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ANALYSIS AND MODELLING THE HYDROLOGICAL PERFORMANCE OF RESERVOIRS IN NORTH OF IRAQ

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Master's Thesis

Supervisor

Asst. Prof. Dr. Mohsen SEYEDİ

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ABSTRACT

ANALYSIS AND MODELLING THE HYDROLOGICAL PERFORMANCE OF RESERVOIRS IN NORTH OF IRAQ

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The water resources in a region is important founding that strengthen the infrastructure and support the water demand for various purpose. The management and controlling on the reservoirs behind the dam is effective issue in which theses formation can storage huge amount of water. The inflow rates toward the reservoirs that varied along the year are enhance the overall storage according the state of the feeding river(s).The precipitation also feed the accumulation of storage water while the losses can be occurred by the outflow rates toward the downstream areas and the evaporation rates. The study aimed to build effective analysis for three reservoirs in Iraq, these reservoirs were varied in elevation and the storage capacity as well as their weather condition. The reservoirs taken were that located behind Mosul Dam, Dukan Dam, and Dibis Dam. For each reservoir the study arranged the effective parameters that contribute to the water balanced inside the reservoir including the inflow and outflow rates and the weather conditions. The linearization procedure was applied on the monthly inflow rates to convert them to daily inflow rates for examine the variation of the water storage and the elevation of water surface for each reservoir. The volume elevation relationship for each reservoir was evaluated for each reservoir by sing Surfer program. The study mixed of the results of these relationship with the daily change in volume to determine the

predicted change in water elevation that showed in related graphs. The study showed the change in storage volume average outflow for Mosul, Dukan, and Dibis Dams that conserve high and low fluctuation in volume change variation in storage of water. For Mosul Dam the outflow rate was test in 400 m^3/s and 500 m^3/s, For Dukan dam in 150 m^3/s and 200 m^3/s, and for Dibis Dam in 150 m^3/s and 170 m^3/s.

Keywords: Hydrology, Water quantity, Analysis, Water demand, Reservoir.

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ABBREVIATIONS

Q	:	Inflow rate toward the reservoir
q	:	Outflow rate toward the downstream area
P	:	Precipitation rate
E	:	Evaporation rate

LIST OF SYMBOLS

ΔV : The change in storage volume in cubic meter per month

A : Area of reservoir in square meters

t : Time

1. INTRODUCTION

A water reservoir is a man-made body of water produced repeatedly in a river valley by means of water retaining structures for the accumulation and storage of a quantity of water to be used in the national economy. Reservoirs are classified into two types: lake type reservoirs and river-type reservoirs. The formation of a body of water with physical qualities that differ greatly from the attributes of incoming water is typical of lake-type water storage places. Winds cause the majority of the streams in those reservoirs. River (in-channel) reservoirs have an elongated shape; streams in them are often of the gravity type; and their water body is similar to river water in terms of attributes [1].

The essential reservoir elements are indicated by its capacity, water surface area, and amplitude of quantity of water level fluctuation during operation. Surface water storage regions are constructed structures for water involving that help improve water security for local communities. Reservoirs come in a variety of shapes and sizes, ranging from damming natural bodies of water for storage to ground excavation in low-lying plains fed by rainwater or diverted rivers. Water that has been stored can be used for a variety of applications, including irrigation, industrial, home usage, hydropower generation, and flood control [2].

Surface reservoirs were especially significant in locations with long dry seasons and high rainfall variability, and in regions where seasonal water availability is expected to rise as a result of climate change. Surface reservoirs are thus one of the most important adaptation strategies in locations with limited and fluctuating water availability. Implementation. Selecting the size and function of the reservoir necessitates careful research and analysis of community demands [3].

Tiny scale, common pond reservoirs, for example, could be well suited for remote and small communities, or even families, because they require minimal complex assessments and building efforts. In these instances, education on health implications, particularly vector-borne disease concerns, would be more important. Larger metropolitan populations and industrial centers, in turn, are more likely to necessitate larger reservoirs and, as a result, more extensive and complex rating processes, as well as socioeconomic influence assessments in some circumstances. Large storage facilities, such as multipurpose dams, must also be operated and maintained to ensure continued security and stability, as well as maximum operational efficiency. Basic reservoir

management involves deposit clearance, pump, pipe, and other equipment maintenance, and monitoring of situation environmental and socioeconomic variables [4].

1.1 WATER STORAGE RESERVOIRS REQUIRED

There are several reasons why water reservoirs are an essential component of which water resource projects. The most important are listed below: The ebb and flow of water in rivers is erratic in time. There are many rivers that have torrential flow. Frequently, 60–70 percent of the total annual quantity of water discharge runs in a short excessive water can lead to flood period, which is accompanied by protracted dry periods. The average yearly flow of any domestic canal in Serbia is greater than 509 m3/s. During a low flow period, it drops 10 times and stands at roughly 50 m3 /s. This is insufficient even for the ecological needs of the water ecosystem. The relationship between the minimum monthly discharge with a 95% occurrence probability and the maximum annual discharge with a 1% occurrence probability is frequently larger than 1:1000 [5].

1.1.1 Dams and Reservoirs are Created for a Variety of Reasons Including

a) Hydroelectric energy generating - the water stored behind the dam is utilized to power turbines that are linked to generators that generate electricity [6].

b) Flood management — the dam is used to retain the amount of water flowing down the river during floods and release It should be spread out over time so that human settlements and agricultural lands are not flooded[7].

c) Agriculture - the amount of water held behind the dam is released to provide a sufficient amount supplying crops with water during the dry period or even during drought years and water scarcity [8].

d) Water transfers to compensate for flow deficits in the receiving river, stored water behind a dam is transferred to another river regime via pipelines or canals. The receiving river also has a stabilizing dam, which allows the transferred water to be stored until it is needed. After that, the water can be used for domestic, agrarian, or industrial uses. [9].

e) Domestic water supply - the water stored behind dams is gradually released into domestic supply systems, primarily in towns and cities, to maintain a continuous supply of water for cooking, having a drink, washing, and so on [10].

f) Navigation –dams are being used to limit the fall in which of the river, particularly in places of high slope so that boats can pass. Dams are related with navigation lock regulations in certain circumstances. Dams are utilized in the same way to retain water that may be released during the dry season to maintain appropriate depth for passage [11].

1.2 RESERVOIRS AND ECOSYSTEMS

Dams in use for power generation, on the other hand, are likely to be substantially different in design from those used for flood control or navigation. Power generation necessitates a continuous and regular discharge of water, but irrigation demand is largely seasonal. The most noticeable sign of dams is the conversion of an ecosystem with unidirectional (one-way) water flow to one with no flow. As a result, animals and plants accustomed to a river's normal flowing conditions may struggle to survive; in contrast, the few adapted to hanging waters may thrive.

Other pest species, such as certain types of snails that act as human host for human parasitic infections, could thrive in reservoirs' trying to stand waters[12].

Watershed stream water tends to slow and reserves suspended matter in a reservoir. The load consists of both inanimate matter that settles to the water storage bed as silt and suspended natural particles. The presence of silt in the water storage area suggests that the basin will gradually fill in the long term, lowering the utilizable volume of water. This has the effect of decreasing the reservoir's life duration, and is an especially important factor when dam construction is constructed along a stream of river that transports a large load of suspended particles. Reservoirs typically hold a large amount of water for an extended length of time. This may be the case in big reservoirs for several months, but with run-of-the-river dams, the water moves through at a rate comparable to that of the undammed river [13].

The amount of water that reaches a water storage location from headwater streams slows down and deposits its suspended load. As a result, the upper portion of the reservoir becomes increasingly marshy. The deposition of silt in the water storage place (or natural lake) means that

each lake has a finite life and will eventually become so clogged with silt that it is unable to perform the purpose for which it was designed. Experience has revealed that the rate where most dams fill with silt surpasses initial predictions, resulting in a reduction in the dam's beneficial life. The economic justification for dam construction is not realized in several jurisdictions due to their shorter life period [14].

1.3 PROBLEM STATEMENT

The water storage in a country is important infrastructure wealth. Controlling the water quantities that gained in by the inflow rates toward the catchment areas and the weather conditions can support conserving these resources. In Iraq the reservoirs distributed on the area of the north on the rivers. The lack of water that can be provided to the different sectors like agriculture, hydropower generation, and public demand is happened when the amount of storage water been non-sufficient. At such case the dam function effected negatively and the water provided not meet the required quantities.

1.4 CONTRIBUTION

The study aimed to build significance view on the way for controlling of water storage quantities in Iraq. The destination of the study was the reservoirs in north Iraq at which these area impact by the variation of inflow rates and weather condition. The study outline can improve the better saving of these water quantities by analyzing the condition of the reservoirs including the topographic behavior. The investigation of the way for improving the hydrological status of the reservoirs in regions of Mosul, Dibis and Dukan, by analyzing the inflow and outflow water quantities with the available topographic area and converting the study output into tables and charts and graphs in the way of easing the controlling of these water formation toward better operation with respect with the influence parameters like lateral inflows and weather conditions.

1.5 OBJECTIVE

a) Gathering the required information about the parameters that influence the overall water quantities like the inflow rates, the precipitation intensity, and the potential evaporation.

b) Dealing with the formation of earth in the study areas by analysis the topographic maps with the data that been obtained from official lines in which these information been used to evaluate the available surface areas and the volumes between each two contour lines by using Surfer program with merging with geographic information system (GIS) mapping software.

c) Building of applicable model based on the analysis result for defining the conditions of each reservoir in the study along the operation of adjacent dam.

d) Explaining in graphs and charts the results and the relationships of effective parameters by using Excel program.

2. LITERATURE REVIEW

2.1 SIGNIFICANCE OF RESERVOIRS

Storage water has enabled the manipulation of water resources for human benefit and has significantly impacted the hydrological cycle. Dams have been impounded. As a result, hydrologists, aquatic biologists, river and coastal morphologists, and biogeochemists are all interested in describing reservoirs around the world. Because of which of these key changes, the effects on which reservoirs should be considered in forecasts of present and future water availability, floods, and droughts. In contrast to most previous land surface models, a new generation of global hydrological models aims to account for the influence of reservoirs. In this respect, global reservoirs characterization is a major problem for the advancement of global hydrological models [1]. Depth-storage and area-volume correlations are required to replicate the effect of reservoirs, but they are difficult to obtain. Area-volume correlations are particularly fascinating because they enable practical observation of stored volumes by satellite route sensing. The Surface Water and Ocean Topography (SWOT) mission, which will launch in 2020, would enhance the temporal and spatial resolution of similar observations to the order of weeks and a few hundred meters [2].

2.2 HYDROLOGICAL CYCLE OVERVIEW

The water cycle, also known as the hydrologic cycle, explains the journey of water molecules from the Earth's surface to the atmosphere and back again, in some cases deep below the surface. This massive scheme, fueled by solar energy, is a constant exchange of moisture between the oceans, the atmosphere, and the land. Evaporation—the process by which water changes from a liquid to a gas—from oceans, seas, and other bodies of water (lakes, rivers, and streams) accounts for almost high percent of the moisture in our atmosphere. The majority of the remaining percent contained in the atmosphere is emitted by plants through transpiration [3].

Plants absorb water through their roots and then release it through microscopic pores on the underside of their leaves. Furthermore, a very little amount of water vapor reaches the atmosphere by sublimation, the process by which a quantity of water converts straight from a solid (ice or snow) to a gas. Sublimation results in the progressive shrinking of snow banks in circumstances

where the temperature remains below freezing. Evaporation, absorption, or sublimation, as well as volcanic spreading's, account for nearly all of the water vapor in the atmosphere that isn't introduced by human activity. While evaporate from of the oceans is the primary mode of transport for the surface-to-atmosphere component of the hydrologic cycle, transpiration is equally important. The main parameters of cycle were explained in figure 2.1

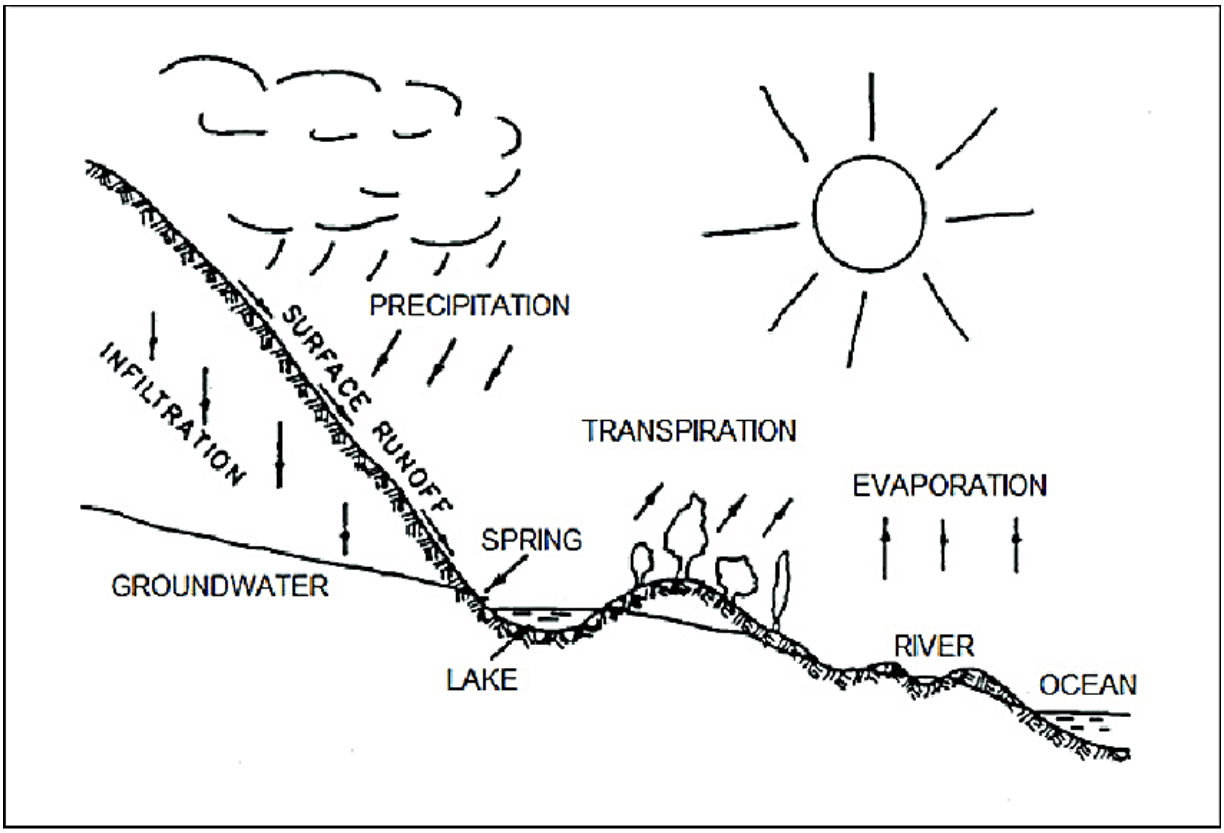

Figure 2.1: Main parameters of hydrological cycle [5]

When water reaches the lower atmosphere, rising air currents move it upward, frequently to the upper atmosphere, where the air is cooler. The amount of water vapor in the chilly air is more likely to condense from a gas to a liquid and produce cloud droplets. Droplets may expand and generate precipitation (rain, snow, sleet, freezing rain, and hail), which is the major mechanism for delivering water from the air to the Earth's surface [6]. When precipitation descends above the earth's surface, it takes several courses in its succeeding journeys. Most of it evaporates and returns to the atmosphere, while others soak into the ground as soil moisture or groundwater, and still others run off into rivers and streams. Almost all of the water eventually flows into the seas or other bodies of water, where the cycle repeats. Part of the quantity of water is intercepted with the

help of humans or other life forms at various phases of the cycle for drinking, cleaning, irrigating, and a wide range of other applications [7].

2.2.1 Precipitation

Precipitation is any sort of condensation from water vapor in the atmosphere that falls due to gravity, and it includes rain, snow, sleet, hailstorm, and fog. Precipitation levels and kinds influence specific soil formation, natural vegetation, and the formation of runoff, which carries soils, nutrients, and pollutants. Freshwater that evaporates (or sublimates) from the Earth's crust is stored in the atmosphere as water vapor before returning to the Earth's surface as precipitation. When raindrops fall from the sky, some are caught by flora (trees, grass, and crops), and this is referred to as interception [8].

A fraction of the intercepted precipitation evaporates back into the atmosphere from the earth's surfaces and never makes it to the ground. Net rainfall refers to rainwater that does not fall on the soil surface. Important characteristics of precipitation include the annual amount and type (rainfall versus snowfall), all of which have significant implications for plant availability of water, soil moisture, and groundwater recharge [9].

Raindrop diameter and precipitation intensity (amount of precipitation per relating unit time) influence specific soil erosion; storms that produce higher precipitation intensity and larger raindrop size produce more specific soil erosion in general. Storm duration and frequency have an impact on states such as flooding and drought. For instance, if half of the yearly rainfall falls in a single event, there is a greater chance of flooding during that period and a subsequent state of drought during the remaining period. The seasonal distribution of rain is also significant [10].

Typically, excessive rainfall falls throughout the agronomic growing season to support crop growth, with the remaining rain falling somewhat equally throughout the year. Because of decreased plant uptake, rain that falls outside of the growth season has a better chance of infiltrating the soil and replenishing groundwater [11].

2.2.2 Evapotranspiration

Evapotranspiration is the combined impact of evaporation (the movement of a quantity of water straight into the atmosphere as water vapor from a surface, such as the soil or a body of water) and transpiration (the process by that plants carry quantity of water from the specific soil into leaves, in the place it is released to the atmosphere as water vapor) [12].

This phrase refers to water that evaporates directly from soil, water, and plant surfaces, as well as water that is drawn directly from the soil through plant transpiration. High wind, sun radiation, and heat can all increase the rate of ET, whereas a high proportion of water vapor in the air (high relative humidity) can lower the possibility for ET. Some producers arrange irrigation or harvesting activities based on ET projections, which is a measure of the maximum ET rate for a specific set of parameters defined by solar radiation, temperature, moisture, and wind conditions and similarly assumes that specific soil moisture is not limiting. In reality, when plants transpire and extract plant-available water from the soil, the earth begins to dry out, and the evapotranspiration rate begins to fall. This is due to the matrices necessary or suction of the soil structure, which means that as the water content diminishes, the remaining soil water is held more tightly in the specific soil pores. The real ET rate, or what is actually transpired, is known to as actual evapotranspiration (AET) [13].

2.2.3 Infiltration

Some rainwater can penetrate the soil when it reaches a specific soil surface. The movement of water through the soil is referred to as infiltration. Water infiltration varies greatly from location to location and is determined by soil characteristics features such as soil water meanings, texture, bulk density, organic matter relevance, permeability, porosity, as well as the presence of any constrictive layers in the soil. Permeation is the rate at which water moves through soil [14].

Porous materials, such as sands or gravels, have higher infiltration or permeability than clay soils. Porosity is a measure of the amount of open space and voids in a soil that can actually hold water. Liquid trapped in soil pores is stored in the soil, some is available to the plants via transpiration. Additionally, plants can use the liquid contained in the particular soil at the a later time, supplying plants with a buffering capacity during rainfall[15].

Soil construction is a major concern in agroecosystems and it can be controlled using various tillage strategies or soil amendments. The infiltration rate of any particular soil varies above a rainfall event, usually decreasing significantly as the soil becomes saturated. When enough rain falls, the infiltration rate approaches a constant comparable to a soil's saturated hydraulic conductivity. Because saturated conductivity is more broadly related to all crop productivity, this is a critical issue in both hydrology and agricultural management[16] .

Many soils with low saturated fat conductivity are prone to water logging, reducing crop yields. When agricultural soils remain saturated for an extended period, the soil's oxygen level depletes, resulting in earth stress. As a result, ditch and tile drainage are used to remove excess water. Climate, land management, and landscape scale elements all have an impact on infiltration. Infiltration is reduced in compacted or frozen soil, for example. No-till soils will have significantly greater infiltration capacity in the future than compacted soils, which have decreased permeability or hydraulic properties[17].

By trying to promote macrospore development, improving permeability, and supplying organic carbon to the soil, vegetation cover can increase infiltration and promote the biological activity of soil microorganisms such as earthworms. Furthermore, vegetation cover improves infiltration by protecting the soil structure from drop of water damage (maintaining porosity) and preventing the formation of soil crusts, which would be associated with low permeability [18].

The application of fertilizer can also have a massive effect on infiltration rates. Stable soil agglomeration (the systemic unit of soil that is glued together, generating porosity) can, for example, significantly improve this same infiltration rate of fine-textured loams and clays, whereas ploughing, due to the wet conditions, can break down these soil aggregates. Traffic from farm equipment above fields can cause soil compaction, further limiting infiltration. Some soils, such as shrink-swell clays, may have a greater quantity lot of " percentages when dry than that when sweaty due to surface cracking and macrospore flow, which allows a greater quantity of water to quickly penetrate the soil [19].

2.3 TOPOGRAPHIC EFFECTIVENESS

Topography is important in data for lake water management, and remote sensing provides a unique opportunity to estimate it in unmeasured areas. Its important matter to provide an up-to-date approach for predicting near-shore topography of water bodies based on a flood frequency plan and a time series of water stages, assuming the equivalence between excessive water contributing to flood frequency and the quantity of water level exceedance probability at a given region [20].

The locations usually are defined as the set of coordinates and are located at the bottom of the quantity of water reservoir (X, Y, Z). These points' data are collected by gathering or, more precisely, measuring their coordinates. The measurement of the X- and Y-coordinates using a GNSS receiver and the derivation of the Z-coordinate using the GNSS measurement of height and the sonar measurement of depth form the foundation of data collection [21].

Method based on flood frequency Formulation of ideas can offer a simple approach for estimating topography above the lowest known quantity of water surface elevation and active storage in which lakes and water storage regions. The water level duration curve is recognized for just one site in the study area. A flood frequency plan for the region is accessible. The surface water bottom level map is then produced by combining the water stage duration curve and the flood frequency map, with the same spatial resolution as the comprehensive water leading to map and the same horizontal reference as the quantity of water level data [22].

Changes in the quantity of water level along the area can be represented by the water level duration curve, which is the water level cumulative probability in decreasing order (the probability that the quantity of water level in the area exceeds a certain value in a given period of time), and the variation in flood extent can be synthesized using the flood frequency at each location in the area [23].

2.4 RESERVOIR CAPACITY

Reservoir altitude is critical for reservoir planning and installation. When sediment loading is a major factor, knowledge of the distribution of sediment in a reservoir is essential for fixing sill elevation of outputs and penstock gate elevation to avoid early loss of services. Deposit accumulation can be evaluated in order to determine the amount to which different allocations of

storage are affected by deposit accumulation. The discharge pattern in a reservoir is influenced by a variety of elements, including the valley slope, reservoir length, particle size in suspended sediment, capacity inflow ratio, and, most importantly, the location of the water storage facility [24].

The distribution pattern is also influenced by the major river's tributaries, depending on their position and quantity of inflow. The sediment deposit is not always contained to the reservoir's small storage increments, but is dispersed below the normal amounts of water surface [25].

Simulation-based methods generate related curves from reservoir morphological features using mathematical equations. In recent decades, remote sensing data has provided an unprecedented opportunity to monitor reservoirs from space. The elevation–area (E–A) connection can be established and utilized to compute the volume values required to produce the area volume relationships by combining the water storage place area and elevation information collected from satellite observations. [26].

2.5 RESERVOIR MANAGEMENT

The optimum use of water resources is becoming more acknowledged as a strategic issue for countries. A major portion of the energetic matrix in numerous countries is supported by hydropower facilities. The enormous reservoirs that feed the processes of those grounds should be controlled in order to supply the most cost-effective operation while also taking into account the limited number of applications that the water reasons should allow. Some of the applications include flood control and prevention, irrigation, river navigability, and others. It is necessary to prioritize improving the operational efficacy of water storage systems in order to maximize the benefits of their use [27].

The smart decisions of the operation for single and multiple reservoir systems includes essentially acting on how much flow rate that out from the dam at any time period. The choice impacts how much water is available for in the coming time periods, interacting with the effect of seasonal rainfall on water storage capacity. Other uses for water will be determined by the availability of water, either in a reservoir (as measured by the reservoir level) or in a stream or river flow in which measured with the help of the water flow. For instance, flood management is improved when there is less water in the storage region, allowing for the impoundment of a large additional volume of

water, whereas more water in the reservoir is more beneficial for irrigation purposes. To go through a better controlling system, the effect of a minimum amount of water must pass through the watercourse, which demands a minimum level should be analyzed [28].

Because the different alternative uses of the quantity of water are clashing with each other and with the energy, the underlying improving problem can be described as a multi-objective improving problem. It is a moving state optimization because of the interdependence in which of the time steps with any acting being confined with the help of the decisions gained in previous stages. The problem initially is nonlinear, owing to the nonlinear relationship between the amount of water flowing through the reservoirs and the level of water out from them [29].

2.6 CURRENT WORK

The study build its outline in the way of analyzing the validity and the hydrological conditions of the reservoirs in regions of Mosul, Dibis and Dukan, by analyzing the inflow and outflow rates that obtained from the surrounding parameters including the feeding discharging toward the reservoirs. The study dealt with the effectiveness of rainfall intensity and the potential evaporation on the reservoir regions. The water quantities with the topographic area for each reservoir were analyzed and converting to mathematical model in which can conduct the hydrological status for each case study. The GIS data for each reservoir were considered inside Surfer program for better recognizing the topographic behavior of the regions and the volume-area relationships. The study explained the results in tables and figures.

2.7 LITERATURE SURVEY

(C. Mo, et al., 2022) The study showed that addressing the problem that the optimum operating model of the current storage area cannot coordinate the contradiction between long-term and short-term benefits, there is an overlap of long-term sound performance and optimal long-term treatment of tanks and the creation of a multi-objective and the optimal operation of an overlapping model of water storage place. The ideal control mode is derived when there is an inaccuracy in the expected runoff at a time close to the appropriate time. The programming algorithm in motion is used to evaluate the optimal long-term scheduling solution in the nested optimal scheduling model, and the algorithm is used to solve the long-run effective scheduling solution. The ideal control

mode is determined by three indicators: the utility of the power generation, the amount of water level above the finite hazard rate, and the amount of unutilized water volume. The results show that, above the hypothesis of meeting the wide waters that lead to flood mitigation goals, nested modeling when a perfectly perfect dispatch plan has higher long-term benefits than when the optimum routing and scheduling plan and actual dispatch plan, proving the superiority of nested modeling work in place. Water storage is an optimum conduction problem, the rate of low risk of water level exceeding is 0.28, and the unutilized amount of water volume is 39.370 m3. Compared with the water phase control mode and the flow management mode, the output control mode has the advantages of increased power generation efficiency, less amount of water level above the risk reduction rate, less unused amount of water volume as a result, from the point of view of financial advantages and balance Risks, the study found that the output control mode in the scheduling-enhanced nested mode is the best control mode [30].

(M. Ren, et al., 2022) The study showed the importance of comparing the results with the classic genetic algorithm schemes and organizing the processes of the water storage place in 2020. The preliminary conclusions were the improved genetic algorithm is able to save time in calculating the penalty with joint efficiency and make the model implementation more convenient. The functionality of the standard genetic algorithm requires consideration of water level constraints, drain capacity constraints, drain capacity constraints, etc., while the improved genetic algorithm takes into account the amount of water balance constraints, maximum safety drain constraints, non-negative constraint, and discharge capacity constraints in the coding . Compared with the scheme based on the 2020 Action Regulations, the optimization of the dispatch scheme by the optimized genetic algorithm occupies the flood management store as much as possible under the premise of ensuring excess water leads to safe flood control in any reservoir itself and downstream protection organisms. The downstream protective body is at risk for 10 hours and 6 hours, respectively, during various flood procedures in July 1991 and June 1999, according to the scheme in the 2020 operating rule. The revised evolutionary algorithm ensures not only the safety of the riverbed, but also the highest water levels At the water storage site at 125.46 m and 123.73 m, which is less than the specified excess water resulting in a flood level of 125.75 m[31].

(T. JIAKAI, et al., 2013) The study showed that in China's Xiang River Basin, there are three storage areas for re-supplied water to Jincheng City. To solve water scarcity problems, a mathematical modeling of the optimal operation of a multi-reservoir system is created, with the smallest amount of water shortage as the target function. A genetic algorithm approach is used to develop the optimum methods for three water storage areas based on the inflow-out rate of data from 1990 to 2007. The result indicates that the total amount of water supply in Jincheng City within the operation scheme is 633 cubic meters, and the scarcity decreases Water from 28.1% to 16.1%. Furthermore, ANN modeling has been proposed for optimal performance. When compared to the genetic algorithm technology, the ANN model performs better, with less simulation error (8%). The optimal process results in any of the reservoirs show that the genetic algorithm is more useful than the BP neural network method. Sample learning is mainly responsible for building the optimal operating state of the function by BP neural network methods. It couldn't be more scientific when allocating annual flows based on unique differences in industrial and domestic water demand. A genetic algorithm capable of taking into account constraints above domestic and commercial water consumption in order to achieve optimal performance. In this case, the genetic algorithm is superior to the BP neural network method. The relative inaccuracy between simulated results using BP neural network methods and actual samples is 8%. On the other hand, the inaccuracy of the genetic algorithm is greater. It is clear that fitting samples using BP neural network methods outperforms the genetic algorithm[32]

(A. Chabi, et al., 2019) The study concerned the management Water Storage Facility, also known as "Society Sucrière in which of Save" (SSS), located in the Oueme for the Save watershed. The study demonstrated an assessment of the water balance quantity in this reservoir. A better understanding of this water balance in the future will enable the reduction of water shortages caused by climate change in the short, medium and long term. It will also allow to meet the population's water needs. The water balance method was used to estimate the water ore in the watershed. Its applicability stems from the theory of quantitative conservation of water volumes. The results showed that the inflows are greater than the outflows over the Iluko Reservoir. Thus, the annual variance in tank volumes obtained in 2012 and 2013 is positive, amounting to 2,179,215 m3 and 598,452 m^3 respectively.. During these times there is little human action performed at a storage site water. Furthermore, above the Iloko Dam, 68 percent of the water volumes evaporate,

0.5 percent seeps out, and 32 percent is withdrawn to provide the agricultural needs and drinking water supply of the city of Savieh and its surroundings. [33]

(S. Kim, et al., 2022) The study found that the effective management of water resources carried out accurate studies of the hydrological components and water balance. At the watershed level, the Hydrological Simulation Program - FORTRAN (HSPF) simulations help achieve this reason. Because the model simulates hydrologic processes using one representative parameter for each land use in the watershed, the accuracy of the model is limited in calculating runoff and infiltration. Accuracy requires field-scale hydrological analysis. Estimated the nominal parameter of the bottom storage area, which significantly affects the sedimentation in HSPF, based on the effective moisture content and depth of the soil layer. The hydrological component analysis suggested recalculating the parameters representing soil properties. Through simulations. Total fluxes were the same for each sub-catchment, but the intrinsic and mean sedimentation ratios were higher than the base flow, evapotranspiration, and infiltration rates, indicating specific soil properties. Results were similar to the values observed when comparing the ratio of base flow to total flow. The proportions of each hydrological component. It is critical to consider soil features when making assessments of water quantity and quality in HSPF simulations[34]

(D. Mulyadi, et al., 2022) The study showed that many settlements continue to depend on matter of infiltration for groundwater as their main source, which may lead to a decrease in the level of groundwater. The main alternative sources of water are necessary to provide the amount of water needed by the settlements. The study aimed to determine the extent of water surplus or deficit in Tangerang Regency, Indonesia, as well as the magnitude of the water demand of the population of the area. As a result, it is necessary to solve the problem of planning dual reservoirs in delivering groundwater to residential areas in order to overcome the problem of drought during the dry season. Thom Thwaite-Matter quantitative analysis, water balance and multiple reservoir design planning were used in this study. The results indicated that the expected water surplus occurred during the period from January to April, with a scale ranging from 25.07 N to 186.09 mm. The water deficit occurs in July-October, and its size varies between 127 mm and 219 mm. The water use pattern in the citizen's home is used as a guideline for the construction of tanks to maintain air availability in residential areas. In the future, the double tank will be equipped with sensors that

can help assess the water level, making it easier to record water needs and prevent water wastage [35].

(S. Byeon, 2015) The study showed that various problems relating to water resource management can be solved through a strategy and a rewarding result such as the smart water network, exploitation of retention ponds behind dams, urban rain harvesting facilities, and any other structures constructed to collect rainwater during future flood events can reduce flood damage and provide an up-to-date supply of national water resources. Similarly, pure waste water, ground water and desalinated sea water can also be used as alternative quantities of water resources. The water balance assessment model is improved as the Smart Water model in the study. In the analysis area, this analysis assessed the amount of water balance in the light of the scenarios and suggested a smart amount of water management system that could cover the basic risks to the water distribution system. ; In the event of an accident in the water supply system, all primary water resources on the island were calculated within the model upgraded by this study. Moreover, the intended capacity of a wastewater treatment plant and a desalination plant may similarly contribute to the amount of self-supply from water resources. The water balance in the study area was studied within the estimation of the amount of water demand and the estimation of water resources in the study area. Despite the fact that the analysis area is an island with no important main water sources such as dams or rivers subject to national regulation, the amount of water resources from rain runoff through small streams, reservoirs and storage ponds was sufficient to cover the amount of water demand. The study suggested easy and necessary directions for the application of smart water control technologies to the island area, which can cover water for non-potable uses in its natural state. Furthermore, the intelligent water control system has been evaluated as being able to address critical issues related to the quantity of the water supply system that lead to short-term water cuts [36].

(S. Latif, et al., 2020) The study analyzed that optimizing water loss or predicting final storage capacity as an increasingly important challenge for the operation of a water storage facility. Accurate projections would lead to better water quality control and more efficient operation of water storage facilities. As a result, flash floods and water crises in Malaysia can be reduced. In the dynamic system, the artificial neural network (ANN) models were evaluated using the radial basis function (RBF) for good effect and accuracy. The study showed that summarized ANN

prediction modeling was improved by using internal flow, dam release, initiation and final storage in any input reservoir, and water losses in any of the resulting reservoir. All data obtained in the Klang Jet Reservoir over the past eleven years (1997-2007) were used to build and test the modeling output. According to the results, the proposed model will give a monthly forecast with a maximum mean square error of 20.07 percent. The benefits of this ANN modeling include providing information on water loss, eventual storage, and changes in water level to improve tank operation [37].

(M.. Yousuf, et al., 2018) The study notes that due to climate change and mismanagement of water resources, the Middle East has witnessed precarious water scarcity over the past few decades. The situation is complicated by the lack of an effective legislative framework at the local level, as well as the inability and poor reputation of local water departments. The majority of Iraqis depend on the surface waters of the Tigris and Euphrates rivers, whose main origins are in neighboring upstream countries. Water problems involving polluted water require an immediate solution worldwide. Unfortunately, Iraq was embroiled in multiple successive conflicts from 1980 to 2003, which prevented the country from building its institutions. Rapid population growth in the transboundary countries above the Tigris and Euphrates, combined with strong agricultural demand, is accelerating water exploitation. In this case, the current status of water control in Iraq will be reviewed from the point of view of the legislative framework, water balance, and transboundary issues in the future, with a particular focus on Kurdistan. Since 2003, the Iraqi and Kurdish parliaments have adopted or amended several legislative instruments. In 2015, the KRG Ministry of Agriculture and Water Resources issued a guide to environmental regulations regarding any environmental components such as air, water and soil in cooperation with the European Union. Recommendations for required activities in water management in Kurdistan will be presented[38].

(N. Ohara, et al., 2011) The study focused on the Tigris-Euphrates (TE) river basin to investigate the effects of various water resource utilizations on the watershed's in-motion water balances. A daily vibrant amount of water balance model was developed in the TE watershed to replicate water resource states corresponding to four consumption situations: non-artificial pre-1970 conditions; (2) current levels of moisture resource development/utilization in Syria and Iraq while preserving and current levels of water asset advancement in Syria and Iraq while preserving pre-1970

circumstances in Turkey. Regular water release scenarios from of the Turkish sector downstream just above the basis of future water utilization estimates in the Turkish portion of the TE watershed; and A minimum amount of time-varying water discharge from Turkey is required to meet current irrigated agriculture water demands in the down - stream region. Each quantity of water balance simulation studies replicated atmospheric and hydrologic conditions during historical critical drought and flood episodes. To estimate irrigation demands, the Food and Agricultural Organization of the United Nations (FAO) used reconstructed atmospheric and harvest distribution data satellite - derived observations. The operations of 15 major dams in the Syrian and Iraqi sections of the TE watershed were dynamically modeled under a range of flow regimes controlled and uncontrolled by Turkey, the upstream country. According to the study, different constant-discharge volumes of water releases from the Turkish sector can meet agricultural water demands in Iraq and Syria efficiently. Furthermore, if the seasonality of irrigation quantity of water demands in the lower TE region is considered when scheduling water releases from Turkey, those releases can be reduced while still meeting downstream countries' current irrigation water demands. Moisture diversion from of the Tigris to the Euphrates within the Samarra-Thartar complex could allow for value freedom in this region's water distribution. Furthermore, because of the arid climate in the lower TE river basin, a significant amount of water evaporates on the way to the reservoirs. Due to the non-large surface area-to-storage volume of the upstream TE water storage regions and the cooler climate in the upstream sector of a watershed, storing water in the upstream region appears to be more effective than storing water in the downstream region in reducing reservoir quantity of water evaporation [39].

3. METHODOLOGY

3.1 METHODOLOGY

3.1.1 Mosul Dam

Mosul Dam is located on the Tigris River about 60 kilometers northwest of Mosul, Iraq. It is the largest dam in the world, with a storage capacity of 11.11 billion cubic meters at normal working levels (330 m. above sea level). The dam was built on alternating layers of certified limestone, gypsum, and marl. Since its inception in 1986, this dam has experienced significant water seepage beneath its foundation. Since that time, grouting operations have been implemented to address this issue. The seepage is thought to be caused by the dissolution of gypsum beds inside the foundation, which was not carefully considered by the designers[1].

3.1.2 Dukan Dam

The Dukan Reservoir in Iraq's Kurdistan Region has really been studied to determine the reservoir's properties and essence, as well as the deposited sediments on its bottom surface. A site investigation as well as grain size analyses on deposit samples collected at 32 locations represent an entire reservoir area formed when the Lesser Zab River was dammed in 1959 were used to complete this analysis. The Dukan Dam, a multi-purpose concrete arch dam on the Lesser Zab River, was constructed to control inundation during torrential rainfall, as well as for irrigational generation. The larger reservoir is located north and is symmetrical, covering approximately 250 square kilometers. The smaller sub-reservoir is located south of the dam and is irregularly rectangular in shape. In this manner, 32 sediment samples were collected from the bottom of the Dukan reservoir[2].

3.1.3 Dibbs Dam

The Dibis Dam, also known as the Dibis Regulator, is a gravel-alluvial fill hydroelectric dam located on the Lesser Zab River about 130 kilometers upstream from its confluence with the Tigris River. The dam is located in Kirkuk Governorate, Iraq, directly north of the town of Dibis. The Dibis dam's primary function is to divert water from the Lesser Zab River into the Kirkuk Irrigation Project. This dam is located approximately 130 kilometers upstream from the confluence of the

Lesser Zab River with the Tigris River in Iraq. The dam's purpose is to divert water from the Lesser Zab River into the Kirkuk Irrigation Project's main canal. It was built between 1960 and 1965 as part of the larger Kirkuk Irrigation Scheme to irrigate 300,000 hectares of extremely fertile land[3].

3.2 MOSUL RESERVOIR

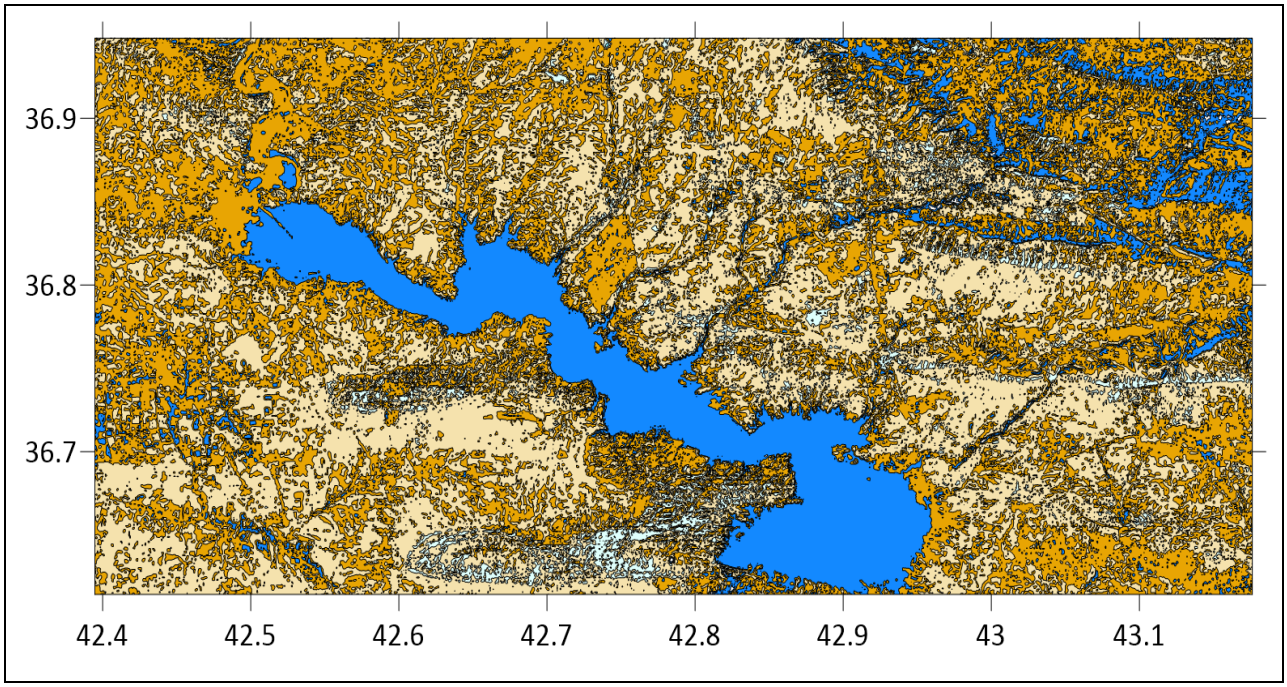

Figure 3.1: Imagery Analysis of the region of Mosul reservoir (Surfer program)

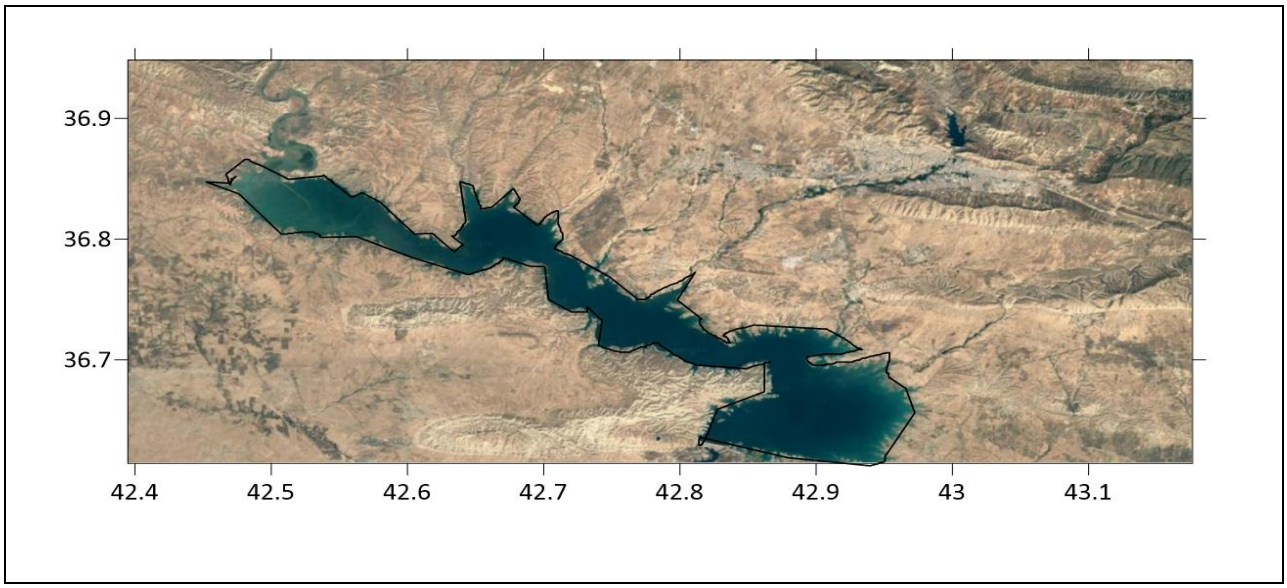

Figure 3.2: Boundary of the region of Mosul reservoir (Surfer program)

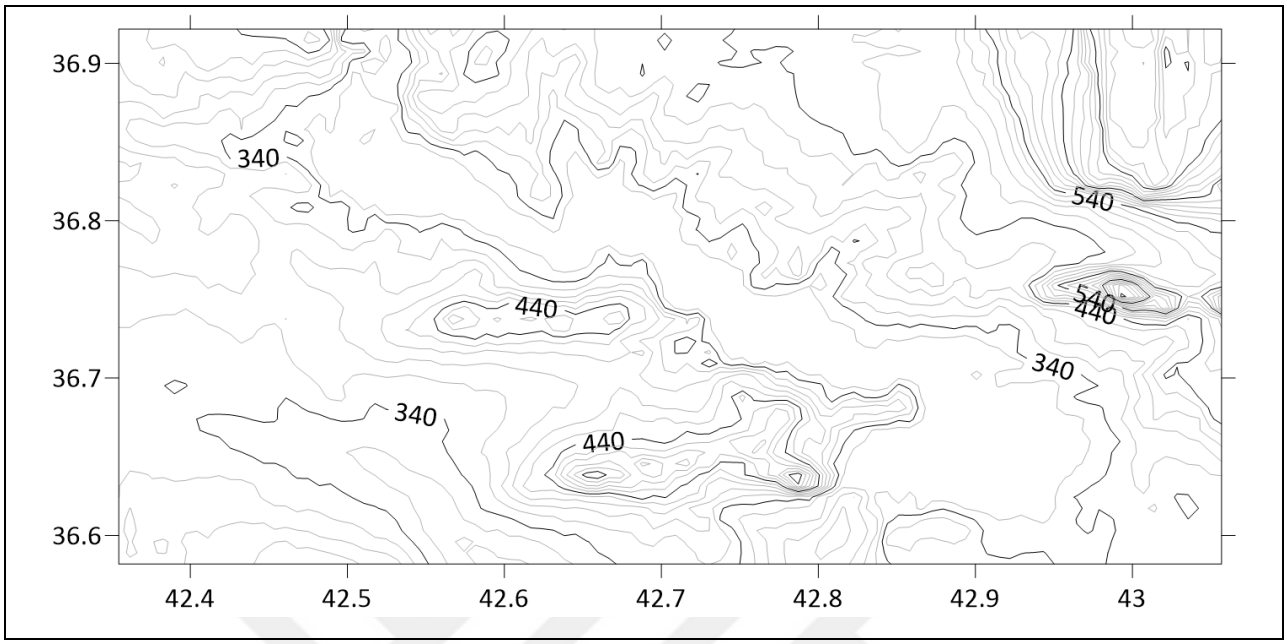

Figure 3.3: Contour lines of the region of Mosul reservoir (Surfer program)

3.3 DUKAN RESERVOIR

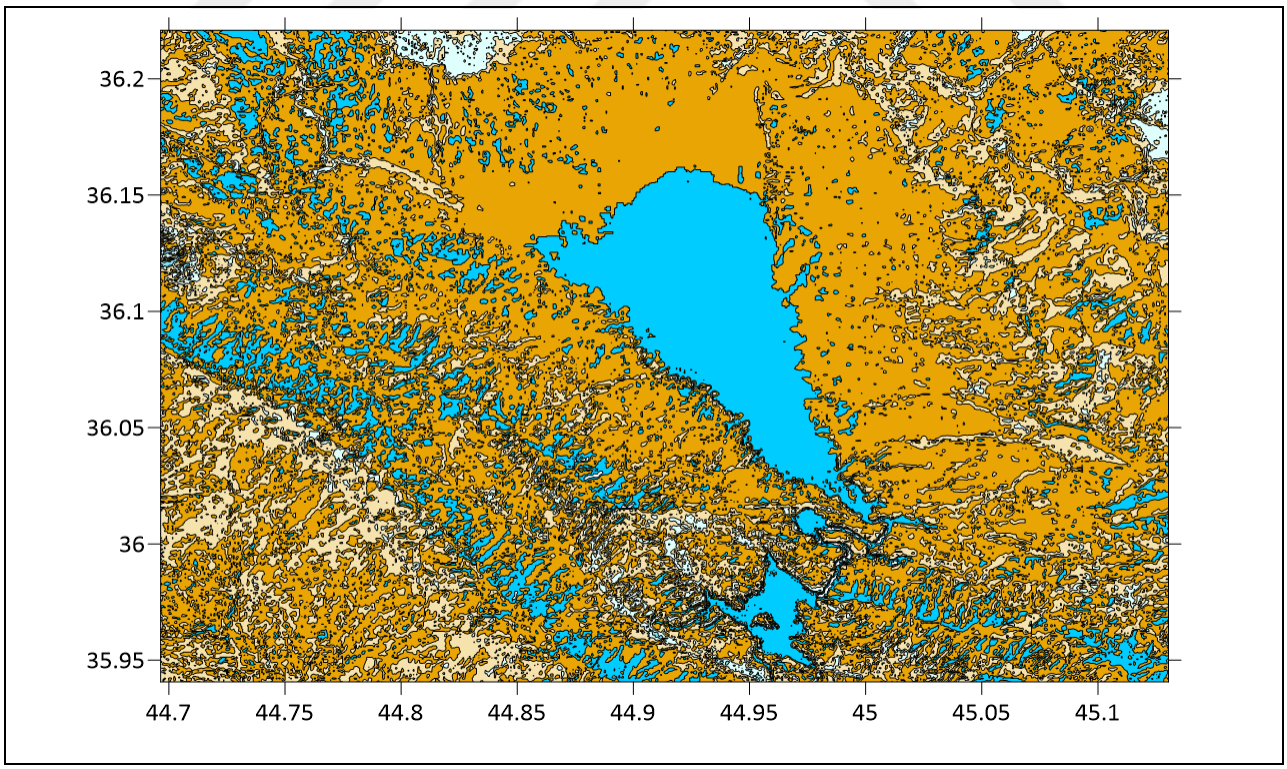

Figure 3.3: Imagery Analysis of the region of Dukan reservoir (Surfer program)

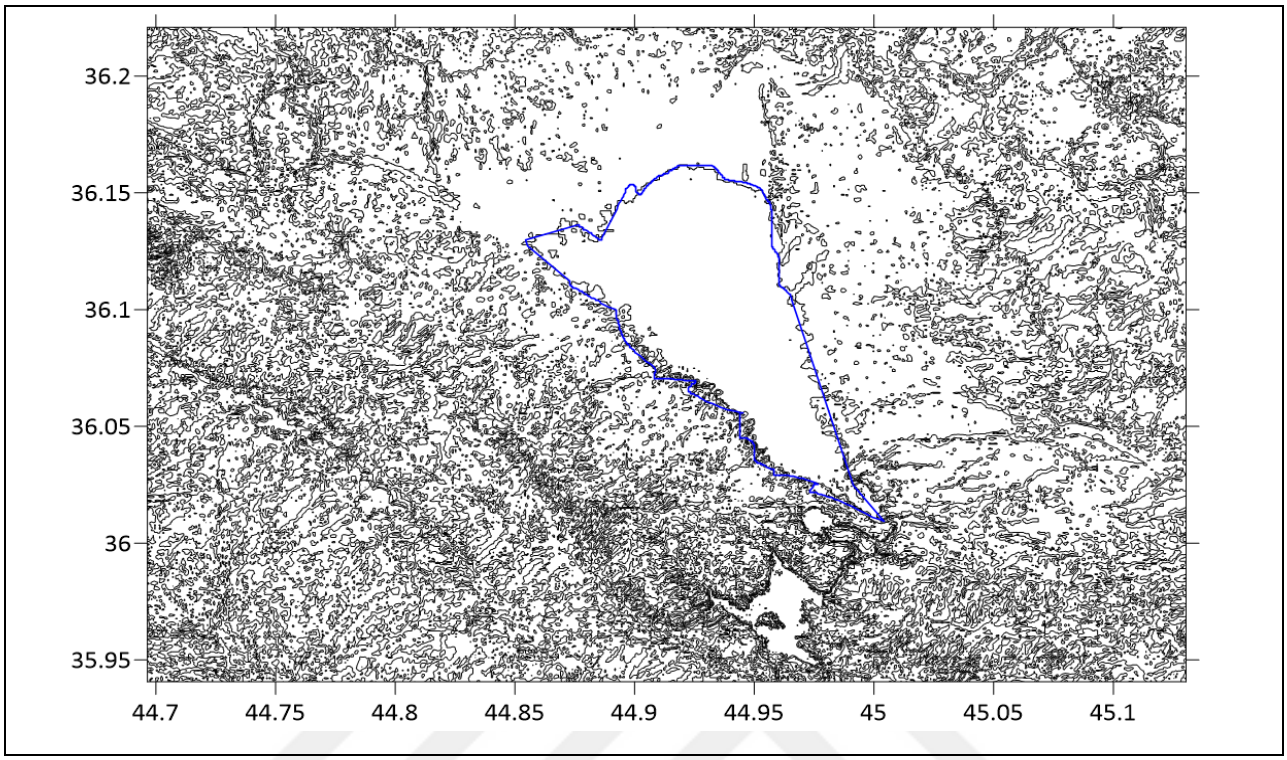

Figure 3.4: Boundary of the region of Dukan reservoir (Surfer program)

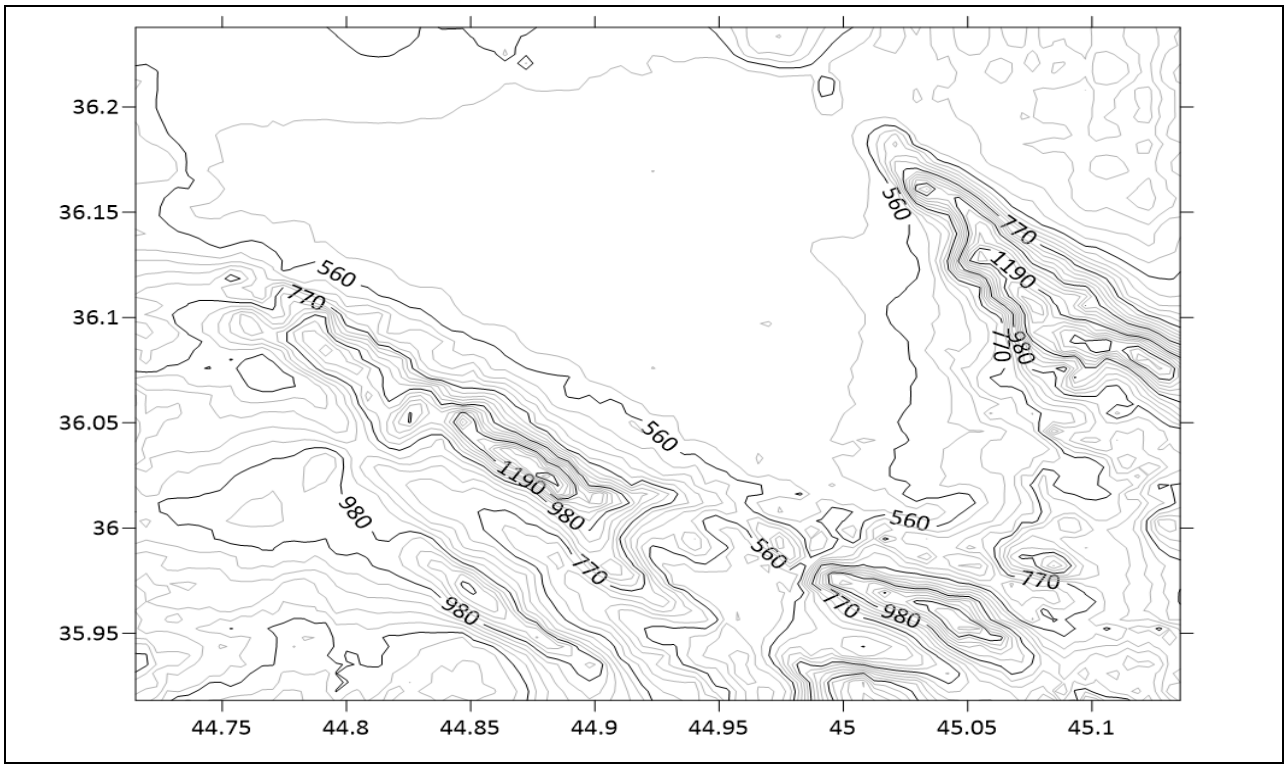

Figure 3.5: Contour lines of the region of Mosul reservoir (Surfer program)

3.4 DIBIS RESERVOIR

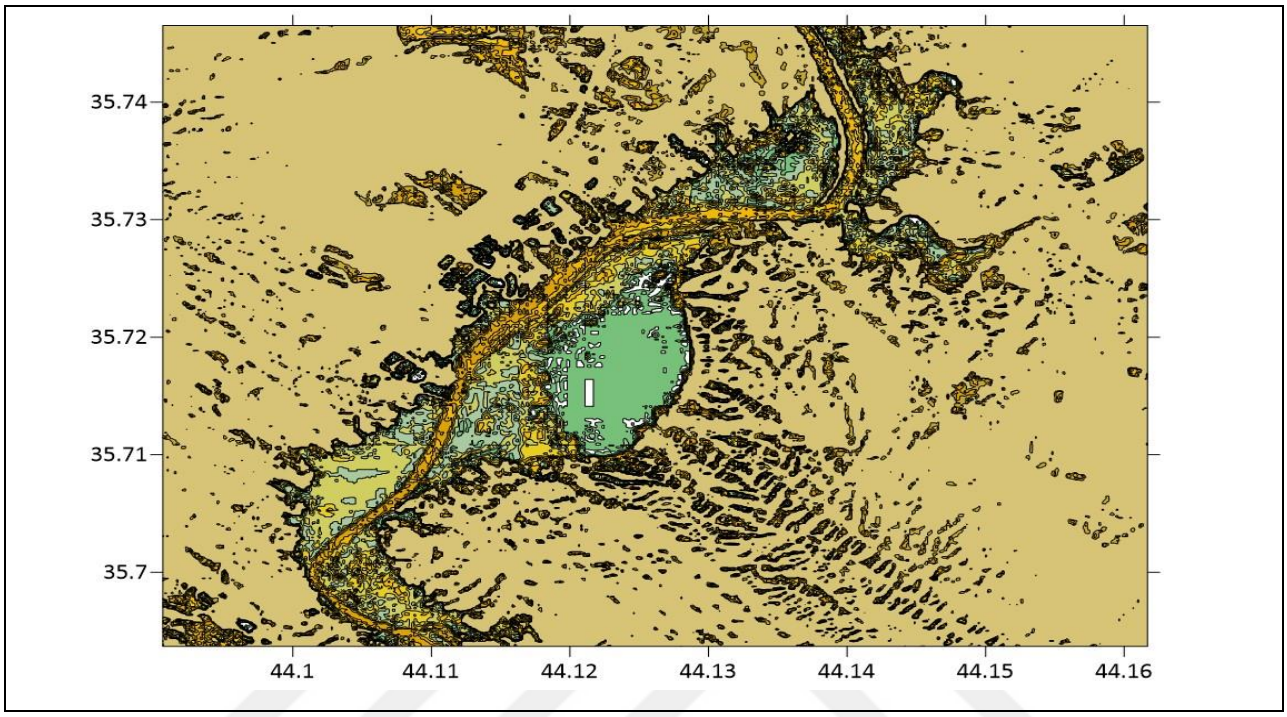

Figure 3.6: Imagery Analysis of the region of Dibis reservoir (Surfer program) Km

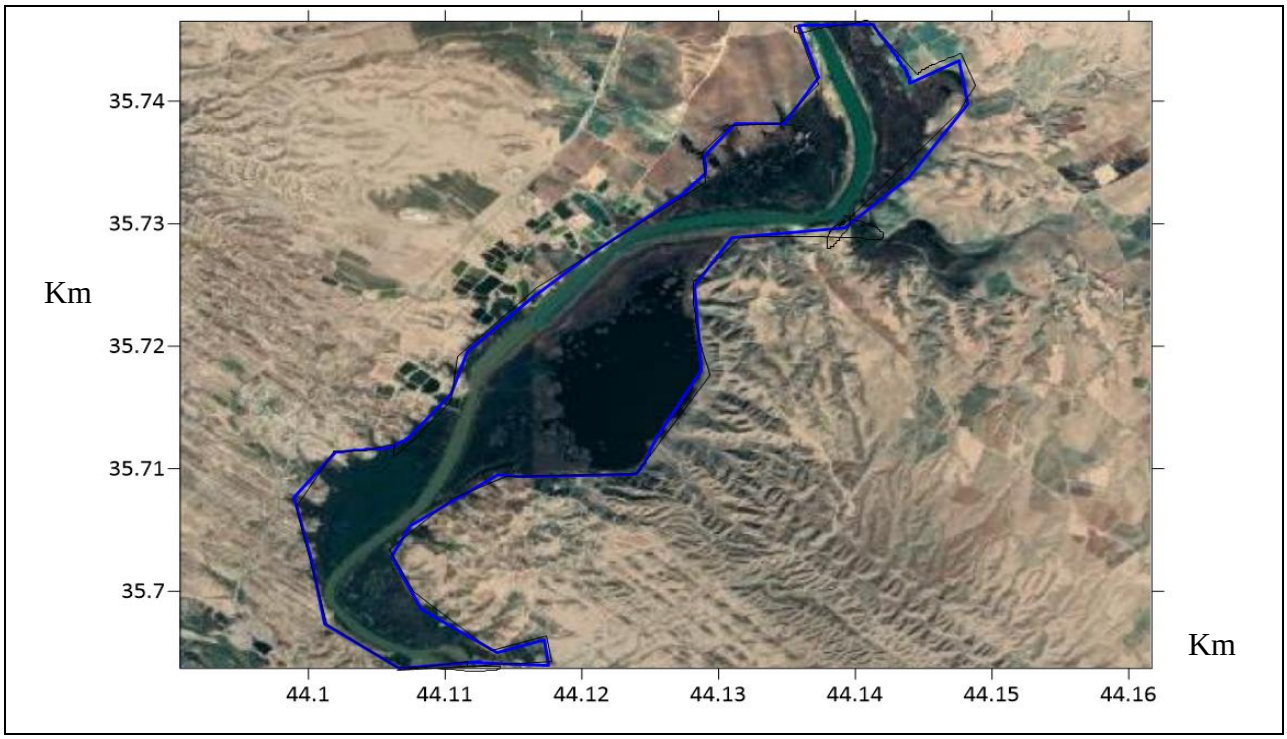

Figure 3.7: Boundary of the region of Dibis reservoir (Surfer program)

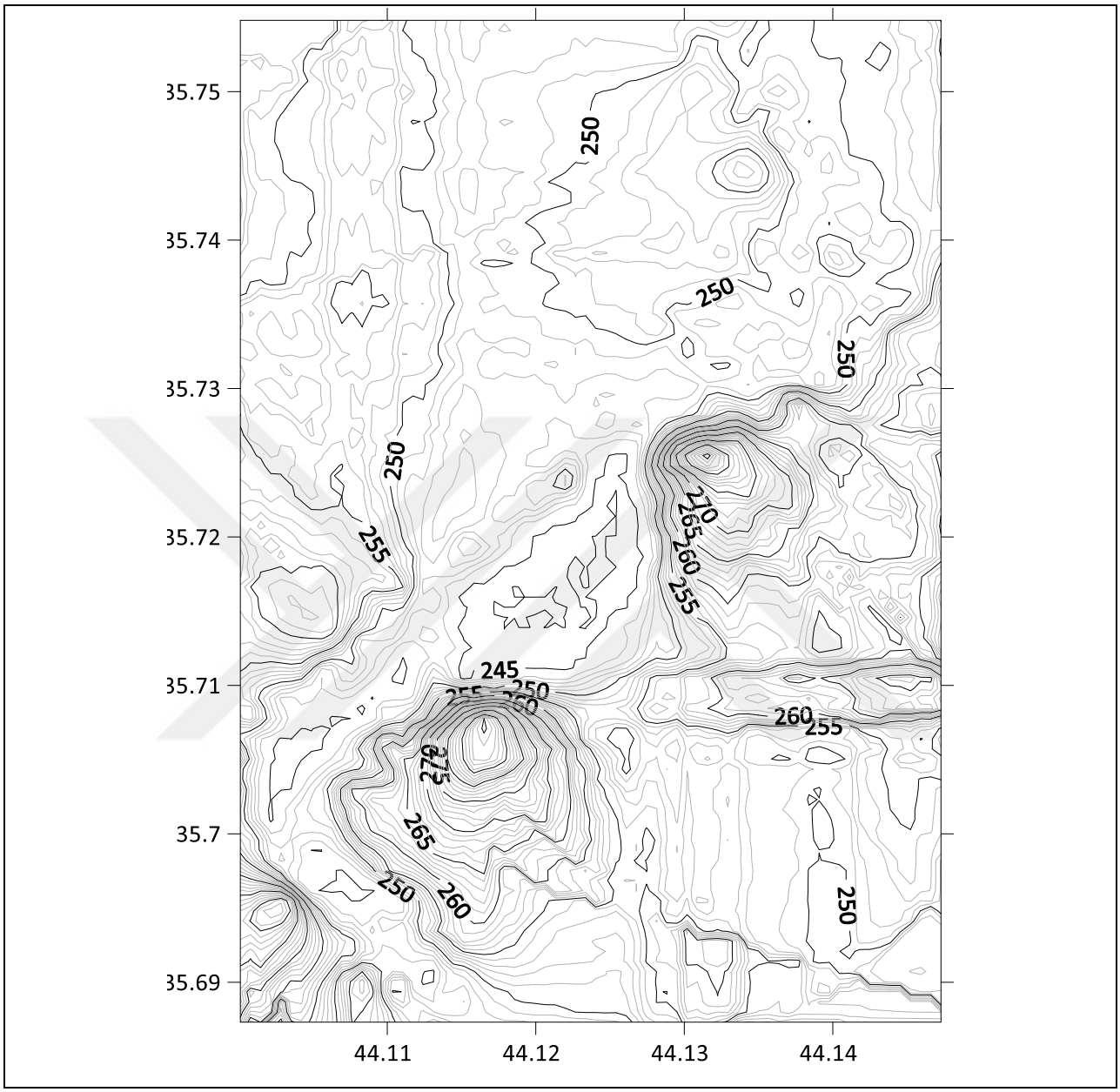

Figure 3.8 : Contour lines of the region of Dibis reservoir (Surfer program)

Table 3.1: Monthly inflow rates for the three dams

Month	Mosul Dam	Dukan Dam	Dibis Dam
1	480	226	155
2	620	363	150
3	990	450	162
4	1520	506	139
5	1210	304	142
6	580	135	172
7	210	64	241
8	110	43	272
9	112	48	254
10	102	53	216
11	290	84	175
12	410	159	164

Table 3.2: Monthly precipitation intensity for the three dams

Month	Precipitation (mm)		
	Mosul Dam	Dukan Dam	Dibis Dam
1	62	129	23
2	64	145	25
3	63	136	28
4	44	99	25
5	5	42	13

Table 3.2: Monthly precipitation intensity for the three dams" Continued"

Month	Precipitation (mm)		
	Mosul Dam	Dukan Dam	Dibis Dam
6	2	0	3
7	0	0	0
8	0	0	0
9	0	0	0
10	11	13	13
11	45	77	25
12	57	112	23

Table 3.3: Monthly evaporation rates for the three dams

Month	Evaporation (mm)		
	Mosul Dam	Dukan Dam	Dibis Dam
1	27	40	45
2	43	60	68
3	90	90	82
4	132	140	132
5	135	240	224
6	335	390	442
7	402	410	508
8	339	370	498
9	250	250	303
10	143	166	140
11	60	70	74
12	27	40	42

3.5 WATER BALANCE CONCEPTS

the equation of water quantity balance for income and outcome available water quantity per month is as following [4]:

$$P + Q = E + q \qquad (3.1)$$

Where:

Q= inflow rate toward the reservoir

q = outflow rate toward the downstream area

P = precipitation rate

E = Evaporation rate

Both E and P depend on the surface area of the reservoir

4. RESULT AND DISCUSSION

4.1 ANALYSIS AND RESULTS

By using the data that obtained from Surfer program, the variation of the volume above the minimum elevation of the reservoir with minimum storage area was evaluated and linearized as the following :

4.1.1 Mosul Reservoir: Elevation –Volume Relationship

The minimum elevation of the reservoir surface water was assigned at 320 m, the surface area of the reservoir was evaluated as 390 km². Figure 4.1 explained the magnitudes of volumes at each contour line above the elevation of 320m figure 4.2 showed the linear regression for these data and the results included in table 4.1.

Same results explanation procedure was adopted for Dukan reservoir (in figures 4.3, figure 4.4 and table 4.2) and for Dibis reservoir (in figure 4.5, figure 4.6, and table 4.3)

Table 4.1: The Variation of volume and elevation for Mosul Reservoir (Surfer)

Elevation (m)	Volume ($*10^6$ m^3)
320	0
320.5	1116
321	1711
321.5	2353
322	2935
322.5	3571
323	4146
323.5	4874
324	5081

Table 4.1: The Variation of volume and elevation for Mosul Reservoir (Surfer) "continued"

Elevation (m)	Volume (*10^6 m^3)
324.5	5661
325	6251
325.5	7373
326	7871
326.5	8126
327	8135
327.5	8216
328	8283
328.5	8342
329	8419
329.5	8481
330	8585

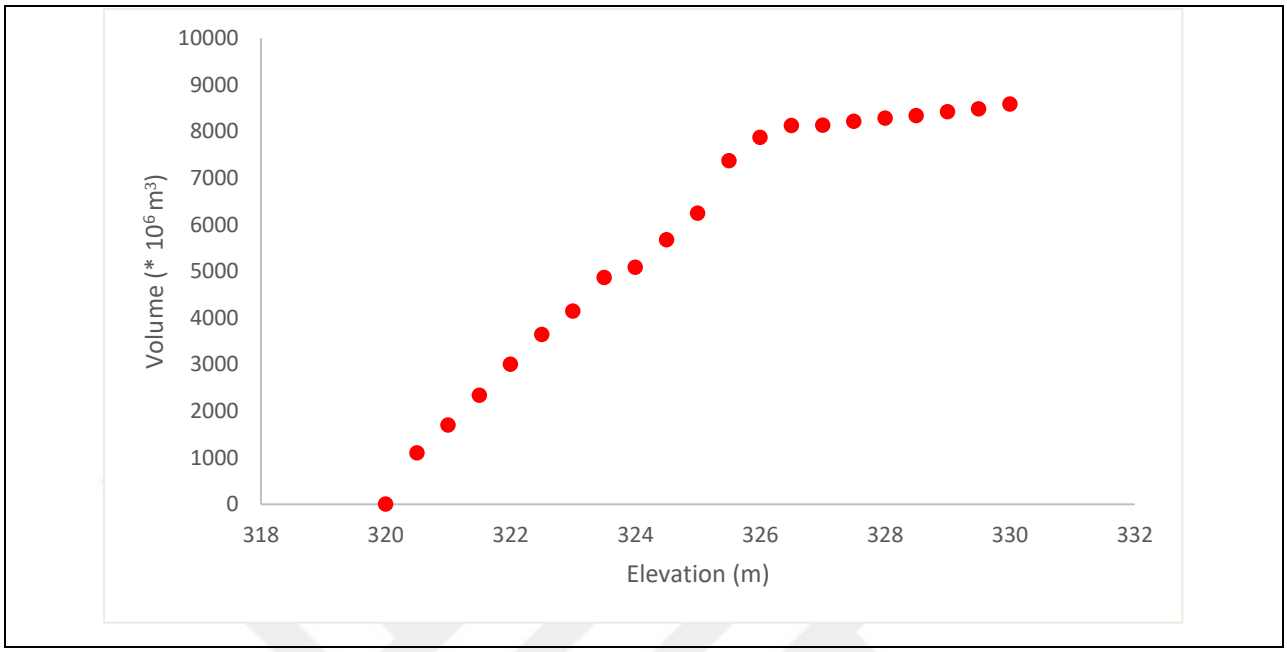

Figure 4.1: The Variation of volume and elevation for Mosul Reservoir (Surfer)

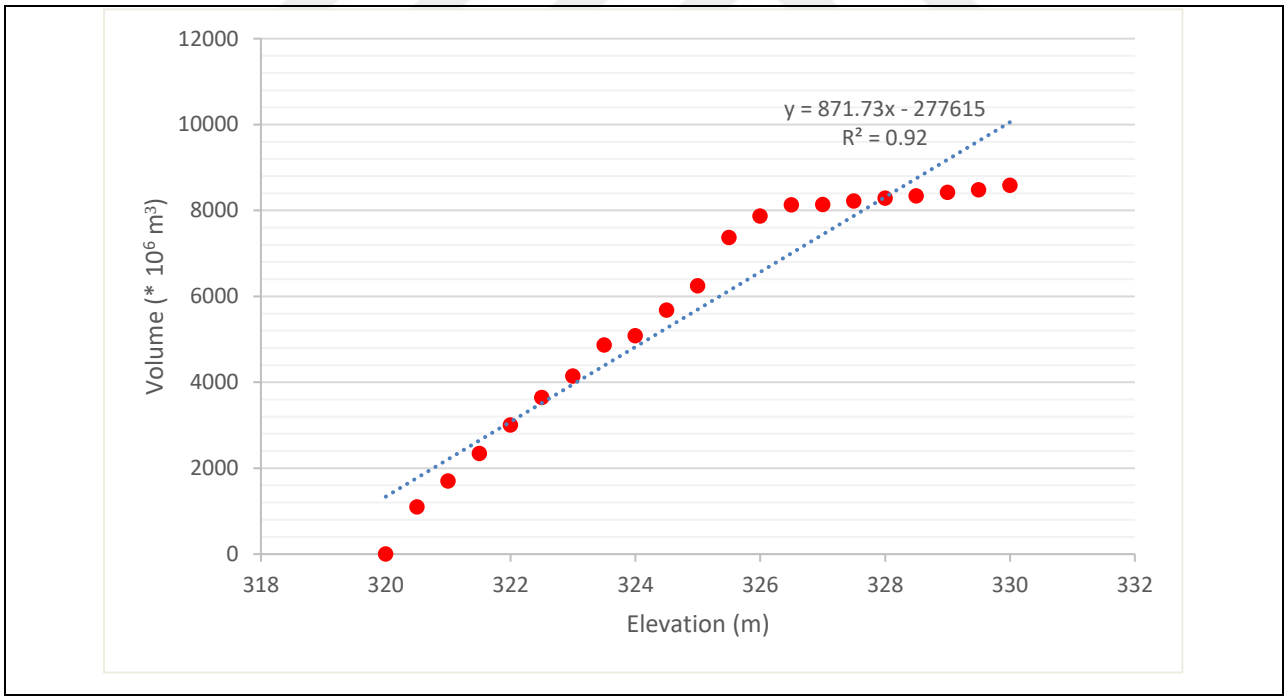

Figure 4.2: Linear regression for volume and elevation for Mosul Reservoir

4.1.2 Dukan Reservoir: Elevation –Volume Relationship

The lowest elevation of reservoir taken was 500m while the surface area was 270 km^2

Table 4.2: The Variation of volume and elevation for Dukan Reservoir (Surfer)

Elevation (m)	Volume (*10^6 m^3)
500	0
500.5	2087.4
501	3266.2
501.5	4449.1
502	5533.3
502.5	5729.9
503	6018.4
503.5	6348.6
504	7157.9
504.5	7288
505	7459
505.5	9092
506	10894
506.5	10967
507	11992
507.5	12815
508	13637
508.5	15671
509	17862
509.5	18911
510	19738

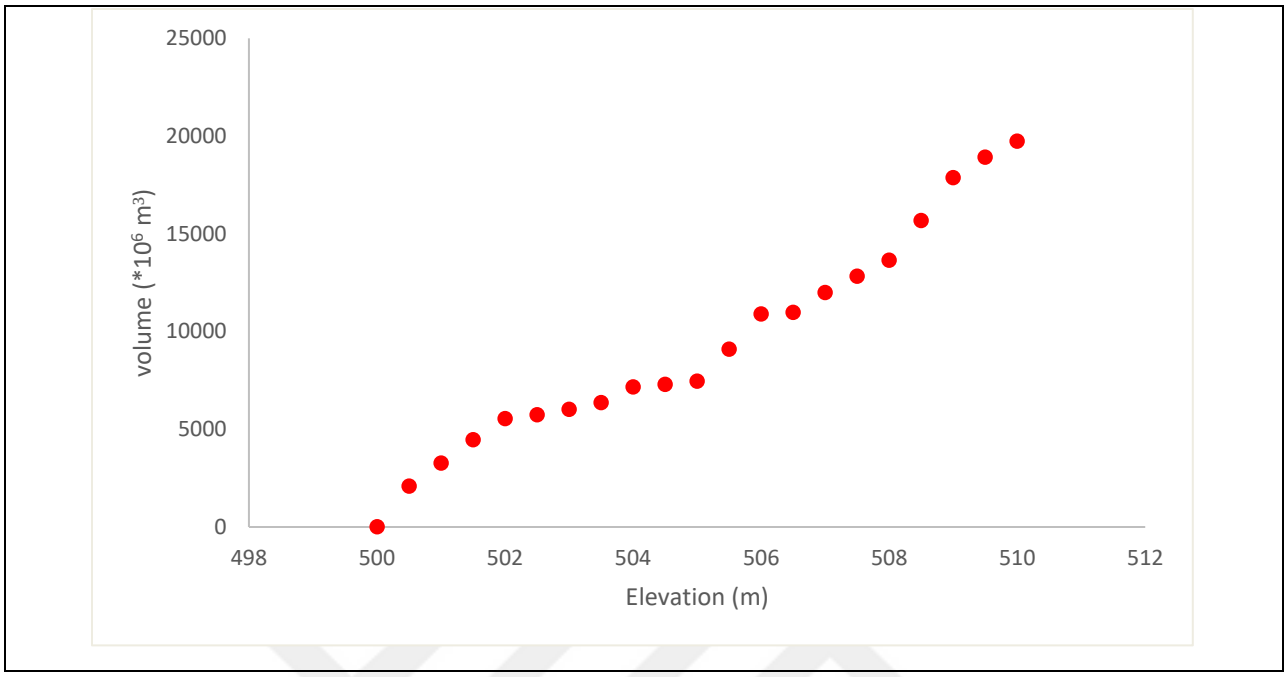

Figure 4.3: The Variation of volume and elevation for Dukan Reservoir (Surfer)

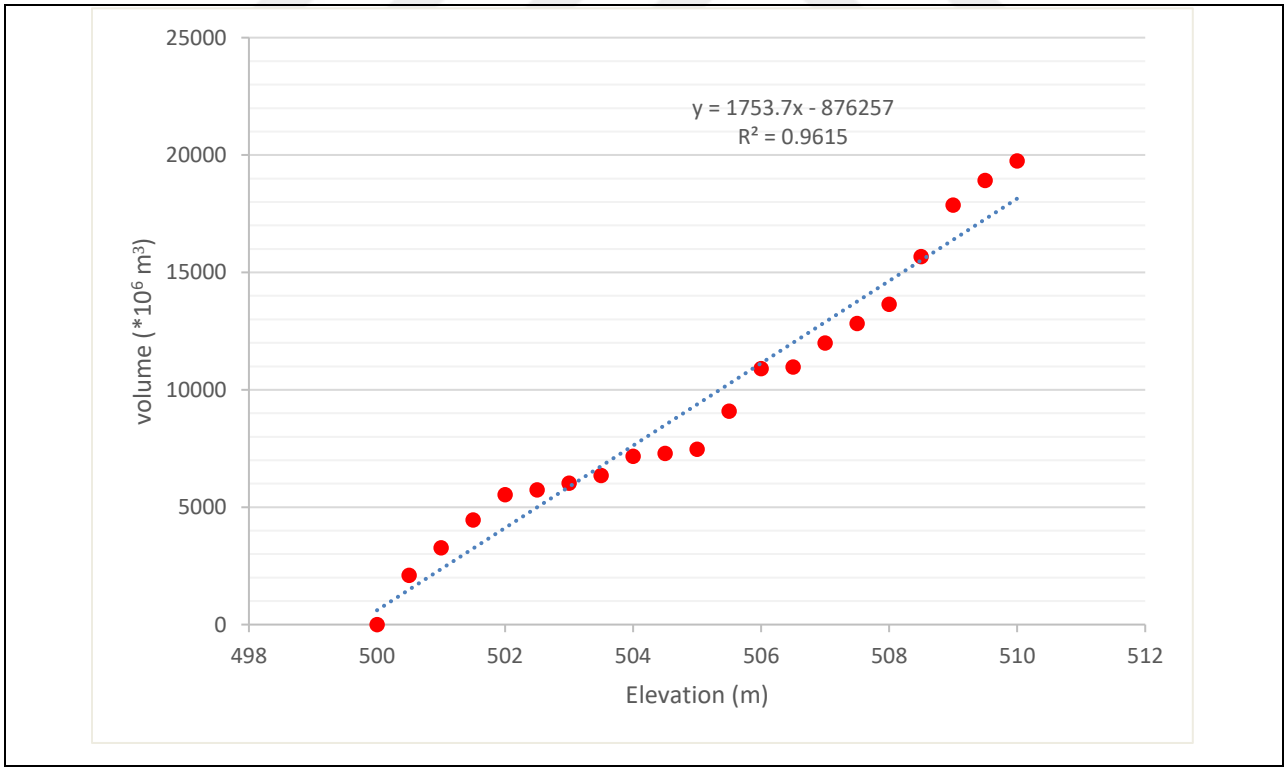

Figure 4.4: Linear regression of volume and elevation for Dukan Reservoir

4.1.3 Dibis Reservoir: Elevation –Volume Relationship

For Dibis Dam, the elevation that obtained as low water level was 245 m and the surface area was 8 km^2

Table 4.3: The Variation of volume and elevation for Dibis Reservoir (Surfer)

Elevation (m)	Volume (*10^6 m^3)
245	0
245.5	256
246	310
246.5	345
247	541.6
247.5	570.7
248	712
248.5	1045
249	1231
249.5	1324
250	1456
250.5	1613
251	1755
251.5	1811
252	1886
252.5	1908
253	2032
245	0
245.5	256
246	310
246.5	345

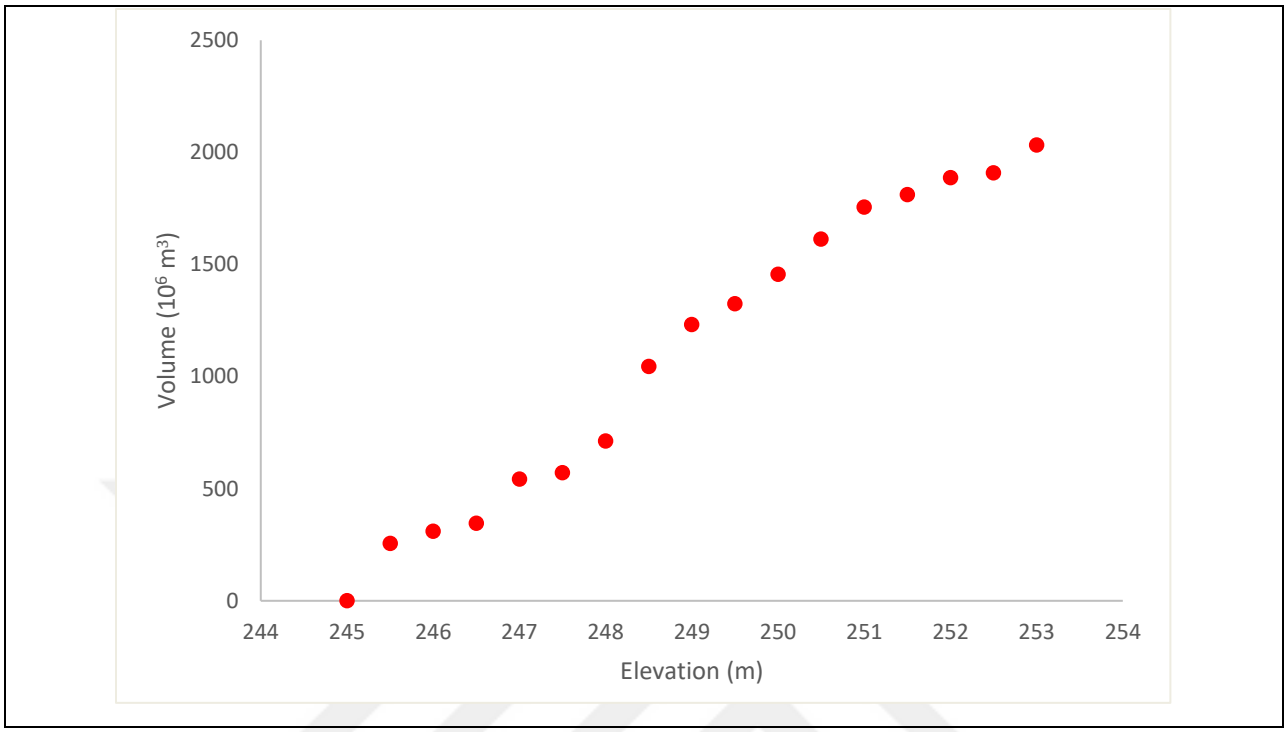

Figure 4.5: The Variation of volume and elevation for Dibis Reservoir (Surfer)

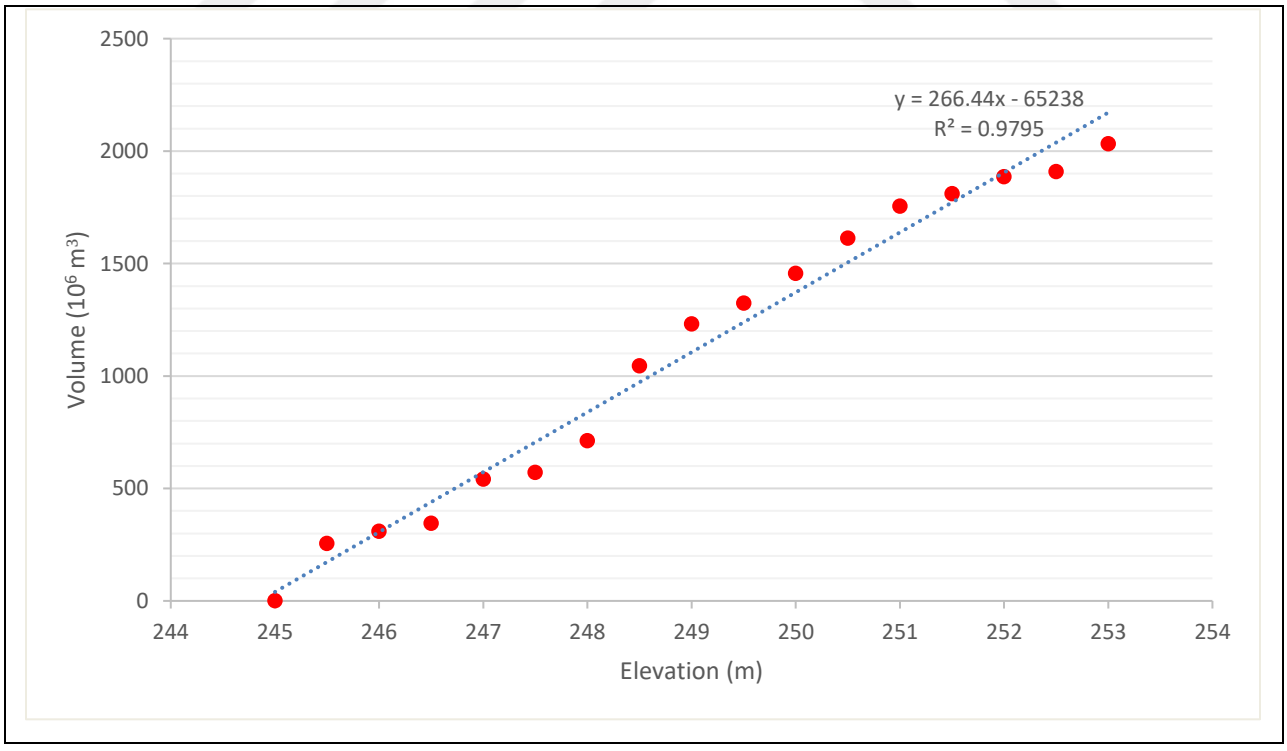

Figure 4.6: Linear regression of volume and elevation for Dibis Reservoir

4.2 VARIATION OF INFLOW RATES

4.2.1 Mosul Reservoir Monthly Inflow Rates

The variation in inflow rates toward the Mosul reservoir per month was sketched in figure 4.7 and 4.8. The lines that drew in figure 4.8 explained the assumption of the change in month inflow from peak to peak.

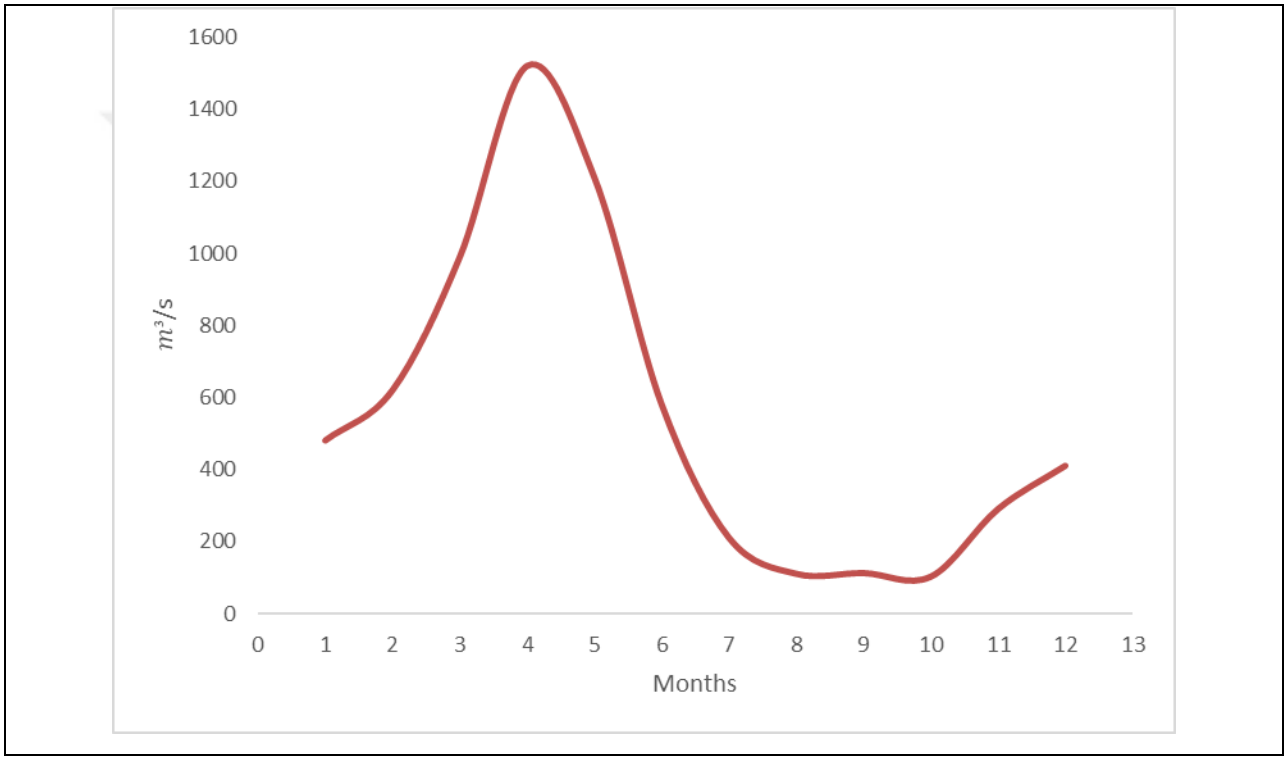

Figure 4.7: Inflow rates toward Mosul Reservoir

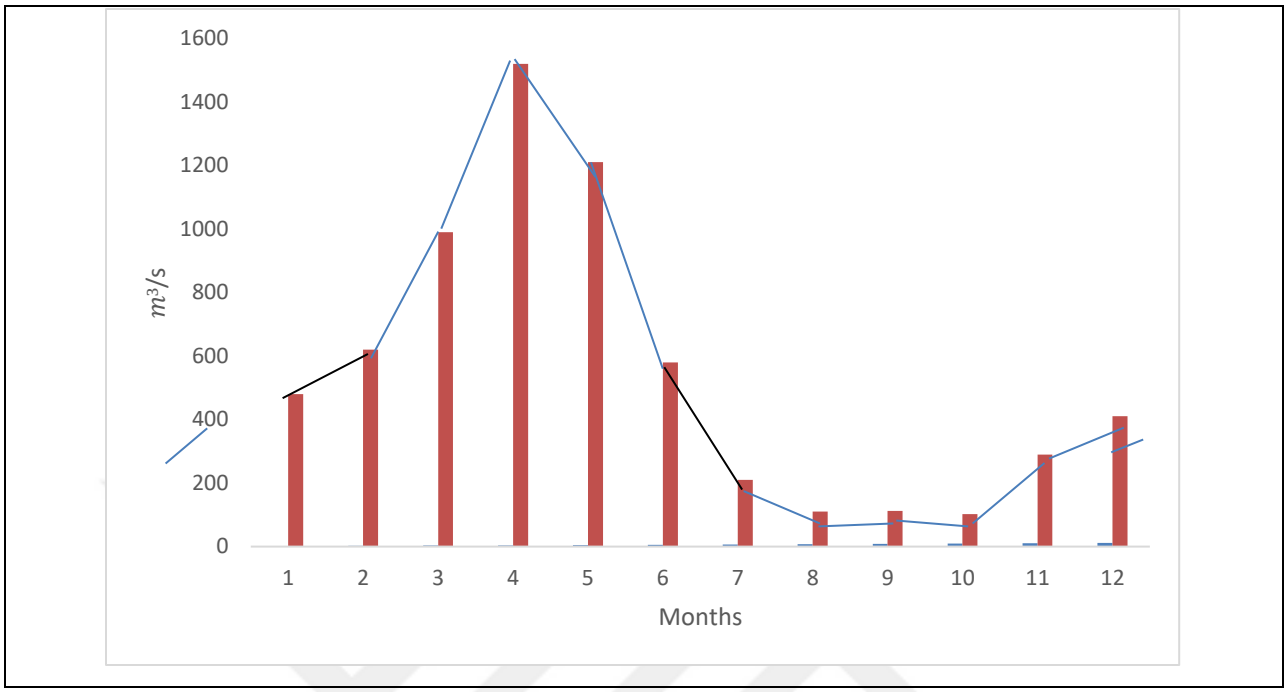

Figure 4.8: The Linear changing of Inflow rates toward Mosul Reservoir

By using the data set in appendix A that gained from the Iraqi Ministry of Water Resources as these data covered the average inflow rates values that recorded for the year of 2021, the following figures (4.9 to 4.20) showed the linear fittings for the data of inflow rates for Mousl reservoirs:

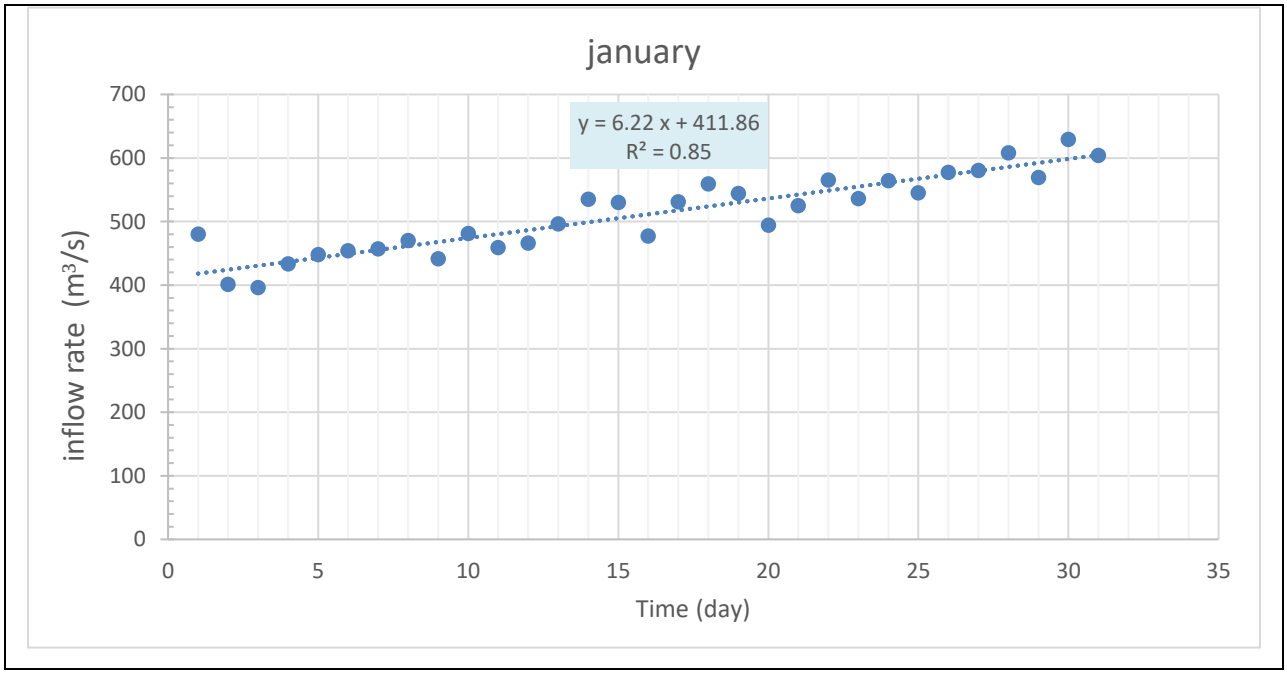

Figure 4.9: Linear regression of inflow rates toward Mosul Reservoir (January)

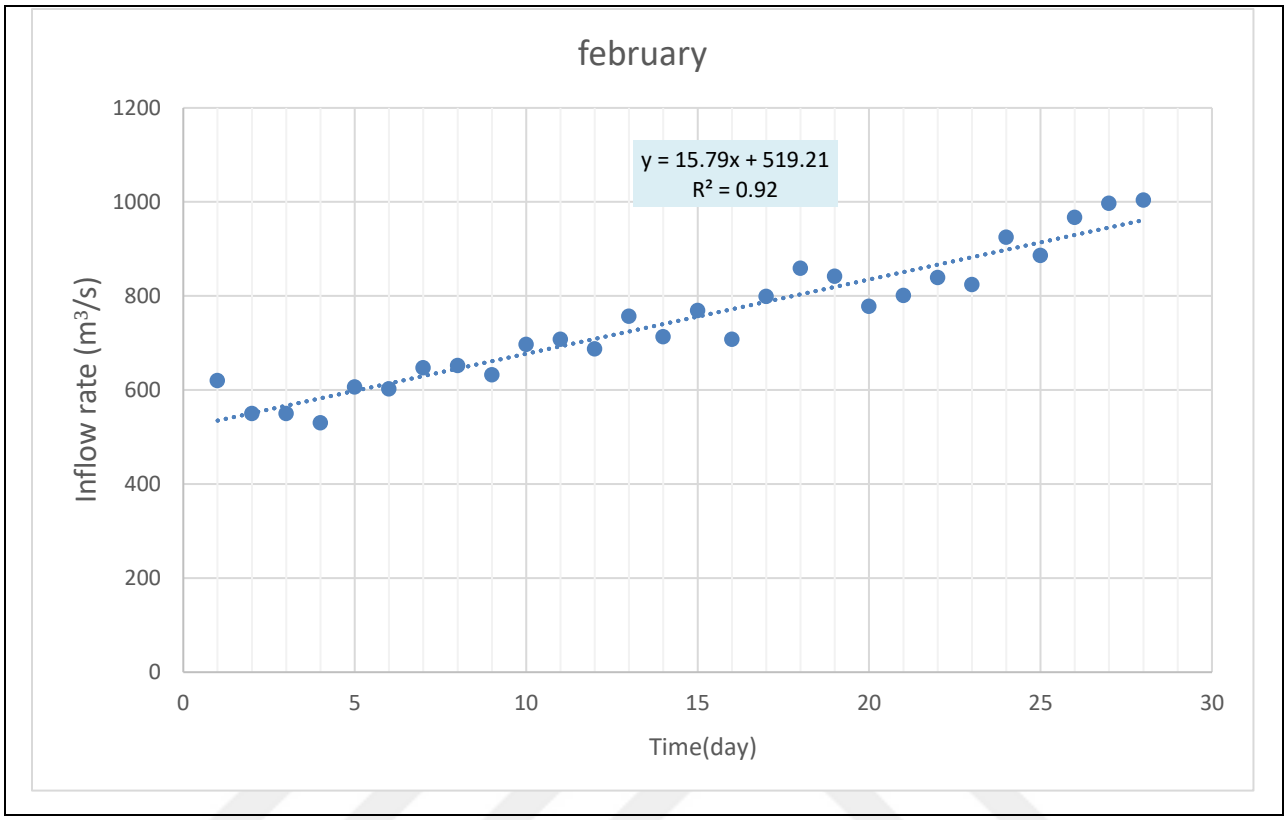

Figure 4.10: Linear regression of inflow rates toward Mosul Reservoir (February)

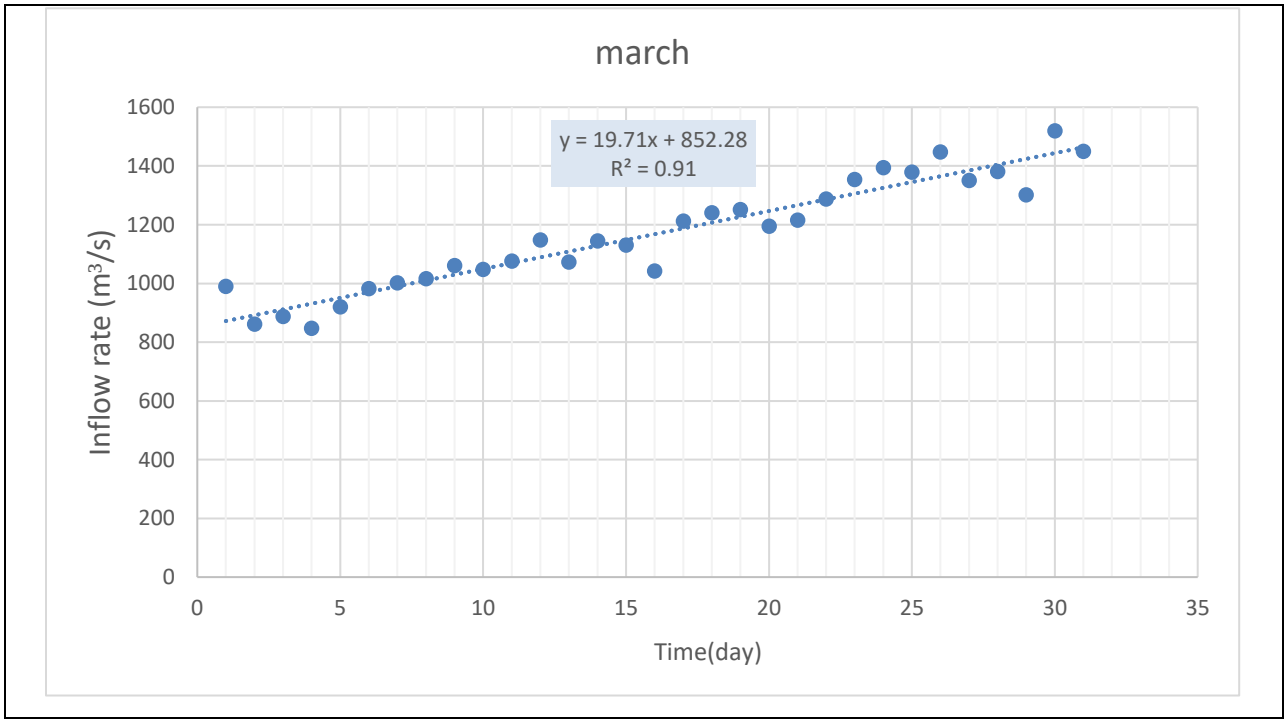

Figure 4.11: Linear regression of inflow rates toward Mosul Reservoir (March)

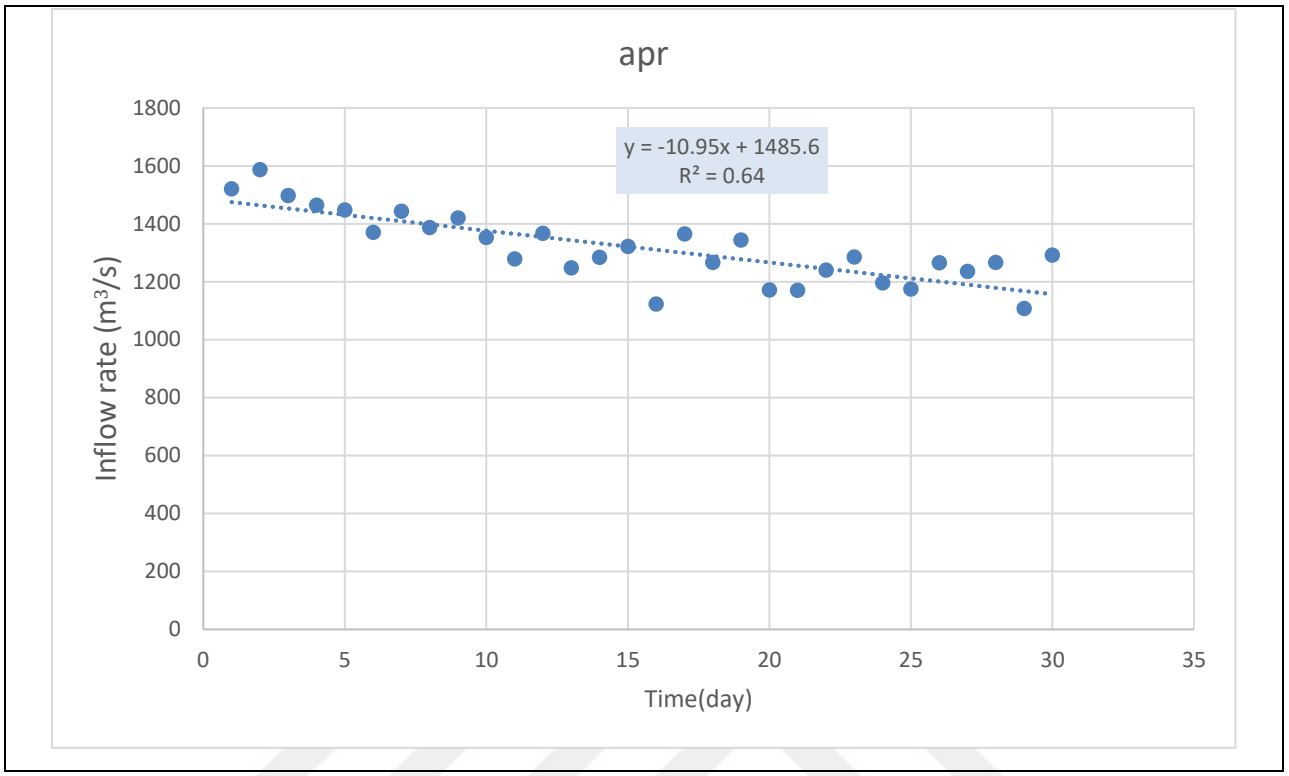

Figure 4.12: Linear regression of inflow rates toward Mosul Reservoir (April)

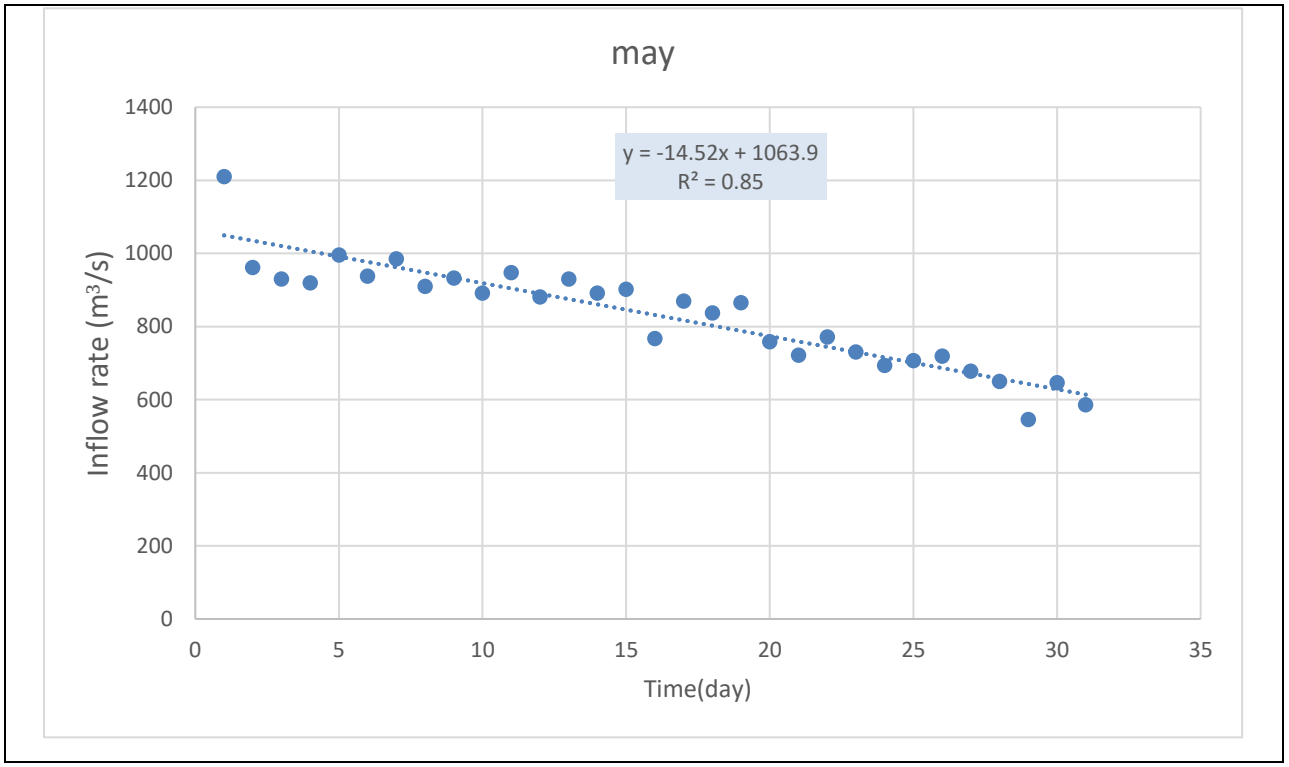

Figure 4.13: Linear regression of inflow rates toward Mosul Reservoir (May)

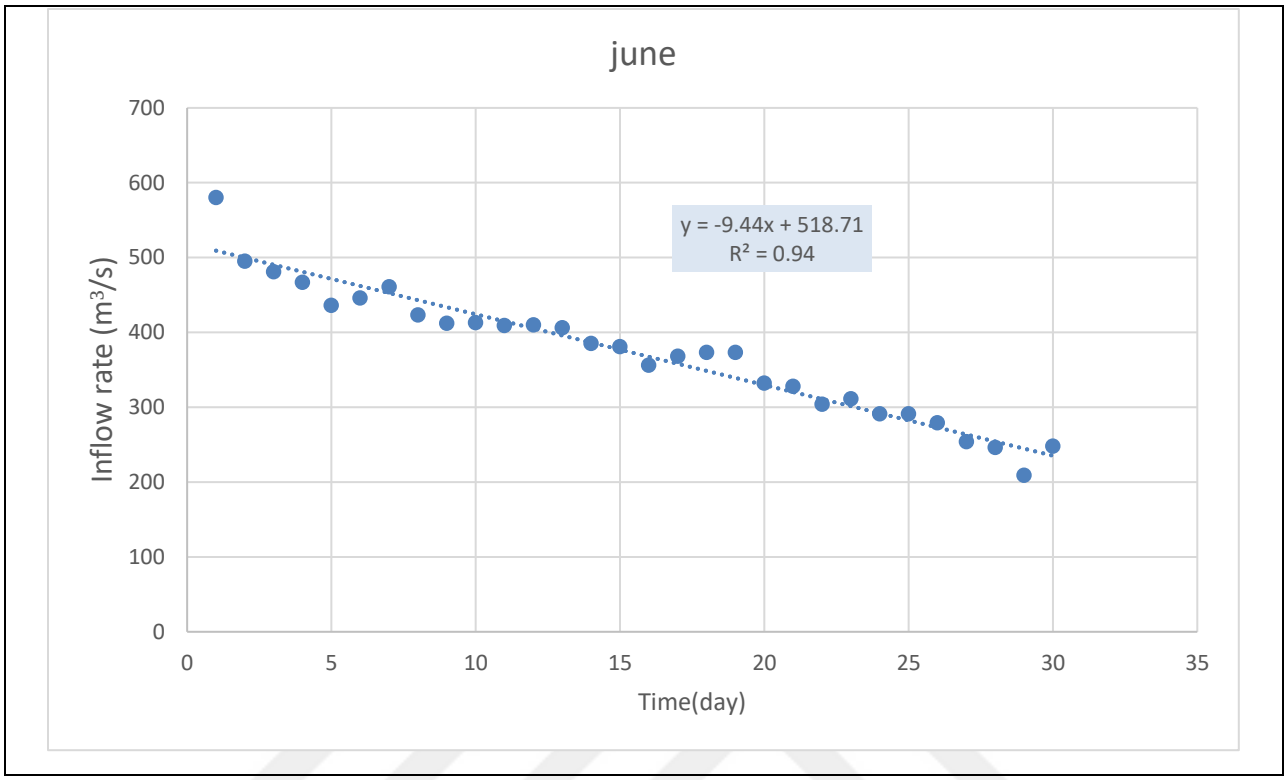

Figure 4.14: Linear regression of inflow rates toward Mosul Reservoir (June)

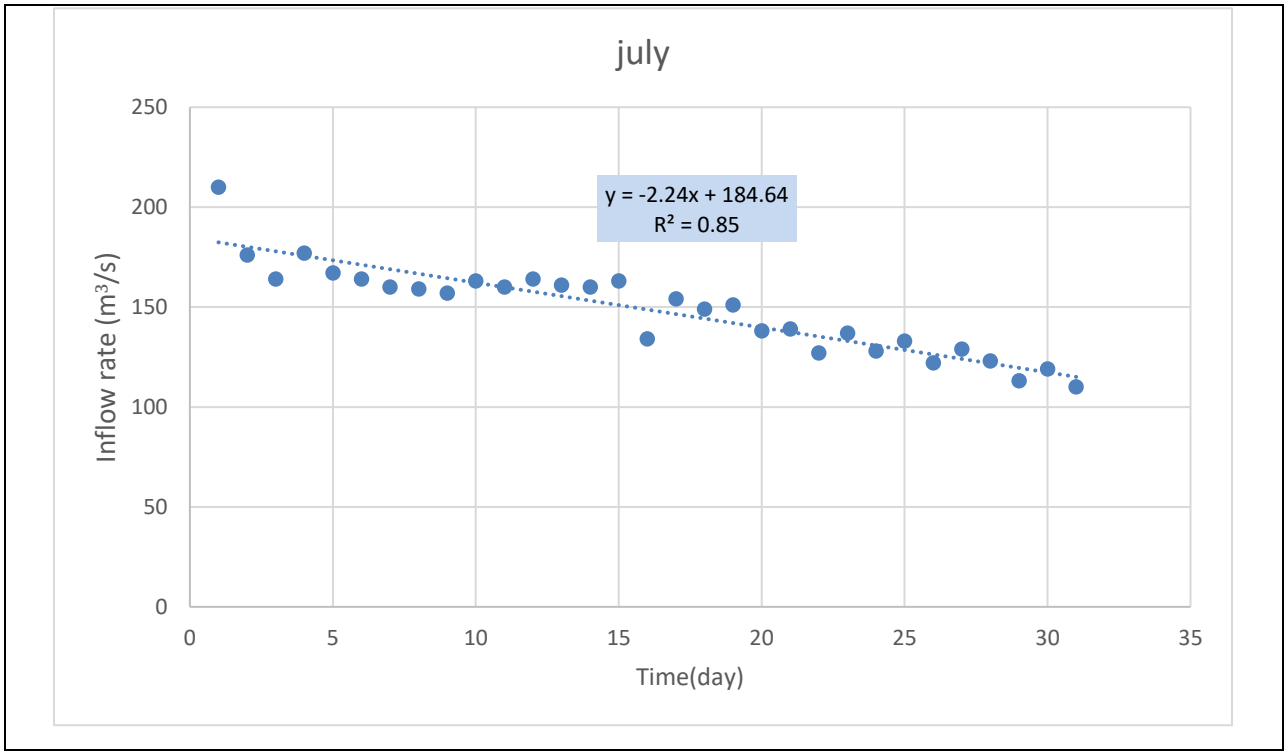

Figure 4.15: Linear regression of inflow rates toward Mosul Reservoir (July)

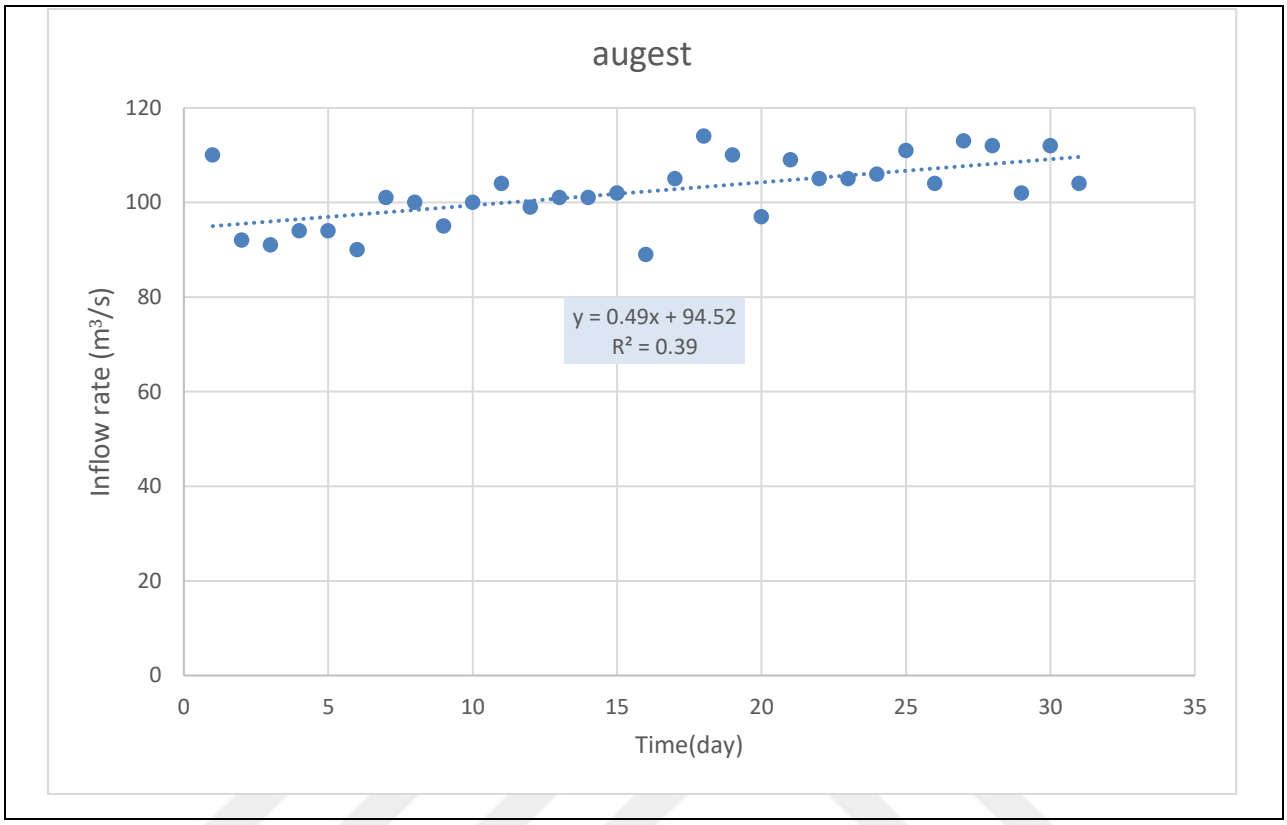

Figure 4.16: Linear regression of inflow rates toward Mosul Reservoir (August)

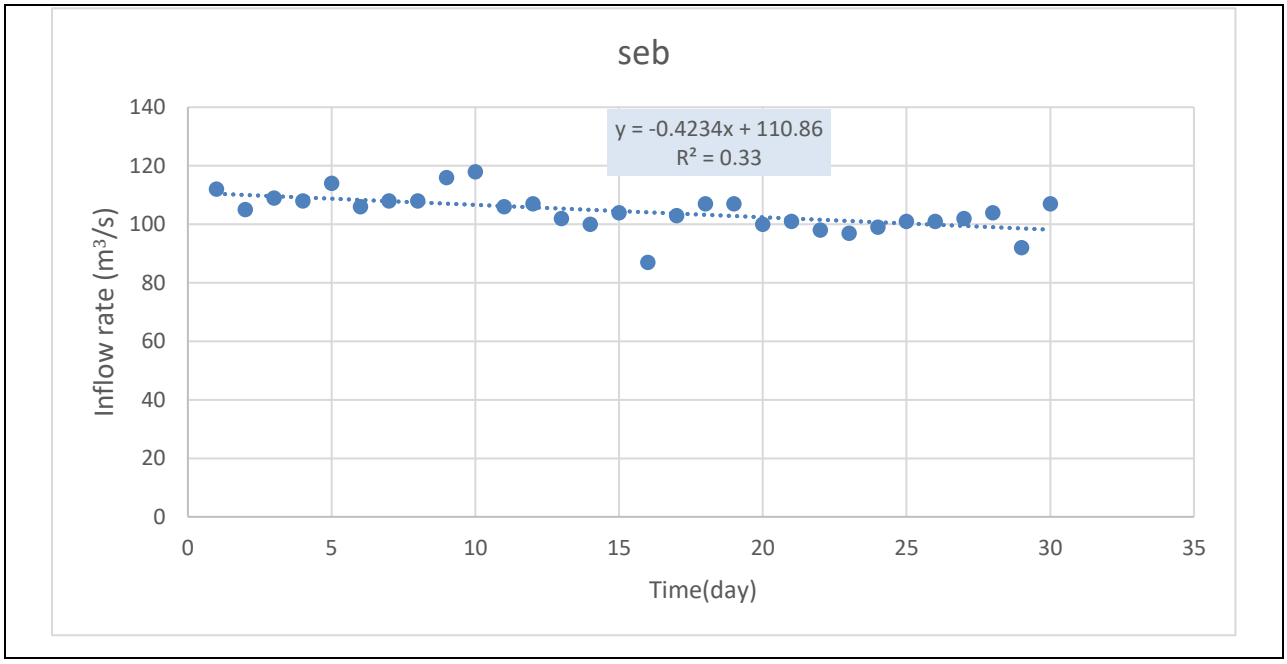

Figure 4.17: Linear regression of inflow rates toward Mosul Reservoir (September)

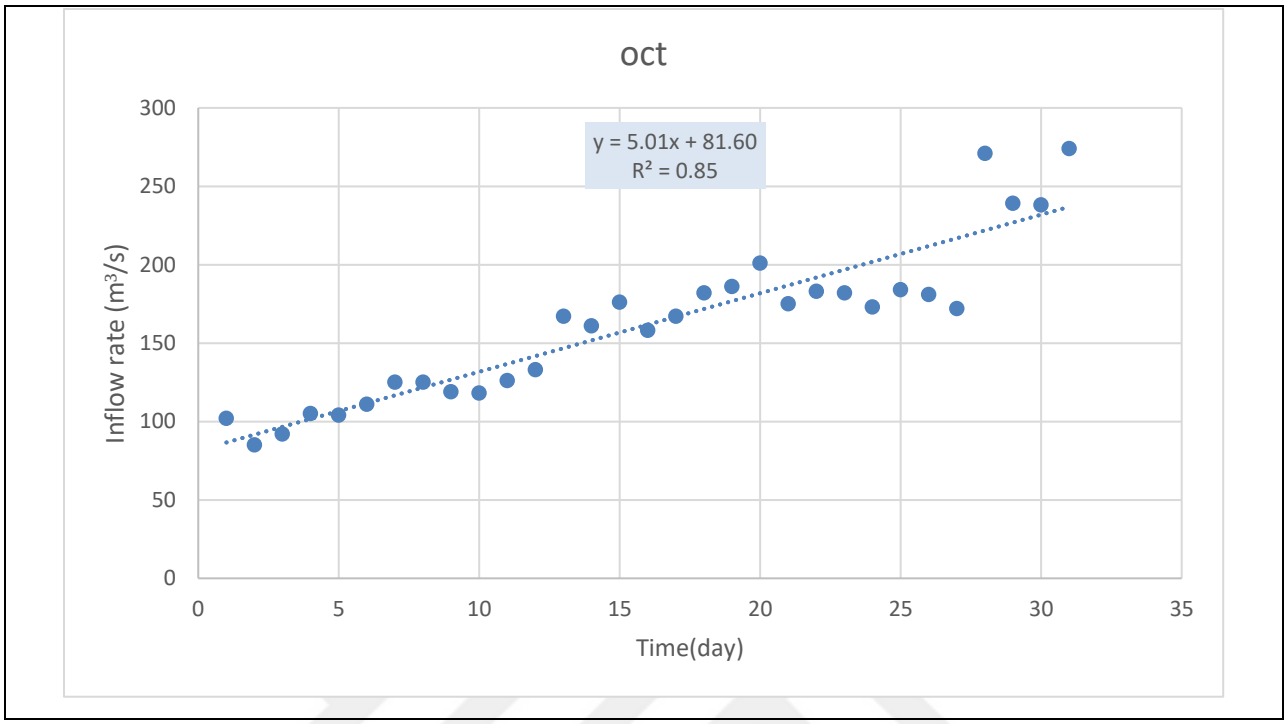

Figure 4.18: Linear regression of inflow rates toward Mosul Reservoir (October)

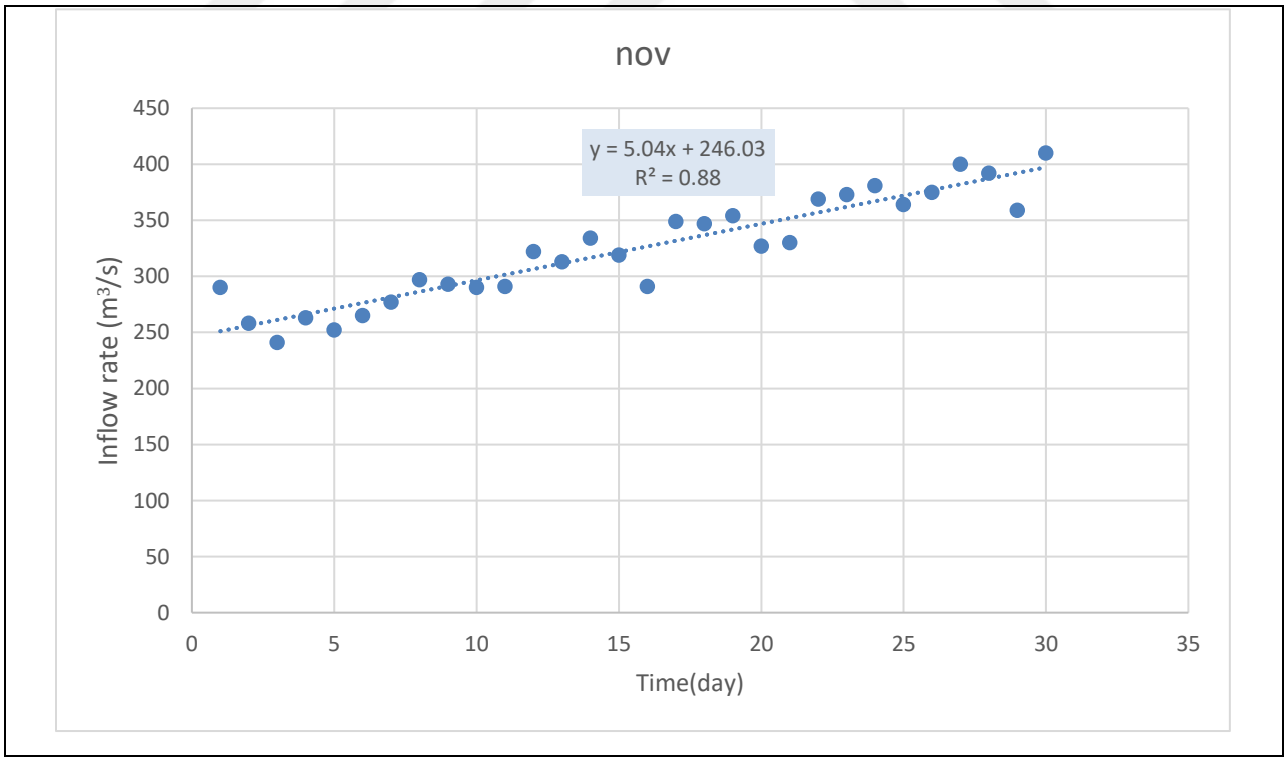

Figure 4.19: Linear regression of inflow rates toward Mosul Reservoir (November)

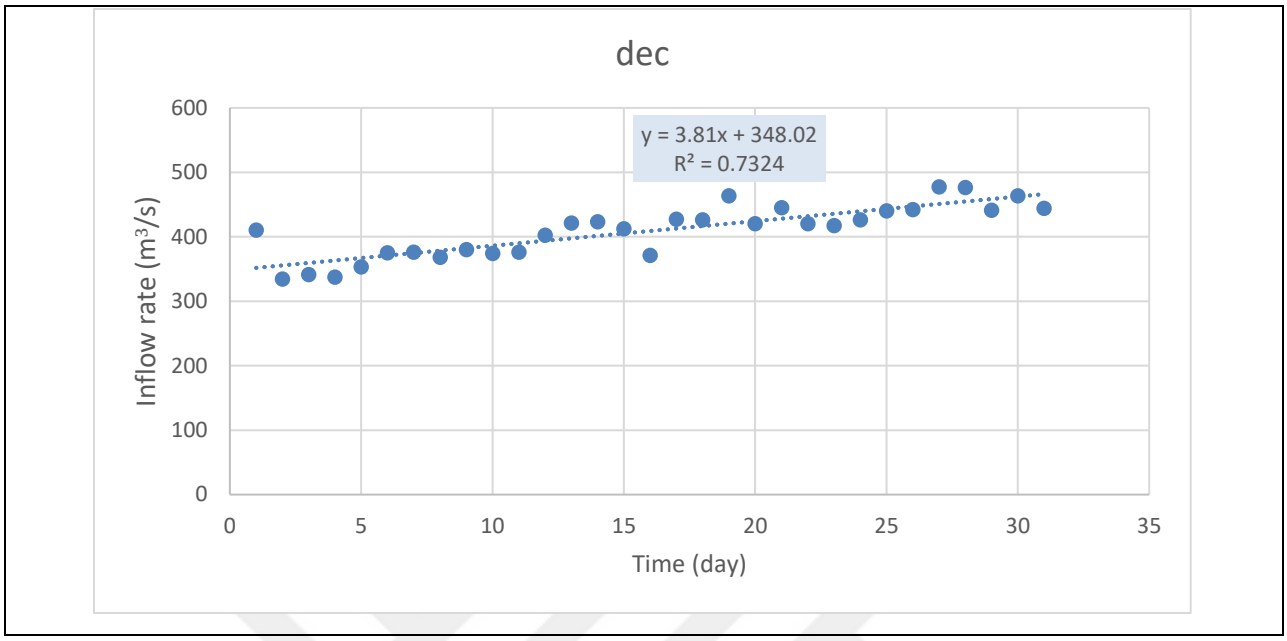

Figure 4.20: Linear regression of inflow rates toward Mosul Reservoir (December)

The summary of the predicted linear equations were as in table 4.4

Table 4.4: Linear regression formulas for inflow rates toward Mosul Reservoir

Month	Range	Daily inflow (m3/s)
1	1/1 – 31/1	y = 6.22x + 411.86
2	1/2 – 28/2	y = 15.79x + 519.21
3	1/3 – 31/3	y = 19.71x + 852.28
4	1/4 – 30/4	y = -10.95x + 1485.6
5	1/5 – 31/5	y = -14.52x + 1063.9
6	1/6 – 30/6	y = -9.44x + 518.71
7	1/7 – 31/7	y = -2.24x + 184.64
8	1/8 – 31/8	y = 0.48x + 94.52
9	1/9 – 30/9	y = -0.42x + 110.86
10	1/10 – 31/10	y = 5.01x + 81.60
11	1/11 – 31/11	y = 5.04x + 246.03
12	1/12 – 31/12	y = 3.81x + 348.02

By the water balanced equation, the change in storage volume can be determined by the following:

$$\Delta V = Q + p * A - E * A \quad (4.1)$$

$$\Delta V = Q + (P - E) * A \quad (4.2)$$

Where:

ΔV = the change in storage volume in cubic meter per month

Q = inflow rates toward the reservoir in cubic meter per month

P = precipitation in (m / month)

E = evaporation in (m/ month)

A = area of reservoir in square meters

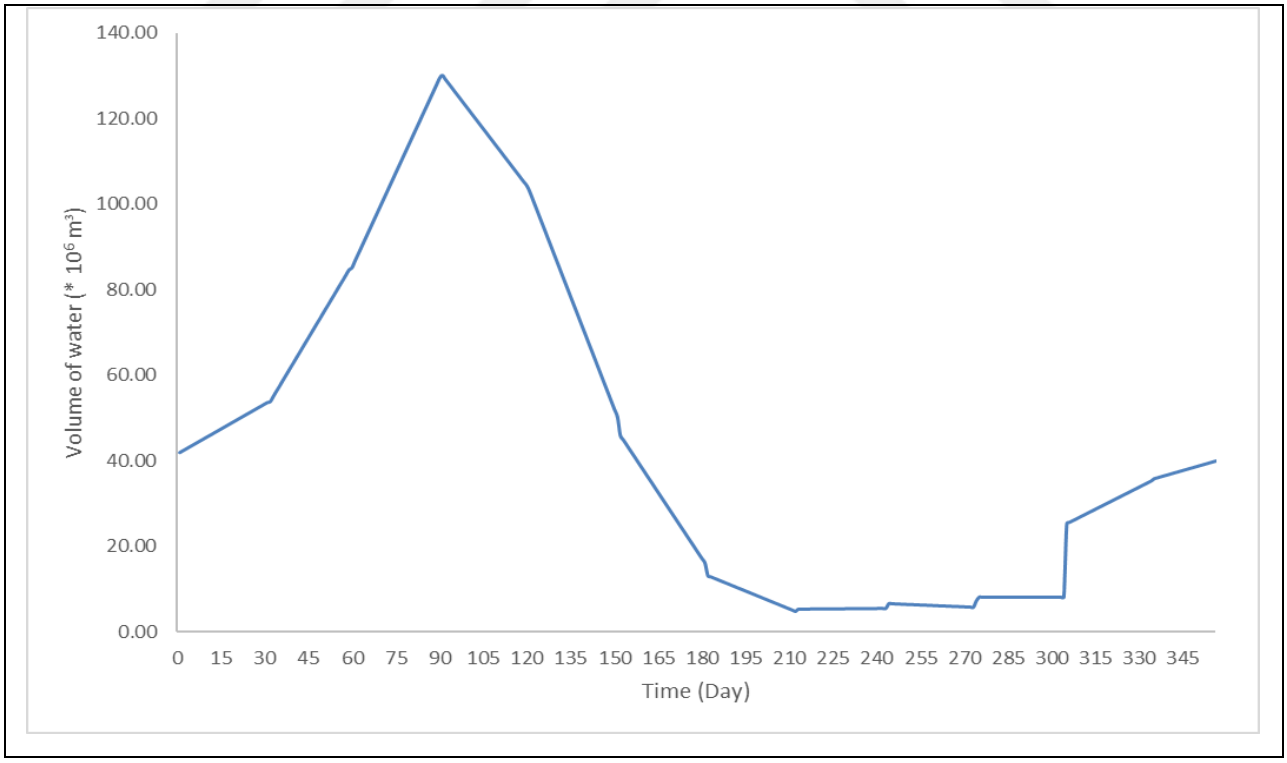

Figure 4.21: Resultant of water storage volume in Mosul Reservoir

The outflow toward the downstream area was taken as average outflow rate. In figures 4.22 and 4.23, the behavior of yearly quantity of water storage when the average outflow rate was 400 m3/s and 500 m3/s respectively.

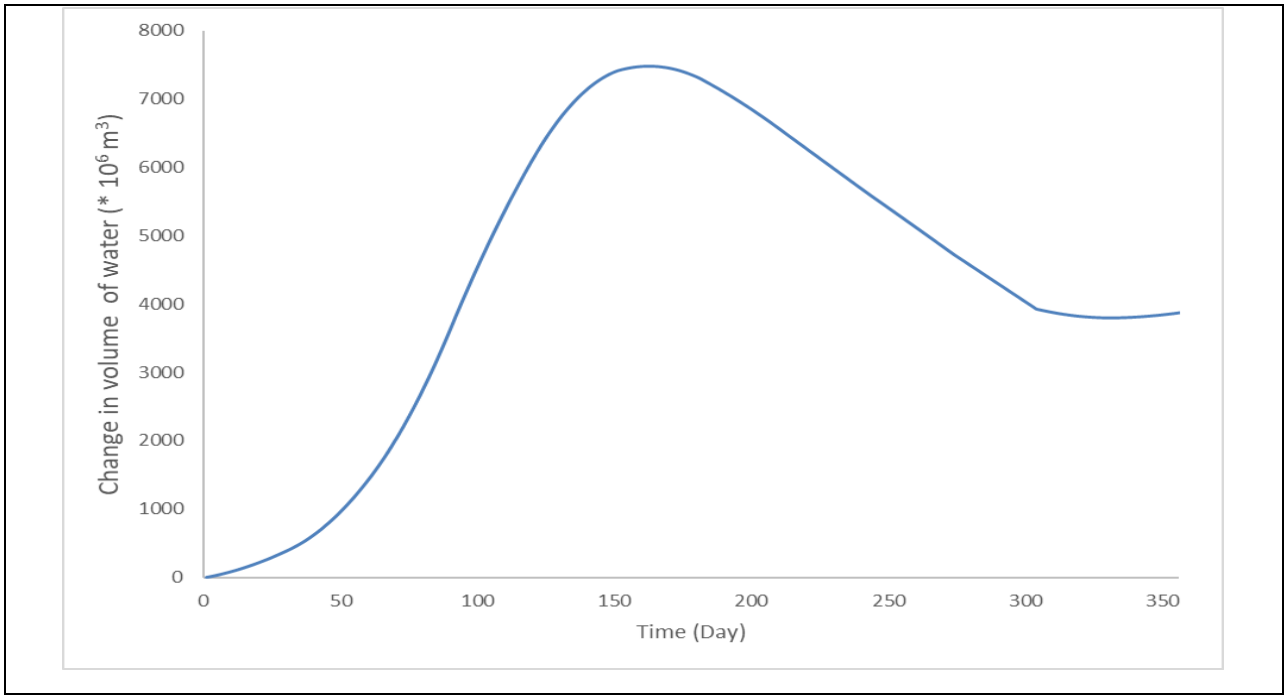

Figure 4.22: Volume of water storage in Mosul Reservoir (average outflow rate = 400 m3/s)

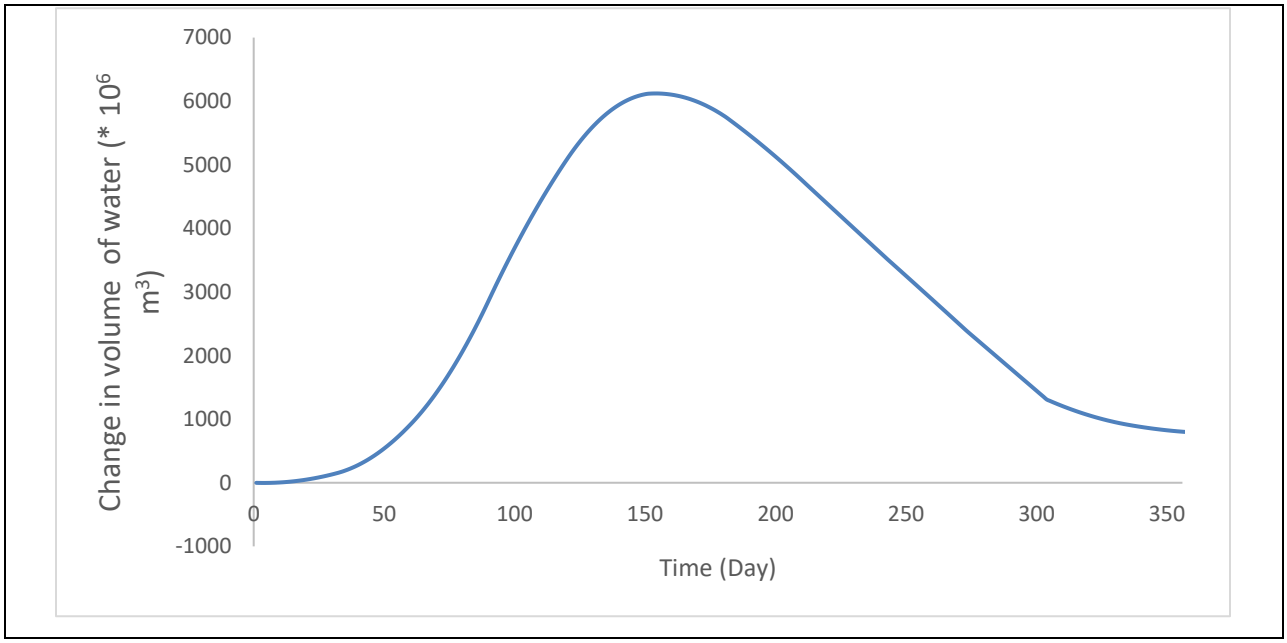

Figure 4.23: Volume of water storage in Mosul Reservoir (average outflow rate = 500 m3/s)

According to the volume elevation relationship, the accumulative volume can reach to maximum elevation as the range explained in figure 4.24

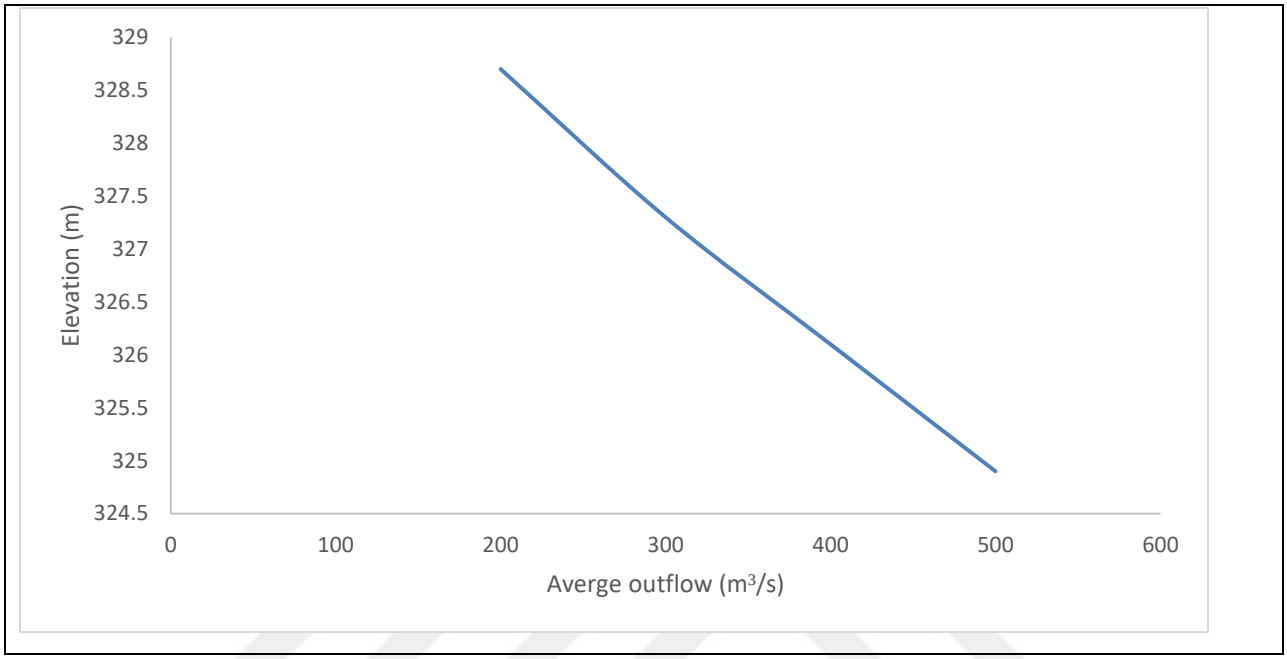

Figure 4.24: Maximum elevation of water storage in Mosul Reservoir with respect to average outflow

4.2.2 Dukan Reservoir Monthly Inflow Rates

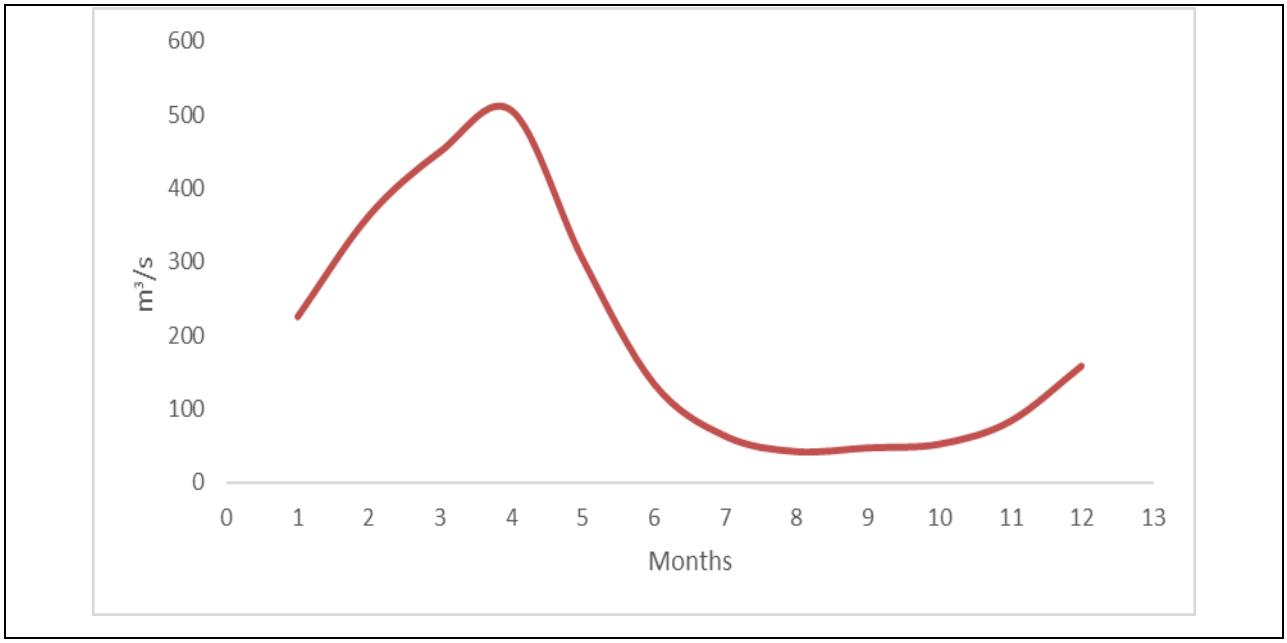

Figure 4.25: Inflow rates toward Dukan Reservoir

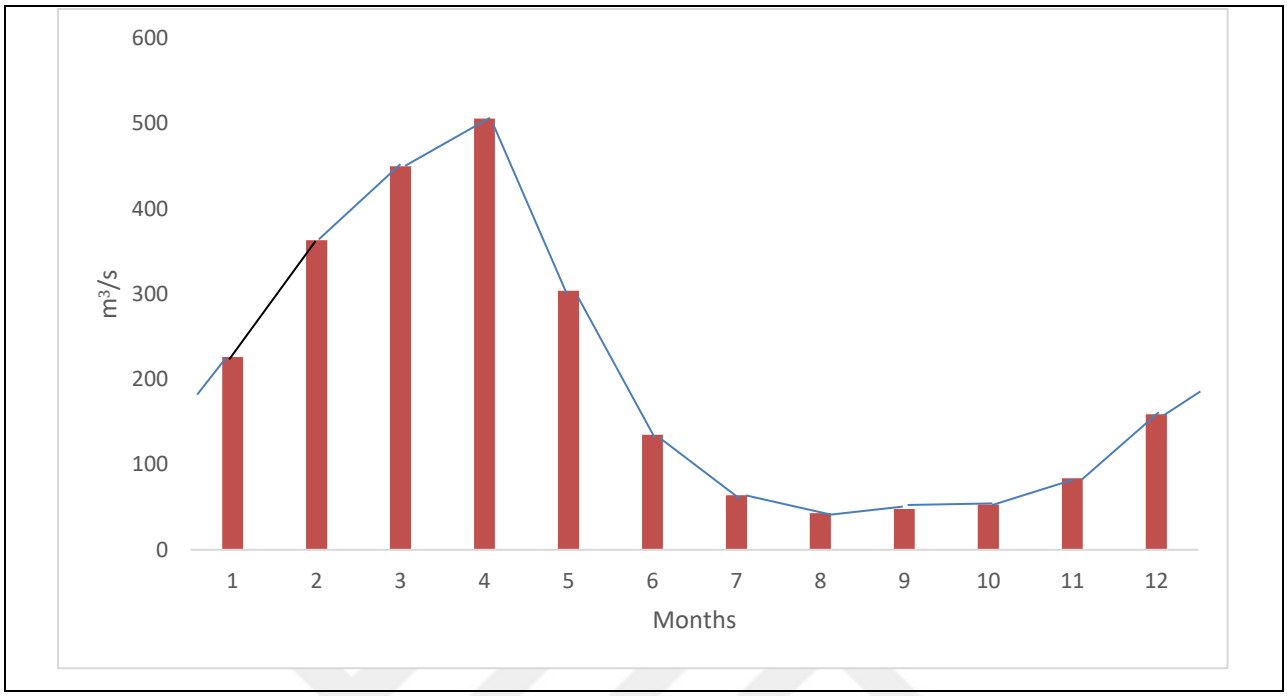

Figure 4.26: The explanation of the changing of monthly inflow rates toward Dukan Reservoir

Table 4.5: Linear regression formulas for inflow rates toward Dukan Reservoir

Month	Range	Daily inflow (m3/s)
1	1/1 – 31/1	y = 5.03x + 190.93
2	1/2 – 28/2	y = 4.37x + 310.37
3	1/3 – 31/3	y = 3.30x + 393.04
4	1/4 – 30/4	y = -4.41x + 442.29
5	1/5 – 31/5	y = -4.15x + 271.91
6	1/6 – 30/6	y = -1.73x + 121.08
7	1/7 – 31/7	y = -0.45x + 57.36
8	1/8 – 31/8	y = 0.29x + 37.63
9	1/9 – 30/9	y = 0.37x + 40.69
10	1/10 – 31/10	y = 1.14x + 44.81
11	1/11 – 31/11	y = 2.85x + 69.56
12	1/12 – 31/12	y = 2.79x + 137.01

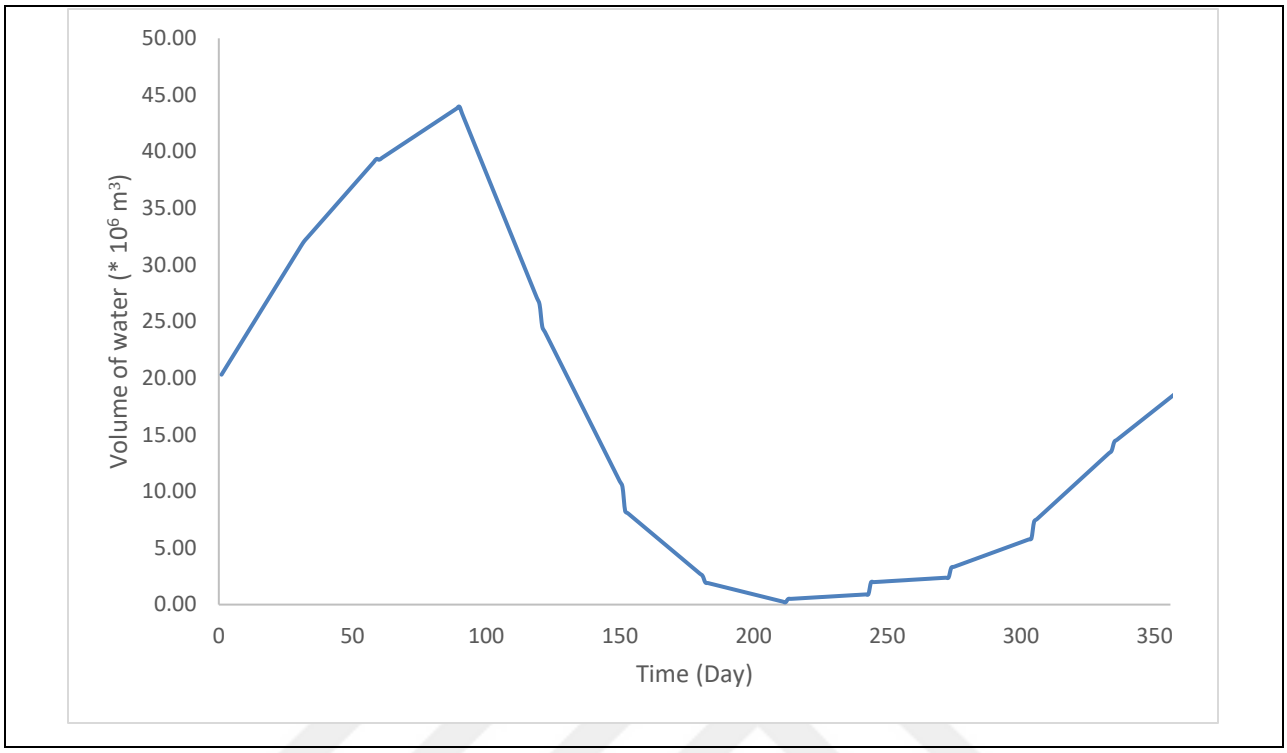

Figure 4.27: Resultant of water storage volume of Dukan Reservoir

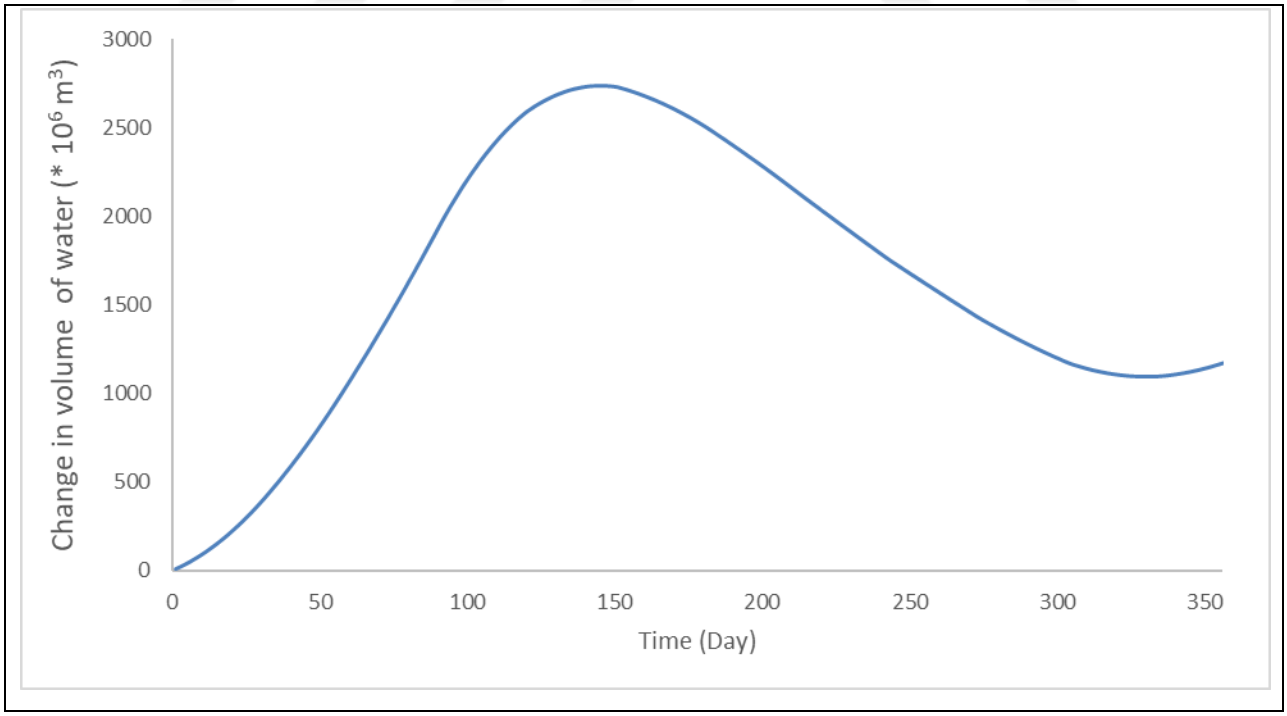

Figure 4.28: Volume of water storage in Dukan Reservoir (average outflow rate = 150 m3/s)

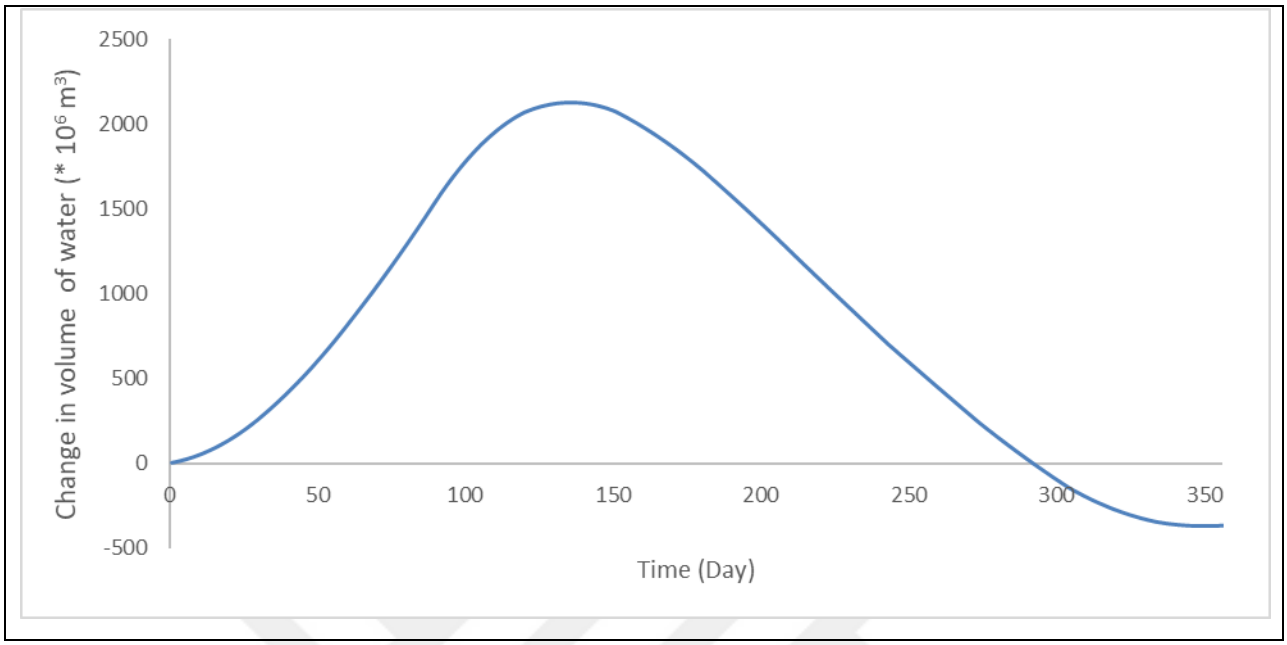

Figure 4.29: Volume of water storage in Dukan Reservoir (average outflow rate = 200 m3/s)

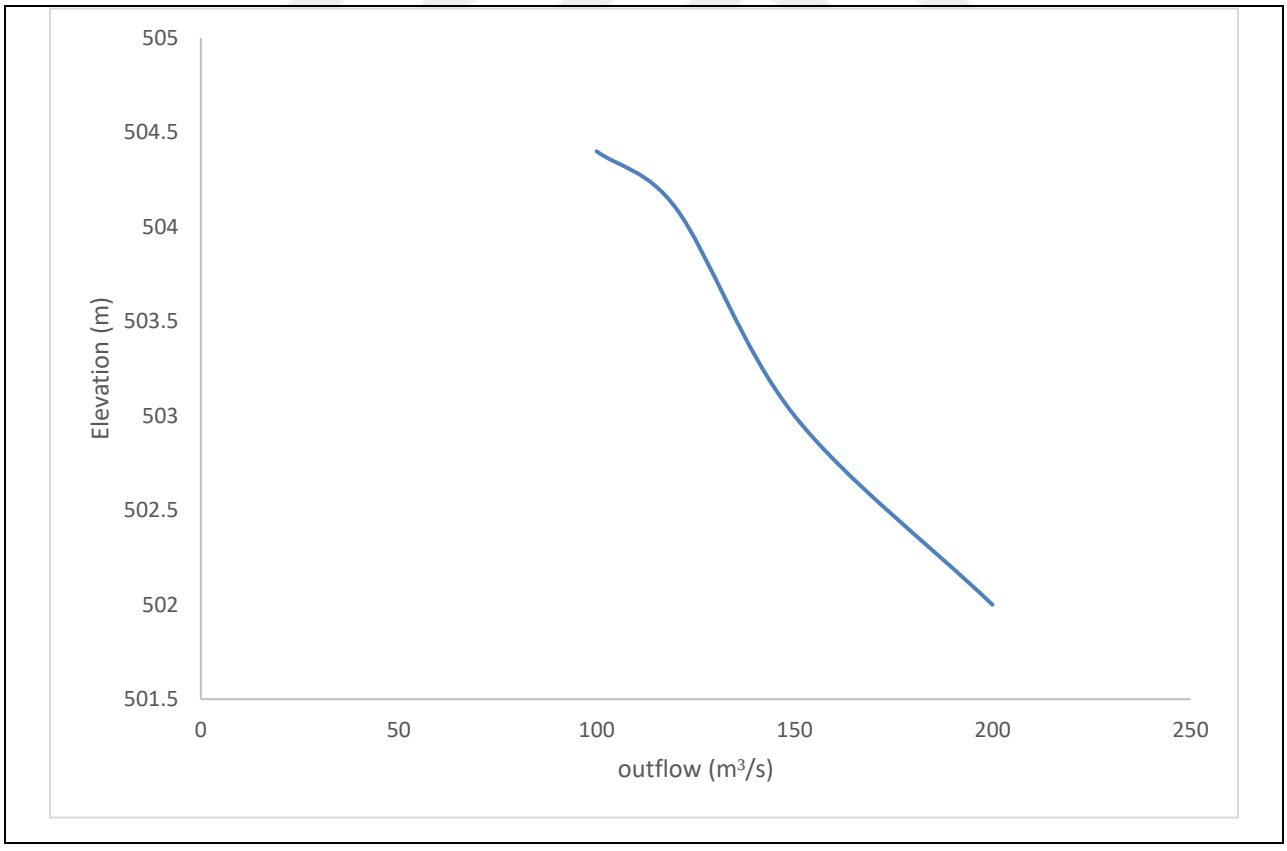

Figure 4.30: Maximum elevation of water storage in Dukan Reservoir with respect to average outflow

4.2.3 Dibis Reservoir Monthly Inflow Rates

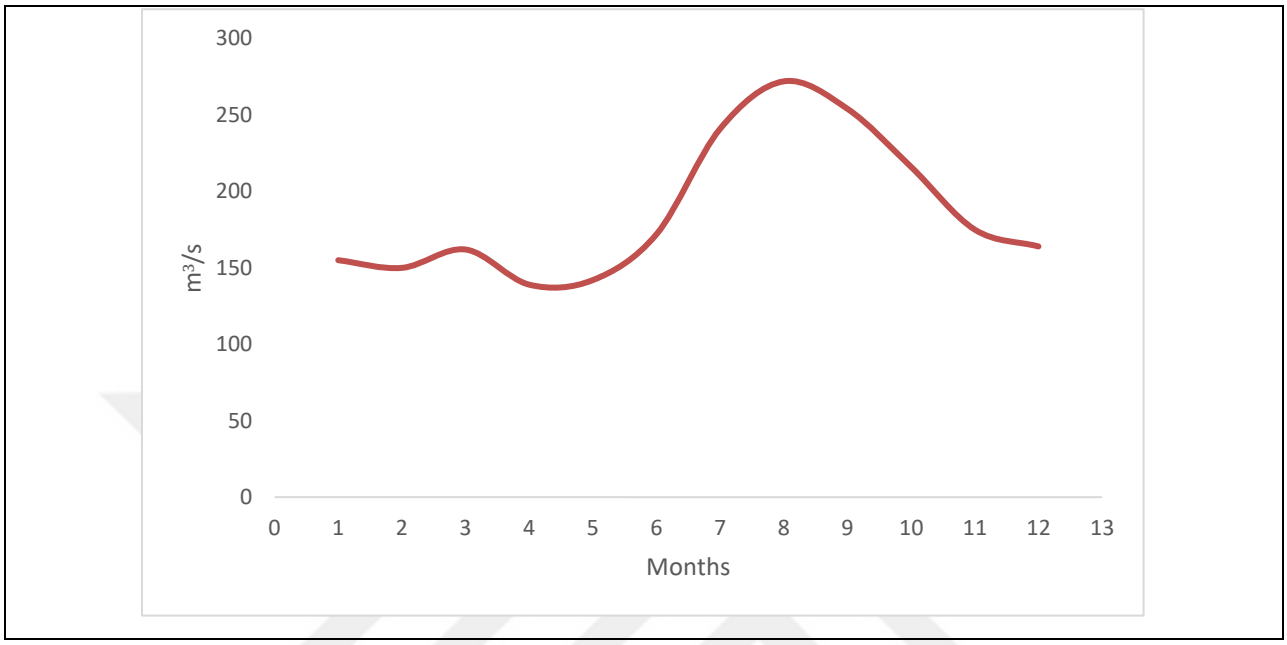

Figure 4.31: Inflow rates toward Dibis Reservoir

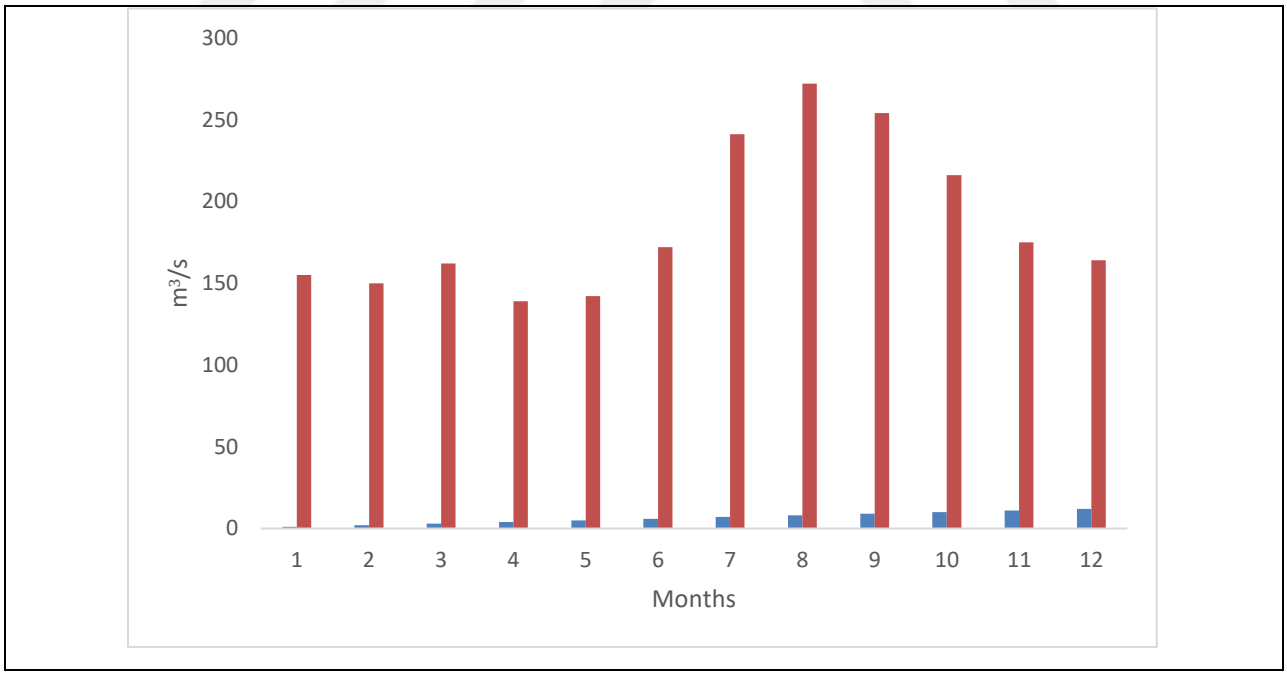

Figure 4.32: The Explanation of the changing of monthly Inflow rates toward Dibis Reservoir

Table 4.6: Linear regression formulas for inflow rates toward Dibis Reservoir

Month	Range	Daily inflow (m3/s)
1	1/1 – 31/1	y = 1.21x + 117.83
2	1/2 – 28/2	y = 1.14x + 133.37
3	1/3 – 31/3	y = -0.75x + 157.09
4	1/4 – 30/4	y = 0.71x + 125.36
5	1/5 – 31/5	y = 1.46x + 127.49
6	1/6 – 30/6	y = 2.94x + 151.29
7	1/7 – 31/7	y = 2.07x + 213.97
8	1/8 – 31/8	y = 1.73x + 209.61
9	1/9 – 30/9	y = 0.87x + 193.55
10	1/10 – 31/10	y = -1.28x + 212.91
11	1/11 – 31/11	y = 1.10x + 132.85
12	1/12 – 31/12	y = 1.09x + 125.57

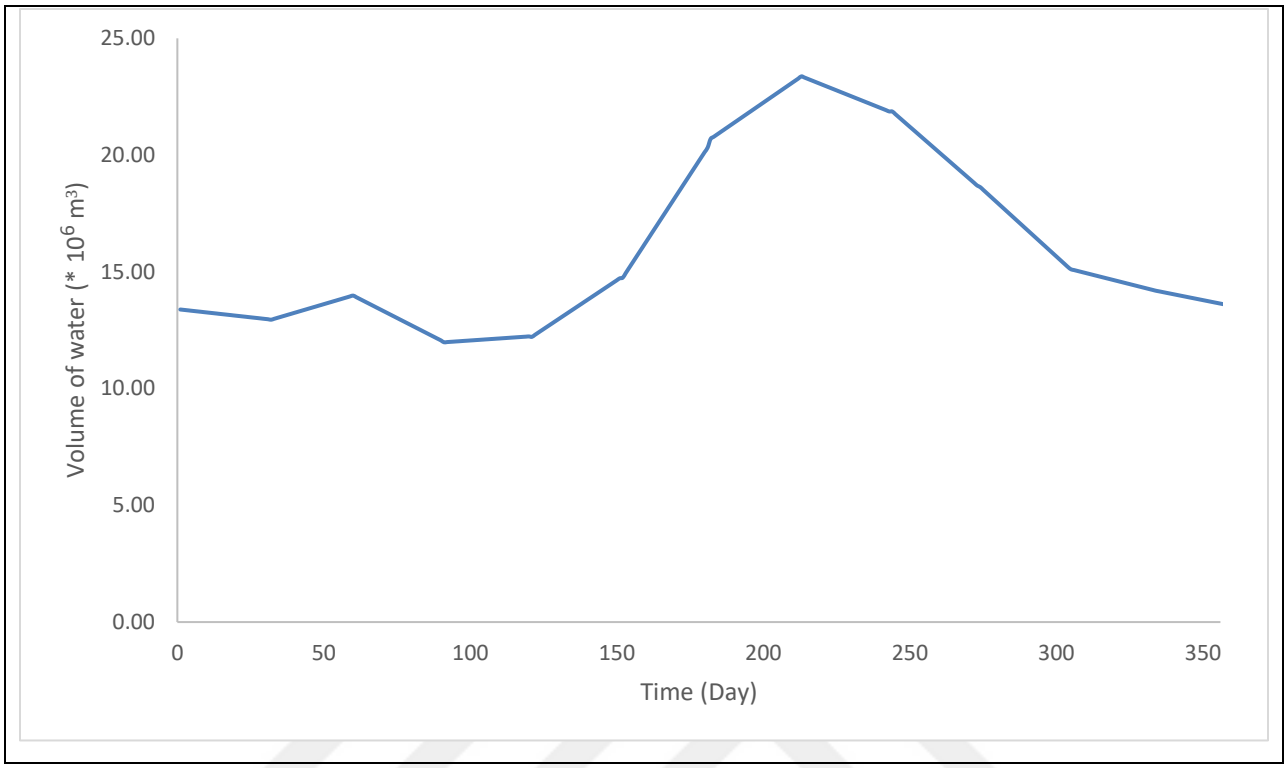

Figure 4.33: Resultant of water storage volume in Dibis Reservoir

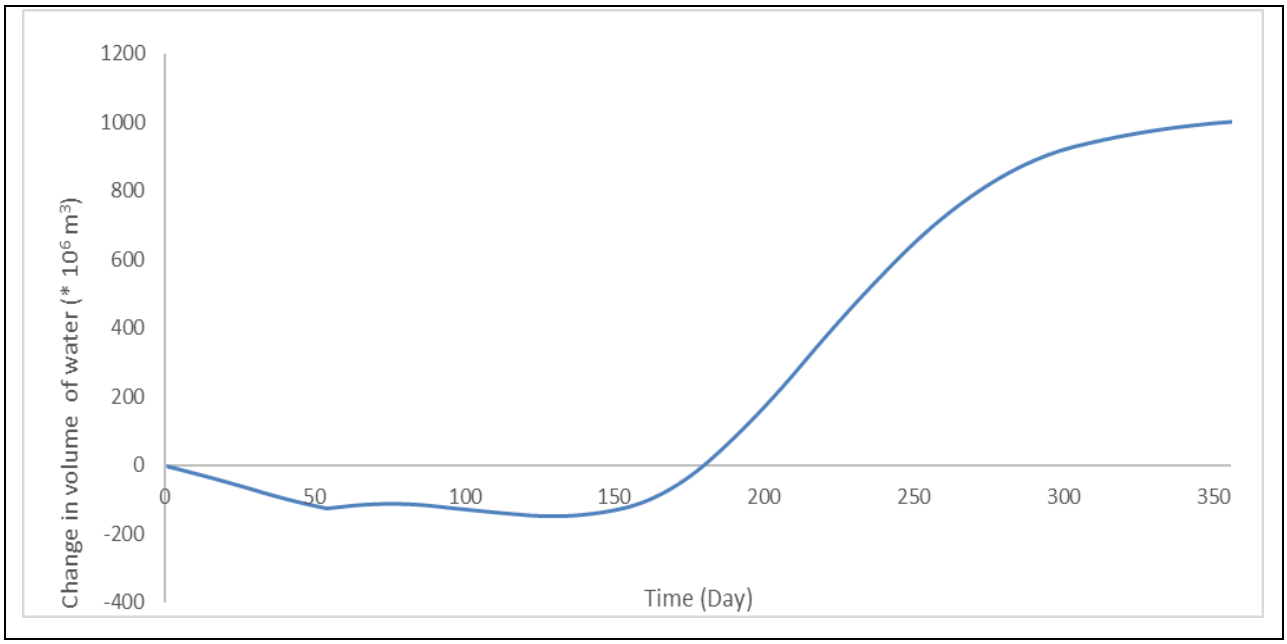

Figure 4.34: Volume of water storage in Dibis Reservoir (average outflow rate = 150 m3/s)

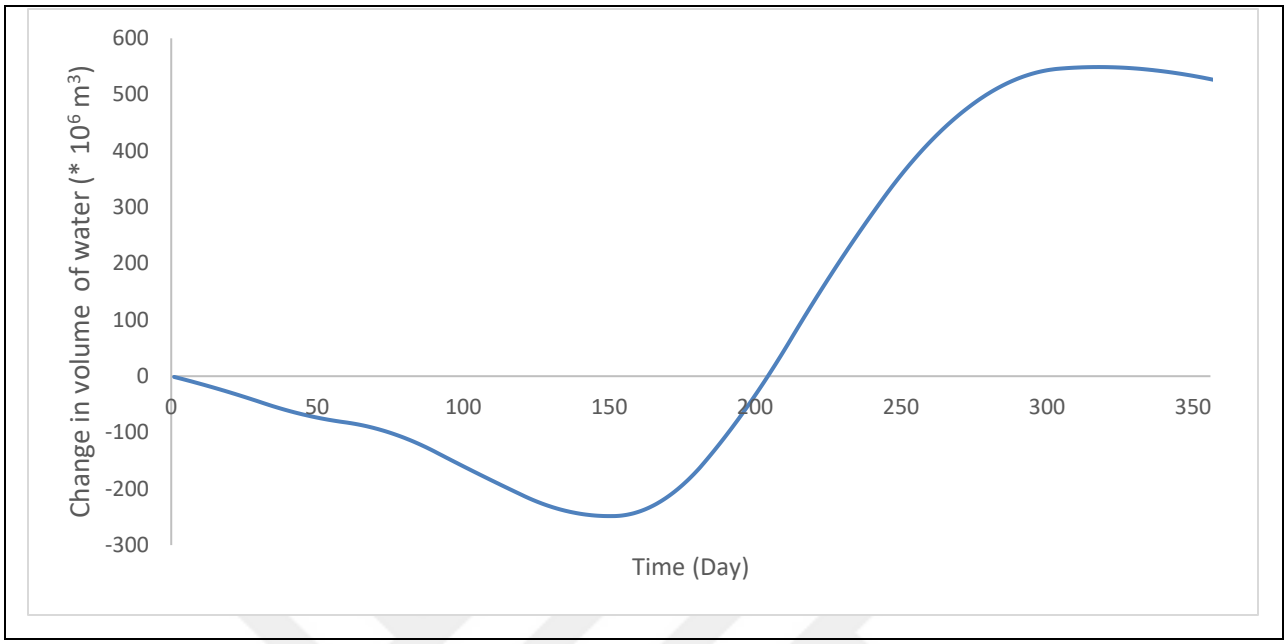

Figure 4.35: Volume of water storage in Dibis Reservoir (average outflow rate = 170 m3/s)

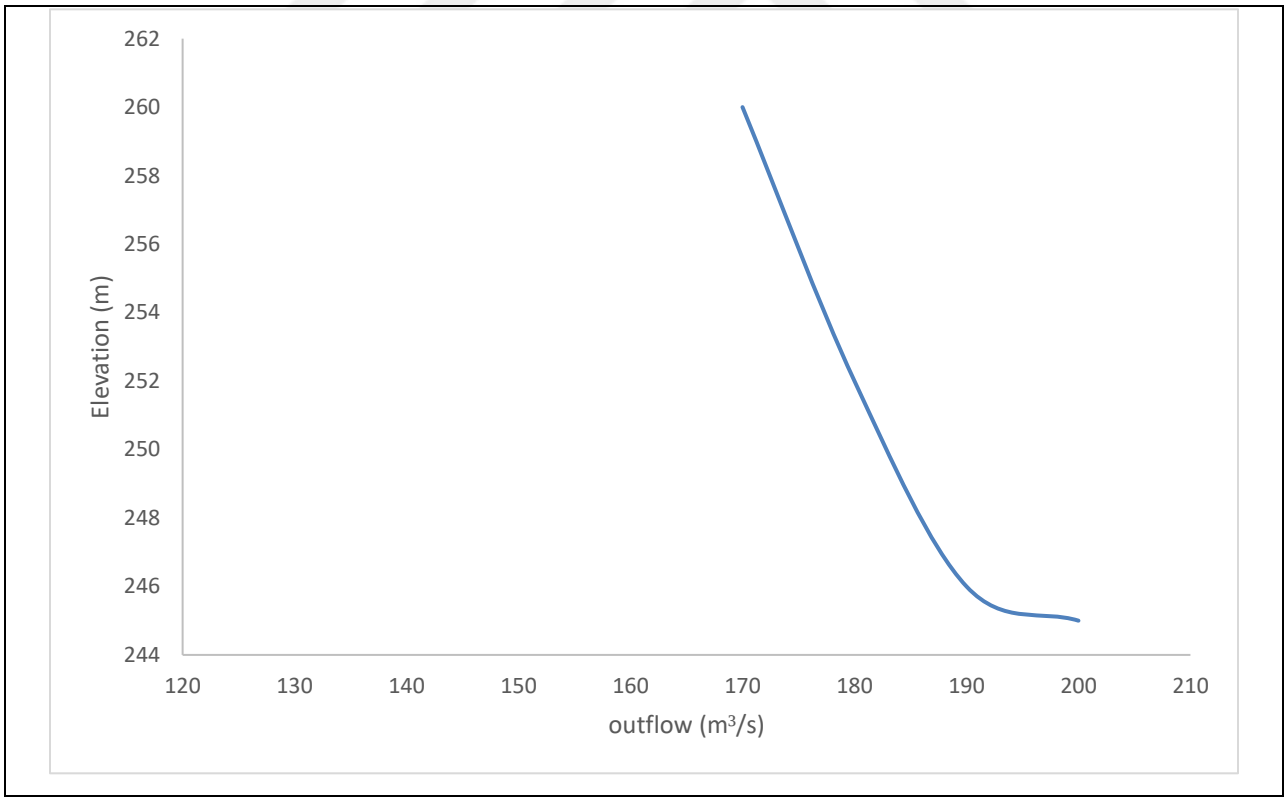

Figure 4.36: Maximum elevation of water storage in Dibis Reservoir with respect to average outflow

5. CONCLUSION AND FUTURE WORK

5.1 CONCLUSION

The analysis of the performance of three reservoirs in Iraq was carried out by the study. The reservoirs were that lied behind the Mosul, Dukan , and Dibis dams. These reservoirs varied in the topographic formation, the storage capacity, the monthly inflow rates, and the weather conditions. The study build the topographic analysis for the imagery map of each reservoir area by using Surfer program based on the GIS data. The elevation-Volume relationship was evaluated by the program that support the analysis data by building a conjunction between the water storage quantity for each reservoir in study and the predicted elevation of surface water. The surface area of each dam was determined in normal elevation to be used under water balanced equation for assigning the effect of the rainfall intensity and the evaporation on the overall storage of water. The inflow rate for each month was linearized then resultants formulas that link the positive and negative changing in volume per day for each reservoir was implemented. The study showed the change in storage volume average outflow for Mosul, Dukan, and Dibis Dams that conserve high and low fluctuation in volume change variation in storage of water. For Mosul Dam the outflow rate was test in 400 m^3/s and 500 m^3/s, For Dukan dam in 150 m^3/s and 200 m^3/s, and for Dibis Dam in 150 m^3/s and 170 m^3/s. the inflow rates diagrams for Dibis dam showed high increment of water volume in July, August, and September months while the Dukan and Mosul Dams showed increment in storage for the months of March and April. The difference for the increment range in Dibis Dam can be reflect the effect of the Dam by the output of Dukan dam as the two dams placed on the stream line of the Lesse Zab River. The elevation change of the surface area was explained by the study in related graphs with respect to outflow rates. For Mosul dam the elevation can raise to about 330 m for less than 200 m^3/s in normal inflow conditions. For Dukan Dam, the elevation up to 504 m when the outflow rate round to 100 m^3/s. For Dibis Dam, the elevation can reach about 260 m for outflow less than 150 m^3/s. the study outline aimed to support the controlling of these reservoirs for better management in current and upcoming time.

5.2 FUTURE WORK

a) The future idea can be based on the mathematical modeling of water demand to assess the contribution of water storage to different uses of water such as domestic consumption, irrigation and industrial sector.

b) Upcoming studies could cover the issue of the effect of sedimentation on the storage capacity of aquifers in the ecological and hydrological pathways.

c) The feasibility of the hydroelectric power system is one of the effective matters that can be analyzed in the storage capacities of the reservoir as population growth has increased and the need for a sustainable source of electricity has increased for a long time.

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APPENDIX A

The following table included the data that gained from the Iraqi Ministry of Water Resources about the recorded average inflow rates toward the three reservoirs in the year of 2021.

Table A-1: The Inflow rates (m^3/s) toward Mosul reservoir

Day	1	2	3	4	5	6	7	8	9	10	11	12
1	480	620	990	1520	1210	580	210	110	112	102	290	410
2	401	550	861	1586	962	495	176	92	105	85	258	334
3	396	550	887	1497	930	481	164	91	109	92	241	341
4	433	530	847	1464	920	467	177	94	108	105	263	337
5	448	606	920	1447	996	436	167	94	114	104	252	353
6	454	602	982	1370	938	446	164	90	106	111	265	375
7	457	647	1002	1443	985	461	160	101	108	125	277	376
8	470	652	1016	1386	910	423	159	100	108	125	297	368
9	441	632	1060	1420	933	412	157	95	116	119	293	380
10	481	697	1047	1352	892	413	163	100	118	118	290	374
11	459	708	1076	1278	948	409	160	104	106	126	291	376
12	466	687	1148	1367	881	410	164	99	107	133	322	402
13	496	757	1072	1247	930	406	161	101	102	167	313	421
14	535	713	1144	1284	892	385	160	101	100	161	334	423
15	530	769	1130	1321	902	381	163	102	104	176	319	412
16	477	708	1042	1122	767	356	134	89	87	158	291	371
17	531	799	1212	1364	870	368	154	105	103	167	349	427
18	559	859	1240	1266	837	373	149	114	107	182	347	426
19	544	842	1251	1343	865	373	151	110	107	186	354	463
20	494	778	1195	1171	759	332	138	97	100	201	327	420
21	525	801	1215	1170	722	328	139	109	101	175	330	445
22	565	839	1287	1239	772	304	127	105	98	183	369	420
23	536	824	1354	1285	731	311	137	105	97	182	373	417
24	564	925	1394	1195	694	291	128	106	99	173	381	426
25	545	886	1379	1174	707	291	133	111	101	184	364	440
26	577	967	1447	1265	719	279	122	104	101	181	375	442
27	580	997	1350	1235	678	254	129	113	102	172	400	477
28	608	1004	1381	1266	650	246	123	112	104	271	392	476
29	569		1301	1107	546	209	113	102	92	239	359	441
30	629		1519	1291	647	248	119	112	107	238	410	463
31	604		1450		586		110	104		274		444

Table A-2: The Inflow rates (m^3/s) toward Dukan reservoir

Day	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
1	226	363	450	506	304	135	64	43	48	53	84	159
2	181	298	354	406	246	116	52	38	38	45	70	141
3	198	300	392	411	241	113	55	34	40	48	73	140
4	209	320	400	398	241	103	53	35	40	47	77	147
5	217	308	400	398	251	107	51	40	40	49	84	144
6	213	336	413	413	243	105	54	40	43	51	88	151
7	224	349	388	406	249	111	54	37	41	49	90	154
8	233	349	415	394	247	107	56	40	42	52	93	157
9	239	357	436	402	226	100	54	42	43	54	97	163
10	229	344	421	395	229	106	52	42	47	54	93	166
11	247	356	447	401	222	107	51	39	48	61	105	174
12	242	354	429	386	221	101	52	43	47	58	104	166
13	260	395	442	385	217	103	52	43	45	60	108	168
14	260	377	441	407	225	96	55	43	47	63	107	184
15	291	396	463	406	220	103	52	42	47	66	113	183
16	235	351	410	335	187	86	46	38	43	55	104	167
17	283	395	479	405	206	95	50	43	52	69	126	181
18	301	395	492	374	208	94	52	47	50	71	129	194
19	302	418	495	403	216	93	53	44	49	72	132	201
20	271	397	433	358	179	85	46	44	49	68	125	192
21	306	412	435	331	182	80	47	44	49	65	121	194
22	314	381	473	325	171	78	48	44	46	68	135	190
23	305	391	456	337	181	83	49	44	48	69	126	203
24	305	411	468	320	170	80	46	46	49	75	133	197
25	334	409	461	324	175	78	48	46	50	72	140	208
26	334	452	494	321	163	76	44	45	49	76	148	214
27	337	417	511	323	161	76	47	46	50	79	155	220
28	343	437	500	338	164	74	46	49	54	77	157	218
29	304		433	280	135	62	40	41	47	70	140	207
30	350		510	328	156	73	44	47	55	83	159	233
31	323		482		131		41	46		79		220

Table A-3: The Inflow rates (m^3/s) toward Debis reservoir

Day	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
1	155	150	162	139	142	172	241	272	254	216	175	164
2	121	134	151	119	126	142	197	214	187	208	138	118
3	113	134	157	126	119	154	206	208	183	197	126	128
4	114	137	150	126	132	155	208	203	189	214	129	120
5	124	138	156	116	130	162	210	198	187	199	129	126
6	121	129	164	125	126	171	218	218	207	212	135	132
7	128	132	160	126	136	175	224	221	200	199	136	130
8	120	132	151	123	137	171	227	211	201	207	136	131
9	126	149	164	133	142	168	221	224	200	202	133	135
10	121	137	135	132	145	174	233	226	191	200	141	138
11	129	140	138	134	145	174	224	218	201	189	136	129
12	134	152	150	138	141	193	250	238	194	205	147	138
13	135	151	147	132	145	198	249	231	197	192	150	135
14	129	155	143	132	149	195	253	243	195	199	155	137
15	134	153	147	142	153	195	262	219	202	200	148	144
16	129	150	121	144	153	207	249	236	199	196	157	144
17	139	161	145	142	151	205	268	237	203	203	148	149
18	143	165	155	146	164	212	257	233	213	195	153	145
19	142	159	145	144	169	215	275	238	217	207	159	148
20	148	163	130	149	170	216	280	245	213	174	148	147
21	139	164	142	150	160	215	280	233	207	170	155	144
22	149	157	131	149	162	222	282	249	221	175	166	142
23	143	167	144	150	163	240	282	256	215	185	159	154
24	144	158	140	143	171	230	259	249	211	175	163	155
25	146	162	144	141	162	220	247	251	209	174	157	153
26	153	161	137	140	160	220	253	264	225	178	160	153
27	149	155	135	139	171	220	274	258	228	186	158	160
28	153	155	148	139	171	238	259	271	211	182	169	157
29	154		121	131	151	217	242	272	230	169	162	153
30	157		147	141	178	230	283	259	224	189	173	167
31	162		137		154		250	261		165		161