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ENHANCING THE APPLICATION OF SUSTAINABLE ENERGY IN IRAQ BY DESIGNING OF PUMP STORAGE HYDROPOWER NETWORK

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Master's Thesis

Supervisor

Assoc. Prof. Dr. Sepanta NAİMİ

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ABSTRACT

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The matter of sustainable energy is so significance line to be studied as this source of energy can serve the environment for the accumulation of pollutants and can improve the development in various sectors. Hydropower is one of these energies that can be based on the falling of water in the region of dams. In Iraq, the increasing of population lead to seek the ways to enhance the using of more types of electrical source that can adopt by the many dams that constructed on the water resources. The study examined the degree of improvement that can be obtained from construction of hydropower systems after the dam's body of Mosul, Dukan, and Darbandikhan. For each dam, the variation of height as the water surface of reservoirs were detected. The study used the Surfer program to process the GIS information of the dams regions and evaluation the contour lines. The study analyzed the ability to take the benefits from hydropower stations according to the inflow toward these regions, the topographic of the upstream areas, and the weather conditions. Each dam was analyzed with respect to water quantity balance. The predicted change in head per month for the three dams were set in specific tables to show the variety of available head along the period of operation. The head and the available discharge toward the turbines (as portion of the total outflow) were considered in the power equation to find the amount of power that could be generated in each month for the three dams. The generated powers were explained in tables. The results indicated that the Mosul Dam can give highest amount power following by Dukan and Darbandikhan dams. The study showed in figures (using Microsoft Excel program) the verity of these amounts of generated powers for each month. The study use the correlation techniques with supporting of Matlab program to derive effective formulas that link the inflow rates toward the turbines with the amount of power generated. The formulas were set in tables for the three dams that divided for each month.

Keywords: Sustainable Energy, MATLAB Program, Hydropower Network, Outflow.

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ABBREVIATIONS

KW	:	Kilo Watt
Hd	:	The Main Inflow to The Reservoir
Hp	:	Surface inflow to the reservoir from adjacent areas
Ho	:	Outflow quantity of water
Hopp	:	Subsurface Outflow from The Reservoir to Adjacent Areas
Hw	:	Amount of Seepage

LIST OF SYMBOLS

H : Available Head

Q : The Rate of water quantity that move through the turbine

ή : Overall efficiency

P : Quantity of precipitation

E : Amount of evaporation

1. INTRODUCTION

1.1 INTRODUCTION

Renewable energy is one of the vital sources to meet the various requirements all over the world. Wind, biomass, nuclear and hydropower are among the renewable energy sources. One of the most consistent and flexible renewable energy sources is hydroelectricity. In addition to the production of this energy, hydroelectric dams are of great importance for irrigation [1]. The consumption of electric energy is mainly in city centers compared to remote areas, and this can be observed in most countries of the world [2].The development of using of hydroelectric energy is important step to respond to all human needs and to be an alternative to other sources of energy such as coal and wood fuels. It can support the providing local electric energy [3]. Hydropower or water power is power derived from the energy of falling water or fast running water, which may be harnessed for useful purposes. Since ancient times, hydropower from many kinds of watermills has been used as a renewable energy source for irrigation and the operation of various mechanical devices, such as gristmills, sawmills, textile mills, trip hammers, dock cranes, domestic lifts, and ore mills. The hydropower system can be considered as low negative impact project for environment. It not involved the problem of greenhouse gases nor leading to generation of acid rain or any other atmospheric pollution that causes dangerous reflection on the human nearby [4]. The potential energy in the water is converted to produce electricity using pumps and turbines. The water is pumped to high levels for the purpose of storing energy. A system consisting of a channel containing a pressure column, a main and rear tunnel and a suction pipe is used for the purpose of connecting the hydroelectric power station to the lower and upper tanks, and these parts are also used in the traditional way [5]. Most of the Arabian Peninsula countries have not adopted solar energy due to the fact that oil is relatively cheap and easily accessible. There are no incentives to look for alternative forms of energy at this time. In addition, protecting the environment is not a top priority. From an economic point of view, hydropower generates many profits because it is multifunctional and of a sustainable nature. The hydroelectric project does not consume the water that is stored, as the water flows continuously without decreasing its quantity, meaning that there are no losses in the water of the river, which represents the water resource [6]. The flow of reservoir water has great importance in generating electric power, and this quantity is measured in cubic meters per second. These water reservoirs are built to benefit from them in many aspects, such as controlling flood waters, correct management of reservoir water flow, controlling the discharge rate of water and identifying the lowest flow for water [7]. Dam construction is mostly aimed for multiple functions, including irrigation water provision, hydropower, and some others that bring substantial social benefits. However, global warming impacts on the interaction of the positive outcomes of damming remain little known, particularly in terms of the sustainability of their co-benefits . For conserving the amount of electrical energy, especially in the processes of generation and consumption, there must be a balance between them, that any imbalance in this system causes fluctuations in voltage and frequency, and when it reaches the worst cases, this leads to a power outage as a result of exposure of the energy operating system to danger. Peak hours are one of the most difficult times to achieve a balance between generation and consumption [8]. Tigris and Euphrates rivers are the main rivers in Iraq, and they are considered important sources for providing water for all aspects of life such as agriculture, industry, human uses and others. The energy security and supplies of energy are the key components for progressing countries. Renewable energy resources are rapidly being recognized as clean sources of energy to withstand damages to environment and to avoid future crisis, energy consumption and energy demands in the progressing Middle East countries are reviewed. First, the growth of energy consumption of the region through recent years is presented which show the rapidly growing energy demand in the Middle East countries. The northern region of the country depends on the water resources of the .Tigris River, and the geographical location of this region is important in water management in Iraq [9]. The matter of increasing the construction of hydropower plants in Iraq was discussed in past time because the availability of many positions of water storage in northern of Iraq behind the dams. Due to different obstacles, the subject of hydropower still not take place for satisfying the real needing for using of sustainable energy [10].

1.2 PROBLEM STATEMENT

Needing of using energy source that sustainable and environmentally friendly is so important way for supporting the reclamation in ecosystem and improve human life condition. In Iraq consuming of electricity rising rapidly due two increment of population and their requirement and the growing of industrial sectors and other construction projects.

Using of hydropower energy can support the improvement of the availability of electricity to cover future expansion and development.

1.3 CONTRIBUTION

Renewable energy is a useful energy collected from renewable resources, which naturally supports a clean environment and human life. Hydroelectric power is one of the important applications of using this type of energy. The study includes investigating the design of the hydroelectric storage network for pumps. The network design is based on meter lines, reservoir distribution before dams, and terrain in Iraq to improve electricity generation.

1.4 AIM AND OBJECTIVE

The study aimed to build a design of Pump Storage Hydropower Network for improving the application of sustainable energy that covered the places of reservoir before dams of Dukan, Mosul, and Darbandikhan in Iraq for satisfying the generation of electricity using potential water energy according to the availability of using elevated storage water.

This study involved the following:

a. Geometrical and Hydrological analysis of the study zones including contour lines behavior, water resource distribution mainly the places of reservoirs behind dams, average water demand, evaporation rate, and seepage.

b. Using Excel program to apply statistics formulas for bonding the raw data and results of part one.

c. Applying scientific equations of fluids and electricity generation with water head for building the network design, the input parameters include flow rates, water levels, reservoirs capacities, required efficiency, generation capacity, average water demand, and any other useful information.

d. Using Matlab Software for deriving and explaining the results in graphs and diagrams.

2. LITERATURE REVIEW

2.1 HYDROPOWER TECHNIQUE

Hydroelectric power stations are equipped with generators and turbines, as they are operated using hydropower, which in turn generates electric power. As the water energy is initially converted into mechanical energy, and then this energy is converted into electrical energy. The process of energy conversion, in which energy is lost by a specific amount, is due to generators as well as turbines [11]. Iraq is heavily dependent on the Euphrates and Tigris, which provide nearly all of the water supply; groundwater accounts for only 2-9% of all withdrawals. As a consequence, the trans boundary twin rivers originating in Turkey are at the very heart of both the water challenges in Iraq and regional controversies over diminishing water flows and deteriorating water quality. Moreover, Iraq ranks among the countries most vulnerable to climate change; the consequences of climate change, such as changing precipitation .The hydroelectric tank prefers to absorb and retain water at a level that is at the lower limit of the design level, for the purpose of storing the largest amount of energy for the purpose of generating hydroelectric power on a daily basis, as well as for the purpose of preventing any spillage that occurs at the dam. The energy that is stored in the water storage region increases gradually and cumulatively with the rise in the water level [12]. The development of the operational policy of the reservoir includes, in the first place, some complex operations for the purpose of improving the total amount of stored energy in the reservoir, as well as other requirements of the reservoir, if any. For hydroelectric power, flood control is the secondary function of a dam and reservoir which is generally not exploited [13]. In addition, since the annual flow of many sediments that are recorded for the purpose of exceeding the design value of the amount of water and the presence of sediments that are deposited inside the living storage of the reservoir in the case when there are large floods, the reservoir continues to lose a lot of its storage capacity For water [14]. The hydroelectric power stations contain two basic configurations, one of which represents dams that have reservoirs and the other represents river flow stations, which are without reservoirs. The dam scheme can be divided into small dams with the organization process that takes place at night and day, as well as large dams that include stations which it is reversible for the purpose of pumping storage and the purpose of this is for energy storage in addition to continuous regulation at night and day and seasonal storage [15]. The process of designing small hydroelectric power is usually done for the purpose of operating in the river. This process is considered not affecting the environment because there is no significant interference with the natural flow of river water. Small hydro power is often used for generation applications that are distributed unlike diesel generators and other types of small power stations dedicated to providing electricity to serve the rural population. The water that is released from the reservoir on the upper side of the inlet dam which has sufficient potential energy and that it flows through a tunnel or tube to the turbine. Hydropower is a clean, renewable and reliable energy source that serves national environmental and energy policy objectives. It is one of the most important renewable sources for production of electric power due to several obvious reasons. It is renewable in nature, unlike wind, supply variability within shorter time period is less and most importantly green house gas (GHG) emission is least. This potential energy of the water is converted into a form of kinetic energy as the turbine blade rotates, causing the generator to activate to produce electricity. Hydroelectric power has some advantages such as its operational flexibility. The hydropower factor depends largely on the station that is selected and its services, which represent the detection of the range for peak load and base load [16]. The general state of hydropower system was explained in figure (2.1).

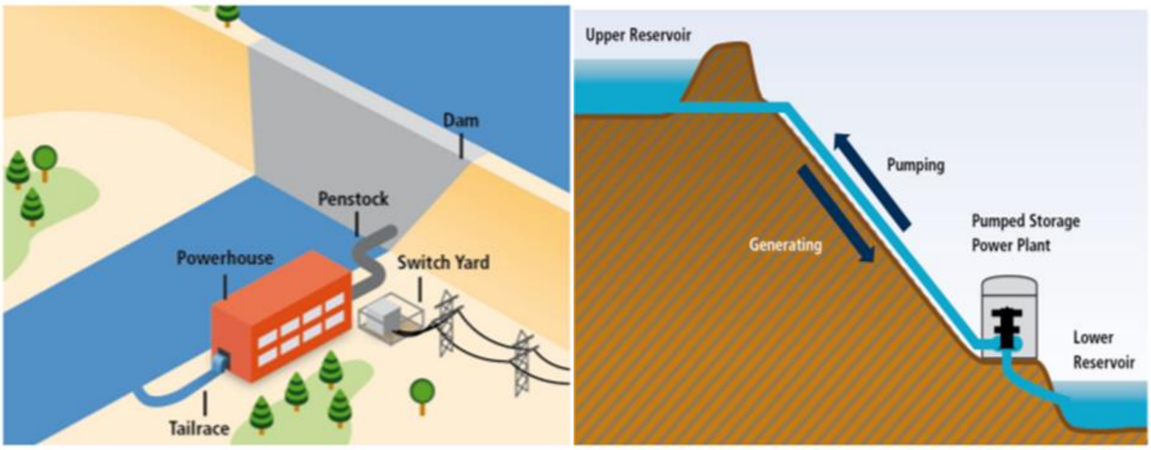

Figure 2.1: General State of Hydropower System [17].

2.2 BENEFITS OF HYDROPOWER ENERGY

The advantages of using hydropower system can be illustrated by the following steps:

a. Economic Growth of Developing Countries: With the progress being made for the purpose of having a better standard of living, the amount of energy demand in many developing countries is increasing dramatically. The development that takes place in the infrastructure, especially those related to electricity, is a matter of great importance and vitality for the purpose of ensuring the sustainable growth of the economic level. The development of energy enhances its self-sufficiency, because water energy resources are considered renewable and local energy [18]. It is also of great importance in contributing for the purpose of improving the balance of payments for self-sustainable economic growth and international trade, through the passage of many years of practical application processes. The technology for hydroelectric power generation has become well established and highly efficient. The transfer of technologies that are suitable for engineers in developing countries allows the production of reliable and safe quantities of electrical energy. The implementation of many important construction works for hydroelectric power stations can be done using the local currency, and therefore this leads to providing significant and beneficial effects on local employment in addition to contributing significantly to the increase in the level of economic prosperity of the state [19].

b. Using of New Energy: It is known that many potentially developed water resources all over the world equate to approximately high magnitude of kilowatt hours per year. Most of these water resources are located in developing countries, due to the continuation of the many increases in demand for electric power. The process of developing these water resources as that lack in development leads to a significant contribution to the process of mitigating the global demand for the amount of energy as well as the balance of supply other source of energy other than hydropower can deliver multi-pronged benefits. The development of hydropower can ensure energy security, provide food security and health security and, in addition, preserve environment, reduce greenhouse gas emission and create recreational facilities [20].

c. Using of Local Source Energy: The largest amount of electricity consumption is mainly in city centers, in addition to the lack of balance with remote areas. The technology of developing hydroelectric energy is of great importance in providing local electricity, as well as in enhancing the level of local prosperity. It is important for many important human needs such as alternative energy that is used instead of coal and wood fuels for heating as well as for lighting. It is also considered an alternative energy that solves it replaces human as well as animal labor for the uses of irrigation, drinking water supply and sewage, and is also used as a driving force for small water treatment plants and cultural norms The benefits of hydropower consist of the minimal level of noxious and greenhouse gas emissions, it's energy security from political instability, and its renewable, non-depletable nature. The costs of hydropower consist of negative effects on the river ecosystem and of social changes in communities in the vicinity of large projects [21].

d. Stabilization in Electricity Rate :Hydroelectric power generation does not bear any costs, but the large investment process is reflected in the presence of a large proportion of the cost of the capital required to produce energy. The cost of production is usually higher at the beginning of the service life than the cost of the thermal power plant, that there is no fuel cost, and this means that there is a significant increase in the cost of producing the low unit and that is in exchange for the inflation that occurs once the plant is completed, and this allows the use of a source It is stable in energy and at the same time has a low price for the longest possible period [22].

e. Positive Issues in Environment: Every year with the increase in energy use, the process of burning fossil fuels has led to a significant increase in the volume of carbon dioxide (CO_2), and the process of global warming has become a risk that causes global problems for the environment. The cause of acid rain and the problems it causes, which are the result of the emission of many gaseous pollutants into the atmosphere. In many countries, coal and wood fuels are the most important sources of energy, and this is the reason for increased desertification and deforestation. As a result of these conditions, there will be an increase in demands for the purpose of developing other and non-fossil sources of energy. Specifically, the development of hydroelectric power and it is considered one of the types of renewable energy that offers many good advantages against the presence of negative factors of flue gases and carbon dioxide that cause environmental pollution [23].

f. Efficiency Enhancement in the Whole Power System :Usually, energy requirements change frequently, depending on the time of day. One of the most important features of hydroelectric power stations, which is controlled by a pond or reservoir, as well as the pumped hydroelectric energy storage station, which has the ability to respond immediately to such changes. On the contrary, as thermal power plants provide the highest degree of efficiency during the continuous operation process, but one of its disadvantages is that it cannot be loaded with a rapid load, which follows the feature of requesting changes in energy requirements. Therefore, the process of combining thermal energy and hydroelectric energy leads to a higher efficiency of the entire power system [24].

2.3 PUMP STORAGE HYDROPOWER

Hydroelectric power depends on the simplest physical concepts. Hydroelectric power plants initially convert the attractive energy of water or potential energy into mechanical energy, and then it is converted into electrical energy. The flow of water diverts the turbines which are connected to the generator, then the generated electricity flows to a sub-station, where at this point the voltage is increased, after this process it is fed into the power grid as well as supplying the end users. Because hydropower depends on the water cycle mainly, it is considered renewable energy, that is, it is considered an endless system where it is constantly recharged [25]. Hydropower is a site-specific technology that needs to be adapted in accordance with the specific features of the terrain, hydrology and local geology. The design process changes according to the local conditions available, where the gates represent a set of barriers that allow making regulation for the purpose of releasing water. These gates can take various forms, such as sliding gates, fixed gates, caterpillar gates, and radial gates as they are used for power intakes, or can be used for lower exits, or for the purpose of river diversion works. In addition, they are used as drain gates for the purpose of controlling the process of flooding into the reservoirs [26].

The stations for generating energy that are stored by pumping are operated depending on the amount of renewable energy produced, which is variable according to the weekly and daily cycles. Through the storage capacity of the upper magnitude of water in the storage region, the process of determining the operating period is carried out at full capacity, as it is designed for the purpose of providing peak electric power during periods where there is a high demand for electricity [27]. The hydroelectric power system, which is stored by pumping, is considered one of the most efficient energy storage systems in terms of efficiency and is also considered to be of a very wide range, where the typical efficiency. Existing lakes or reservoirs can be used, depending on the Hydrological conditions and topography of the site. New reservoirs must be established in the case where reservoirs are available, and in many cases the lower reservoir is a river that the dam can control or the current power plant. There are many concepts that anticipate the use of underground reservoirs for water storage. There are various investigations for the purpose of using caves, abandoned mines and man-made storage tanks, which is an additional option for the purpose of using the sea as an upper or lower reservoir, but at this time there is only one example for the purpose of seawater storage using water pumping [28]. Many hydroelectric power stations can be built, the process of which is pumped for the purpose of storage within the infrastructure, and examples of that are artificial infrastructures that are dedicated to making snow, drinking water networks, as well as navigation locks. This type of plant is often small in size and also provides storage for large amounts of distributed energy as well as flexible production of the amount of electricity. The plants specialized in generating hydroelectric power, which are stored using pumping, as they are net consumers of energy. The deficiency is compensated by the flexibility that is provided by these factories[69]. Mostly, pumped hydropower is the most flexible, mature, and cost-effective form of bulk energy storage [29] .

The main role of hydroelectric power plants, which is stored by pumping, is in two directions. The first represents balancing the network for changes that are due to energy demand, as well as

balancing changes resulting from power generation, such as traditional hydroelectric power stations, where pumped power plants can provides a wide range of network installation services [30]. The figure (2.2) showed the elevation dependency by the position of hydropower pump stations.

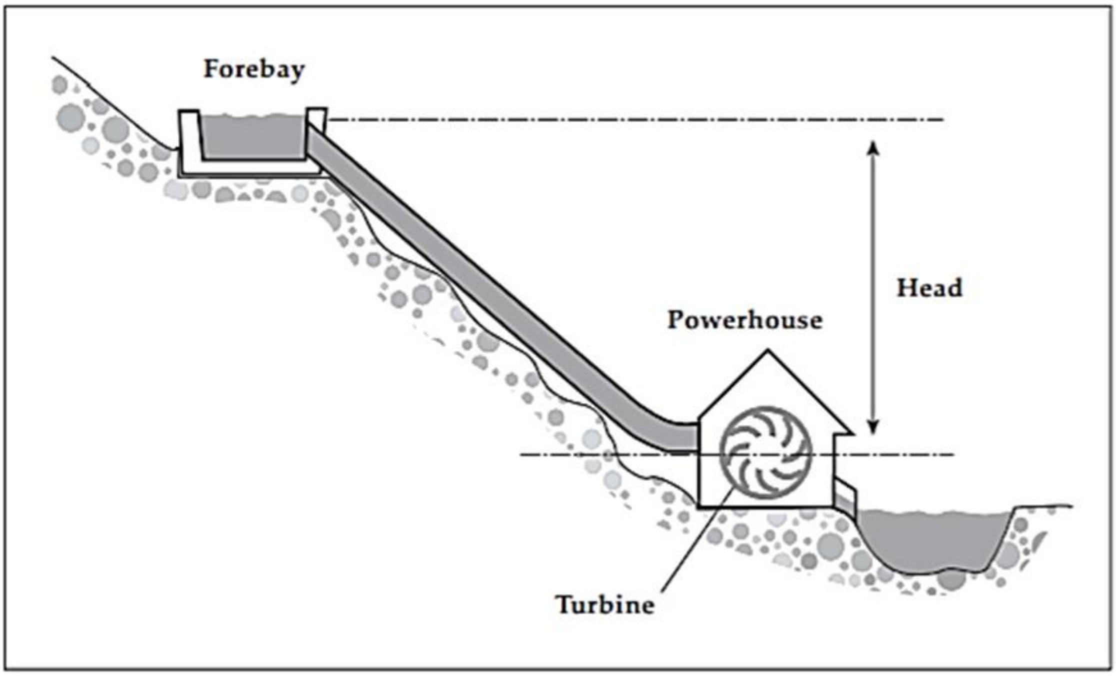

Figure 2.2: Head of Water and The Position of Hydropower Pump Station [16].

2.4 HYDROPOWER VALIDITY IN IRAQ

The electricity sector has a long history of struggles. The network, as well as the power stations before many years suffered many deteriorations and damages, as the infrastructure suffered many damages due to the unstable public conditions since 2003. Mismanagement and corruption led to the slow progress in the process of expanding storage and rebuilding the sector, at a time when the demand for energy continued rapidly due to the rapid population growth, as well as the spread of consumer devices, such as air conditioners [31]. The supply of fuel to power stations represented multiple problems, and this continued to high levels the process of burning associated gas. The current generation of electricity in Iraq depends mainly on natural gas, the supply of which has increased significantly. The reason for this is due to the increase in the production of associated gas, which is the by-product of oil. The increase in the supply of natural gas has helped reduce the process of burning crude oil For the purpose of liberalizing and generating and fuel oil for exports, with all that there was a shortage of the amount of energy. Although Iraq possesses a large share of the river basins, but there are approximately noticeable share of the amount of surface water resources that originate outside the borders of Iraq, as the main feed of the Euphrates and of the Tigris originates from Regions out of Iraq [32]. Dams in iraq can be used noticeably for enhancing the trend of hydropower system, these dams can play important roles in strengthen the water infrastructure system in Iraq as well as cover the gaps and the lacks in electricity system when it weel operated for better water occupation. There are three main dams located on the Tigris River, which are the Dukan dams, the Darbandikhan dam and the Mosul dam that can satisfy the needing of renewable electricity in large related regions in Iraq [33]. The distribution of water resource overall Iraq lands can be explained in the figure (2.3)

Figure 2.3: Water Resources Distribution in Iraq [34].

2.5 LIMITATIONS OF HYDROELECTRIC ENERGY

a. Reduced Plant Locations electricity from hydropower is renewable, there are limited sites in the over world that are proper for plant building. On top toward this, some of these places are not close to major cities in that could fully advantage from the energy [35].

b. Higher initial Magnitude of money while in the case of no available barrier on earth is easy to build, hydro grounds do require the related construction side to build a dam to cease running water. As a result, they cost more than similarly sized organic fuel plants. Although, they will not require to worry relating to purchasing fuel other time on. So it does even out over the long-term [20].

c. Carbon and the gas of Methane Emissions While the reliable electricity generation in the plant makes not produce spreading; there are spreading from the water storage regions they create. Specific plants that are for the bottom of a reservoir start to decompose. With when plants eliminate, they release huge quantities of the element of carbon and methane [36].

2.6 HYDROPOWER AND WATER AVAILABILITY

Hydropower is the major dominant clean energy with the low carbon source generating. Electricity from hydropower generates energy in the way from water and each change in non-artificial water circle that led by the case of climate change had its influencing on the energy [37]. The problem can formed in the case of tendency to droughts while electricity from hydropower is the major reliable renewable force, so it is dependent on the amount of quantity of water in any gained location. Thus, the performance of a hydro plant would be significantly influenced by an intensive drought [38]. The problem can be attended in the state when water storage behind the constructed dams as the case when stream flow is constrained in a storage region [39]. The flow speed decreases and amount of sediments is deposited, as that, streams that transfer much suspended sediment are poor regions for reservoirs; covering by silt will rapidly decrease storage capacity with the severely shorten the useful life of a small water storage region until in bigger reservoirs, so that, sedimentation parts is considered a common and serious problem [40]. As result of removal of the deposited sediments from reservoirs is more generally reflect portion of cost that be effective, reservoirs on a sediment laden stream are typically planned to supply a reserve of storage capacity to offset the consumption caused by depositing [41].Water reservoirs range in volume and complexity from small single-purpose constraining to huge and complex multiple-purpose constraining. A single-purpose water storage place is designed to fulfill only single function, such of irrigation, hydroelectric energy. The branch has been for construction of many purpose reservoirs designed to serve at simple case two principal features [42]. In state of using this technology in developing countries, all the lack of materials and labor in constant regions and the cost must be taken into attention [43].

2.7 EFFECT AND CLIMATE CHANGE

The effect toward climate change in the way over hydropower is majority influenced by the change of the river runoff. The change of rain and temperature are the most conducting factors. Increase of the extreme climate events and increased erosion furthermore forces the hydropower resultant. Altering in precipitation with increment of heat can leads to an intensification of the water circle on the planetary specific scale [44]. The most robust large-scale option of climate modeling projections seems to be an increase in precipitation in the tropics and a decrease in the subtropics, and also it well known that an increase can happen in between high latitudes. In areas accompanied with reduced precipitation the annual runoff, connected electricity from hydropower production will reducing [45]. An increase of the precipitation in specific period of time is not automatically product an increase of energy resulting in the close to adequate scale. Power grounds are optimized in which for the designed rate of flow and an increase can only been used in a limited range [46]. High temperature causes stiffer water evaporation from the continents and from all quantity of water in surfaces, also streamlines of rivers and lakes. The evaporation reduces presenting river water [47]. The water vaporized from basins or reservoirs is a direct missed quantity for the discharge and for the energy production. Evaporation and discharge loss include a bigger majority in dry areas and relatively non-deep reservoirs with a larger surface region. The future constructions in dry areas should strive to solutions with more deep reservoirs, with less size surface area and instead of single big reservoir a system of smaller reservoirs should be selected [48]. Climate alteration can cause increment of variability of precipitation events and will pose significant troubles for hydroelectric creations. The increased in the difference of precipitation lead to bigger quantity of water enhancing the severe and non-stability floods and in other side the difference can lead to state of droughts. The drought can be occur in hot seasons, in other hand, raising of temperature can cause of upper point snowmelt in cold region. Dams and reservoirs can manage flood pulse of the river and help by specific buffering downstream areas from dangerous impacts [49]. Accompanied with optimal water controlling increased flood water could be in the water storage place and used for production. At the same time stronger sediment and demolition flow can rigid block or damage components such as spillways. Additionally, the dam structures must be to be confirmed under such more extreme flooding actions [50]. As results, the high participation can lead to problem of flood as excessive water can lead to unstable situation the hydropower system if not controlled , in other hand, droughts decrease water availability and therefore the magnitude of the provided energy so that in case of a longer state of drought, not just the rate of flow, but also the available head for energy production would be reduced [17].

2.8 CURRENT WORK

The study examined the validity of designing of Pump Storage Hydropower Network in Iraq for enhancing the application of sustainable energy. The position of these station were studied in the to be in the pathway of the three main dams: Dukan, Mosul, and Darbandikhan in Iraq for satisfying the generation of electricity by using potential water energy with the dependency of the availability of using elevated storage water. The work made for building network of pump station and investigating the value that reflecting by using that source of water in the electricity generation trend as renewable energy approach.

2.9 LITERATURE SURVEY

The study had illustrated in review the procedures for growing up the using of hydropower plant to meet the increment of electrical demand in Turkey. The study moved in surveying about the available dams and rivers that can be adopted to the projects of hydropower. The case study was Deriner Dam that located in north of Turkey on the river of Çoruh. The influence of annual precipitation on the projects was explained. The study outline aimed to enhance the understanding of using of clean energy toward best controlling of water resources and sustainable development [51].

The study had explained the using of pump storage hydropower and the way of placed it in the stream between upper reservoir and lower reservoir for reaching best benefits of hydropower generation. The study illustrated the principals and purpose of general design of separated turbine-pump and reversible pump turbine. The fluctuation of water level in reservoir and its impact on the overall generation efficiency was illustrated in the study. The hydropower plants in Rjucan and Holen that located in Norway were the case studies that adopted in the research outline [52].

The study had made scientific comparison for the using of the energy of wind, solar, and hydropower. The study explained the validity of using hydropower and the chance of growing up the construction of small hydropower plants worldwide in several researches. Using of the energy that based on the discharge of the river was illustrated in the study. The study aimed in its outline for improving the understanding of public awareness toward the matters of clean energy and sustainable development [75].

The study had predicted mathematical model for controlling the performance of pump storage that used for hydropower generation depending on the related scientific equations like power production and Bernoulli equations. The main parameters that influence the performance of the hydroelectric system were analyzed. The available water in the upper reservoir and in the lower reservoir in addition to the required power supply demand were investigated. The study involved explaining the difference between single speed turbine and adjustable speed for best electrical generation [53].

The study had explained the generation of electricity production of small hydropower with the integration of irrigation consumption. The study place was Calabria located in Southern Italy. Using of turbines in the way of irrigation pipelines was adopted in the study for evaluation the efficiency of this procedure for the hydropower generation and irrigation requirement. The effect of discharges and the elevations between water sources (reservoirs and rivers) and the points of water supply were examined [54].

The study had analyzed using of hydroelectric reservoirs in Brazil in the current time and future. The investigation of the impact of change in climate on the generation of hydropower was part of the study. The outline of the research involved the influence of humidity, temperature, evaporation, precipitation, characteristics of available reservoirs, and using of water for the purpose of irrigation on the efficiency of reservoir for hydroelectric using [55].

The study carried out the application of optimization methods including Lagrange relaxation and mixed integer linear programming in analysis the efficiency of hydropower generation with water discharge. The study found that Lagrange relaxation procedure gives more efficient results for hydro pumped storage plants, while the method of mixed integer linear programming can be adopted only in large scale of data. The study aimed to explain the ways for using less water for high generation of electricity [56].

Effective management of water resources requires participation from a variety of groups. Stakeholders include communities, NGOs, governments, and individuals. The aim of this work is to investigate the potential use of statistical control charts to the normal process of monitoring water-related building projects [78].

The studied using of underground pump storage for hydropower generation. The case study area was Martelange that located in Southeast of Belgium. The main parameters like volume and behavior of underground reservoir were analyzed in the way of their influence on the overall stability of operation and electricity production. The study had put interest on the ventilation of the chambers that constructed underground for the holding the required water quantity. The research had used a proper model that reflected the operation of the upper reservoir and the action of underground [57][76].

The studied the assessment of impact resulting from climate change on the availability of water storage which is produced for electric energy. The study covers the analysis of tropical basin in Colombia. The study analyzed the influence of precipitation, evaporation and humidity on the schemes of this energy for hydropower generation. Specific time series were adopted for examining the impact of each parameter. The study explained in diagrams the relative effect of each parameter on the water balance of study areas [77].

The scope of the study was to examine using of small hydropower sources for hydroelectrically generation in the areas of Hanseok, Deoksong, Socheon in South Korea. The study dealing with climate change as impact parameter to be analyzed. The study predicted the magnitude of discharges for the mentioned areas for along coming years and the impact of the results on the validity of using hydropower generations. The sustainable energy was the aim of the study by prediction the chance of increasing of using small hydropower generation sources for covering more related areas [58].

The goal of his study is to better understand and evaluate how important soil qualities and content are in affecting the phenomena of soil liquefaction that occurs during earthquakes. This paper includes a case study that represents the Karakaya Dam. To accomplish the study objective, two research strategies were used: Excel extrapolation and linear regression-based numerical optimization. The results showed that the zones near the Karakaya Dam, including Azami, Ortalama, and Asgari, will have a mild rise in yearly temperature of roughly 3 to 6 degrees Celsius during the following ten years[79].

3. METHODOLOGY

3.1 METHODOLOGICAL CONCEPTS

The study investigated the effectiveness of three dams: Mosul, Dukan, and Darbandikhan in providing a significant amount of hydropower energy as a sustainable energy source. The three dams' general information was illustrated.

3.1.1 Mosul Dam

The Mosul Dam is among the largest dams in Iraq, and it also ranks fourth in terms of storage for the Middle East. It is also one of the largest dams in the globe. Mosul is 50 kilometers to the northwest. The dam was built in 1981, with construction beginning in 1986. The dam represents projects with many purposes, as it works to deliver water to three irrigation projects, and to mitigate flood threats, and is critical in producing hydroelectric power [59][73].

The reservoir of the Mosul Dam reaches the Tigris River in the upper region and begins to expand around the dam site. The exposed rocks within the reservoir area and dam site are layers of limestone in addition to soft marl layers for the purpose of constructing the Euphrates and the entrance known as the Middle Miocene, which is divided into two portions, lower and higher. The geology of the region is considered to be one of the most complex, since it is made up of a group of periodic deposits represented by limestone, fine green marl, and hard gypsum. Furthermore, the mechanical composition of these rocks is heterogeneous [60][74]. Figure 3.1 explained the location of the Mosul Dam in Iraq and the layout and formation of the reservoir. Figure 3.2 showed the appearance of the dam with respect to upstream and downstream sites.

Figure 3.1: Mosul Dam Location [61].

Figure 3.2: Mosul Dam Appearance [60].

3.1.2 Dukan Dam

The site of the Dukan Dam is on the Lesser Zab River, about 220 km away from its confluence with the Tigris River. Where its location is close to the city of Dokan and is located at a distance of 65 km from the northwest of the city of Sulaymaniyah, in addition, it is 295 km north of Baghdad [62].

The dam area is characterized by its topographical nature, but unfortunately, there is no geological map for the area of the depression that was flooded by the waters of the Dukan Reservoir. The dam area is located in the north-central part of Iraq, that is, it is in the Sulaymaniyah governorate within the Kurdistan region of Iraq. It consists of a mountainous area that includes many mountains such as Rania, Khalikan, Surdash and Bana Barik [63]. The location of the dam as well as the formation of the reservoir was showed in figure 3.3.

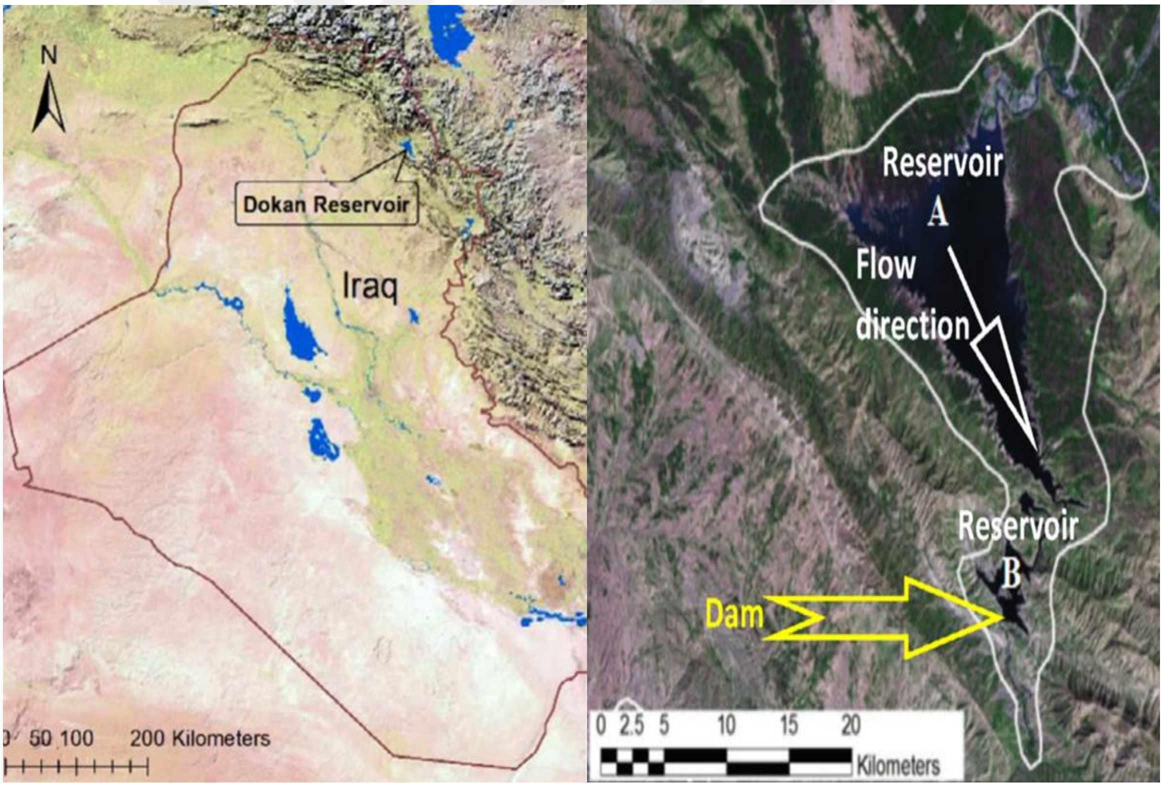

Figure 3.3: Dukan Dam Location [64].

3.1.3 Darbandikhan Dam

The site of the Darbandikhan Dam is at the source of the city of Darbandikhan on the Diyala River, its location is approximately 150 km from the source of the Hemrin Dam.The site of the Darbandikhan Dam is at the end of a narrow gorge where it cuts the slope of Baranand Dag by the Sirwan and Diyala Rivers. The rocks are lower downstream in the southwest direction at about 45 degrees from the dam site. The layers consist of a number of sedimentary rocks of marine origin [65]. Figure 3.4 displayed the position of the dam and the formation appearance of the dam reservoir while figure 3.5 showed the dam with respect to the upstream and downstream regions[70].

Figure 3.4: Darbandikhan Dam Position and Reservoir Formation [66].

Figure 3.5: Appearance of Darbandikhan Dam[65].

3.2 TOPOGRAPHIC OF RESERVOIRS

For satisfying the analysis of the mechanism of water falling toward the hydropower systems, the reservoirs of the three dams in the study were put under topographical analysis for evaluating the available head and the catchment area that can be considered in the state of generating hydropower energy [71] [72]. The topographic behaviors of the reservoirs existing of the three dams according to the Iraqi Ministry of Water Resource were explained in figures 3.6, 3.7, and 3.8.

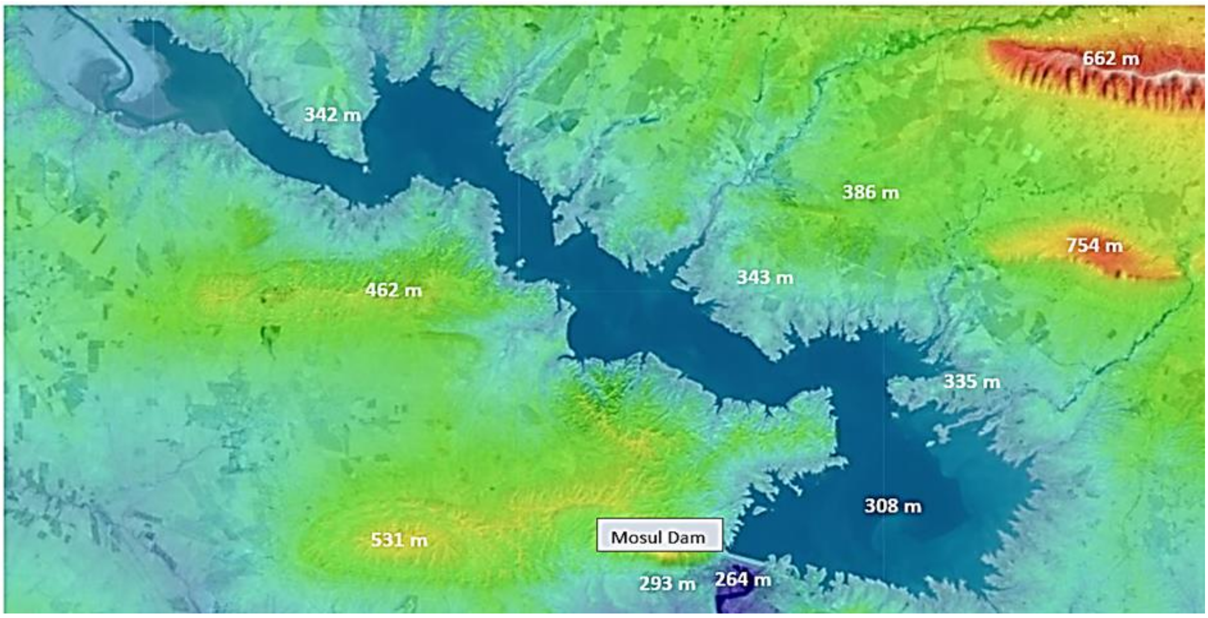

Figure 3.6: Topographic Behavior of Mosul Dam Reservoir.

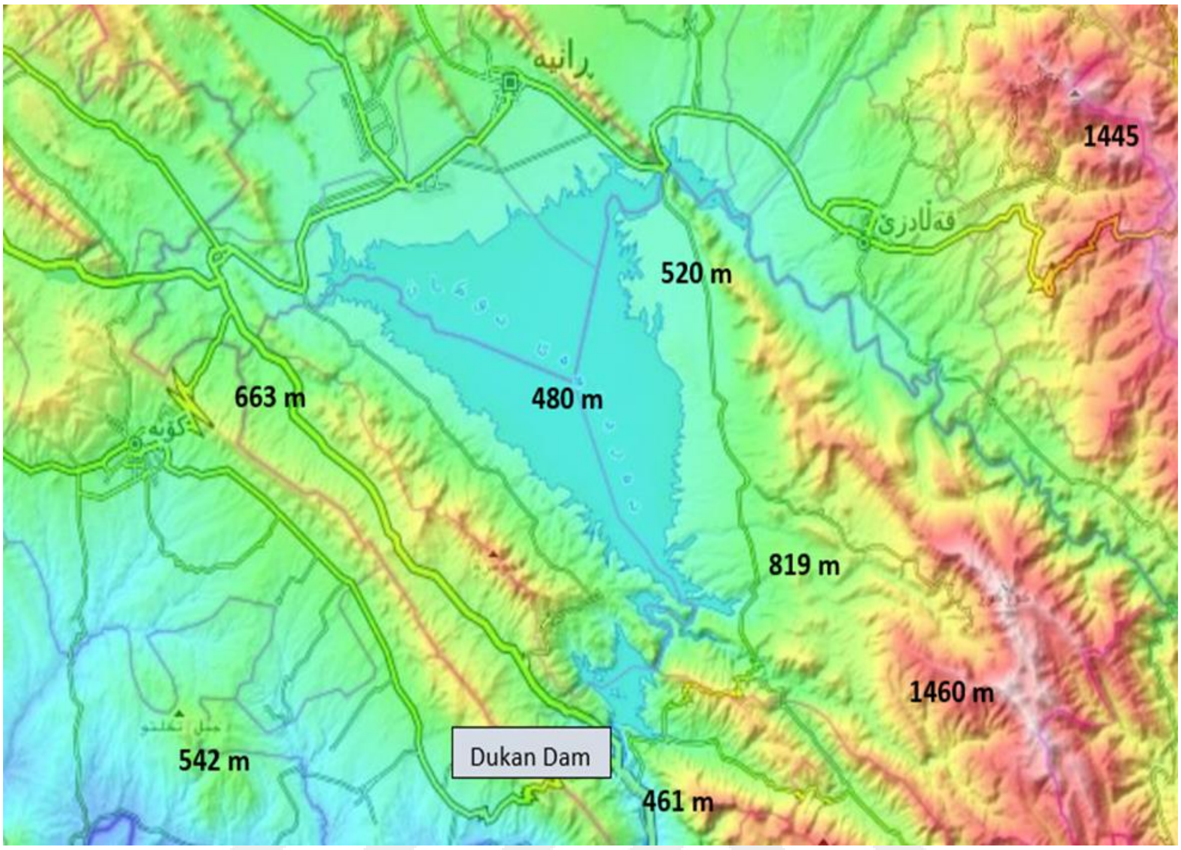

Figure 3.7: Topographic Behavior of Dukan Dam Reservoir.

The imagery map in figure 3.7 showed the elevations in the storage area of Dukan Dam and the surrounding areas. The topographic map showed 480 m as typical elevation in which the elevation decreased to 461 in the downstream. The figure showed also the shape of the storage plan according to these topography.

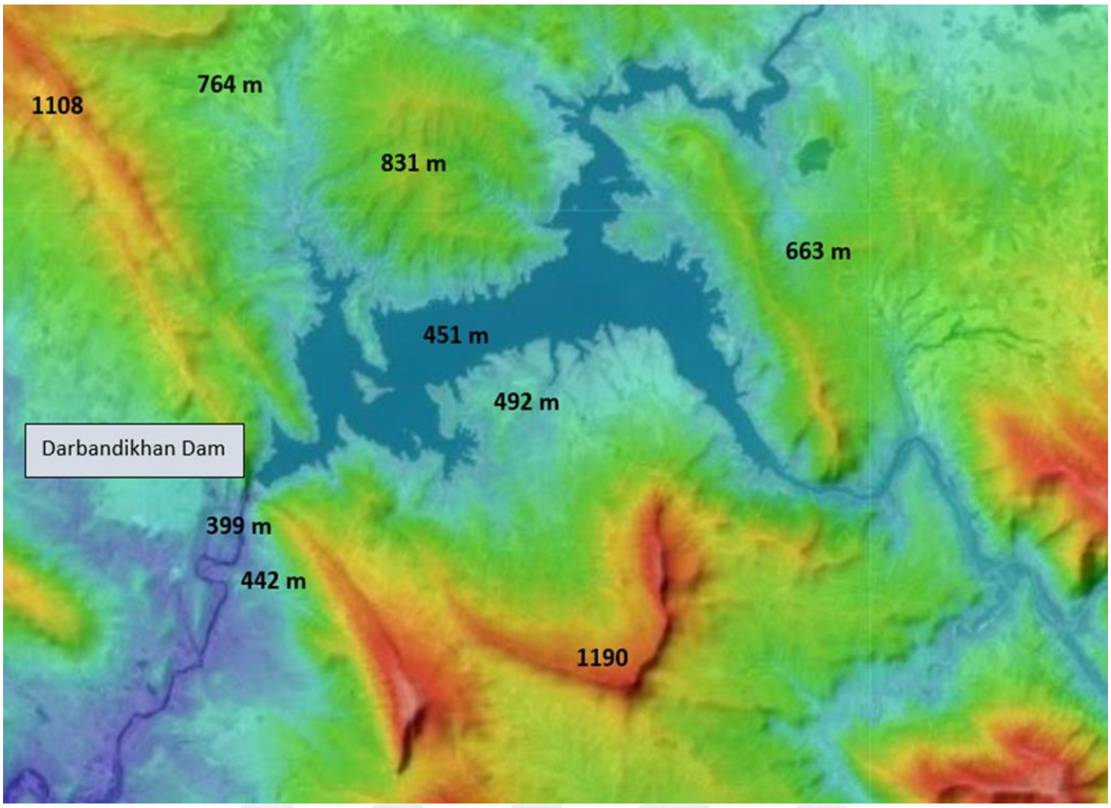

Figure 3.8: Topographic Behavior of Darbandikhan Dam Reservoir.

For the topographic formation in Darbandikhan Dam, the elevation for the upstream area behind the dam in which the reservoir plan found is 451 m, while these elevation been at the range 399 m in the river stream after the dam. These topographic formation gave the mechnaizm to deal with area according to the water balanced system and the storage volume.

For analysis the available area as well as the head of water with respect to the volume of the catchment area. The topographic maps of the three dams were processing inside Surfer program to achieve these parameters. The analysis action of the dams including building of polylines inside the program that move in the borders of the reservoirs formation as shown in figures 3.6, 3.10 and 3.11.

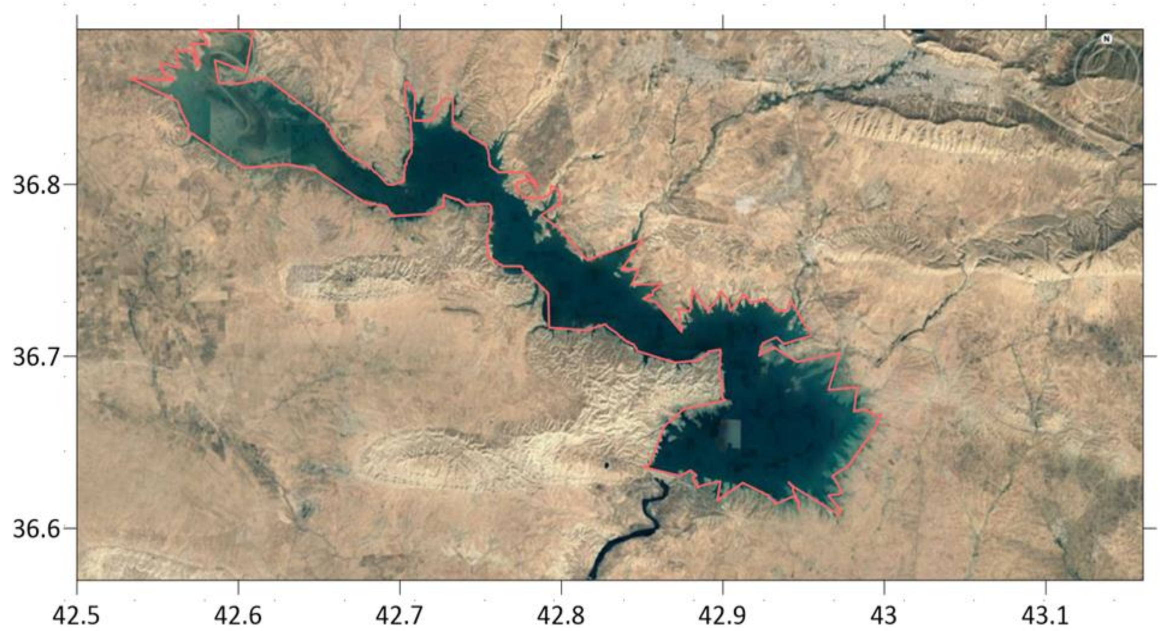

Figure 3.9: Analysis Process of Mosul Dam Reservoir Under Surfer Program

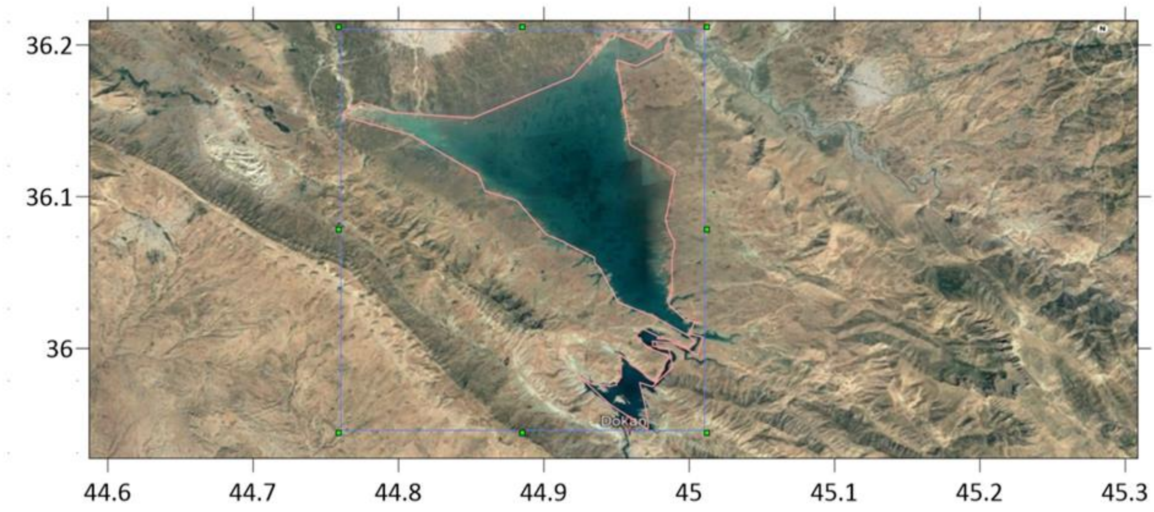

Figure 3.10: Analysis Process of Dukan Dam Reservoir Under Surfer Program.

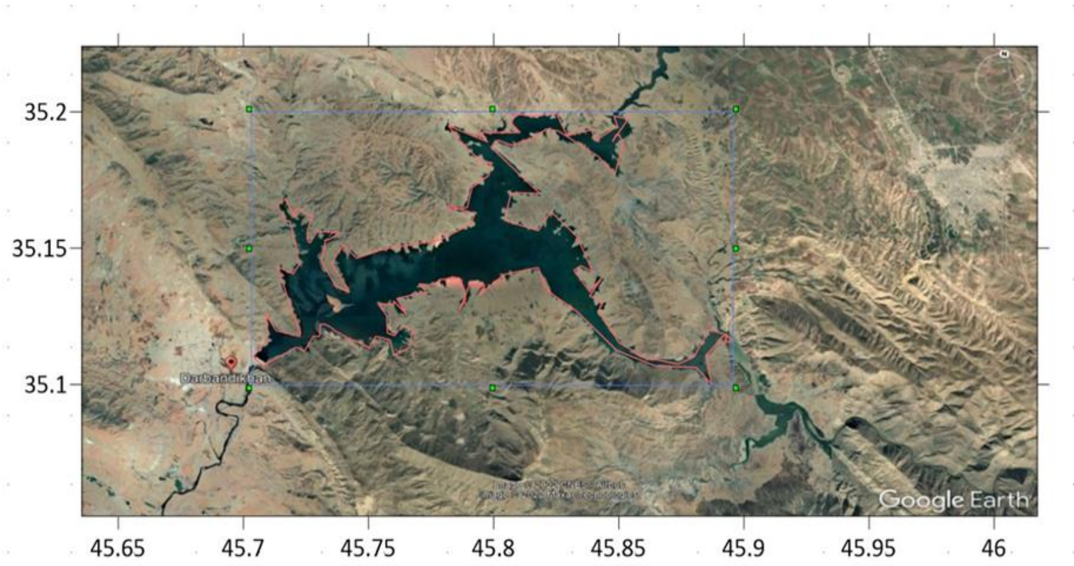

Figure 3.11: Analysis Process of Darbandikhan Dam Reservoir Under Surfer Program.

3.3 HYDROPOWER EQUATION

For estimating of the generated power that can be gained from the falling of the water quantities from the existing reservoirs to the elevation of the hydropower turbines, the following equation can be used [67]:

$$KW = 9.81 * H * ή * Q \tag{3.1}$$

Where:

KW = electric power in kilo watt

H= available head

Q= the rate of water quantity that move through the turbine

ή = overall efficiency

3.4 WATER BALANCE EQUATION

For assigning the quantity of water that can be used in the calculation of the generation of electricity , the amount of water that result from the resultant of inflow to the reservoirs before the dams were evaluated. The calculation of these amounts according to the water head was adopted using the following equation [68]:

$$P + Hd + Hp + Hpp = E + Ho + Hopp + Hw \tag{3.2}$$

Where:

P= quantity of precipitation

Hd= the main inflow to the reservoir

Hp = surface inflow to the reservoir from adjacent areas

E= amount of evaporation

Ho= Outflow quantity of water

Hopp = subsurface outflow from the reservoir to adjacent areas

Hw= amount of seepage

3.5 DATA OF ANALYSIS

3.5.1 Average Flowrate

For building analytical procedure toward gaining of the significance role that can be adopted for using the three dams in generating of hydropower, the data in tables 3.1 was used (source: Iraqi Ministry of water Resource).

Table 3.1: Inflow Rates (Cubic Meter Per Second).

Month	Mosul Dam	Dukan Dam	Derbindikhan Dam
1	480	226	159
2	620	363	257
3	990	450	360
4	1520	506	404
5	1210	304	214
6	580	135	94
7	210	64	61
8	110	43	49
9	112	48	52
10	102	53	61
11	290	84	86
12	410	159	134

3.5.2 Climate Conditions

The amounts of precipitation for the regions of the dams were explained in tables 3.1, 3.2, and 3.3

Table 3.2: Precipitation Per Month for the Dams of Mosul, Dukan, and Darbandikhan.

Month	Precipitation (mm)		
	Mosul Dam	Dukan Dam	Darbandikhan Dam
1	62	129	128
2	64	145	140
3	63	136	138
4	44	99	110
5	5	42	41
6	2	0	0
7	0	0	0
8	0	0	0
9	0	0	0
10	11	13	15
11	45	77	81
12	57	112	119

The average evaporation rate in north Iraq region as gained by the Iraqi Meteorological Organization was explained in table (3.3)

Table 3.3: The Average Evaporation Rate in North Iraq Region.

Month	**Potential Evaporation (mm)**
1	82
2	84
3	85
4	96
5	110
6	186
7	216
8	231
9	211
10	166
11	111
12	87

4. RESULTS AND DISSCSION

4.1 CALACULATION OF AVILABLE HEAD

4.1.1 Mosul Dam

The area that obtained from Surfer program was used from the polygon that surrounding the catchment area and also the coordinate that represented by the longitude and the latitude as showed in figure 4.1, the area obtained was 396 km^2

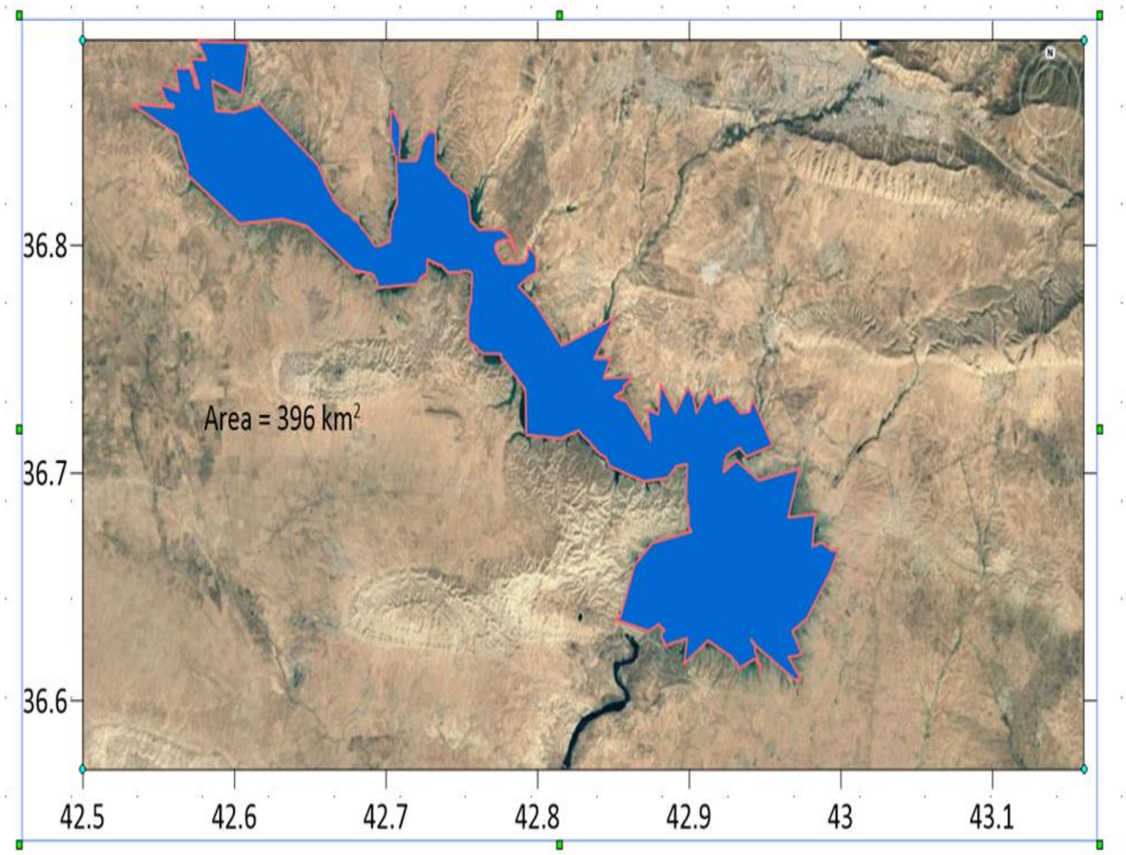

Figure 4.1: The Calculated Area of Mosul Reservoir Under Surfer Program.

The magnitude of catchment area was used in water balance equation to identify the amount of variation in water storage over the operation year with respect to the sufficient outflow. The accumulative head represented the monthly head in which the resultant of precipitation, evaporation and inflow were converted to that head. This head cannot be found as it because of the magnitude of the outflow reduced it to specific level, but it can be used to predict the resultant of available monthly head by dealing it with the outflow rate. The data calculated were summarized in table 4.1 and sketched in figure 4.2:

Table 4.1: Accumulative Head in Mosul Dam Catchment Area.

Month	**P (mm)**	**Inflow (m^3/sec)**	**E (mm)**	**Accumulative head (m)**
1	62	480	82	3.12
2	64	620	84	4.04
3	63	990	85	6.46
4	44	1520	96	9.90
5	5	1210	110	7.82
6	2	580	186	3.61
7	0	210	216	1.16
8	0	110	231	0.49
9	0	112	211	0.52
1	11	102	166	0.51
11	45	290	111	1.83
12	57	410	87	2.65

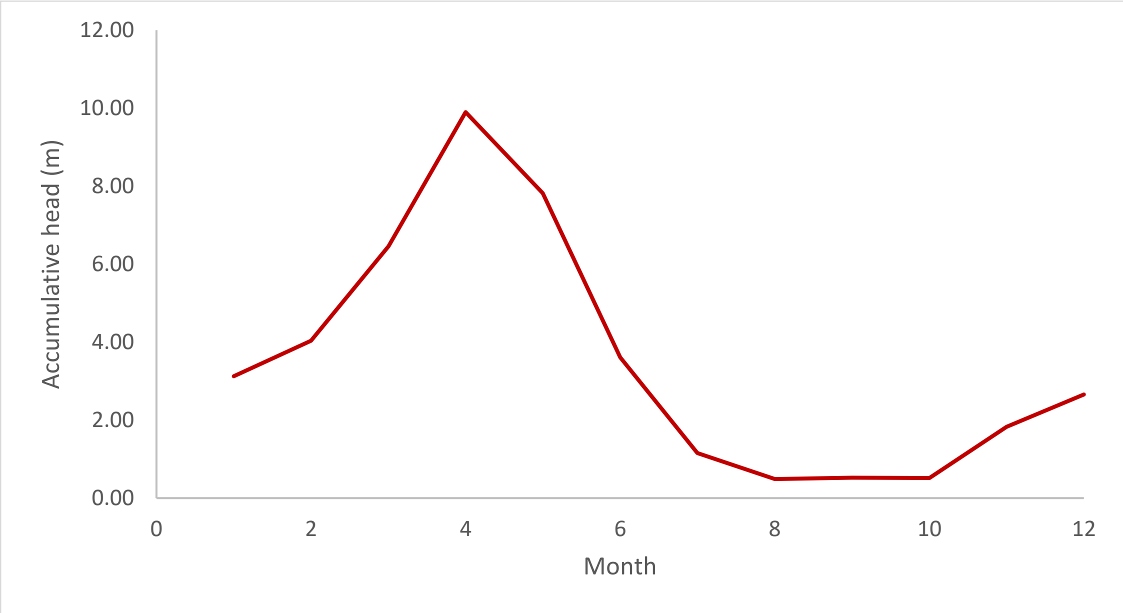

Figure 4.2: The Variation of Accumulative Head for Mosul Reservoir.

As the initial level of the Mosul dam reservoir is 308 m. s. l., the magnitude of available head can be found by the following formula:

Available head = Accumulative head – 0.007 * outflow rate

Where the factor 0.0007 represented the conversion from the cubic meter per second to the unit of m by using the surface area of reservoir.

From the formula, the monthly head can be varied as explained in table 4.2:

Table 4.2: Available Change in Head With Respect To Outflow Rate in Mosul Reservoir.

		Outflow rate (m^3/sec)				
Month	**Accumulative head**	**200**	**250**	**300**	**350**	**400**
1	3.12	1.72	1.37	1.02	0.67	0.32
2	4.04	2.64	2.29	1.94	1.59	1.24
3	6.46	5.06	4.71	4.36	4.01	3.66
4	9.90	8.50	8.15	7.80	7.45	7.10
5	7.82	6.42	6.07	5.72	5.37	5.02
6	3.61	2.21	1.86	1.51	1.16	0.81
7	1.16	-0.24	-0.59	-0.94	-1.29	-1.64
8	0.49	-0.91	-1.26	-1.61	-1.96	-2.31
9	0.52	-0.88	-1.23	-1.58	-1.93	-2.28
10	0.51	-0.89	-1.24	-1.59	-1.94	-2.29
11	1.83	0.43	0.08	-0.27	-0.62	-0.97
12	2.65	1.25	0.90	0.55	0.20	-0.15

Table 4.2: Available Change in Head with Respect to Outflow Rate in Mosul Reservoir.

"Table Continued"

		Outflow rate (m^3/sec)					
Month	**Accumulative head**	**450**	**500**	**550**	**600**	**650**	**700**
1	3.12	-0.03	-0.38	-0.73	-1.08	-1.43	-1.78
2	4.04	0.89	0.54	0.19	-0.16	-0.51	-0.86
3	6.46	3.31	2.96	2.61	2.26	1.91	1.56
4	9.90	6.75	6.40	6.05	5.70	5.35	5.00
5	7.82	4.67	4.32	3.97	3.62	3.27	2.92
6	3.61	0.46	0.11	-0.24	-0.59	-0.94	-1.29
7	1.16	-1.99	-2.34	-2.69	-3.04	-3.39	-3.74
8	0.49	-2.66	-3.01	-3.36	-3.71	-4.06	-4.41
9	0.52	-2.63	-2.98	-3.33	-3.68	-4.03	-4.38
10	0.51	-2.64	-2.99	-3.34	-3.69	-4.04	-4.39
11	1.83	-1.32	-1.67	-2.02	-2.37	-2.72	-3.07
12	2.65	-0.50	-0.85	-1.20	-1.55	-1.90	-2.25

4.2 DUKAN DAM

For analysis the conditions of Dukan reservoirs, same were conducted as in the calculation procedure of Dukan dam. The catchment area under Surfer program was showed in figure 4.3.

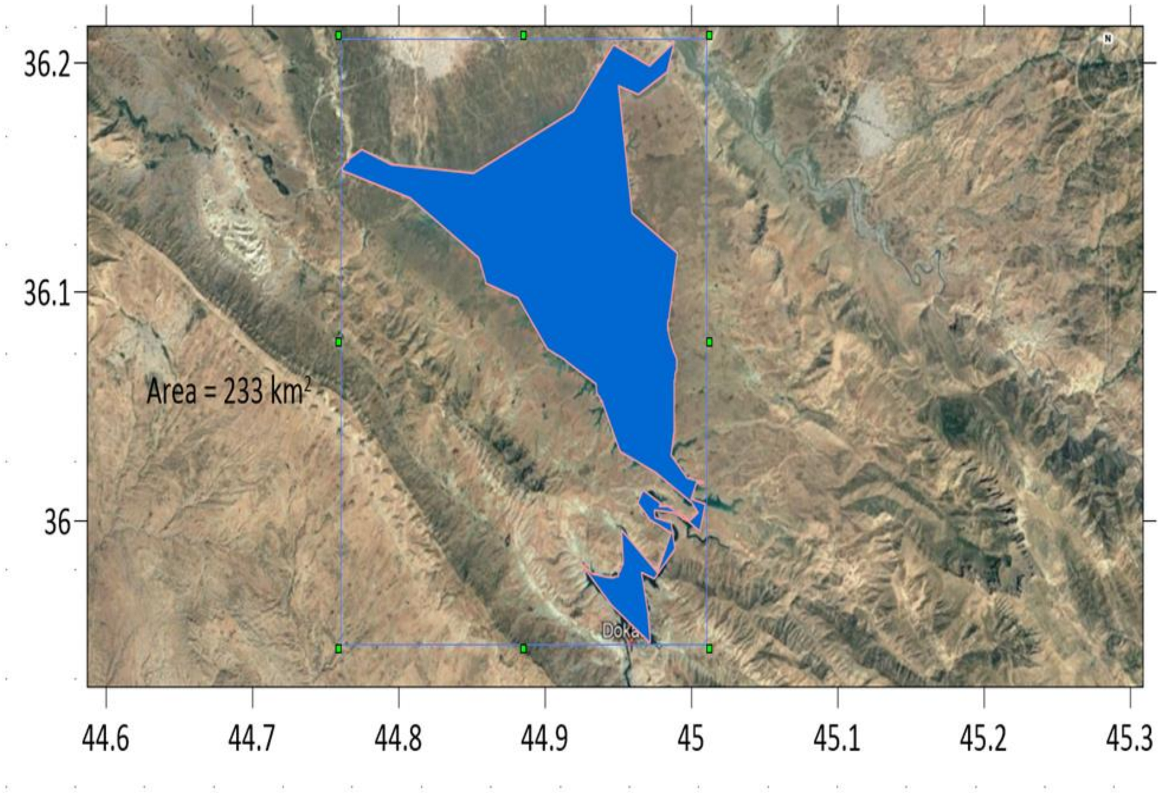

Figure 4.3: The Calculated Area of Dukan Reservoir Under Surfer Program.

The accumulative head data were explained in table 4.3 and available head data were explained in table 4.4. the initial level of the Dukan catchment area was taken as 480 m. the area as gained by Surfer program was 233 km^2

The formula for available head with respect to the outflow rate was:

Available head = Accumulative head – 0.011 * outflow rate

Table 4.3: Accumulative Head of Dukan Dam.

Month	P (mm)	Inflow (m^3/sec)	E (mm)	Accumulative head (m)
1	129	226	82	2.56
2	145	363	84	4.10
3	136	450	85	5.06
4	99	506	96	5.63
5	42	304	110	3.31
6	0	135	186	1.32
7	0	64	216	0.50
8	0	43	231	0.25
9	0	48	211	0.32
1	13	53	166	0.44
11	77	84	111	0.90
12	112	159	87	1.79

Table 4.3 showed the head that can the water level been raised behind the dam in each month, the head at these case is the water level that can be obtained by the impact of the inflow rates, the participation rates, and the evaporation rates.

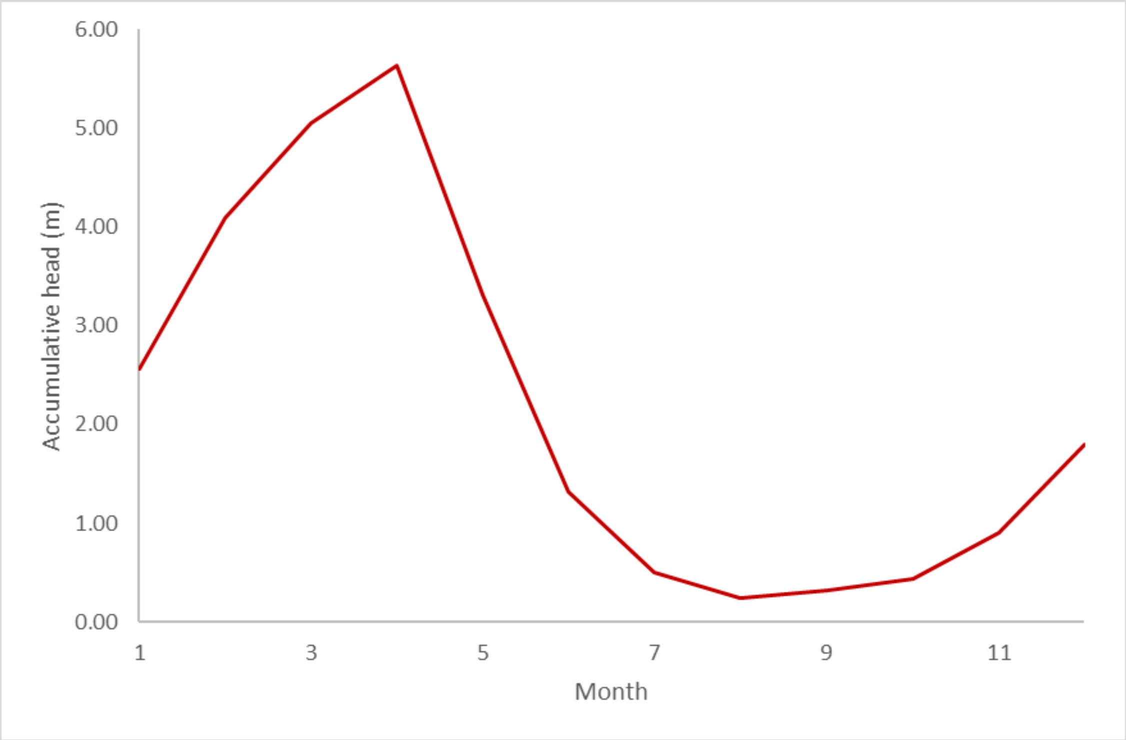

Figure 4.4: The Variation of Accumulative Head for Dukan Reservoir.

Figure 4.4 showed the sketch of the available head according to the data in table 4.3

Table 4.4: Available Change in Head with Respect to Outflow Rate.

		Outflow rate (m^3/sec)				
Month	**Accumulative head**	200	250	300	350	400
1	2.56	0.36	-0.19	-0.74	-1.29	-1.84
2	4.10	1.90	1.35	0.80	0.25	-0.30
3	5.06	2.86	2.31	1.76	1.21	0.66
4	5.63	3.43	2.88	2.33	1.78	1.23
5	3.31	1.11	0.56	0.01	-0.54	-1.09
6	1.32	-0.88	-1.43	-1.98	-2.53	-3.08
7	0.50	-1.70	-2.25	-2.80	-3.35	-3.90
8	0.25	-1.95	-2.50	-3.05	-3.60	-4.15
9	0.32	-1.88	-2.43	-2.98	-3.53	-4.08
10	0.44	-1.76	-2.31	-2.86	-3.41	-3.96
11	0.90	-1.30	-1.85	-2.40	-2.95	-3.50
12	1.79	-0.41	-0.96	-1.51	-2.06	-2.61

Table 4.4: Available Change in Head with Respect to Outflow Rate. "Table Continued"

		Outflow rate (m^3/sec)					
Month	**Accumulative head**	450	500	550	600	650	700
1	2.56	-2.39	-2.94	-3.49	-4.04	-4.59	-5.14
2	4.10	-0.85	-1.40	-1.95	-2.50	-3.05	-3.60
3	5.06	0.11	-0.44	-0.99	-1.54	-2.09	-2.64
4	5.63	0.68	0.13	-0.42	-0.97	-1.52	-2.07
5	3.31	-1.64	-2.19	-2.74	-3.29	-3.84	-4.39
6	1.32	-3.63	-4.18	-4.73	-5.28	-5.83	-6.38
7	0.50	-4.45	-5.00	-5.55	-6.10	-6.65	-7.20
8	0.25	-4.70	-5.25	-5.80	-6.35	-6.90	-7.45
9	0.32	-4.63	-5.18	-5.73	-6.28	-6.83	-7.38
10	0.44	-4.51	-5.06	-5.61	-6.16	-6.71	-7.26
11	0.90	-4.05	-4.60	-5.15	-5.70	-6.25	-6.80
12	1.79	-3.16	-3.71	-4.26	-4.81	-5.36	-5.91

Table 4.4 showed the real case at which the how the water level behind the dam (accumulative head) been changed according to various outflow rates

4.3 DARBANDIKHAN DAM

In figure 4.5, the surface area of Darbandikhan reservoir was obtained from Surfer program in which equal to 45 km^2

Table 4.5: Accumulative Head with Respect to Outflow Rate.

Month	P (mm)	Inflow (m^3/sec)	E (mm)	Accumulative head (m)
1	128	159	82	1.81
2	140	257	84	2.91
3	138	360	85	4.06
4	110	404	96	4.51
5	41	214	110	2.31
6	0	94	186	0.86
7	0	61	216	0.46
8	0	49	231	0.31
9	0	52	211	0.37
1	15	61	166	0.53
11	81	86	111	0.93
12	119	134	87	1.52

The accumulative head and the available change in head were included in tables 4.5 and 4.6 respectively. Figure 4.5 showed the accumulative head with respect to months. The formula for Darbandikhan reservoir available change in head was:

Available head = Accumulative head – 0.058 * outflow rate

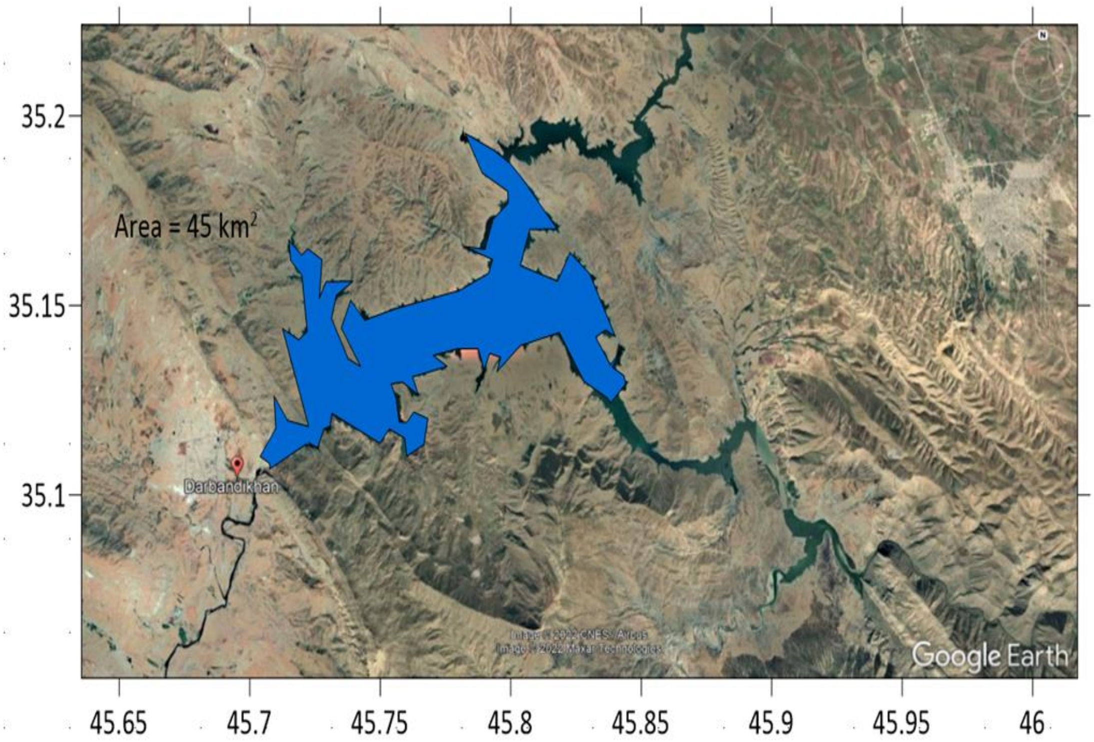

Figure 4.5: The Calculated Area of Darbandikhan Reservoir Under Surfer Program.

Figure 4.5 explained the work of the Darbandikhan Reservoir inside Surfer program, these work strategy ease the finding of the reservoir area of the dam upstream plan. the heads that can the water level been raised behind the dam in each month, the head at these case is the water level that can be obtained by the impact of the inflow rates, the participation rates, and the evaporation rates were illustrated in figure 4.6

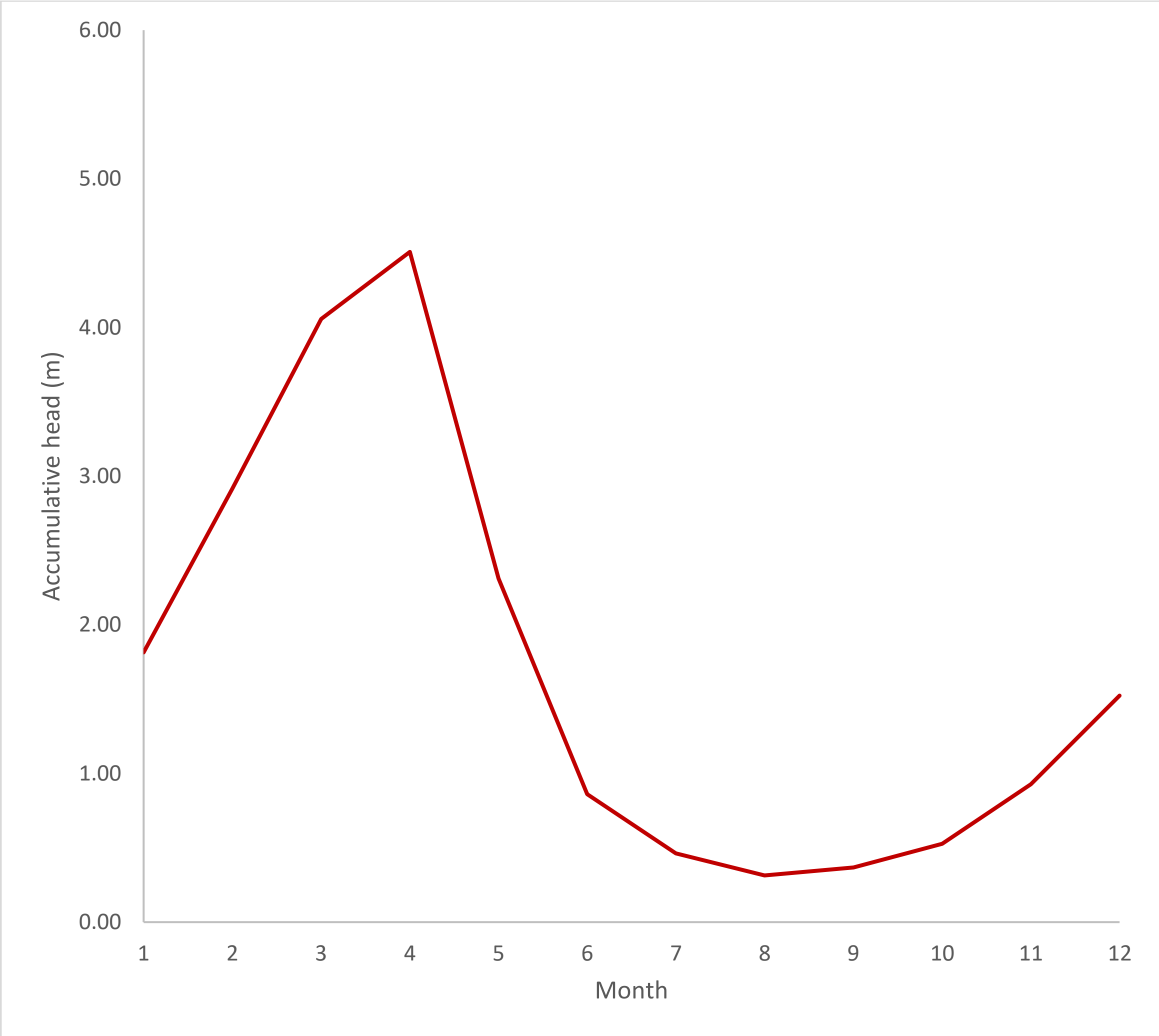

Figure 4.6: The Variation of Accumulative Head for Darbandikhan Reservoir.

Table 4.6: Available Change in Head with Respect to Outflow Rate.

		Outflow rate (m^3/sec)					
Month	**Accumulative head**	10	20	30	40	50	60
1	1.81	1.24	0.66	0.09	-0.49	-1.07	-1.64
2	2.91	2.34	1.76	1.19	0.61	0.03	-0.54
3	4.06	3.48	2.91	2.33	1.75	1.18	0.60
4	4.51	3.93	3.36	2.78	2.20	1.63	1.05
5	2.31	1.74	1.16	0.58	0.01	-0.57	-1.14
6	0.86	0.28	-0.29	-0.87	-1.44	-2.02	-2.60
7	0.46	-0.11	-0.69	-1.27	-1.84	-2.42	-2.99
8	0.31	-0.26	-0.84	-1.41	-1.99	-2.57	-3.14
9	0.37	-0.21	-0.78	-1.36	-1.94	-2.51	-3.09
10	0.53	-0.05	-0.62	-1.20	-1.78	-2.35	-2.93
11	0.93	0.35	-0.23	-0.80	-1.38	-1.95	-2.53
12	1.52	0.95	0.37	-0.21	-0.78	-1.36	-1.93

Table 4.6: Available Change in Head with Respect to Outflow Rate. "Table Continued"

		Outflow rate (m^3/sec)				
Month	**Accumulative head**	70	80	90	100	110
1	1.81	-2.22	-2.79	-3.37	-3.95	-4.52
2	2.91	-1.12	-1.69	-2.27	-2.85	-3.42
3	4.06	0.03	-0.55	-1.13	-1.70	-2.28
4	4.51	0.48	-0.10	-0.68	-1.25	-1.83
5	2.31	-1.72	-2.30	-2.87	-3.45	-4.02
6	0.86	-3.17	-3.75	-4.32	-4.90	-5.48
7	0.46	-3.57	-4.15	-4.72	-5.30	-5.87
8	0.31	-3.72	-4.29	-4.87	-5.45	-6.02
9	0.37	-3.66	-4.24	-4.82	-5.39	-5.97
10	0.53	-3.50	-4.08	-4.66	-5.23	-5.81
11	0.93	-3.11	-3.68	-4.26	-4.83	-5.41
12	1.52	-2.51	-3.09	-3.66	-4.24	-4.81

4.4 EVALUATION OF HYDROPOWER GENERATION CAPACITY

The resultant of each head according to the change of head and the initial elevation for each amount of monthly outflow were converted to the hydropower electricity generated in MW and evaluated in tables 4.7, 4.8, and 4.9. The efficiency of hydropower generator was considered as 0.8.

Table 4.7: Generated Hydropower in (MW) for Mosul Reservoir.

Month	**Flowrate for hydropower generation (m^3/sec)**										
	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7
1	0.62	0.77	0.92	1.06	1.20	1.34	1.48	1.61	1.74	1.87	1.99
2	0.64	0.79	0.94	1.09	1.23	1.37	1.51	1.65	1.78	1.91	2.04
3	0.68	0.84	1.00	1.15	1.31	1.46	1.61	1.75	1.90	2.04	2.17
4	0.73	0.91	1.08	1.25	1.42	1.58	1.74	1.90	2.06	2.21	2.36
5	0.70	0.86	1.03	1.19	1.35	1.51	1.66	1.81	1.96	2.11	2.25
6	0.63	0.78	0.93	1.08	1.22	1.36	1.50	1.63	1.76	1.89	2.02
7	0.59	0.73	0.87	1.01	1.14	1.27	1.40	1.52	1.65	1.77	1.88
8	0.58	0.72	0.86	0.99	1.12	1.25	1.37	1.50	1.61	1.73	1.85
9	0.58	0.72	0.86	0.99	1.12	1.25	1.37	1.50	1.62	1.73	1.85
10	0.58	0.72	0.86	0.99	1.12	1.25	1.37	1.50	1.62	1.73	1.85
11	0.60	0.75	0.89	1.03	1.16	1.30	1.43	1.55	1.68	1.80	1.92
12	0.62	0.76	0.91	1.05	1.19	1.32	1.46	1.59	1.72	1.84	1.96

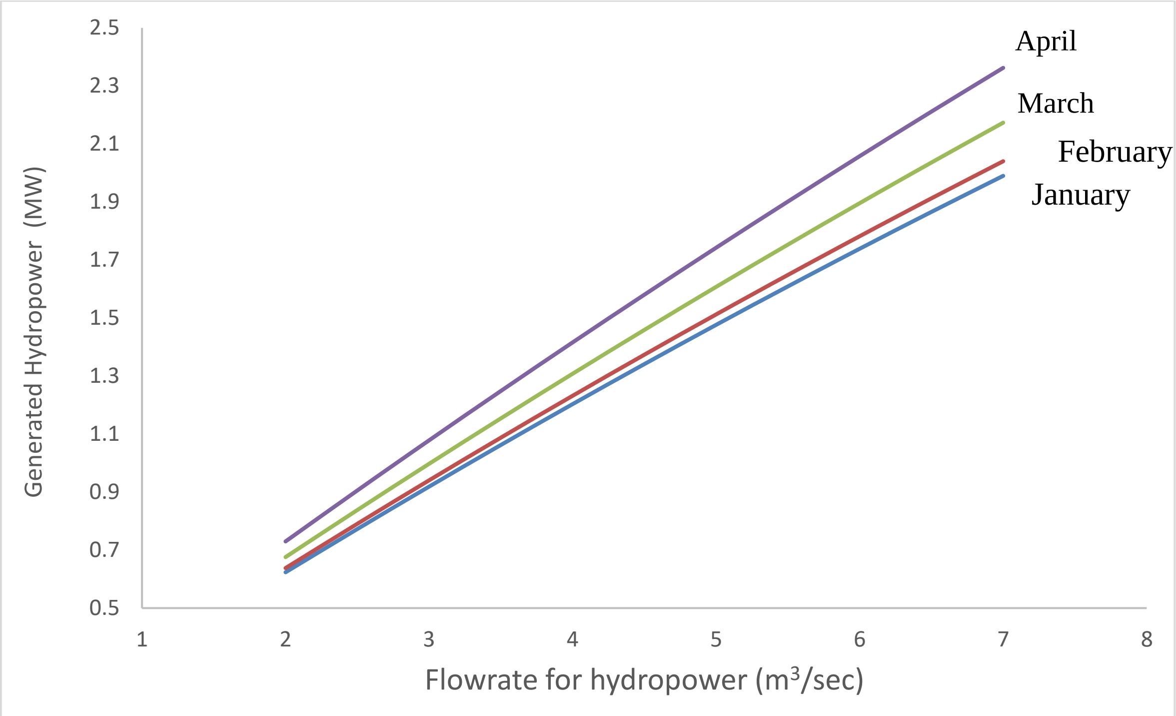

Figure 4.7: The Generated Hydropower for Mosul Reservoir in (January –February- March-April).

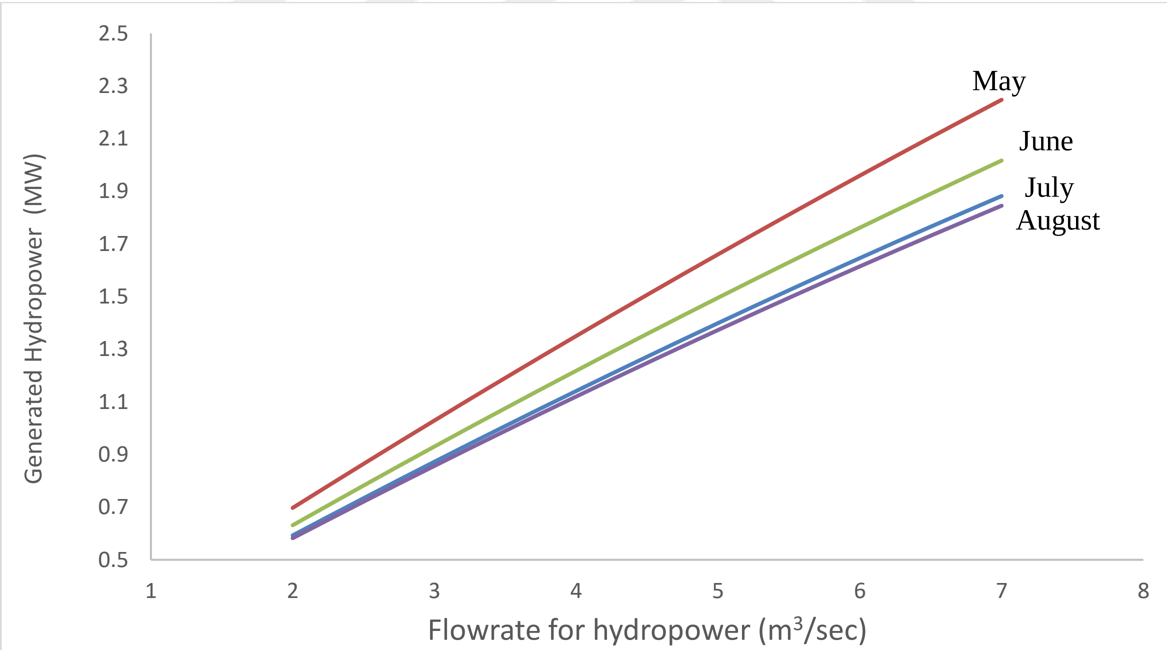

Figure 4.8: The Generated Hydropower for Mosul Reservoir in (May – June- July-August).

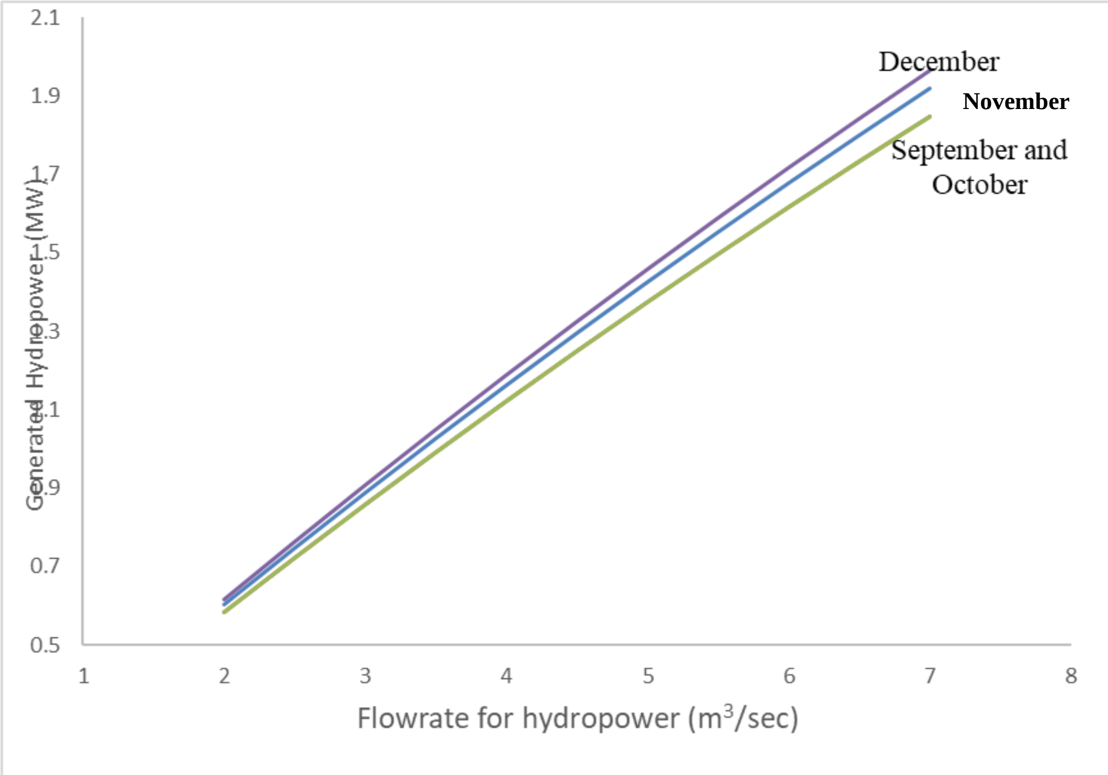

Figure 4.9: The Generated Hydropower for Mosul Reservoir in (September-October-November-December).

Table 4.8: Generated Hydropower in (MW) for Dukan Reservoir.

Month	Flowrate for hydropower generation (m^3/sec)										
	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7
1	0.46	0.57	0.67	0.76	0.85	0.94	1.02	1.10	1.18	1.25	1.31
2	0.48	0.60	0.70	0.80	0.90	0.99	1.08	1.17	1.25	1.32	1.40
3	0.50	0.61	0.72	0.83	0.93	1.03	1.12	1.21	1.29	1.37	1.45
4	0.51	0.63	0.74	0.85	0.95	1.05	1.14	1.23	1.32	1.40	1.48
5	0.47	0.58	0.68	0.78	0.88	0.97	1.05	1.13	1.21	1.28	1.35
6	0.44	0.54	0.64	0.73	0.81	0.90	0.97	1.05	1.12	1.18	1.24
7	0.43	0.52	0.62	0.70	0.79	0.87	0.94	1.01	1.08	1.14	1.20
8	0.42	0.52	0.61	0.70	0.78	0.86	0.93	1.00	1.07	1.13	1.18
9	0.43	0.52	0.61	0.70	0.78	0.86	0.93	1.00	1.07	1.13	1.19
10	0.43	0.52	0.62	0.70	0.79	0.86	0.94	1.01	1.08	1.14	1.19
11	0.43	0.53	0.63	0.72	0.80	0.88	0.96	1.03	1.10	1.16	1.22
12	0.45	0.55	0.65	0.74	0.83	0.91	0.99	1.07	1.14	1.21	1.27

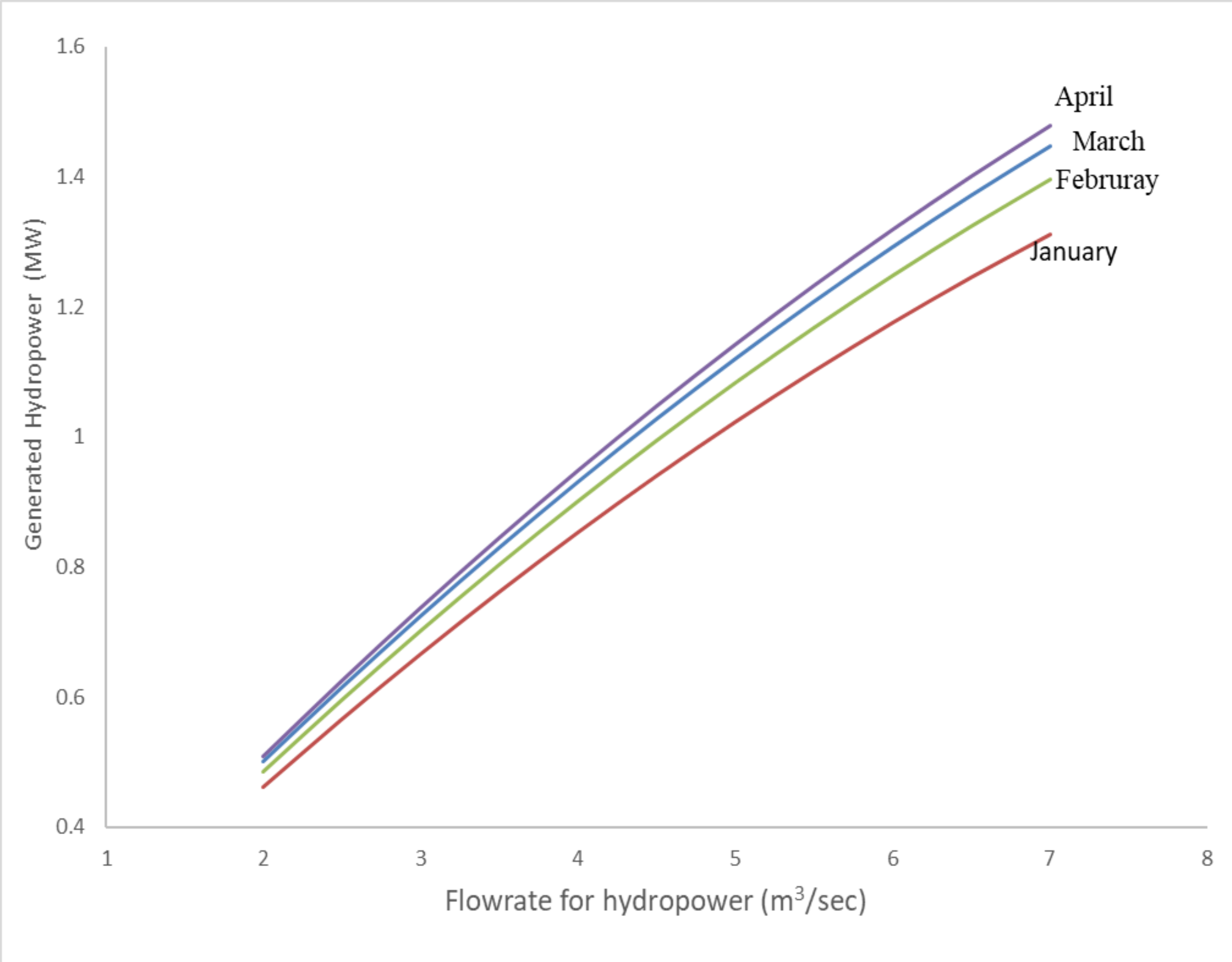

Figure 4.10: The Generated Hydropower for Dukan Reservoir in (January-February-March-April).

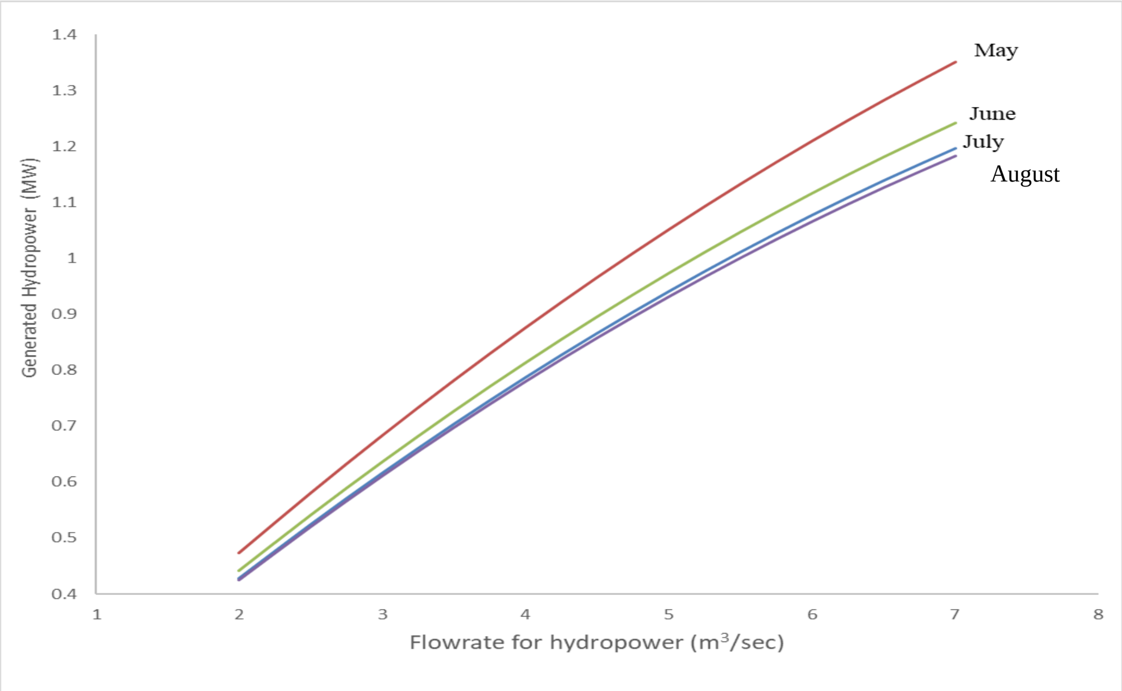

Figure 4.11: The Generated Hydropower for Dukan Reservoir in (May – June- July-August).

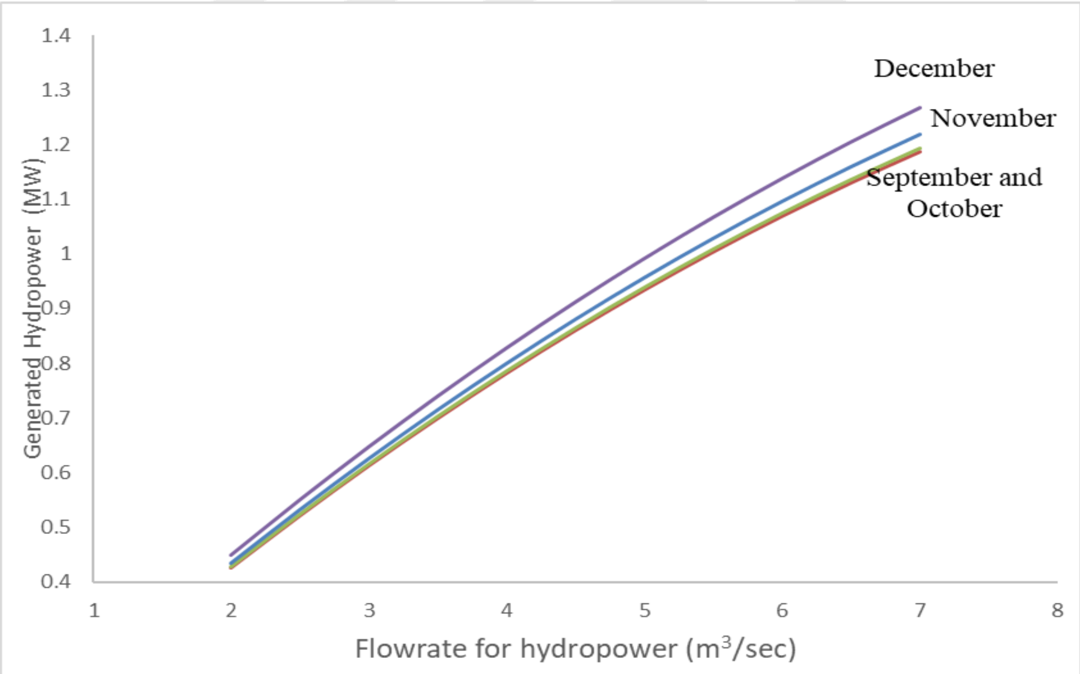

Figure 4.12: The Generated Hydropower for Dukan Reservoir in (September-October-November-December).

Table 4.9: Generated Hydropower in (MW) for Derbindikhan Reservoir.

Month	Flowrate for hydropower generation (m^3/sec)										
	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7
1	0.16	0.19	0.21	0.23	0.25	0.26	0.27	0.27	0.27	0.26	0.25
2	0.18	0.21	0.24	0.26	0.28	0.30	0.31	0.32	0.32	0.31	0.31
3	0.20	0.23	0.27	0.30	0.32	0.34	0.35	0.36	0.37	0.37	0.37
4	0.20	0.24	0.28	0.31	0.33	0.36	0.37	0.38	0.39	0.40	0.39
5	0.17	0.20	0.23	0.25	0.26	0.28	0.29	0.29	0.29	0.28	0.27
6	0.15	0.17	0.19	0.21	0.22	0.23	0.23	0.23	0.22	0.21	0.19
7	0.14	0.16	0.18	0.20	0.21	0.21	0.21	0.21	0.20	0.19	0.17
8	0.14	0.16	0.18	0.19	0.20	0.21	0.21	0.20	0.19	0.18	0.16
9	0.14	0.16	0.18	0.19	0.20	0.21	0.21	0.21	0.20	0.18	0.17
10	0.14	0.16	0.18	0.20	0.21	0.21	0.22	0.21	0.20	0.19	0.18
11	0.15	0.17	0.19	0.21	0.22	0.23	0.23	0.23	0.22	0.21	0.20
12	0.16	0.18	0.21	0.23	0.24	0.25	0.25	0.26	0.25	0.24	0.23

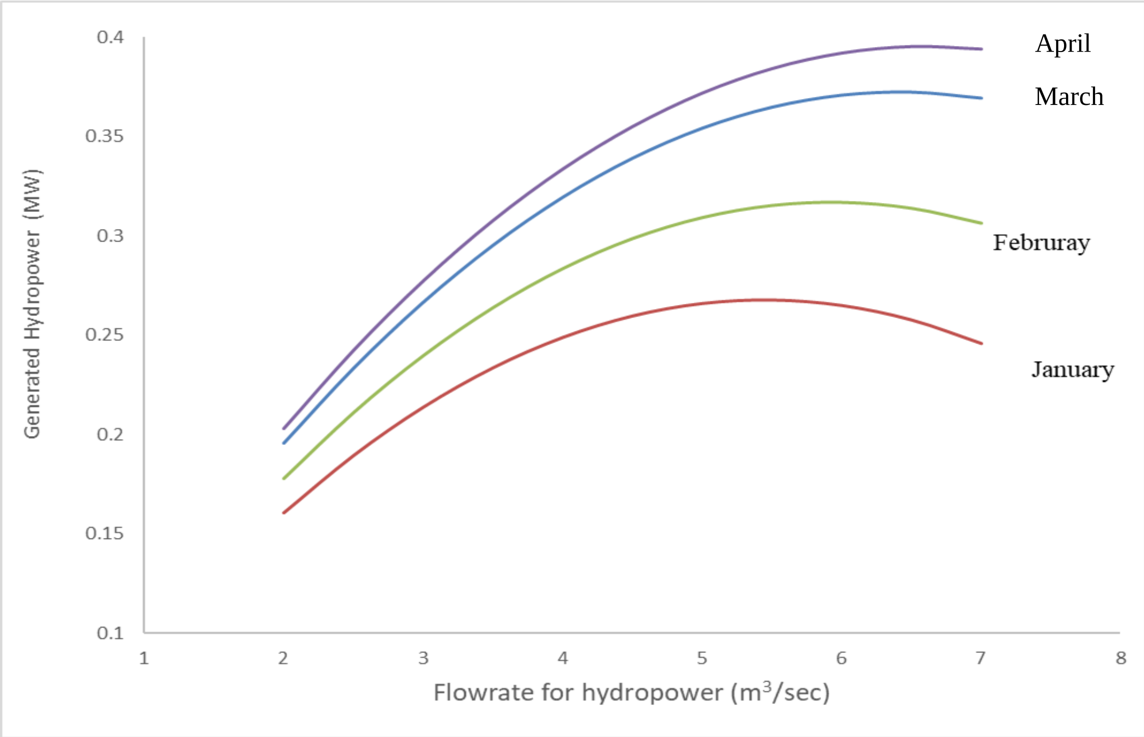

Figure 4.13: The Generated Hydropower for Darbandikhan Reservoir in (January – February-March-April).

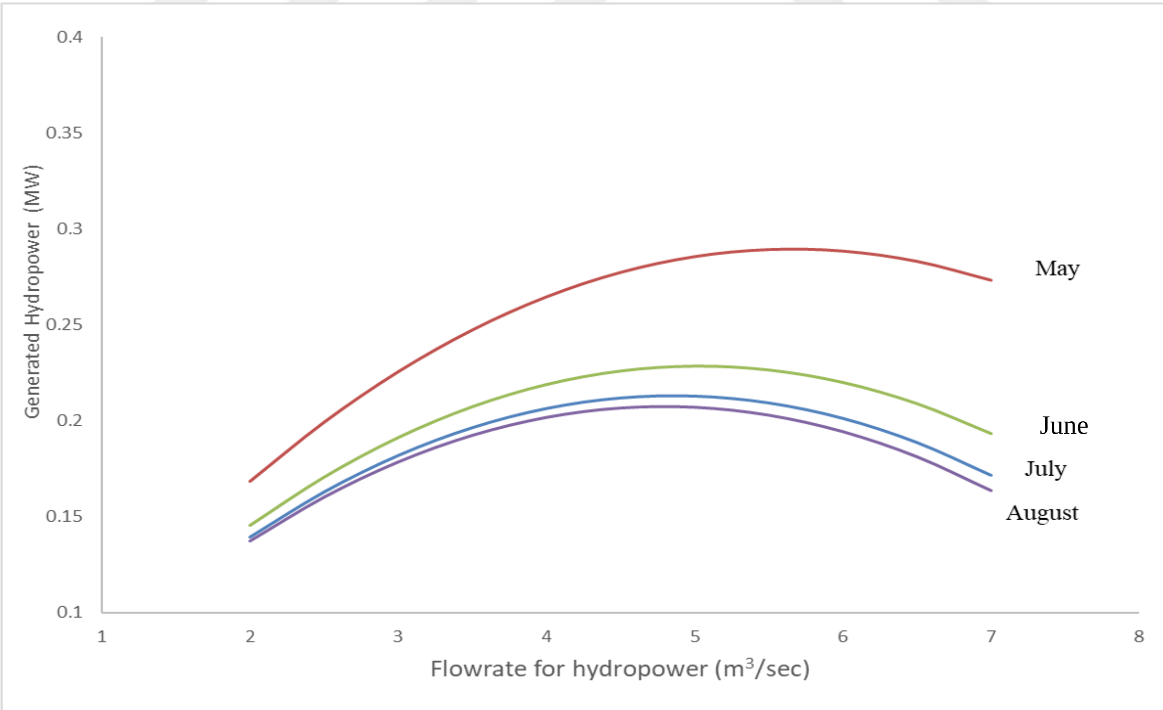

Figure 4.14: The Generated Hydropower for Darbandikhan Reservoir in (May – June- July-August).

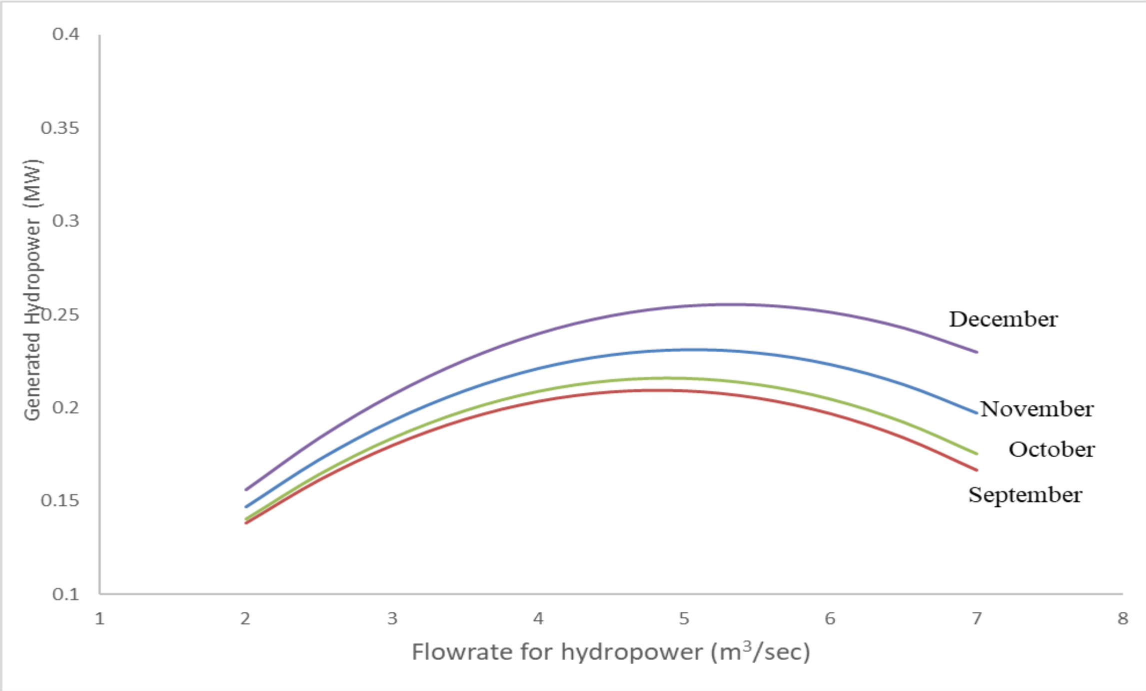

Figure 4.15: The Generated Hydropower for Darbandikhan Reservoir in (September-October-November-December).

4.5 CORRELATION WORK

For building formulas that reflect the changing of hydropower generating with respect to the available input flowrate to the hydropower turbine system, Matlab program was used for analysis the data of the three dams. The correlation for Mosul dam reservoir and Dukan reservoir appeared in linear pathway while that for Derbindekhan dam appeared in quadratic increment. The Mosul reservoir correlation for January month inside Matlab Program was showed in figure 4.16

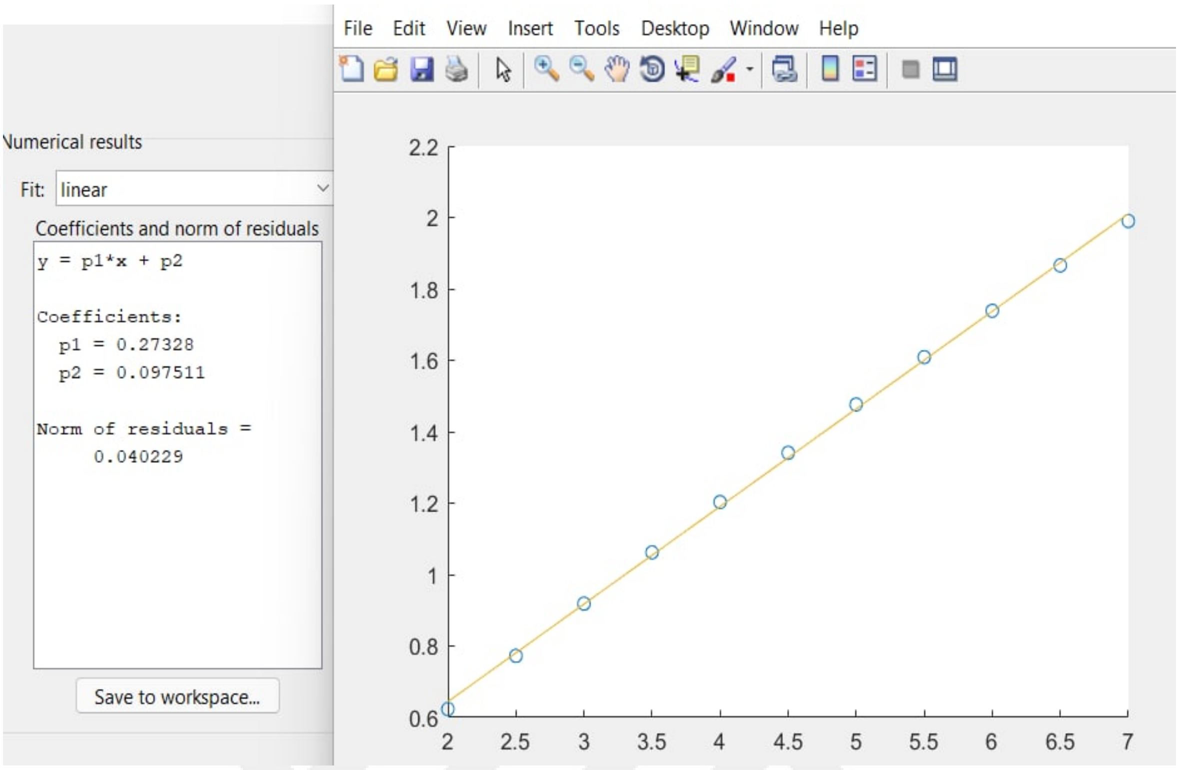

Figure 4.16: The Linear Correlation for Mosul Reservoir (Matlab).

The correlation that made by MATLAB program was made for the three Dams. Figure 4.16 showed the correlation equation for Mosul Dam at January month. These correlations was made for each month to get the relationship between the outflow rates and the generated hydropower based on the analysis results of the reservoirs conditions and the topographic areas. The results of equations were set in tables 4.10, 4.11, and 4.12.

The equations that predicted for the three dams that bond the generation of hydropower in (MW)

Table 4.10: The Monthly Formula for Generated Hydropower (in MW) for Mosul Reservoir.

Month	Hydropower generation (MW) =
1	0.27 q + 0.098
2	0.28 q + 0.098
3	0.3 q + 0.098
4	0.33 q + 0.098
5	0.31 q + 0.098
6	0.28 q + 0.098
7	0.26 q + 0.098
8	0.25 q + 0.098
9	0.25 q + 0.098
10	0.25 q + 0.098
11	0.26 q + 0.098
12	0.27 q + 0.098

Table 4.11: The Monthly Formula for Generated Hydropower (in MW) for Dukan Reservoir.

Month	Hydropower generation (MW) =
1	0.17 q + 0.15
2	0.18 q + 0.15
3	0.19 q + 0.15
4	0.19 q + 0.15
5	0.18 q + 0.15
6	0.16 q + 0.15
7	0.16 q + 0.15
8	0.15 q + 0.15
9	0.15 q + 0.15
10	0.15 q + 0.15
11	0.16 q + 0.15
12	0.16 q + 0.15

Table 4.12: The Monthly Formula for Generated Hydropower (in MW) for Darbandikhan Reservoir.

Month	Hydropower generation (MW) =
1	$-0.009\ q^2 + 0.098\ q + 0.0007$
2	$-0.009\ q^2 + 0.1068\ q + 0.0004$
3	$-0.009\ q^2 + 0.116\ q + 0.0001$
4	$-0.009\ q^2 + 0.1196\ q$
5	$-0.009\ q^2 + 0.102\ q + 0.0005$
6	$-0.009\ q^2 + 0.0903\ q + 0.0009$
7	$-0.0089\ q^2 + 0.0871\ q + 0.001$
8	$-0.0089\ q^2 + 0.086\ q + 0.0011$
9	$-0.0089\ q^2 + 0.0864\ q + 0.0011$
10	$-0.0089\ q^2 + 0.0877\ q + 0.001$
11	$-0.009\ q^2 + 0.0909\ q + 0.0009$
12	$-0.009\ q^2 + 0.0956\ q + 0.0008$

5. CONCLUSION AND FUTURE WORK

5.1 CONCLUSION

The hydropower energy is so effective source of energy as the electricity generated is sustainable the without the pollutants of other generation ways. The benefits of water head and the falling of water in Iraqi dams can reflect important development in the using of these source of energy. The study gathered the required information of three dams in Iraq: Mousl, Dukan, and Darbandikhan dams. The data that gathered including the inflow rates toward the reservoirs, the weather conditions, and the GIS information in the way of analyzing the topographic behavior of the dam regions. The power equation the link between the inflow rate toward the turbines and the available head was obtained. The available head behind the dam was evaluated for each months according to the conditions of inflow and outflow rates and the weather conditions. For each dam. the heads were calculated and explained in tables for each month. The contour lines of upstream region of each dam were assigned by processing the GIS data inside Surfer program. The change in heads were showed in positive and negative magnitude with respect to previous available head for each month. As result of the study, The magnitude of hydropower generated for Mosul dam can reach more than 2 megawatt when using a system of turbines with 80% efficiency and inlet flowrate of 7 cubic meter per second. For same conditions in Dukan Dam, the amount of power can reach to 1.2-1.48 megawatt. The generated power from Darbandikhan dam showed the lowest amounts than the other two dams. Less than 0.5 megawatt was found as maximum as power generated when the inflow rate toward the turbines was 7 cubic meter per second. The variation in output power influenced by the head behind the dam. The graphs of the hydropower power for each month of the three dam were included in the study (using Microsoft Excel Program) to give more figurative view of the increment of power that can be obtained for specific conditions. Building effective formulas for operation the hydropower network of the three dams was part of the study. These equations were set in tables divided foe each month. The equations were built by using the correlation techniques in Matlab program. The input data for each equation was only the inflow rate toward the turbines in which can be consider as portion of the falling discharge toward the downstream areas.

5.2 FUTURE WORK

The analysis of other dams like Hemrin or Haditha Dams can be obtained for upcoming study. The investigation of the generated hydropower amounts and the public demand with respect to the available water resource can be used as an issue of future studies to build effective map of the sustainable energy using from north to south of Iraq. The effective of both hydropower generating and the main stream discharge monthly of agricultural and industrial sectors can be taken as subject for upcoming work. The future studies also can analyze more regions along the Tigris and Euphrates Rivers to examine the validity of construction dams in the way of water storage and generating of sustainable energy source. The studies can analysis the GIS data of specific regions in Iraq that been fed by stream of water resources to find the validity of building hydropower system with capacity relating the nearby using.

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