Lakes Basin (EPASA City Status Report, 2008)

Regional land can generally be classified as residential, industrial and agricultural areas. There are numerous industrial facilities along with the Konya-Adana highway and Haymana highway which constitute border of the Mogan Lake. Several agricultural facilities also can be observed along with those roads. While on the east side of the Mogan Lake, several gas stations and rolling mills are located; on the west and south sides of the lake, several sport and recreational facilities are at service. There are cemetery, brick kiln, small-sized industrial site etc. on the Gölbaşı plane. Agricultural activities usually take place in the plane are receiving precipitation with close proximity to the lakes. Reeds and morasses can be observed on the wetlands. Fruit and vegetable farming continues in the valley basement areas with irrigation. The lands in the periphery of the Mogan Lake turn out to be marshiness during winter season because underground water is close to the surface (Yurtseven, 2006).

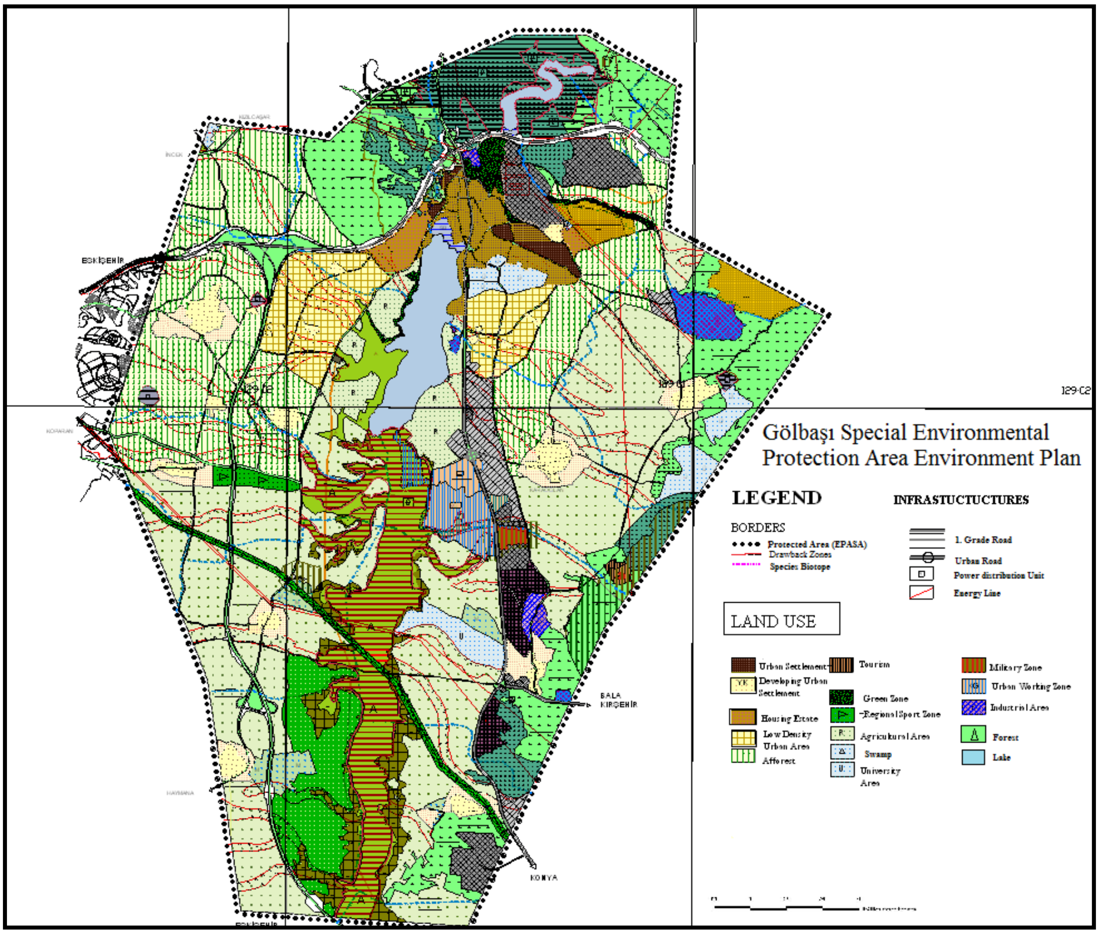

Figure 3.5 Gölbaşı Special Environmental Protection Area1/25.000 Scale Environment Plan (EPASA City Status Report)

Environmental Protection Agency For Special Areas Directorship prepared 1/25.000 scale Environment Protection Area Master Plan to protect ecologic balance and to provide foundation for protection usage decisions (Figure 3.5). In this plan, strict protection limitation issued for wetlands and swamp areas; and by including the provision of *"...no any building can be constructed on these areas and no any intervention and no action can be taken without relying on methods determined by scientific researches..."*, ecological values for the region was emphasized (EPASA City Status Report, 2008).

3.2 Data and Their Acquisition Methods for Study Area and Its Periphery

In this chapter of the study, it is intended to give information about the Mogan Lake whose general characteristics was introduced and defined in the material chapter of this paper. In this context, data collection processes were carried out by personal efforts, demanding information from the relevant government institutions and through the literature search in this subject. Data employed in this study were obtained under three stages and then, integrated together:

- On-site investigation and observations,
- Obtained relevant maps and other visual materials belong to the region,
- Meteorological quantitative data.

3.2.1 On-site Investigation and Observations

The field study, which is the first stage, includes observation studies to find out the effects over the natural character of the lake which is caused by the possible changes in the lake water level; and monitoring structuring and land use around the Mogan Lake.

In accordance with the first stage, the lake was visited during spring, when it reaches to the highest water level with the other nature photographers who visit the lake on a certain schedule; and they are probed about the changes that they observed over the time. As a result of the observations, it is concluded that the soil part in the periphery of the lake which was not under the effect of the water 2 weeks ago, is now flooded by the lake and this sort changes occur periodically during a year (Figure 3.6).

Figure 3.6 Increasing water level observed during the field study.

Another observation during the field studies in conjunction with the first stage is that the lake has a rich habitat in terms of flora and fauna diversity. Thus, possible excessive changes in the water level of lake potentially have adverse affect on creatures in the basin.

Figure 3.7 Flora and fauna diversity in the Mogan Lake.

As it can be seen from Figure 3.7, the region hosts many bird species primarily ferruginous duck, tufted duck and cormorant. It has been found that there are both continuously residing and immigrant birds within the lake ecosystem; and that migrant birds lodge in the area for nutrition and reproduction on certain time of the period. It is projected that upon the hunting ban issued for the region, bird population will be eventually increased.

Figure 3.8 Low-density settlement areas around the Mogan Lake.

In accordance with the second observation stage, land use and the distance of the structuring to the lake which is in the periphery of the Mogan Lake were investigated (Figure 3.8). In general, it is understood that agricultural, tourism, recreational and commercial land uses are common in and around the Mogan Lake. The settlement density has been increased over the time. Especially on the northern part of the lake, while residential areas have been concentrated, in other parts there are some commercial recreational purpose places.

Figure 3.9 Agricultural areas in the periphery of the Mogan Lake

It was observed that the periphery of the lake and inner parts are composed of reeds and swamp areas; and that beyond the reed areas there are agricultural lands. It was determined that most of these lands are confined with wire fences; and additionally there are low density residential areas among those lands (Figure 3.9). It is also understood that there are private properties in the surrounding region of the lake.

Figure 3.10 The Mogan Park and the activity areas in the lake

There is a recreation area (the Mogan Park) on the western part of the lake (Figure 3.10). The Mogan Park stands out with its 40 hectares size (The Ankara Municipality, 2008) housing daily facilities, sport areas, piers, picnic and open recreation areas.

3.2.2 Obtained Relevant Maps and Other Visual Materials Belong to the Region

In this chapter of the study, the information providing base for the statistical analysis such as maps and other spatial material will be given. The most important maps for calculating the volume of the lake are bathymetric maps. Therefore, it is beneficiary to investigate the relationship between the hydrographic measurements and bathymetric maps.

The hydrographic measurements cover the geodesic and oceanographic measurements performed on the places under water. A geodesic study has two important elements: position and depth measurements. Similar to the geodesic measurements, hydrographic measurements have developed with a great pace. In addition to the classic hydrographic measurements applied today, there are computer aided modern data collection systems used (Kalkan and Alkan, 2005).

Measured water levels from the lake can be easily represented by the maps and graphics. The most frequently used ones are water level surface maps, water level change maps, water depth maps, water level profiles and lake hydrographs. If aquifer geometry and limnological details are known, water level surface maps, water-table maps and bathymetric maps can be classified more certainly.

3.2.2.1 Bathymetric Data

The most recent study presenting the Mogan Lake's bathymetric condition was implemented by the Environmental Protection Agency for Special Areas on April, 23rd and 24th in 1998. In this study, depth measurements were performed over the uniformly distributed profiles on the lake surface.

By selecting several reference points around the lake, adequate amount of station must be determined due to the size of the lake. By means of a boat, the determined stations are visited at constant speed and during these travels, depth signals are measured and recorded by sonar depth measurement equipment at certain period interval. Finally, several marked measurement points along with each line are obtained so that contour lines can be drawn to reveal the bathymetric map of the lake (EPASA, 1998).

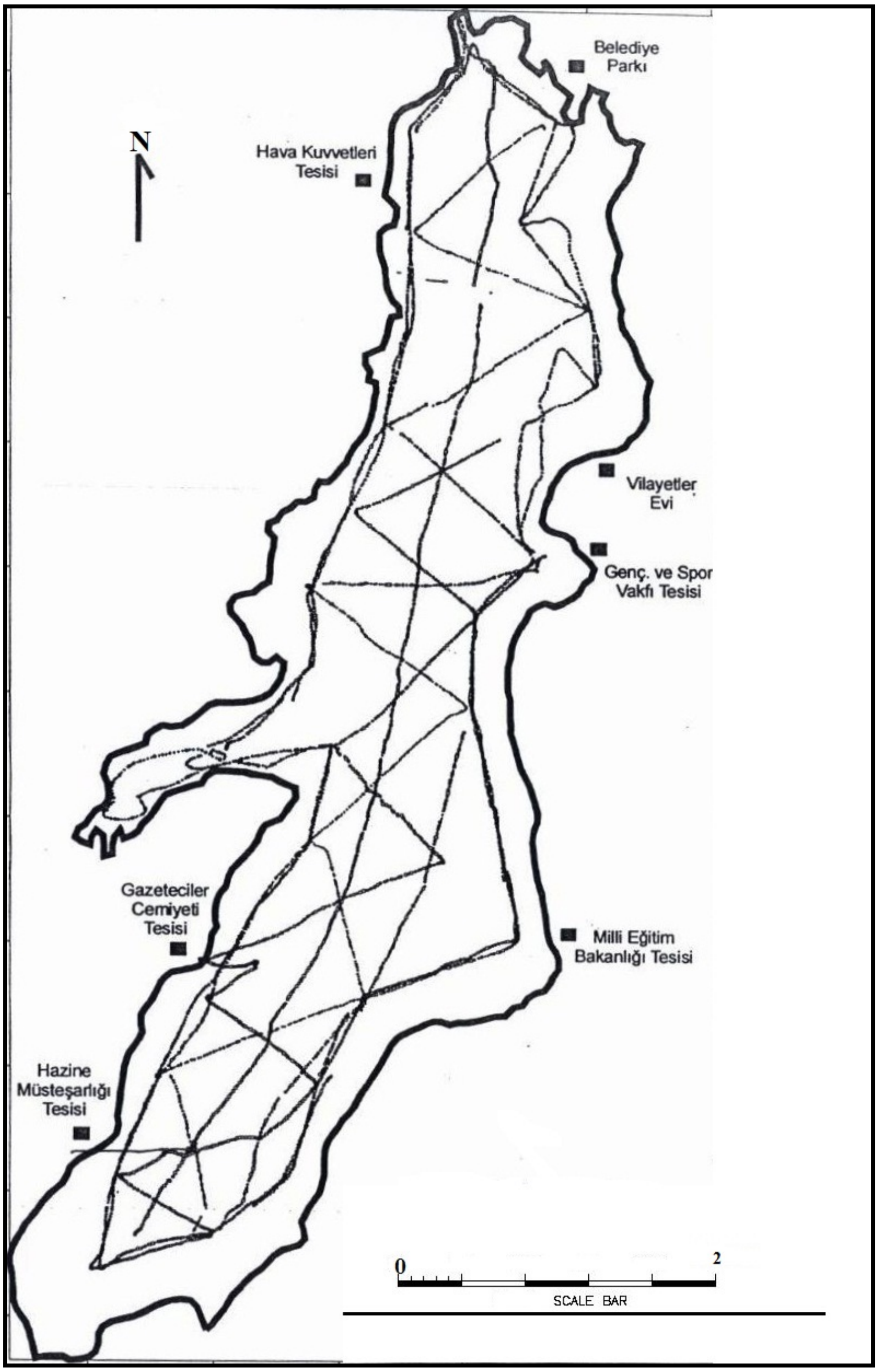

Figure 3.11 Followed profile cross-sections during the bathymetric measurements (EPASA, 1998)

The bathymetric map of the Mogan Lake which is prepared according to the method described above and in a raster form was illustrated in Figure 3.11. It was observed that the profile lines were arranged with equal distance and each of the areas are tried to be travelled as much as possible.

3.2.2.2 Satellite Images by Years

It must be taken into consideration that satellite images with high resolution can be exploited in determination studies for coastal line and shore edge line for dam and lakes with excessive large areas. Although the studies implemented by this method do not provide the visual base of the research, they provide supportive data to develop relevancy. In this study, several satellite images with 3 and 4 years interval were taken from the Google Earth software; and they were compared to construct shore edge line, and to scale and georeference the bathymetric measurements (Figure 3.12, Figure 3.13, Figure 3.14).

Figure 3.12 The satellite image of the Mogan Lake from September 2003 (Google Earth)

Figure 3.13 The satellite image of the Mogan Lake from October 2007 (Google Earth)

Figure 3.14 The satellite image of the Mogan Lake from October 2010 (Google Earth)

Water level of the lake may present different status on different months of the year. Therefore, the images selected on separate months which are not close to each other may lead us to wrong conclusions. For the image comparison, September and October months are selected for our study. Since northeast and northwest and northern parts of the lake were blocked with concrete sets, there has been any change found through satellite images. For rest of the lake which is used as a natural reserve park, it was observed that the shore edge lines have experienced great changes especially on the southern part.

3.2.2.3 Other Visual Data

Similar to the satellite images, other visual data are also supportive to prepare basic data for the analysis. The bathymetric cross-section graphs of the Mogan Lake are presented in this section.

In general, the Mogan Lake is deepening gradually after 75-100 m from the shore line; and it is descending to an almost flat basement showing a soft ruffle. As it can be seen from Figure 3.15, the Mogan Lake's basement elevation is laying at approximately 969 m; and partially it is ascending to 973 m (EPASA, 1998).

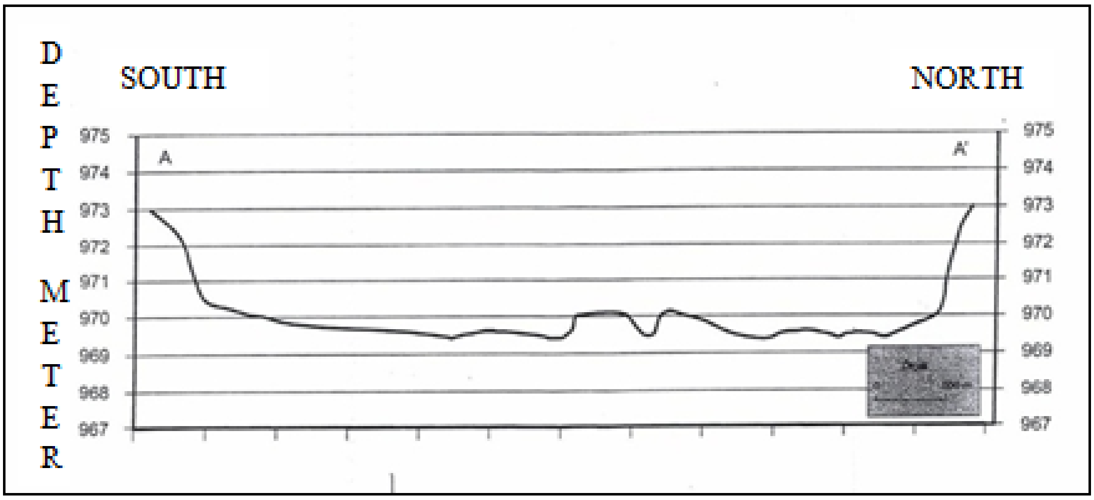

Figure 3.15 The Mogan Lake's North-South bathymetric cross-section (EPASA, 1998)

Figure 3.16 and 3.17 show the bathymetric cross-sections based on the measurements carried out by the Special Environment Protection Agency in 1968, 1990, 1995 and 1998.

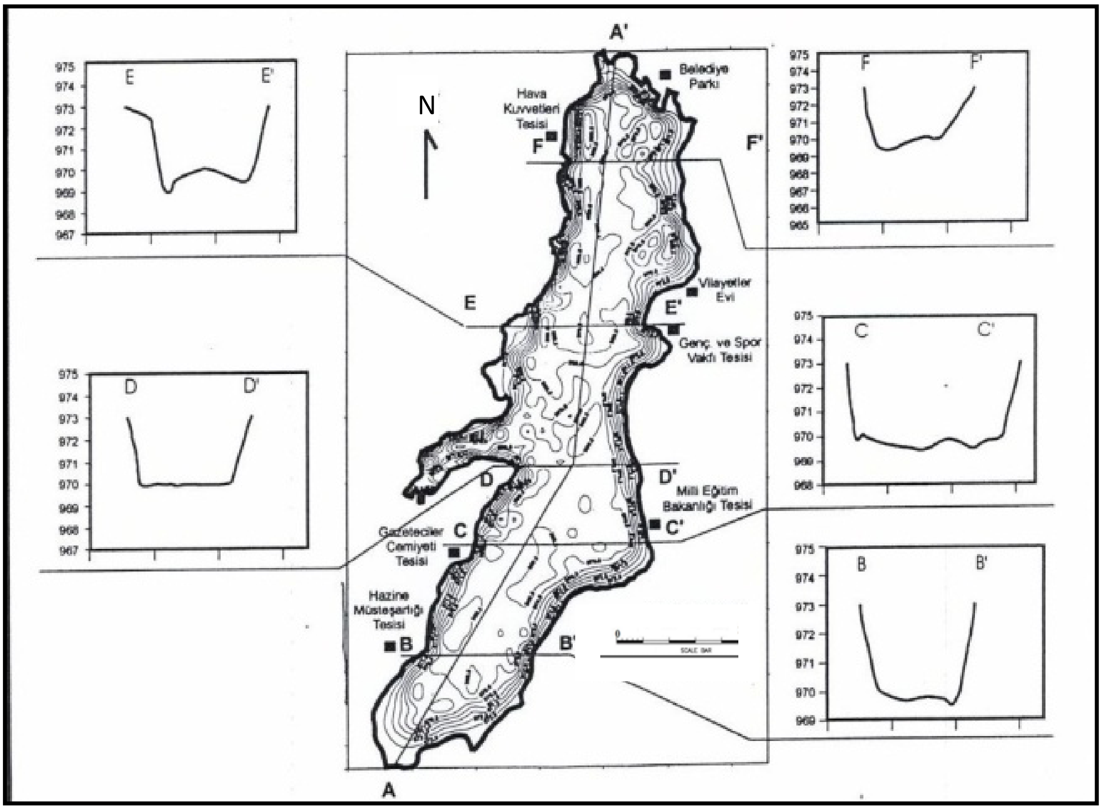

Figure 3.16 The east-west bathymetric cross-sections of the Mogan Lake (EPASA, 1998)

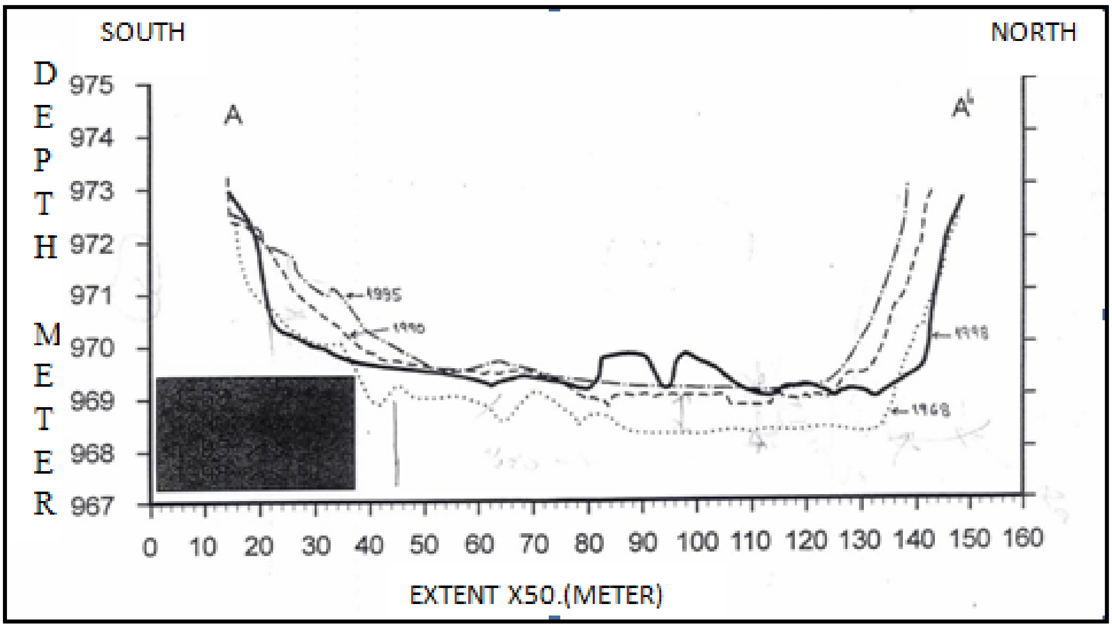

Figure 3.17 The comparison of the Mogan Lake's north-south bathymetric cross-section with the previous measurements (EPASA, 1998)

As a result of the investigation of the maps and other visual data of the lake, it was observed that the sediment transportation has been primarily condensed on three areas. These areas are bay side which is 300 m north of the Kandil Hill; the east side bay area which is north side of the Vilayetler Hall; and Gölbaşı drainage channel which is close to the municipal park on the north-east side. The sediments on the shores of these areas are thicker compared to the morphological structure of the places in close proximity (EPASA, 1998).

3.2.3 Quantitative Data

Statistical techniques are being utilized commonly to summarize data obtained as result of quantified researches; and to determine the possible relationship among variables. In scientific researches, there are several descriptive statistical methods to determine the level of relationship among variables. Scale types to collect data determine statistical techniques that are being used in the analysis of data. Meaningful assessments of the data that are obtained as a result of research and to prepare them for analysis have significant importance as much as appropriate statistical techniques used in the research (Tonta, 1999).

Quantitative data utilized in the study were investigated under two chapters. First, quantitative data regarding the water level of the lake by years are considered; second, meteorological factors affecting water level are evaluated.

3.2.3.1 Water Level Statistics

Water level change is the variation of the water depth or water volume as a result of the alterations in the affective factors. The basic factor affecting water level or water volume is precipitation. Especially, water level of the lake is expected to increase periodically due to seasonal precipitations. To set up strong foundation for our study, all factors affecting the water level must be associated with the water level. However, this study is limited to meteorological factors.

In this sense, water level measurements pertaining to the past years were obtained from the Special Environment Protection Agency. This data covers a 14-year period from October 1996 to October 2011. Graphs for this data are prepared as two separate graphs of 7-year durations (Figure 3.18 and Figure 3.19). To be able compare the results, they were obtained on the first day of the month determined for measurement.

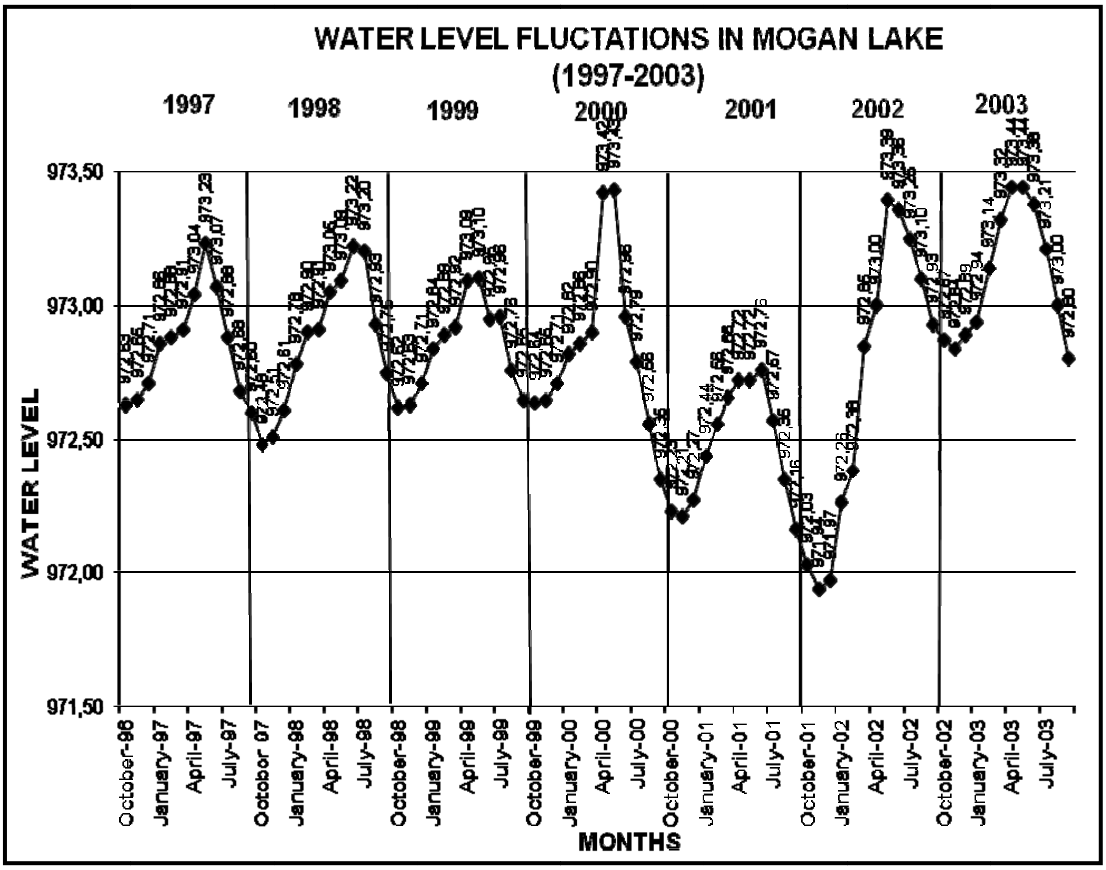

Figure 3.18 The Mogan Lake's water levels between 1997 and 2003 (EPASA, 2011)

When we investigate the first seven year period, it was observed that there were seasonal variations in the water level; and there was increase on the lowest water level in the years 2002 and 2003. It was determined that the lowest water level was measured as 971.9 on November 2001; the highest value was measured as 973.4 on May 2000. Observing the highest and lowest values in different months can be viewed as a normal situation. The effect of the winter precipitation can be seen on April and May; and thus water level increases during these months. In the later stage, the lowest water levels are observed during October and November months due to increasing evaporation rate during summer; and ineffective precipitation during summer and fall season.

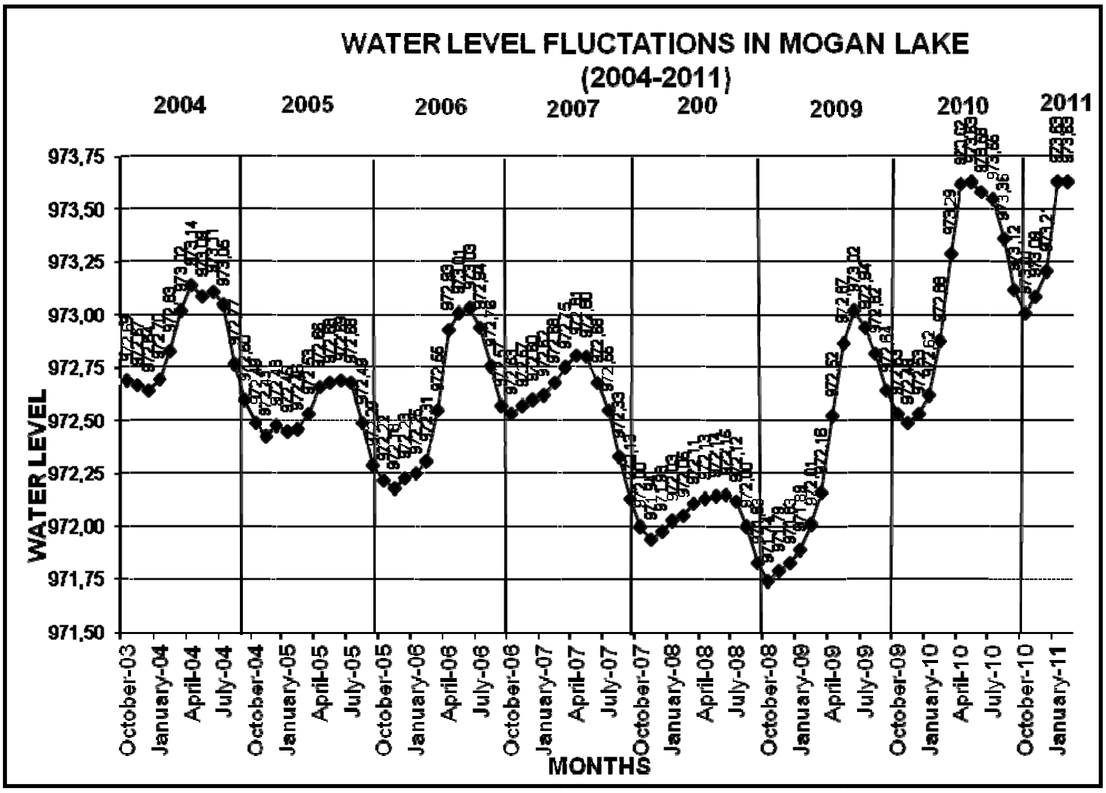

Figure 3.19 The Mogan Lake's water levels between 2004 and 2011 (EPASA, 2011)

Based on the determinations made from the second graph, the lowest water level of the lake was measured as 971.7 on November 2009. Moreover, this value was the lowest value since 1996. on the other hand, the highest value was measured as 973.6 on May 2010 and January, February 2011, which was the highest value of last 14 years. Observing the highest values on January and February months in 2011, emphasizes that there may be other factors affecting the water level beside meteorological factors. It was assessed that another possible reason would be the fact that precipitaiton fell in that year affected more compared to the other years; and the increase in the water level occurred sooner than the expected time. Thus, the meteorological must be investigated in this context.

3.2.3.2 Meteorological Quantitative Data

Observing meteorological events and implementing meteorological measurements regarding the study place of the interest are the most significant stage of this study. By means of observations and measurements, it was evaluated that whether there is significant relationship between meteorological events and the water level; and thus, the cause-effect relationship regarding chains of events that are composing the purpose of this study can be provided. However, there are several issues to be mentioned on the observations. Firstly, there must be accordance among measured values in terms of date, unit and experiment area. Furthermore, measurements must be performed at certain quality based on an appropriate periods to construct experimental condition.

Inputs required to build water level forecasting system must have a quantitative data characteristic. Quantitative variables to construct the systematic are amount of evaporation, number of windy days, pressure, humidity, temperature and precipitation. In the applied modeling, while precipitation data has positive effect on water level, other variables have reducing effect on water level. Since anthropological effects do not show persistence; and hydrological currents are taken as a result of meteorological characteristics, they are not constituting an experimental condition.

Quantitative data regarding the mentioned variables must be measured under a certain observation net so that they can be used in the regression analysis. Data must be continuous and correct to acquire meaningful results as a result of the formulation of the quantitative data. Thus, required data for the study were listed and they were demanded from the Meteorology Directorships of Ankara and Balıkesir.

From the Meteorology Directorship of Ankara, meteorological observation data covering the period of last 10 years including “monthly average pressure, monthly average evaporation, monthly average relative humidity, monthly average wind speed, monthly average temperature, and monthly total precipitation" were obtained so that they can be exploited in the regression analysis.

All meteorological data from January 2000 to December 2010 were obtained to be added to the data set from the Meteorology Directorship. However, water level values were obtained for the period of 1996-2011. In this case, precipitation data seems like a subset of the water level data. Therefore, the overlapping dates constitute the data used in estimation of the model.

Before the estimation of the model, all the possible meteorological factors are reviewed. Below are the detailed explanations about the characteristics of the obtained data.

3.2.3.2.1 Precipitation Factor. The precipitation process can be described as "first, air ascends into the atmosphere due to any reason, as it ascends, the temperature of air decreases till a certain condensation level which causes the humidity in the air to turn into a type of precipitation and fall onto the earth. In terms of hydrology, the most significant precipitation types are rain and snow. While rain waters can easily aggregate and start to runoff; waters resulting of the snowing takes longer period of time to cause runoff. For any type of precipitation, there must be enough vapors in the atmosphere. Formation of water vapor is relevant with transformation of surface water of the earth into vapor. For the further process, it requires to cool down. As the temperature of air decreases, its carriage capacity reduces; eventually it causes water vapor to transform into liquid form. In the last stage, condensing molecules of the water vapor coalesce to form rain drops which can fall onto the earth (Bayazıt, 1999). From the point of this explanation, it is considered as the most important factor increasing the total monthly precipitation.

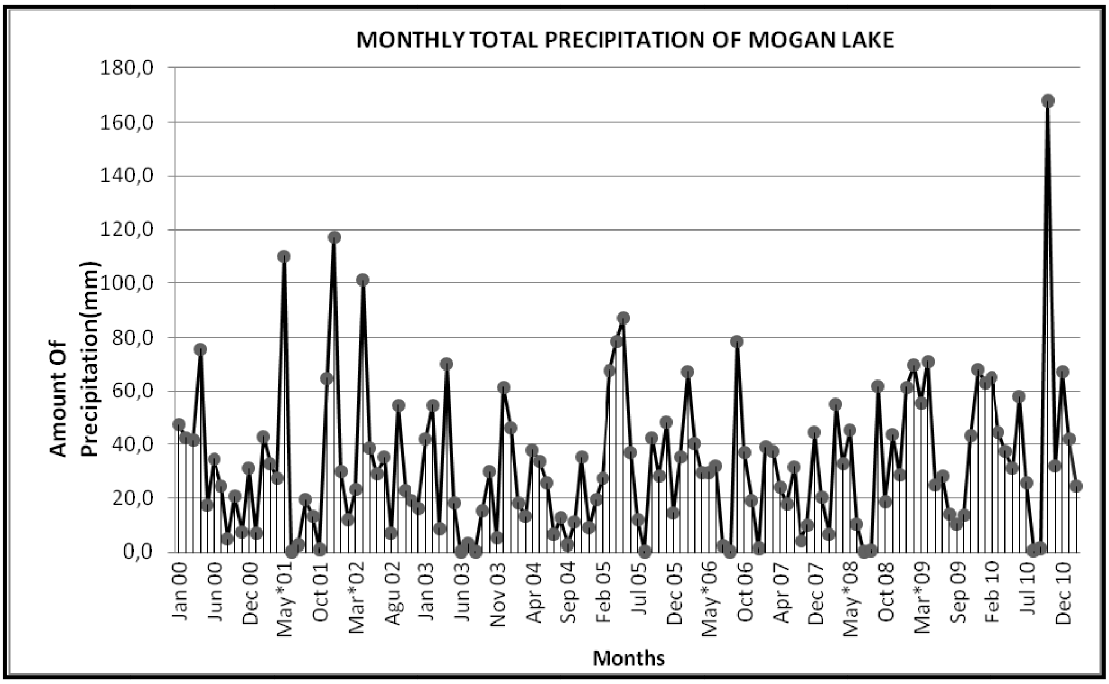

Figure 3.20 Monthly total precipitation of Mogan Lake (Meteorology Directorship, 2011)

Monthly total precipitation data taken from the Meteorology Directorship were organized in the graphic form for evaluation purpose (Figure 3.20). According to thisdata, while the highest total precipitation occurred on October 2010 with 167.6 mm value; the minimum measurement value observed during the summer season with 0 mm value. The monthly total precipitation for this 10-year period was 32.9 mm; and its standard deviation was calculated as 27.20115.

3.2.3.2.2 Evaporation Factor. Evaporation is the event in which water transforms from the liquid form into gas form. When the molecules on the water surface posses sufficient kinetic energy, they disentangle from the pulling effect of the other molecules that is trying to hold them; and they leap out into the air. Around the water surface, there is constant molecule transition from the water to the air and vice versa. If molecules passing from water to air more than the others, this is called “evaporation”. Water molecules transit into the air from the water surface on 1-10 mm daily rate depending on meteorological conditions. Since there are many parameters affecting the evaporation, we can not take the evaporation rate as a single factor reducing the water level. About this reduction, wind, temperature, pressure and humidity factors must also be evaluated at the same time (Bayazıt, 1999).

3.2.3.2.3 The Wind Factor. The wind moves water molecules in the air and cause them to collapse with each other. As molecules collapse, they coalesce and increase the capacity of air to hold more water molecules. Thus, as the wind speed increases till a certain level, the evaporation rate increases too (Figure 3.21). For the maximum level of evaporation in the wetland areas, there must be high wind speed (Karakaplan, 1973).

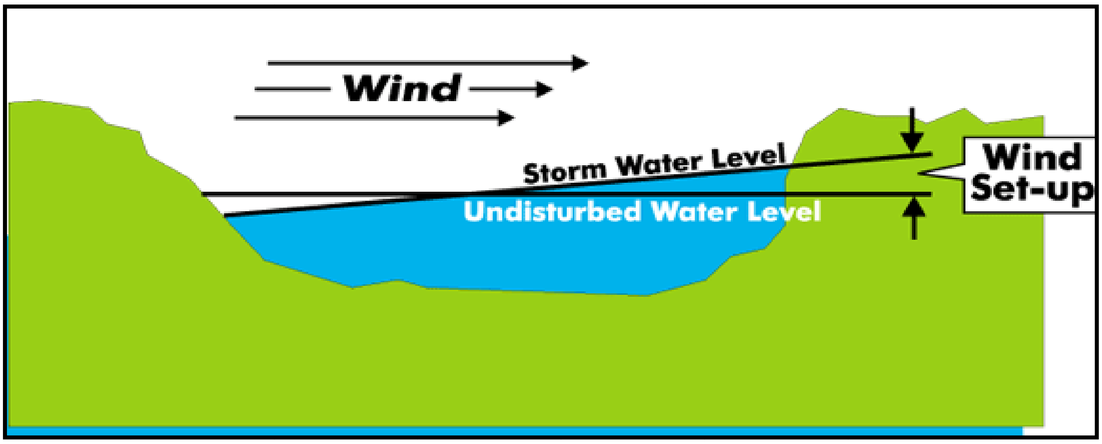

Figure 3.21 Lake profile showing wind set-up (Mohr, 2011)

The average monthly wind speed data obtained from the Meteorology Directorship were organized as graphic so as to be assessed (Figure 3.22). According to these data, while the maximum average wind speed rate was observed 3.3m/sec on July 2008, the minimum rate was observed 1.5 m/sec on November 2006. The average wind speed measured in this 10-year period is 2.3 m/sec and its standard deviation was calculated as 0.400281.

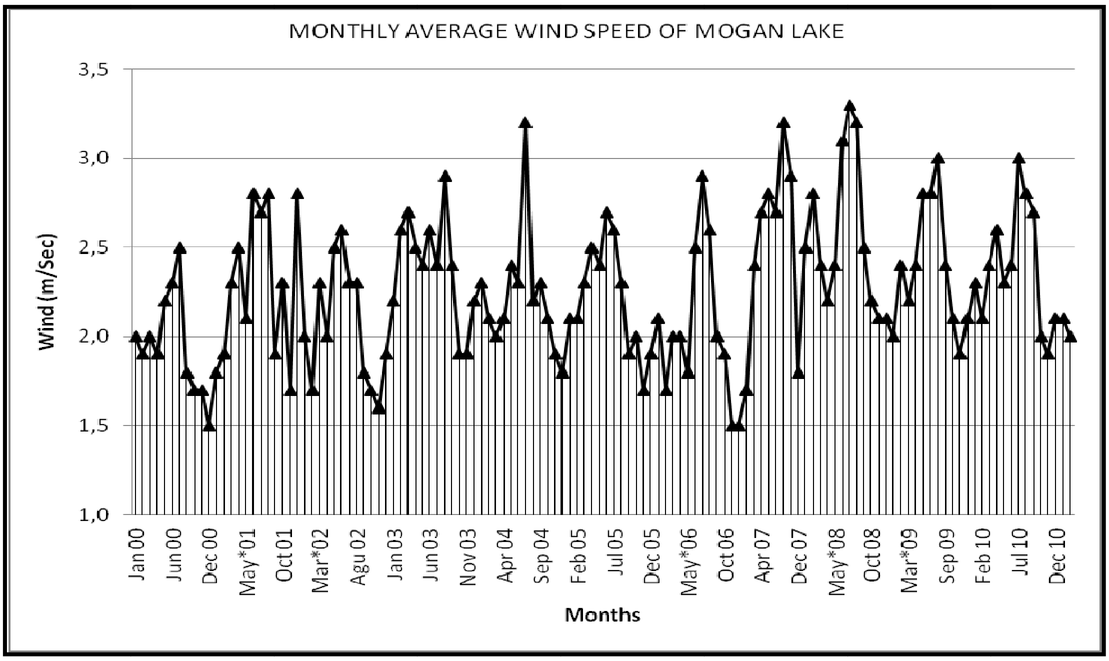

Figure 3.22 Monthly average wind speed of Mogan Lake (Meteorology Directorship, 2011)

3.2.3.2.4 Temperature Factor. The vapor pressure in the water masses increases due to the temperature effect. Since evaporation is related with the vapor pressure difference between air and water, conditions with equal temperature may not increase the evaporation rate. For the continuous evaporation, as evaporation occurs, the water loses its temperature and the air heats up (Figure 3.23). Otherwise, when the air and water temperatures are equal, evaporation rate may reduce (Karakaplan, 1973)

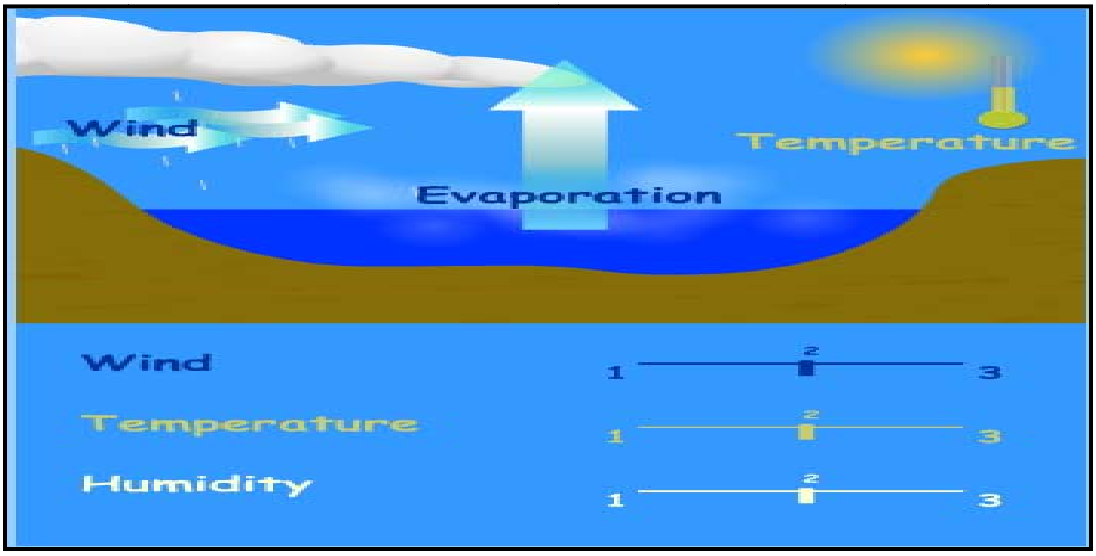

Figure 3.23 Lake profile showing wind set-up (Mohr, 2011)

The average monthly temperature data obtained from the Meteorology Directorship were organized in a graph and they were assessed (Figure 3.24). According to these data, while the highest average temperature was recorded as 28.4 C° on August 2010, the lowest temperature was recorded as -3.9 C° on January 2008. The average temperature and its standard deviation for this 10-year period were calculated as 12.5 C° and 8.64698 respectively.

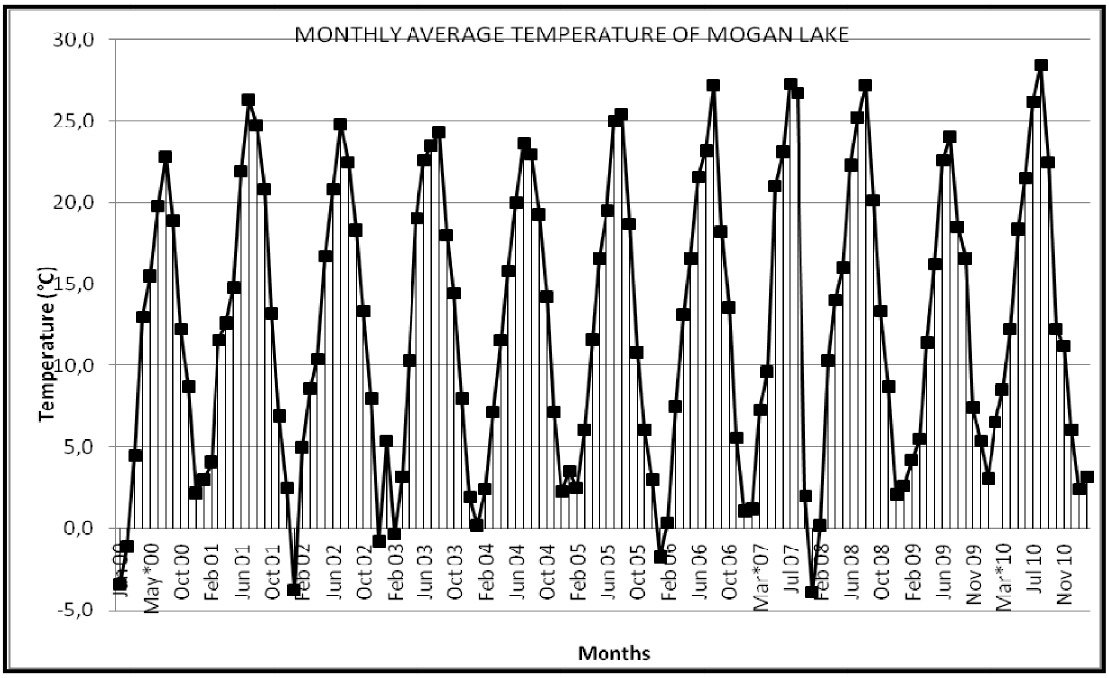

Figure 3.24 Monthly average temperatures measured at Mogan Lake (Meteorology Directorship, 2011)

3.2.3.2.5 Humidity Factor. Humidity is another reference of water or water vapor in the air. Somehow, there is always humidity in air. It is not always in the same amount in the atmosphere because as the air temperature increases, its humidity capacity increases too. Conversely, as the temperature drops, its capacity reduces. Thus, while the air was able carry more humidity when it was warm, it releases some of it as precipitation when its temperature decreases.

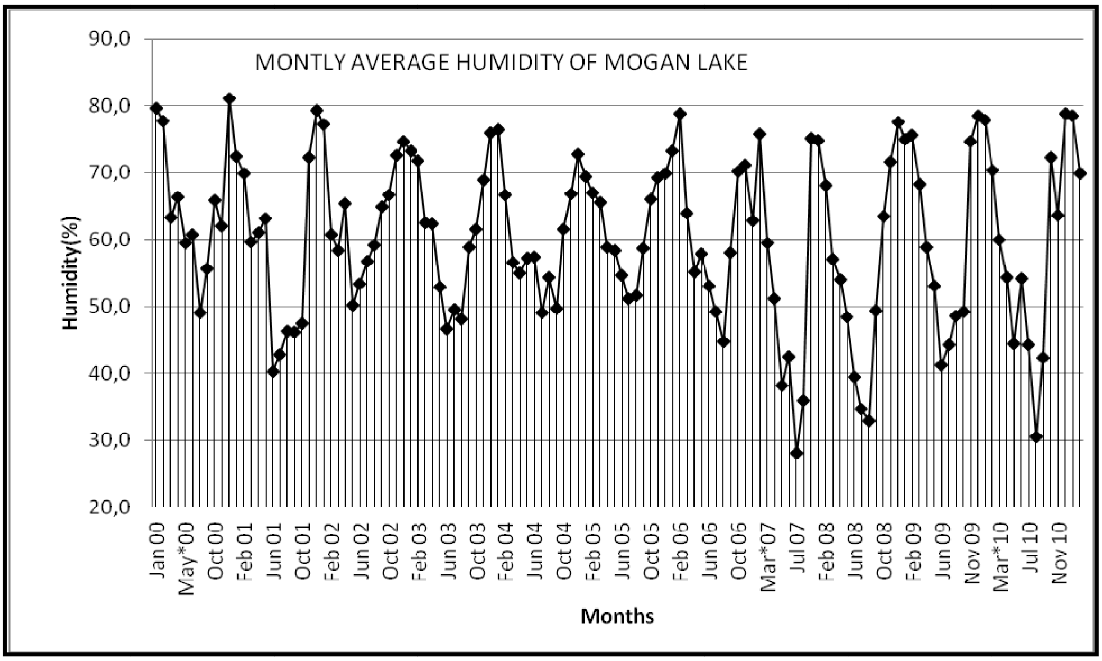

Figure 3.25 The monthly average humidity measured at Mogan Lake (Meteorology Directorship, 2011)

Monthly humidity data regarding the study area was obtained from the Meteorology Directorship and they were organized in a graph for an assessment (Figure 3.25). According to data, while the highest average humidity was recorded as 81.1% on December 2000, the lowest measurement was recorded as 28.1% on July 2007. The average humidity and standard deviation for the 10-year period were calculated as 60.2% and 12.17032 respectively.

3.2.3.2.6 Pressure Factor. The atmospheric pressure, P, is the pressure exerted by the weight of the earth's atmosphere. Evaporation at high altitudes is promoted due to low atmospheric pressure as expressed in the psychometric constant. The effect is, however, small and in the calculation procedures, the average value for a location is sufficient. A simplification of the ideal gas law, assuming 20°C for a standard atmosphere, can be employed to calculate (Food and Agriculture Organization, 1998).

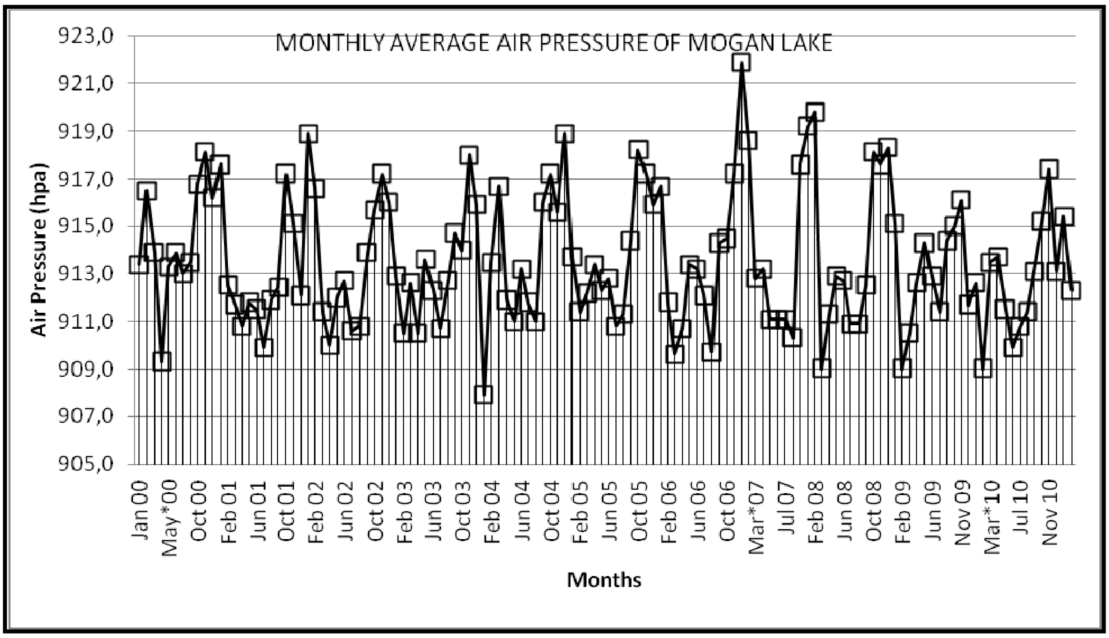

Figure 3.26 The monthly average vapor pressure measured at Mogan Lake (Meteorology Directorship, 2011)

Average monthly pressure data obtained from the Meteorology Directorship were organized in a graph for an assessment (Figure 3.26). According to the data, while the maximum average pressure was recorded as 921.9 on December 2006, the minimum pressure was recorded as 907.9 on January 2004. The average pressure and the standard deviation calculated for this 10-year period was 913.5 and 2.761035 respectively.

During data collection process, there have been numerous and various data obtained from several written sources, institutions and personal observations in different forms. These data are required to be gathered, organized and recorded. As it was stated previously, it is quite important to achieve consistency among these data to obtain correct conclusion. Therefore, these data conveyed into the computer form so that they can be ready for analysis performed by the Office, Cad, and GIS programs. Organized data sets were presented in the appendices section at the end of this study.

CHAPTER FOUR
METHODS AND ANALYSIS

In the study, regression analysis is used to examine the affects of meteorological factors on water levels in the Mogan Lake. The estimated regression would help to model the changes in the water level.

In general, the observed data do not present whole process. The process must be modeled to make more reliable decisions. Models can be used to produce data for planning and design or forecasting future values of the relevant processes. It is possible to generate more realistic and reliable scenarios and to make more accurate decision by selecting the right model defining time series (Bacanlı and Baran, 2004).

4.1 Digitizing of the Bathymetric Maps

The bathymetric maps of the Mogan Lake were obtained as a raster data. In the projected study, layers with topological foundations that are composed of points and lines are required. The raster data does not fulfill this requirement in this sense. Therefore, obtained raster maps for the depth contours were scanned, digitized, scaled and georeferenced using CAD and GIS software. This digital map can be considered as the bathymetric-elevation map of the Mogan Lake.

According to the bathymetry-elevation map of the Mogan Lake, the elevation of the deepest section of the lake was measured as 969.0 meters; and the highest water elevation was measured as 973.5 meters; thus it can be understood that the depth of this place is around 4.5meters. For more sensitive results, bathymetric contours of the lake depth were drawn for every 0.5 meters using spatial interpolation techniques available in GIS packages (Figure 4.1).

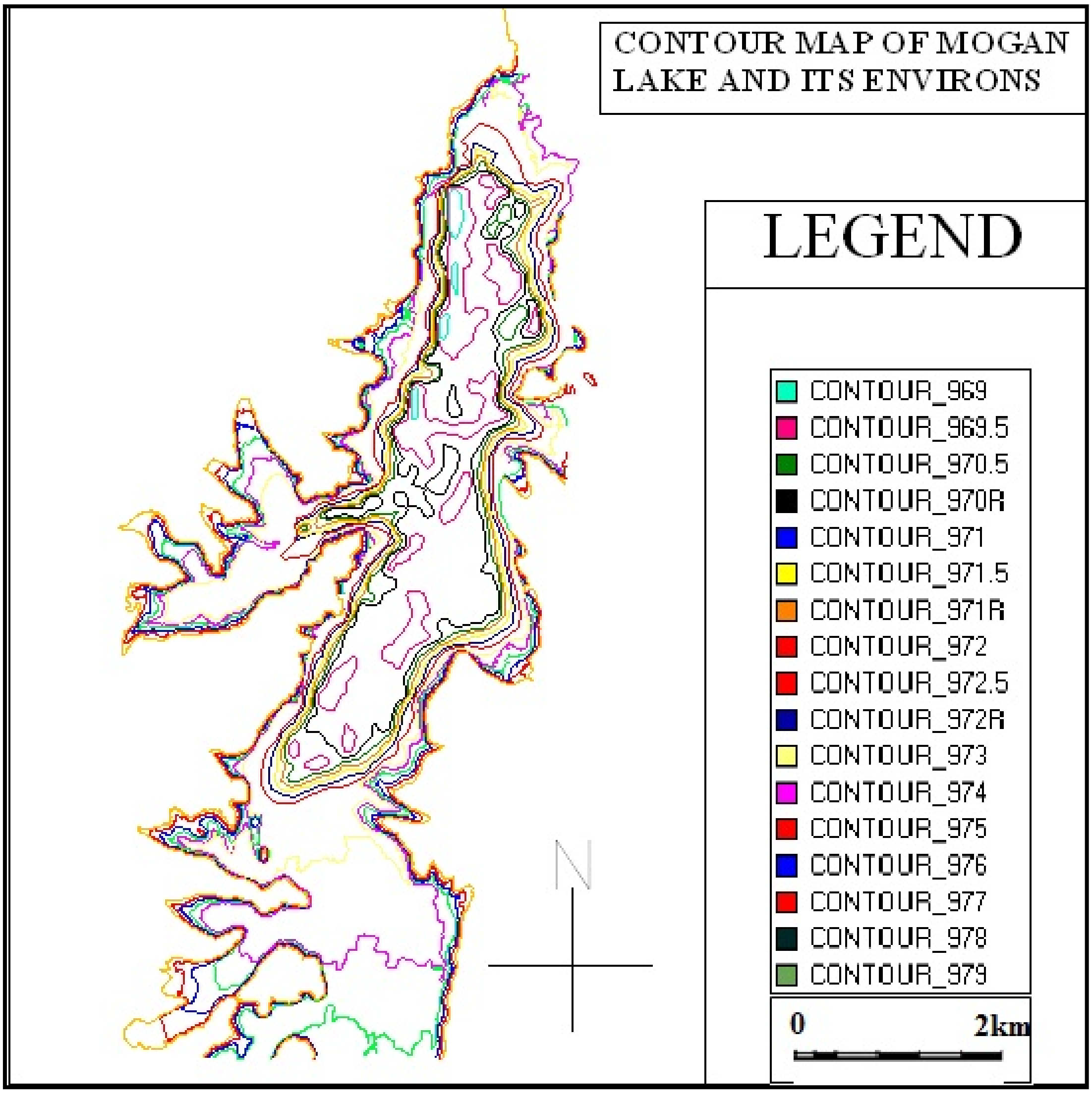

Figure 4.1 Contour map of the Mogan Lake and its environment

In the Mogan Lake, the most recent water level was measured on February 2011 as 973.6 m. The water level has shown differences over the years due to the effects of independent variables. According to the water level data, the contours on the most recent water level are considered as flood areas which are outside of the lake water capacity area. Contour lines drawings after the maximum water level were prepared by assigning elevation value for every 1 m until the 979 m elevation (Figure 4.1).

Furthermore, it was paid attention that every elevation has quality of polygon. Thus, required closed areas to calculate volume were obtained. By entering point (z) values required for the volume calculation for each contour, data about the elevation were completed so that bathymetric contours of the Mogan Lake and elevation contours of the lake regarding the lake's radius were obtained. Thus, the digital bathymetry-elevation map of the Mogan Lake is obtained prepared.

4.2 GIS Based Modeling of the Topographic Maps

Parallel to the developments in Geographical Information Systems, establishing and implementing the Digital Elevation Models (DEM) for several fields are easier today. A digital elevation model is an appropriate structure to reflect the constantly changing topographical face of the earth. This model is a general data source for the land analysis and other 3-dimensional applications. General land characteristics such as land slope, direction, skewness, basin area and slope length can be determined easily from the DEM (Gündoğdu, 2003).

The digital elevation models are being applied in wide range of area today. A digital elevation model must be established by using best-representing elevation values for the land to conduct our study sensitively. Geographical information system software uses these values and finds the intermediate values by interpolation and will provide digital elevation model (Gündoğdu, 2003).

In this study, primarily the data in the CAD format were transformed into SHP data form and they were organized in the ArcGIS environment to build up a Digital Land Model. First, triangulation was derived from the the digital bathymetry-elevation map of the Mogan Lake to create a TIN surface (Figure 4.2).

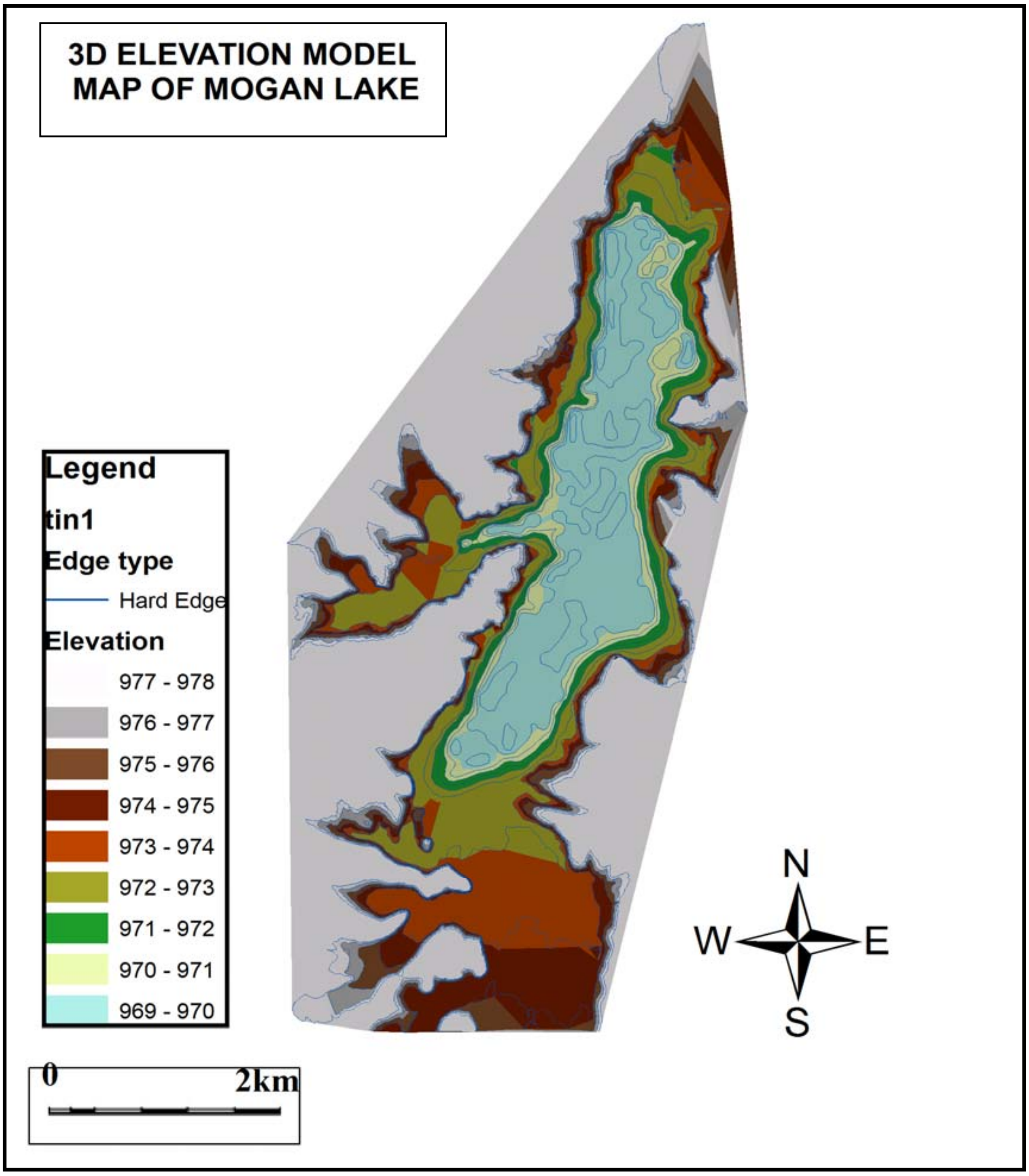

Figure 4.2 3D Elevation model map of Mogan Lake

The digital data generated by this approach have advantages in terms of analysis and recognizing by the GIS. This technological advantage is provided by GIS. An increasing usage and quality of the DEM have extended their application potential to hydrological, hydraulic, water resources and environmental researches (Moore et al., 1991).

Based on the created TIN file, volume calculations were performed for each depth value of the lake by using the “Surface analysis” tool from the 3D analyst menu in

ArcGIS. Thus, volumes of each elevation are calculated so to determine water capacity values (Figure 4.3). These determinations enabled us to obtain dependent variable that will be exploited for the formulization of the independent variables.

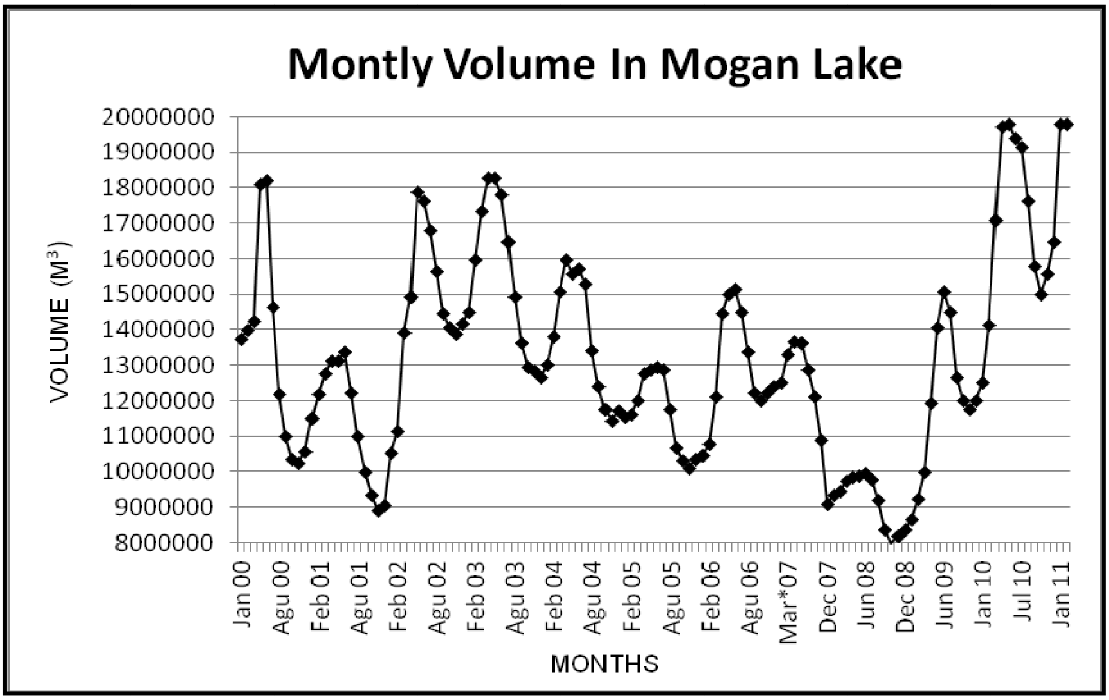

Figure 4.3 Monthly Volume in Mogan Lake

By integrating the determined volume values with the meteorological data, they were prepared for the regression model analysis performed in the next stage. Organized data sets were exhibited in the appendix section of this study.

Shortly, in context of this stage, 3-dimensional elevation model was built in ArcGIS, so that the water volume measurements can be used in the regression analysis.

4.3 Linear Regression Method

Regression analysis is a statistical analysis that is applied to reveal the cause and effect relationship persisting among two or more variables with support of mathematical models. The significance of the relationships among the dependent and independent variables are exposed through the established model; and the value of the dependent variable is calculated based on every different value that is assigned to the independent value. In linear regression, the estimated equation is linear in parameters.

When there is only one independent variable in a regression analysis, it is called simple regression; in case of two or three variables, it is called multiple regression model. In this context, the regression model that is considered for the study regarding the Mogan Lake is a multiple regression model because there are more then one variables. In the multiple regression, while the dependent variable is Y, independent variables are $X_1, X_2, X_3, \ldots\ldots\ldots\ldots X_p$; and this is formulized as "$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots \beta_p X_p + \varepsilon$"

where;

β: parameters of dependent variable,
ε: error (Şıklar, 2000).

In the model, βs are unknown parameters, and they are to be estimeted. With the sampling regression equation, estimations can be obtained. β_0 is a constant term; and while $X_1 = X_2 = X_3$ it shows the average value of Y. $\beta_1, \beta_2,$ and β_3 are regression coefficients. For instance, when β_2, X_1 and X_3 variables remain constant, it shows the effect of the X_2 variable over dependent Y variable. This is also referred as partial regression coefficient. Thus, β_2 gives the amount of difference occurred on dependent variable upon one unit change in the X_2 independent variable after increasing the effect of other variables (Şıklar, 2000).

During model selection, it is important to select most appropriate variables combination explaining the variance of the dependent variable. Graphically, if it is possible to plot a diagram based on data, since each observation is represented by a point on the diagram, if points are condensed around a line for each variables, then it can be said that this line is the best representing one. However, in terms of multiple regression method, there is no graphical assessment opportunity. Therefore, several scales calculated by using the difference between the estimattion values such as R^2 or adjusted R^2 and observed values (Balibeyoğlu, 1989).

Simple linear and multiple regression methods are assessed based on several assumptions (Alpar, 1997):

1- Values regarding X_i independent variable is constant (This is not coincidence variable).
2- For each X_i variable set, there are more than one Y values and y subsets shows normal distribution.
3- Variance values of Y sutsets are equal.
4- ε_i 's average is equal to zero.
5- ε_i has normal distribution.
6- There is no relationship among error terms.
7- Error terms have equal variance.
8- There is no relationship among the error terms and independent variables.
9- There is no relationship among independent variables (Alpar, 1997).

4.4 Regression Analysis

All data required for statistical analysis were calculated through presented analysis methods and brought together. In this section, regression model's establishement stages were explained.

4.4.1 Dependent Variable

The dependent variable in our model is the monthly change in the observed lake volume. This dependent variable is explained using meteorological variables as the independent variables. Before deciding on this dependent variable, two others were also considered:

1- The total water volume of the lake,
2- Ln transformation of the total water volume of the lake,

However, the estimations using these two variables as the dependent variable did not yield statistically satisfying results. Thus, the monthly change in the observed lake volume is used as the dependent variable to measure the change in the water level of the lake (Figure 4.4).

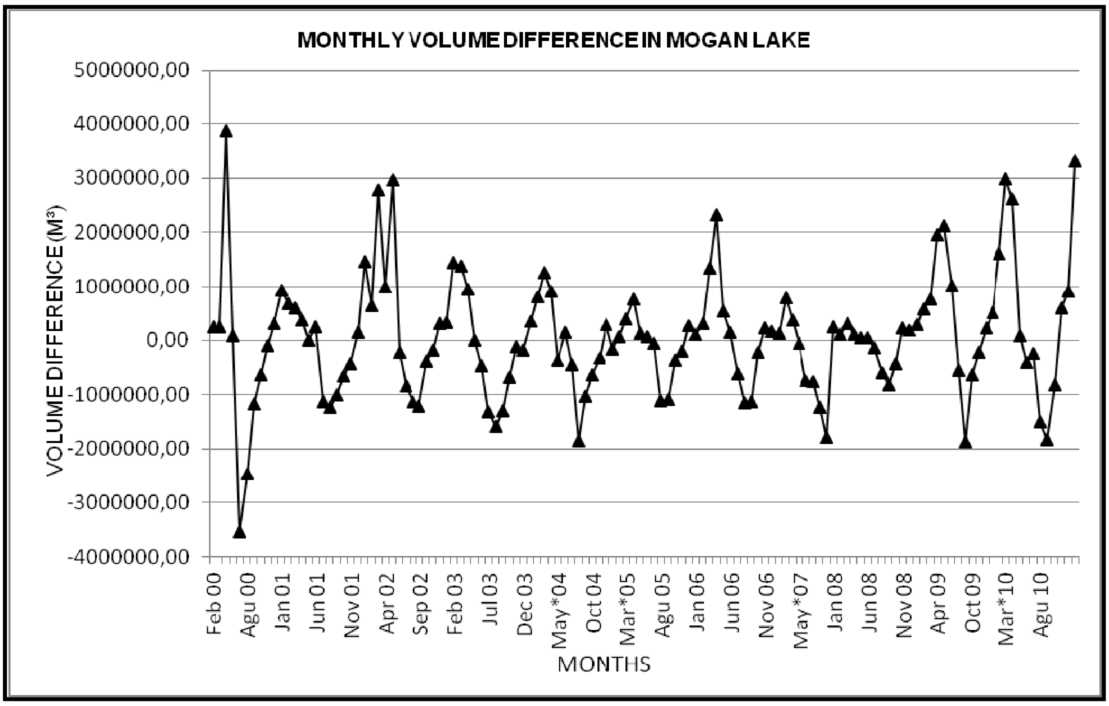

Figure 4.4 Monthly Volume Difference in Mogan Lake

4.4.2 Independent Variables

Independent variables are the factors which are consisted of meteorological factors affecting the lake's volume difference. Again in the regression model, 1n transformations were conducted for all independent variables to obtain most significant results. However, in the regression analysis, the original forms without the ln transformations yielded better results. Therefore, monthly average values of average temperature, average wind speed, total precipitation, average vapor pressure and average humidity factors were used as the independent (explanatory) variables in the regression analysis. Evaporation factor was not used in the regression analysis because it reflects the total effects of the other variables and it increases internal dependency effect.

To reveal the relationship among the dependent variable and independent variables, data from the dates in which both variables existed together were used as an analysis input. Thus, the sample used in the estimation consists of 129 observations pertaining to the years between 2000 and 2010.

4.4.3 Regression Results

As it was explained before, the observed water levels were transformed into volume values through the GIS techniques. In this section, the estimation of the regression, where the change in water volume is the dependent variable, and the meteorological variables are the explanatory variables are presented.

All quantitative data obtained in this end were organized by the Excel software. In the latter stage, required amendments were performed so that organized data can be employed in SPSS software in harmony. By means of the SPSS software, the multiple linear regression model was run by all data entries and the output which explains the variation in the dependent variable best was selected. In other words, to explain the variance in the dependent variable, number of independent variables in the model were increased and decreased; and three different data type in the dependent variable were tried; and over 100 combinations were examined. Among the tried models, the model statistically best explaining the variance in the dependent variable was selected.

The steps in building the model can be summarized as follows: The files added into the database is made selectable by means of regression – linear command in the "Analyze" menu in the opened window. Thus, the menu that is required for the application of the function opens. Then, dependent and independent variables are identified for each combination; and "calculate" command is selected. In the resulting information window, there are the significance values for each independent variable and the R^2 for the model. While the combinations were being evaluated, the model with the high R^2 values and dependent variables that are statistically significant are considered. As mentioned before, three variables were initially considered as the dependent variable:

1- The monthly change in the observed lake volume,
2- The total water volume of the lake,
3- Ln transformation of the total water volume of the lake,

As a result, the models with the monthly change in the observed lake volume as the dependent variable gave the most significant results. Among the independent variables, the variables giving the most significant results were determined and listed on the table 4.1

Table 4.1 Independent variables whose relationship with volume difference were investigated

Dependent Variable	Independent Variables
Volume Difference	Average Temperature
	Average Wind Speed
	Total Precipitation
	Average Vapor Pressure
	Average Humidity

The least-squares linear regression method is used in the analysis. The selected model explains 56% of the variance of the dependent variable (R^2= 0.559). The assumption of linearity and normalcy is also tested with graphics. As, shown in Figure 4.5, that there is no relation between the residuals and the predicted values. Figure 4.6 shows that the residuals exhibit a close distribution to normal values.

In this selected linear model the independent variables are Average Temperature, Average Wind Speed, Total Precipitation, Average Vapor Pressure, Average Humidity:

Monthly Volume Difference = $\beta_0 + \beta_1$ Average Temperature + β_2 Average Wind Speed + β_3 Total Precipitation + β_4 Average Vapor Pressure + β_5 Average Humidity

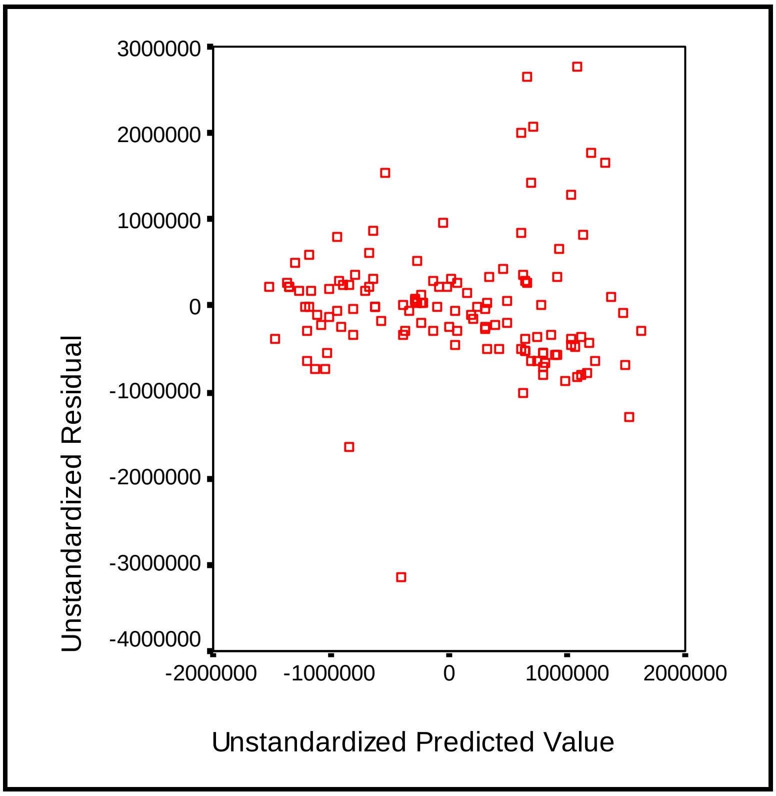

Figure 4.5 Graphic of residual and predicted value

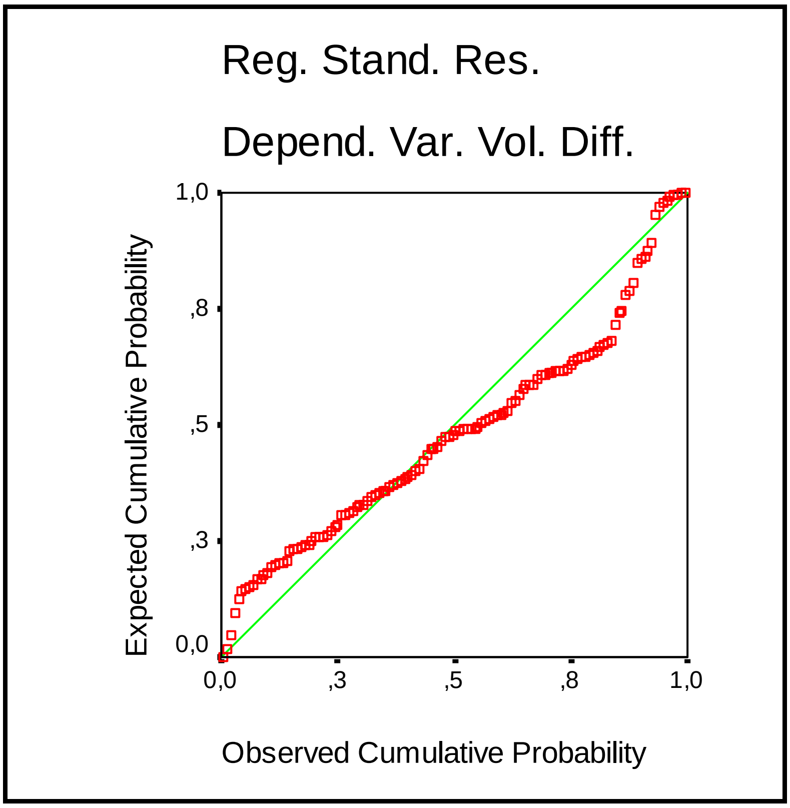

Figure 4.6 Graphic of residual and predicted value

The parameter estimates of the selected model demonstrated in table 4.2. Average temperature, total precipitation, average vapor pressure, average humidity are significant at the 0.05 level and the average wind speed is significant at the 0.10 level. The signs for all variables, except Total Precipitation, are negative indicating an inverse relation with the monthly volume difference. This indicates an increase in the water level with an increase in these variables.

Table 4.2 Parameter Estimations

Variable	**Estimated Coefficients Unstandardized**	**Standart Error**	**t-statistics**	**p-value (Pr > |t|)**
Constant	76243027.494	29816896.249	2.557	0.012
Average Temperature	-117406.320	16828.086	6.977	.000
Average Wind Speed	-491108.588	250195.808	1.963	.052
Average Humidity	-36122.048	14311.985	2.524	.013
Total Precipitation	11700.301	3190.628	3.667	.000
Average Vapor Pressure	-78611.524	32357.546	2.429	.017

By using estimated coefficients in Table 4.2, the change in water levels can be modeled:

Monthly Volume Difference = 76243027.494 - 117406.320 x Average Temperature - 491108.588 x Average Wind Speed + 11700.30129303 x Total Precipitation - 78611.52353941 x Average Air Pressure - 36122.0475 x Average Humidity

Regression analysis allows us to designate several future flood scenarios. For this designation, previous flood incidents have been observed to select the volume of the highest water level so that it can be compared with the volume amount of the most recent water level. The volume difference between these top levels gives the water augmentation which may lead possible flood in the region. Furthermore, meteorological factors that may increase the water level were tried and included in aforesaid scenarios.

The first scenario is based on the meteorological factors, which uses the average values of the last decade. Thus, realistic deductions regarding the weather conditions were made for the period of time ahead. The estimation analysis for this first scenario was presented on Table 4.3.

Table 4.3 Scenario-1

Coefficients	Unstand. Coeff.		Stand.Coeff.	t	Sig.	Val.
		Std. Error	Beta			Est.
(Constant)	76243027,49	29816896,25		2,557041043	0,011803	
Precipitation (m^3)	11700,30129	3190,627968	0,284604041	3,667084163	0,000367	140
Temperature (^{o}c)	-117406,3203	16828,08554	-0,899437043	-6,97680791	1,78E-10	4
Wind Speed (m/s)	-491108,5889	250195,8077	-0,17551038	-1,96289695	0,051972	1,7
Pressure	-78611,52354	32357,5464	-0,193755428	-2,42946491	0,016603	910
Humidity (%)	-36122,04758	14311,98495	-0,388913844	-2,52390201	0,012912	47,9
Depend. Var.						
VOL_Dif Estimation m^3	3309827,293					
VOL	16496328,42					
Flood VOL	19804496,31					
VOL_Dif Flood	3308167,89					

In the first scenario, a value as much as close to the value that can cause to flood event was obtained through trial-and-error method on the meteorological data. Thus, a flood risk for a day that carries similarities with a day among our data would be assessed. Based on the calculations, the lake volume that may trigger a flood event in the region is 3308167.89m^3. By applying the parameter values in Table 4.3, the value of 3309827.29m^3 was obtained which is the closest value that may cause a flood incident. It is also thought that a flood risk is apparent for a day in which the estimation values on the Table persist. Another conclusion based on the first scenario, this type of daily weather condition may resemble with any day in winter season. This situation reveals the fact that, it is more probable to experience a flood incident during the winter season.

In the second scenario, the extreme values observed in the last decade were selected so as to calculate the flood volume that could be occurred under these circumstances. The estimation analysis for the second scenario was presented on the Table 4.4.

Table 4.4 Scenario-2

Coefficients	Unstand. Coeff.		Stand.Coeff.	t	Sig.	Value
		Std. Error	Beta			Estimat.
(Constant)	76243027,49	29816896,25		2,557041043	0,011803	
Precipitation	11700,30129	3190,627968	0,284604041	3,667084163	0,000367	167,6
Temperature	-117406,3203	16828,08554	-0,899437043	-6,97680791	1,78E-10	-3,9
Wind Speed	-491108,5889	250195,8077	-0,17551038	-1,96289695	0,051972	1,5
Pressure	-78611,52354	32357,5464	-0,193755428	-2,42946491	0,016603	907,9
Humidity	-36122,04758	14311,98495	-0,388913844	-2,52390201	0,012912	28,1
Depend. Var.						
VOL_Dif Predic.	5538787,998					
VOL	16496328,42					
Flood VOL	19804496,31					
VOL_Dif Flood	3308167,89					

It can be said that the second scenario was the most extreme one based on the volume data for the possible flood incident from the last ten-year-period of time. For the occurrence of the possible scenario, the most extreme values that have been observed till now must be existed. The worst-case scenario was designated for this possibility so that required precautions can be taken. To that end, while flood protection facilities (drainage channels etc.) are being designed, they are at least must be planned to discharge estimated volume load. To obtain more precise results, data pertaining to a longer period of time is required.

CHAPTER FIVE
RESULTS AND CONCLUSIONS

Water level of the Mogan Lake has a structure varying constantly due to the effects in the short/long-term process. Although water levels have dynamic structure, it was observed that its reaction against meteorological effects can be estimated.

While systems structured based on applied statistical models and estimations that will be applied to forecast the changes that may occur as a result of the natural or artificial effects in the water resources, these resources must be taken into consideration rationally and under certain systematical framework by paying attention to the long-term effects. Therefore, this study was concluded by exploiting from many disciplines such as primarily Geographical Information Systems, statistics and urban planning, hydrology, limnology and meteorology.

Meteorological events in the Mogan Lake usually present seasonal routine behaviors. During the years following the years in which minimum or maximum meteorological conditions were experienced, it was observed that the situation has been affected to the water level values. This situation shows that the lake has been affected highly from short-term changes.

The highest water level elevation of the Mogan Lake was measured on May 2011 with 973.6 m within the period studied. When water level reached to this level, a water discharge program was initiated in the lake to prevent flood around. However, there were some buildings that were affected by the flood because discharged water run over from the used sewer infrastructure.

By means of the Arcgis software and available hardcopy maps, 3-dimensinal map of the Mogan Lake was obtained; and by exploiting GIS techniques the water volumes are calculated for observed water levels.

As modeling the total water volume is a more complicated process which requires more explanatory variables, monthly volume differences in water capacities were considered as the dependent variablr. Based on the monthly volume difference calculations, the months when there are changes in the water level can be easily determined. It has been observed that these values give more significant results in the regression analysis.

The selected regression model explains %55.9 of the variance in the monthly water level changes (R^2= 0.559). It is thought that by using longer term data, more accurate results can be obtained.

Other issues that must be considered along with the determined purposes are that implemented study's evaluation in terms of management of basin; and reducing the adverse effects of the water level changes by making water level forecasts. To that end, the areas subject to the risk of flood can be determined by means of the Mogan Lake water capacity calculated by exploiting GIS techniques and elevation contours of the radius of the lake. For such a research, future forecasting can be performed as long as the relationship among statistical modeling, volume differential that is found that it gives significant results and independent variables is assumed stable. Thus, when water level increases, several precautions against flood can be taken by the approach of basin management; and when it reduces, the decisions preventing the damages of low tide to environment and creatures are made and water management strategies can be organized. In this context, if we need to probe the suggestions about the management approaches.

The land that is under the flood risk in the future as a result of water level increase can be determined by regression analysis; and buffer zones can be set by means of GIS techniques based on these projections. Moreover, for the low water level conditions, the minimum danger elevation for the water level must be determined to take precaution when the lake water level decreases to this elevation. This is required to protect ecological balance.

Area protection is based on preservation of the natural characteristics so that creatures survive healthy population and continue their life cycle. The concept of "Important Natural Area" defines the geographical areas with special importance by taking this principle as a foundation. This concept must aim preservation of the most beautiful places of the earth with its original species and natural resources (Uğur, 2009).

A comprehensive water basin planning process is required to build up natural resources dynamics within the all water basin; and to determine the environmental services needed to protect. The level and complexity of this planning process may vary. However, new institutional arrangements that will be adapted to a new context and more extensive planning tools coverage may be required. These tools must evaluate positional planning of the soil and water resources usage by environmental assessments and basin-wide hydrological modeling and Integrated Water Resources Management approaches to take more extensive environmental opinions into consideration (Daeghouth, S, 2008).

It is expected that the conducted study will be beneficiary for the protection and monitoring of wetlands, as well as managing the wetlands, setting principles and decisions that is mentioned in the Ramsar Act. Along with the obtained results and suggestions, the Mogan Lake should be considered with its own natural values, biological diversity and areas for urban usage area; and an integrated management approach must be adopted for the basin.

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APPENDICES

YEAR	MONTH	PRECİPİ	LN_PRECİPİ	TEMP	WİND	LN_WİND	HUMİ	LN_HUMİ	PRES	LN_PRES	FLUC	LN_FLUC	VOL	Ln_VOL	VOL_DIF
2000	1	47,3	3,9	-3,4	2,0	0,7	79,7	4,4	913,4	6,8	972,82	6,8802	13750647,54	16,44	253461,06
2000	2	42,6	3,8	-1,1	1,9	0,6	77,7	4,4	916,5	6,8	972,86	6,8802	14004108,6	16,45	257042,06
2000	3	41,4	3,7	4,5	2,0	0,7	63,3	4,1	913,9	6,8	972,90	6,8803	14261150,67	16,47	3863443,03
2000	4	75,6	4,3	13,0	1,9	0,6	66,3	4,2	909,3	6,8	973,42	6,8808	18124593,69	16,71	78827,83
2000	5	17,3	2,9	15,5	2,2	0,8	59,5	4,1	913,3	6,8	973,43	6,8808	18203421,52	16,72	-3549758,43
2000	6	34,6	3,5	19,8	2,3	0,8	60,8	4,1	913,9	6,8	972,96	6,8803	14653663,09	16,50	-2470643,74
2000	8	24,4	3,2	22,8	2,5	0,9	49,1	3,9	913,0	6,8	972,56	6,8799	12183019,35	16,32	-1175766,48
2000	9	4,5	1,5	18,9	1,8	0,6	55,6	4,0	913,5	6,8	972,35	6,8797	11007252,87	16,21	-640228,98
2000	10	20,5	3,0	12,2	1,7	0,5	65,8	4,2	916,8	6,8	972,23	6,8796	10367023,89	16,15	-104539,77
2000	11	7,4	2,0	8,7	1,7	0,5	62,0	4,1	918,1	6,8	972,21	6,8796	10262484,12	16,14	315472,95
2000	12	31,0	3,4	2,2	1,5	0,4	81,1	4,4	916,2	6,8	972,27	6,8796	10577957,07	16,17	924129,97
2001	1	6,8	1,9	3,0	1,8	0,6	72,4	4,3	917,6	6,8	972,44	6,8798	11502087,04	16,26	680932,31
2001	2	43,0	3,8	4,1	1,9	0,6	69,9	4,2	912,5	6,8	972,56	6,8799	12183019,35	16,32	587445,68
2001	3	32,8	3,5	11,5	2,3	0,8	59,6	4,1	911,7	6,8	972,66	6,8800	12770465,03	16,36	361491,82
2001	4	27,3	3,3	12,6	2,5	0,9	61,1	4,1	910,8	6,8	972,72	6,8801	13131956,86	16,39	0,00
2001	5	110,0	4,7	14,8	2,1	0,7	63,2	4,1	911,8	6,8	972,72	6,8801	13131956,86	16,39	244978,49
2001	6	0,0	-6,9	21,9	2,8	1,0	40,2	3,7	911,5	6,8	972,76	6,8801	13376935,35	16,41	-1135979,71
2001	7	2,5	0,9	26,3	2,7	1,0	42,8	3,8	909,9	6,8	972,57	6,8799	12240955,64	16,32	-1233702,77
2001	8	19,3	3,0	24,7	2,8	1,0	46,4	3,8	911,9	6,8	972,35	6,8797	11007252,87	16,21	-1003419,26
2001	9	13,0	2,6	20,8	1,9	0,6	46,2	3,8	912,4	6,8	972,16	6,8795	10003833,61	16,12	-654499,05
2001	10	1,0	0,0	13,2	2,3	0,8	47,5	3,9	917,2	6,8	972,03	6,8794	9349334,557	16,05	-437611,89
2001	11	64,8	4,2	6,9	1,7	0,5	72,3	4,3	915,1	6,8	971,94	6,8793	8911722,663	16,00	144764,16
2001	12	116,9	4,8	2,5	2,8	1,0	79,4	4,4	912,1	6,8	971,97	6,8793	9056486,823	16,02	1468505,08
2002	1	29,8	3,4	-3,8	2,0	0,7	77,2	4,3	918,9	6,8	972,26	6,8796	10524991,91	16,17	645806,27
2002	2	11,8	2,5	5,0	1,7	0,5	60,8	4,1	916,6	6,8	972,38	6,8797	11170798,17	16,23	2769613,64
2002	3	23,0	3,1	8,6	2,3	0,8	58,3	4,1	911,4	6,8	972,85	6,8802	13940411,81	16,45	979715,76
2002	4	101,1	4,6	10,4	2,0	0,7	65,4	4,2	910,0	6,8	973,00	6,8804	14920127,58	16,52	2968685,36
2002	5	38,7	3,7	16,7	2,5	0,9	50,2	3,9	912,0	6,8	973,39	6,8808	17888812,94	16,70	-234725,69
2002	6	29,0	3,4	20,8	2,6	1,0	53,4	4,0	912,7	6,8	973,36	6,8808	17654087,25	16,69	-851614,04

YEAR	MONTH	PRECİPİ	LN_PRECİPİ	TEMP	WİND	LN_WİND	HUMİ	LN_HUMİ	PRES	LN_PRES	FLUC	LN_FLUC	VOL	Ln_VOL	VOL_DIF
2002	8	6,6	1,9	22,5	2,3	0,8	59,1	4,1	910,8	6,8	973,10	6,8805	15664179,05	16,57	-1207832,19
2002	9	54,7	4,0	18,3	1,8	0,6	64,9	4,2	913,9	6,8	972,93	6,8803	14456346,86	16,49	-388317,65
2002	10	22,7	3,1	13,3	1,7	0,5	66,7	4,2	915,7	6,8	972,87	6,8803	14068029,21	16,46	-191092,05
2002	11	19,0	2,9	8,0	1,6	0,5	72,6	4,3	917,2	6,8	972,84	6,8802	13876937,16	16,45	319611,40
2002	12	16,2	2,8	-0,8	1,9	0,6	74,6	4,3	916,0	6,8	972,89	6,8803	14196548,56	16,47	325332,58
2003	1	42,0	3,7	5,4	2,2	0,8	73,3	4,3	912,9	6,8	972,94	6,8803	14521881,14	16,49	1443240,97
2003	2	54,6	4,0	-0,3	2,6	1,0	71,8	4,3	910,5	6,8	973,14	6,8805	15965122,11	16,59	1377640,93
2003	3	8,6	2,2	3,2	2,7	1,0	62,5	4,1	912,6	6,8	973,32	6,8807	17342763,03	16,67	939603,36
2003	4	70,3	4,3	10,3	2,5	0,9	62,4	4,1	910,5	6,8	973,44	6,8808	18282366,4	16,72	0,00
2003	5	18,0	2,9	19,0	2,4	0,9	52,9	4,0	913,6	6,8	973,44	6,8808	18282366,4	16,72	-471912,65
2003	6	0,0	-6,9	22,6	2,6	1,0	46,6	3,8	912,3	6,8	973,38	6,8808	17810453,75	16,70	-1314125,33
2003	7	3,0	1,1	23,5	2,4	0,9	49,5	3,9	910,7	6,8	973,21	6,8806	16496328,42	16,62	-1576200,84
2003	8	0,2	-1,6	24,3	2,9	1,1	48,1	3,9	912,7	6,8	973,00	6,8804	14920127,58	16,52	-1294901,26
2003	9	15,1	2,7	18,0	2,4	0,9	58,9	4,1	914,7	6,8	972,80	6,8802	13625226,31	16,43	-674894,13
2003	10	29,8	3,4	14,4	1,9	0,6	61,5	4,1	914,0	6,8	972,69	6,8801	12950332,18	16,38	-120103,91
2003	11	5,2	1,6	8,0	1,9	0,6	68,9	4,2	918,0	6,8	972,67	6,8800	12830228,27	16,37	-178720,63
2003	12	61,5	4,1	1,9	2,2	0,8	75,9	4,3	915,9	6,8	972,64	6,8800	12651507,63	16,35	359168,59
2004	1	46,1	3,8	0,2	2,3	0,8	76,4	4,3	907,9	6,8	972,70	6,8801	13010676,22	16,38	803006,74
2004	2	18,3	2,9	2,4	2,1	0,7	66,7	4,2	913,5	6,8	972,83	6,8802	13813682,96	16,44	1254304,16
2004	3	13,0	2,6	7,2	2,0	0,7	56,6	4,0	916,7	6,8	973,02	6,8804	15067987,12	16,53	897134,99
2004	4	38,0	3,6	11,5	2,1	0,7	55,0	4,0	911,9	6,8	973,14	6,8805	15965122,11	16,59	-375882,52
2004	5	33,8	3,5	15,8	2,4	0,9	57,2	4,0	911,0	6,8	973,09	6,8805	15589239,59	16,56	149997,49
2004	6	25,6	3,2	20,0	2,3	0,8	57,4	4,1	913,2	6,8	973,11	6,8805	15739237,08	16,57	-448568,74
2004	7	6,2	1,8	23,6	3,2	1,2	49,0	3,9	911,8	6,8	973,05	6,8804	15290668,34	16,54	-1851974,99
2004	8	12,6	2,5	22,9	2,2	0,8	54,3	4,0	911,0	6,8	972,77	6,8801	13438693,35	16,41	-1022871,27
2004	9	2,7	1,0	19,3	2,3	0,8	49,7	3,9	916,0	6,8	972,60	6,8800	12415822,08	16,33	-633376,42
2004	10	10,9	2,4	14,2	2,1	0,7	61,5	4,1	917,2	6,8	972,49	6,8799	11782445,66	16,28	-335962,61
2004	11	35,2	3,6	7,2	1,9	0,6	66,8	4,2	915,6	6,8	972,43	6,8798	11446483,05	16,25	279578,83
2004	12	8,7	2,2	2,3	1,8	0,6	72,8	4,3	918,9	6,8	972,48	6,8798	11726061,89	16,28	-168215,04

YEAR	MONTH	PRECİPİ	LN_PRECİPİ	TEMP	WİND	LN_WİND	HUMİ	LN_HUMİ	PRES	LN_PRES	FLUC	LN_FLUC	VOL	Ln_VOL	VOL_DIF
2005	1	19,3	3,0	3,5	2,1	0,7	69,4	4,2	913,7	6,8	972,45	6,8798	11557846,85	16,26	55915,70
2005	2	27,4	3,3	2,5	2,1	0,7	67,0	4,2	911,4	6,8	972,46	6,8798	11613762,55	16,27	396482,00
2005	3	67,6	4,2	6,1	2,3	0,8	65,5	4,2	912,2	6,8	972,53	6,8799	12010244,54	16,30	760220,49
2005	4	78,6	4,4	11,6	2,5	0,9	58,9	4,1	913,4	6,8	972,66	6,8800	12770465,03	16,36	119718,39
2005	5	86,7	4,5	16,6	2,4	0,9	58,3	4,1	912,3	6,8	972,68	6,8801	12890183,42	16,37	60148,76
2005	6	37,1	3,6	19,5	2,7	1,0	54,7	4,0	912,8	6,8	972,69	6,8801	12950332,18	16,38	-60148,76
2005	7	11,9	2,5	25,0	2,6	1,0	51,1	3,9	910,8	6,8	972,68	6,8801	12890183,42	16,37	-1107737,76
2005	8	0,1	-2,3	25,4	2,3	0,8	51,7	3,9	911,3	6,8	972,49	6,8799	11782445,66	16,28	-1098094,12
2005	9	42,6	3,8	18,7	1,9	0,6	58,7	4,1	914,4	6,8	972,29	6,8797	10684351,54	16,18	-369674,71
2005	10	28,0	3,3	10,8	2,0	0,7	66,0	4,2	918,2	6,8	972,22	6,8796	10314676,83	16,15	-207845,35
2005	11	48,1	3,9	6,1	1,7	0,5	69,3	4,2	917,2	6,8	972,18	6,8795	10106831,47	16,13	260192,42
2005	12	14,4	2,7	3,0	1,9	0,6	69,8	4,2	915,9	6,8	972,23	6,8796	10367023,89	16,15	105157,47
2006	1	35,5	3,6	-1,7	2,1	0,7	73,2	4,3	916,7	6,8	972,25	6,8796	10472181,37	16,16	319183,94
2006	2	67,2	4,2	0,4	1,7	0,5	78,9	4,4	911,8	6,8	972,31	6,8797	10791365,31	16,19	1333891,22
2006	3	40,4	3,7	7,5	2,0	0,7	64,0	4,2	909,6	6,8	972,55	6,8799	12125256,52	16,31	2331090,33
2006	4	29,4	3,4	13,1	2,0	0,7	55,1	4,0	910,7	6,8	972,93	6,8803	14456346,86	16,49	537651,00
2006	5	29,5	3,4	16,6	1,8	0,6	57,8	4,1	913,4	6,8	973,01	6,8804	14993997,86	16,52	148097,46
2006	6	31,8	3,5	21,6	2,5	0,9	53,1	4,0	913,2	6,8	973,03	6,8804	15142095,32	16,53	-620214,18
2006	7	2,2	0,8	23,2	2,9	1,1	49,2	3,9	912,1	6,8	972,94	6,8803	14521881,14	16,49	-1144945,79
2006	8	0,1	-2,3	27,2	2,6	1,0	44,7	3,8	909,7	6,8	972,76	6,8801	13376935,35	16,41	-1135979,71
2006	9	78,3	4,4	18,2	2,0	0,7	58,0	4,1	914,3	6,8	972,57	6,8799	12240955,64	16,32	-230711,10
2006	10	37,1	3,6	13,6	1,9	0,6	70,2	4,3	914,5	6,8	972,53	6,8799	12010244,54	16,30	230711,10
2006	11	19,0	2,9	5,6	1,5	0,4	71,2	4,3	917,2	6,8	972,57	6,8799	12240955,64	16,32	174866,44
2006	12	1,3	0,3	1,1	1,5	0,4	62,8	4,1	921,9	6,8	972,60	6,8800	12415822,08	16,33	117475,71
2007	1	39,0	3,7	1,2	1,7	0,5	75,8	4,3	918,6	6,8	972,62	6,8800	12533297,79	16,34	782086,59
2007	3	37,5	3,6	7,3	2,4	0,9	59,5	4,1	912,8	6,8	972,75	6,8801	13315384,38	16,40	372444,84
2007	4	23,8	3,2	9,6	2,7	1,0	51,2	3,9	913,2	6,8	972,81	6,8802	13687829,22	16,43	-62602,90
2007	5	17,9	2,9	21,0	2,8	1,0	38,2	3,6	911,1	6,8	972,80	6,8802	13625226,31	16,43	-735042,89
2007	6	31,7	3,5	23,1	2,7	1,0	42,5	3,7	911,1	6,8	972,68	6,8801	12890183,42	16,37	-764926,90
2007	7	3,9	1,4	27,3	3,2	1,2	28,1	3,3	911,1	6,8	972,55	6,8799	12125256,52	16,31	-1226257,62

YEAR	MONTH	PRECİPİ	LN_PRECİPİ	TEMP	WİND	LN_WİND	HUMİ	LN_HUMİ	PRES	LN_PRES	FLUC	LN_FLUC	VOL	Ln_VOL	VOL_DIF
2007	12	44,4	3,8	2,0	1,8	0,6	75,2	4,3	917,6	6,8	971,98	6,8793	9104902,552	16,02	244432,01
2008	1	20,1	3,0	-3,9	2,5	0,9	74,9	4,3	919,2	6,8	972,03	6,8794	9349334,557	16,05	99004,49
2008	2	6,5	1,9	0,2	2,8	1,0	68,1	4,2	919,8	6,8	972,05	6,8794	9448339,05	16,06	300693,00
2008	3	54,9	4,0	10,3	2,4	0,9	57,1	4,0	909,0	6,8	972,11	6,8795	9749032,05	16,09	101459,28
2008	4	32,7	3,5	14,0	2,2	0,8	54,1	4,0	911,3	6,8	972,13	6,8795	9850491,334	16,10	50960,25
2008	5	45,4	3,8	16,0	2,4	0,9	48,4	3,9	912,9	6,8	972,14	6,8795	9901451,58	16,11	51114,07
2008	6	10,3	2,3	22,3	3,1	1,1	39,4	3,7	912,7	6,8	972,15	6,8795	9952565,65	16,11	-152880,80
2008	7	0,0	-6,9	25,2	3,3	1,2	34,6	3,5	910,9	6,8	972,12	6,8795	9799684,846	16,10	-597709,01
2008	8	0,7	-0,4	27,2	3,2	1,2	32,9	3,5	910,9	6,8	972,00	6,8794	9201975,834	16,03	-814876,18
2008	9	61,6	4,1	20,1	2,5	0,9	49,4	3,9	912,5	6,8	971,83	6,8792	8387099,657	15,94	-422050,61
2008	10	18,6	2,9	13,3	2,2	0,8	63,4	4,1	918,1	6,8	971,74	6,8791	7965049,047	15,89	233676,66
2008	11	43,6	3,8	8,7	2,1	0,7	71,6	4,3	917,6	6,8	971,79	6,8791	8198725,708	15,92	188373,95
2008	12	28,8	3,4	2,1	2,1	0,7	77,6	4,4	918,3	6,8	971,83	6,8792	8387099,657	15,94	284956,39
2009	1	61,5	4,1	2,6	2,0	0,7	75,0	4,3	915,1	6,8	971,89	6,8792	8672056,046	15,98	578886,38
2009	2	69,5	4,2	4,2	2,4	0,9	75,7	4,3	909,0	6,8	972,01	6,8794	9250942,428	16,04	752891,18
2009	3	55,6	4,0	5,5	2,2	0,8	68,2	4,2	910,5	6,8	972,16	6,8795	10003833,61	16,12	1949158,43
2009	4	71,0	4,3	11,4	2,4	0,9	58,8	4,1	912,6	6,8	972,52	6,8799	11952992,04	16,30	2115037,17
2009	5	24,8	3,2	16,2	2,8	1,0	53,1	4,0	914,3	6,8	972,87	6,8803	14068029,21	16,46	999957,92
2009	6	28,0	3,3	22,6	2,8	1,0	41,2	3,7	912,9	6,8	973,02	6,8804	15067987,12	16,53	-546105,98
2009	7	13,9	2,6	24,0	3,0	1,1	44,2	3,8	911,4	6,8	972,94	6,8803	14521881,14	16,49	-1870373,51
2009	9	10,3	2,3	18,5	2,4	0,9	48,6	3,9	914,4	6,8	972,64	6,8800	12651507,63	16,35	-641263,09
2009	10	13,7	2,6	16,6	2,1	0,7	49,2	3,9	915,0	6,8	972,53	6,8799	12010244,54	16,30	-227798,88
2009	11	43,1	3,8	7,4	1,9	0,6	74,6	4,3	916,1	6,8	972,49	6,8799	11782445,66	16,28	227798,88
2009	12	68,0	4,2	5,4	2,1	0,7	78,5	4,4	911,7	6,8	972,53	6,8799	12010244,54	16,30	523053,25
2010	1	63,0	4,1	3,1	2,3	0,8	77,8	4,4	912,6	6,8	972,62	6,8800	12533297,79	16,34	1598877,51
2010	2	65,1	4,2	6,5	2,1	0,7	70,4	4,3	909,0	6,8	972,88	6,8803	14132175,3	16,46	2978328,72
2010	3	44,6	3,8	8,5	2,4	0,9	59,9	4,1	913,5	6,8	973,29	6,8807	17110504,02	16,66	2612832,32
2010	4	37,5	3,6	12,2	2,6	1,0	54,4	4,0	913,7	6,8	973,62	6,8810	19723336,33	16,80	81159,97
2010	5	31,0	3,4	18,4	2,3	0,8	44,4	3,8	911,5	6,8	973,63	6,8810	19804496,31	16,80	-404637,72
2010	7	25,7	3,2	26,2	3,0	1,1	44,2	3,8	910,8	6,8	973,55	6,8809	19158471,83	16,77	-1504384,58

2010	8	0,4	-0,9	28,4	2,8	1,0	30,5	3,4	911,4	6,8	973,36	6,8808	17654087,25	16,69	-1839673,62
2010	9	1,5	0,4	22,5	2,7	1,0	42,3	3,7	913,1	6,8	973,12	6,8805	15814413,63	16,58	-820415,77
2010	10	167,6	5,1	12,2	2,0	0,7	72,3	4,3	915,2	6,8	973,01	6,8804	14993997,86	16,52	595241,73
2010	11	32,0	3,5	11,2	1,9	0,6	63,6	4,2	917,4	6,8	973,09	6,8805	15589239,59	16,56	907088,83
2010	12	67,3	4,2	6,1	2,1	0,7	78,8	4,4	913,1	6,8	973,21	6,8806	16496328,42	16,62	3308167,89
2011	1	42,0	3,7	2,4	2,1	0,7	78,5	4,4	915,4	6,8	973,63	6,8810	19804496,31	16,80	0,00
2011	2	24,3	3,2	3,2	2,0	0,7	69,8	4,2	912,3	6,8	973,63	6,8810	19804496,31	16,80	

(EPASA, 2011 & Meteorology Directorship, 2011)