CONFERENCE AGENDA

2ND SPSBIC

School of Physical Sciences

Second Biennial International Conference

25th – 26th June 2019, Minna

ORGANISED BY

School of Physical Sciences
Federal University of Technology, Minna

25th June (Morning Session)

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2019SPSBIC0021 - Studies of Biogas Production of some Selected Animal Wastes and their Co-Digestion Presenter: Buhari, Idris	2019SPSBIC0028 - Effect of Weather Variables on Reservoir Inflow for Hydroelectric Power Generation in Jebba Dam, Nigeria Presenter: Ndace, D.	2019SPSBIC0020 Differential Transformation Method (DTM) for Solving Mathematical Modelling of Monkey Pox Virus Incorporating Quarantine Presenter: Samuel A. S	2019SPSBIC00014 - Renewable Eenergy: Benefits, Environmental Impact and Strategies for Optimum Exploitation for Sustainable Development Presenter: Danjumma, S. G.
2019SPSBIC0030 - Phytochemical and Antibacterial Studies of Ensete gilletii Leaf Extract and Fraction Presenter: Tanko, E.	2019SPSBIC0029 - Influx foreign drilling rigs into Nigeria: A blessing or Curse Presenter: Mohammed, I. k	2019SPSBIC0027 Analytical Method of Land Surface Temperature Prediction Presenter: Shehu, M. D.	2019SPSBIC00010 - Threats of Climate Change on the Biodiversity of the Hadejia-Nguru Wetlands Presenter: Abubakar, M. M.
2019SPSBIC0038 - Prediction of Phase Equilibria and Construction of Total Phase Diagram for Quinary Li, Na, K, Sr//Cl –H2O System at 25? Presenter: Sherali Tursunbadalov,	2019SPSBIC0034 - Thermal Characterization of Bida Basin Kerogen Presenter: Onyeloye, K. C.	2019SPSBIC0035 - Agreement Between the Homotopy Perturbation Method and Variation Iterational Method on the Analysis of One-Dimensional Flow Incorporating First Order Decay Presenter: Jimoh, O. R	2019SPSBIC0022_1 - Environmental Audit of Camelite Paint Manufacturing Company Located at Agbor, Delta State, Nigeria. Case Study: Analysis of Effluent/Borehole water Discharge Presenter: Molua, C.
2019SPSBIC0040 - Sustainable Energy Production, Science and Technology Development :The Role of Chemistry Education Presenter: Adinoyi, Y. A.	2019SPSBIC0047 - Flood Warning and Mitigation: The Critical Issues of Water Level Forecasting Presenter: Ocheme, J.E.	2019SPSBIC0039 - Boundary Value Technique for the Solution of Special Third Order Boundary Value Problems in Ordinary Differential Equations (ODEs) Presenter: Umaru, M.	2019SPSBIC0022_2 - Protective Shielding Parameters for Diagnostic X-ray Rooms in some Selected Hospitals in Agbor - Delta State Presenter: Molua, C.
	2019SPSBIC0054 - Trend Dynamics of Rainfall on Vegetation Pattern over Mokwa Local Government Area of Niger State, Nigeria Presenter: Umar, A.		

SPSBIC 2019

24th - 28th June, Minna Nigeria

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

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of Participation

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With the paper entitled:

Effect of Weather Variables on Reservoir Inflow for Hydroelectric Power Generation in Jebba Dam, Nigeria

Prof. Kasim U. Isah

CHAIRMAN

Effect of Weather Variables on Reservoir Inflow for Hydroelectric Power Generation in Jebba Dam, Nigeria

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Abstract

This study examined the effect of weather variable on reservoir inflow for hydro-electric power generation in Jebba Dam, Nigeria. The study utilized monthly rainfall, temperature, evaporation, reservoir inflow and outflow from 1993 to 2017. The study objectives were achieved by analysing mean annual trend of rainfall, temperature, evaporation, reservoir flows, for 25 years. Hypothesis was tested for relationship between the weather variables (rainfall, temperature, evaporation) on the amount of reservoir inflow, while the effect of reservoir inflow, and reservoir outflow on the amount of energy generated was tested using correlation coefficient at 5% significant level. The amount of energy generated for the period of study was analysed on monthly basis to know the season more electricity was generated. From the study it reveals that the month of March generate more electricity of (273724 mwh) and the lowest in the month of July (155098mwh). All the weather variables show an increasing trend, while the reservoir inflow pattern exhibit fluctuations at various levels. The results also revealed that rainfall, temperature, evaporation, has a direct effect on the reservoir inflows and subsequently on dam levels and also that reservoir inflow, and outflow have strong relationship with the amount of energy generated which signify that climate variability has a big impact on reservoir inflow and energy production. It was recommended that future hydropower plant investments in the country should take careful consideration into the climatic variables impact on the potential for energy generation.

Keywords: Reservoir inflow, reservoir outflow, temperature, evaporation, rainfall, hydroelectric power generation

1. Introduction

Water is a vital resource to support life on earth. Unfortunately, it is not evenly distributed over the world by season or location; it is also a critical limiting factor for economic and social development in many parts of the world. (Gleick *et al.*, 2009; World Bank, 2006). One of the most efficient ways to manage water resources for human needs is by the construction of dams that create reservoirs for storage and future distribution (ICOLD, 1999; Asmal, 2009).

Nigeria as a nation has more than four decades of history on hydro-electric power development in Africa South of Sahara starting with the Kainji Dam on the lower part of River Niger. The primary purpose of these dams (Jebba, Kainji on River Niger and Shiroro on River Kaduna) was to serve as engine of growth and development. This role has been performed creditably well by supplying not only Nigeria but also those neighboring countries for which River Niger is a common wealth, with the needed energy to power the growing economy. In this paper we are concern with the hydro electric power generation dam, the reservoir and climatic elements that are of interest are rainfall, Evaporation, temperature and reservoir inflow and outflow

2. Literature Reviews

Kabo-Bah, *et al.* (2016) studied Multiyear Rainfall and Temperature Trends in the Volta River Basin and their Potential Impact on Hydropower Generation in Ghana. The effects of temperature and rainfall changes on hydropower generation in Ghana from 1960–2011 were examined to understand country-wide trends of climate variability. Moreover, the discharge and the water level trends for the Akosombo reservoir from 1965–2014 were examined using the Mann-Kendall test statistic to assess localized changes. The annual temperature trend was positive while rainfall showed both negative and positive trends in different parts of the country. However, these trends were not statistically significant in the study regions in 1960 to 2011. Rainfall was not evenly distributed throughout the years, with the highest rainfall recorded between 1960 and 1970 and the lowest rainfalls between 2000 and 2011. The Mann-Kendall test shows an upward trend for the discharge of the Akosombo reservoir and a downward trend for the water level. However, the discharge irregularities of the reservoir do not necessarily affect the energy generated from the Akosombo plant, but rather the regular low flow of water into the reservoir affected power generation.

Kachaje, Kasulo, and Chavula (2016) assessed the potential impacts of climate change on hydropower: on micro hydropower scheme, Malawi. The study reveals that Climate change has the potential to affect hydropower generation by either increasing or reducing flows (discharge) and the head. The study analyzed trends in weather time series (air temperature and rainfall) data from 1980 to 2011 in connection to changes in river discharge and their associated impacts on hydropower generation profile. The Mann-Kendall (MK) test was used to detect trends in air temperature, precipitation and discharge. Correlation analysis was also used to uncover the relationship between discharge and precipitation as well as between discharge and temperature. The MK results highlighted significant rising rates of air temperature, precipitation and discharge in some months and decreasing trend in some other months, suggesting significant changes have occurred in the area.

Bekoe & Logah (2013) assessed the impact of droughts and climate change on electricity generation in Ghana, Ghana has occasionally being experiencing harsh weather conditions such as flooding and hydrological-droughts. Electricity power for the country depends mainly on hydropower generated from a hydropower dam at Akosombo built in 1965. The 2006/2007 electricity power rationing, equating to about 24hrs light in 48 hrs was the severest power rationing ever witnessed in Ghana and the consequences were catastrophic. Out of about 1180MW generated by the two hydropower dams, only about 400MW was produced. This affected all sectors of the economy including industry, mining and domestic. Manufactures were reducing output, this paper analysis 37 years of rainfall in the Volta basin and intake water levels in the Dam site on the Volta lake for hydropower generation to establish whether in reality, the main causes of the power rationing due to low water levels in the Akosombo dam was due to drought. The paper establishes that the 1983, 1997 and 2006/7 power rationing was truly as a result of hydrologic drought whereas the 2003's was not. The paper also suggests that if climate change effects on the water resources of the country are not managed sustainably, drought and floods could affect hydropower generation in future.

3. Methodology

Mean monthly rainfall, evaporation, temperature, reservoir Inflow, outflow, and amount of energy generated for a period of twenty five (25) years from 1993-2017 over the study area were obtained from the hydroelectric-dam Jebba Station in their hydrological unit and generation room. The statistical techniques that were use are all toward establishing relationship between hydropower generations, and weather variables on reservoir for electricity generation in Jebba dam and these includes, time series analysis, Pearson Product moment correlation analysis, using Statistical Package for Social Scientists (SPSS) tool. These methods are briefly discussed in following sections:

3.1 *Trends of weather variables*

This was achieved using time series analysis to detect the trend in weather variables. Trend analysis presents the long term movement of the time series to detect the patterns of weather variables (temperature, evaporation, and rainfall), and reservoir inflow over the hydro station presented using graphs.

3.2 *Effects of weather variables on reservoir*

This was assessed using correlation analysis as shown in equation 1. This was meant to determine the degree of relationship between climate variables and reservoir inflow.

$$R_{xy} = \frac{\frac{1}{n}\sum_{i=1}^{n}(x_i-\bar{x})(y_i-\bar{y})}{\sqrt{\frac{1}{n}\sum_{i=1}^{n}(x_i-\bar{x})^2 \frac{1}{n}\sum_{i=1}^{n}(y_i-\bar{y})^2}} \quad \text{eqn (1)}$$

Where, R_{xy} is the correlation coefficient, n is the sample size, x_i and y_i are the variables being correlated and x and y are the mean values of variables being correlated. The computed correlation values were tested for statistical significance at 5% significance level.

3.3 *Analysis of the mean monthly reservoir inflow and outflow, and mean monthly energy generated*

This was analyse using trend analysis and the variation on amount of energy generated in the study area by getting the overall mean of energy generated for the time frame of study (1993-2017) for each month .

3.4 *Examine the relationship between the reservoirs inflow, outflow patterns on the amount of energy production*

This was achieved using Pearson Product moment correlation co-efficient using Statistical Package for Social Scientist (SPSS) version 20.0 software package. The test was tested at 0.05 level of significance.

4. Results and Discussion

4.1 Analysis of rainfall trend over the study area

The trend in figure1 shows that rainfall in the study area has been fluctuating and the pattern shows gradual increase over the years reaching its zenith in the year 2013 with 122.20mm, although there is also a wide range of fluctuation in the amount of rainfall ranging from the lowest which is the year 2009, 2005, and 2006 with 77.81mm, 78.10mm, 81.07 respectively. With an increase in 2016, 2003, and 2000 with about 115.35mm, 111.54mm, 103.38 accordingly. The study area does not seem to have a major shortage in amount of rainfall as shown in figure 1.

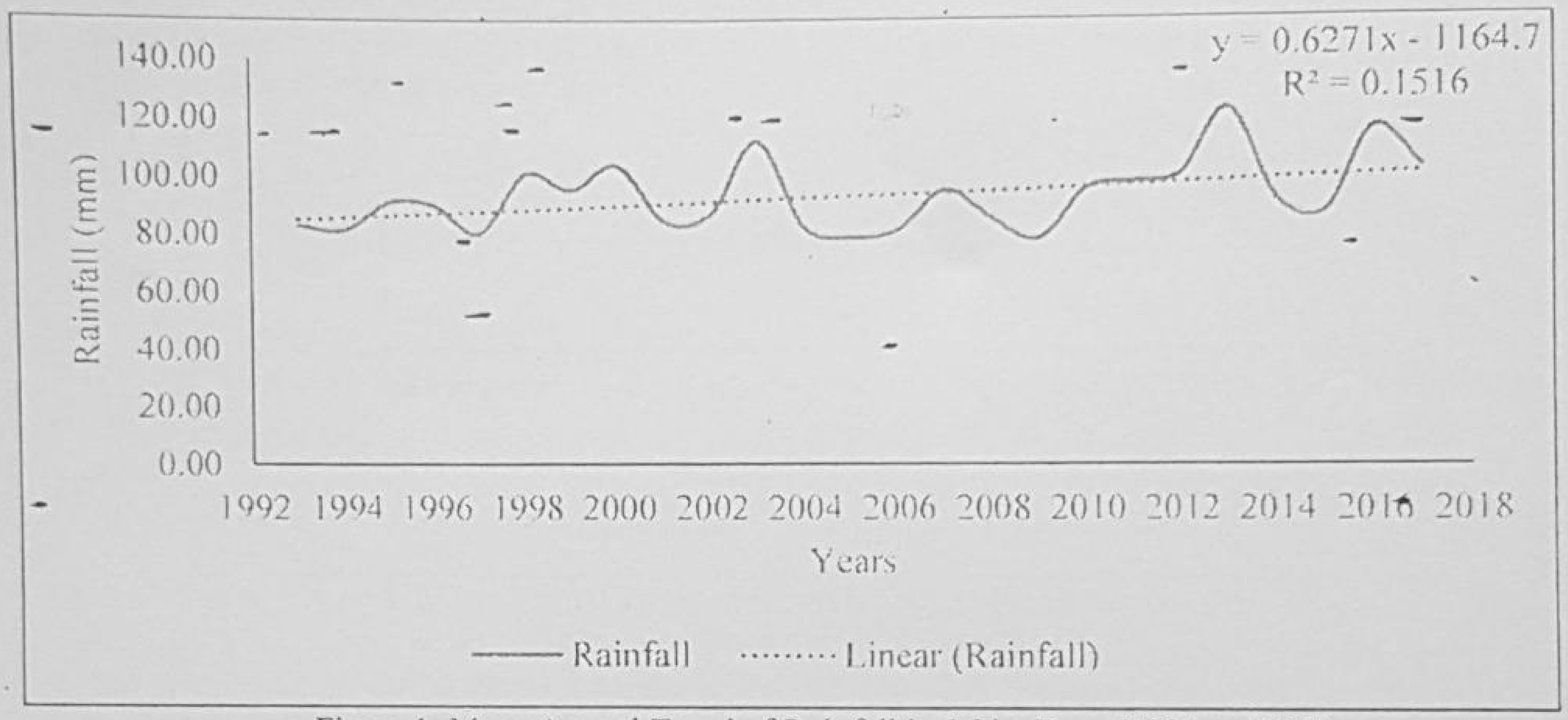

Figure 1: Mean Annual Trend of Rainfall in Jebba Dam (1993 to 2017).
Source: Authors' Data Analysis, 2019.

4.2 Analysis of temperature trend over the study area

temperature of the study area has been on the increase and has been fluctuating, with the lowest annual recorded in the year 1993, 1994, 1995, and 1997 with 28.58°C, 28.63°C, 28.75°C, 28.71°C, respectively showing a sharp drop to 31°C below average. With the increase starting from 29.04°C year 1999, reaching it highest in 2010 with 30.75°C. This increase could be as a result of climate change. An increase in temperature is capable of increasing evaporation rate and it is also capable of increasing precipitation which might lead to flooding thereby causing destruction and break down of equipment required for electricity generation. This further proves the claim made by Cole, Elliot and Strobl (2014).

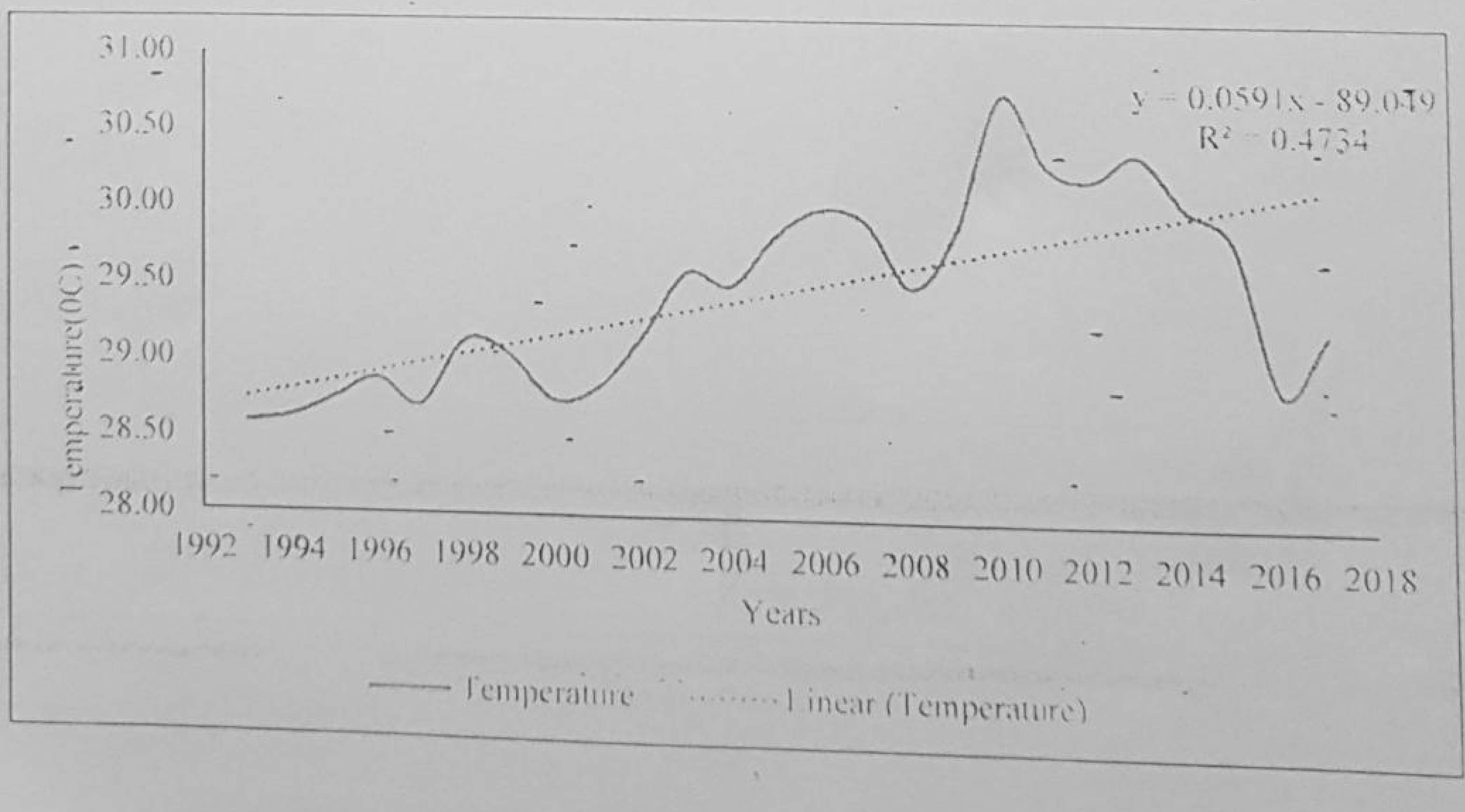

Figure 2: Mean Annual Trend of Temperature in Jebba Dam (1993 to 2017)
Source: Authors' Data Analysis, 2019.

4.3 Analysis of evaporation trend over the study area

The evaporation in the study area has been fluctuating though not too significant because at the year 2002, despite increased evaporation rate of about 19.45mm, which mark the highest amount of evaporation within the study period the station was still able to generate an annual mean power generation of 173869.3mwh which is high when compared with the average amount the station has been generating using the time frame of study. Similarly, the rate of evaporation in the year 2011 dropped sharply to an average of 16.16mm and the power generated was still about 213942.5mwh which is above average. Also, the average evaporation for 2012 is 16.19mm while the amount of power generated in 2012 is among the highest with the figures of about 224478.4mwh in the period of time under study. High rate of evaporation is capable of reducing the amount of water in the reservoir, thereby resulting to shortage in power generation. Though, it can cause increment in precipitation. Cole, Elliott and Strobl (2014) also observed that the greatest loss of potential water resources from hydroelectric facilities comes from the evaporation of water from the surface of reservoirs.

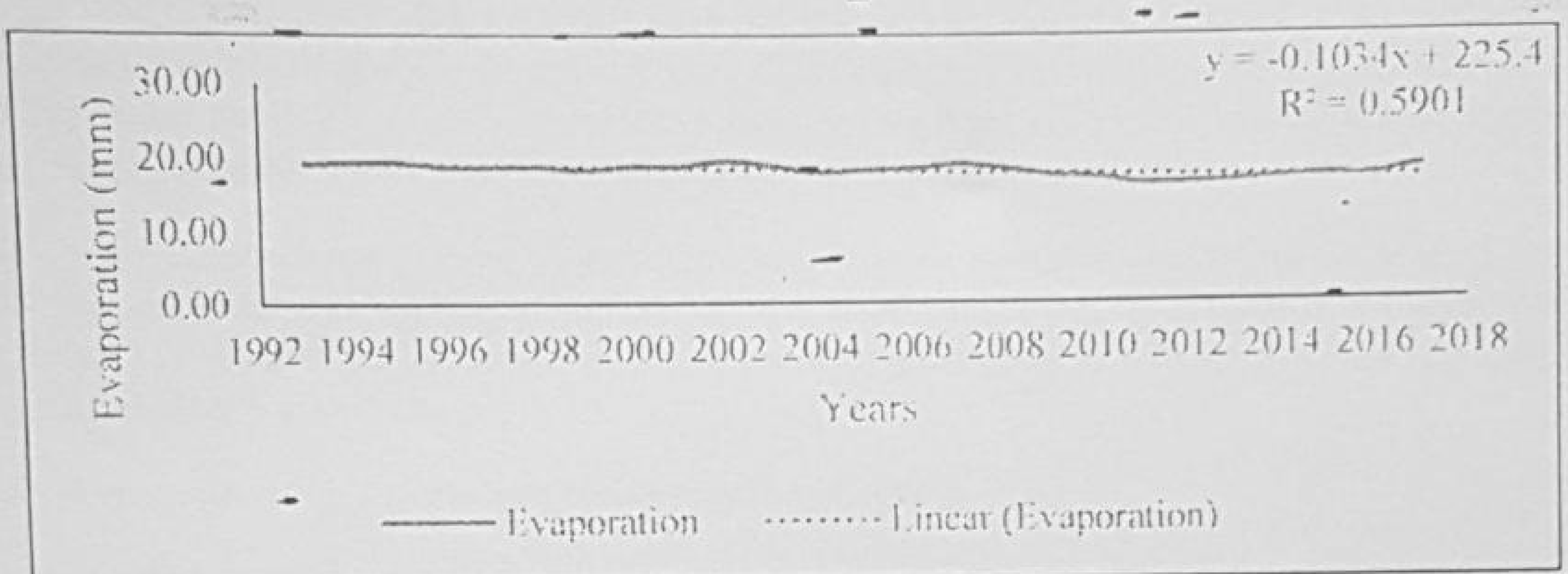

Figure 3: Mean Annual Trend of Evaporation in Jebba Dam (1993 to 2017)
Source: Authors' Data Analysis, 2019.

4.4 Analysis of Trends in reservoir inflow over the study area

Figure 4 shows the Trend of reservoir inflow in the study area for the period of twenty five years (1993-2017). reservoir inflow pattern which has been within and out of the country. It is important to note that reservoir inflow in Jebba dam is a major factor that determine the amount of power generated. In river Niger in Jebba. The flow regime of the River Niger below the Jebba dam is governed by the operations of the Kanji and Jebba. The study reveals that the reservoir inflow exhibit a negative trend though with various degrees of fluctuation from the year 1993, which record the lowest inflow with about inflow of 714.166. And with much increament in the second year of the study period 1994, with an inflow of 1287.333 and a sudden decrease in 1996, and 1997 with inflow of this 934.6667, and this 915.75 respectively while year 1998 to 2017 exhibit tremendous increase at various levels.

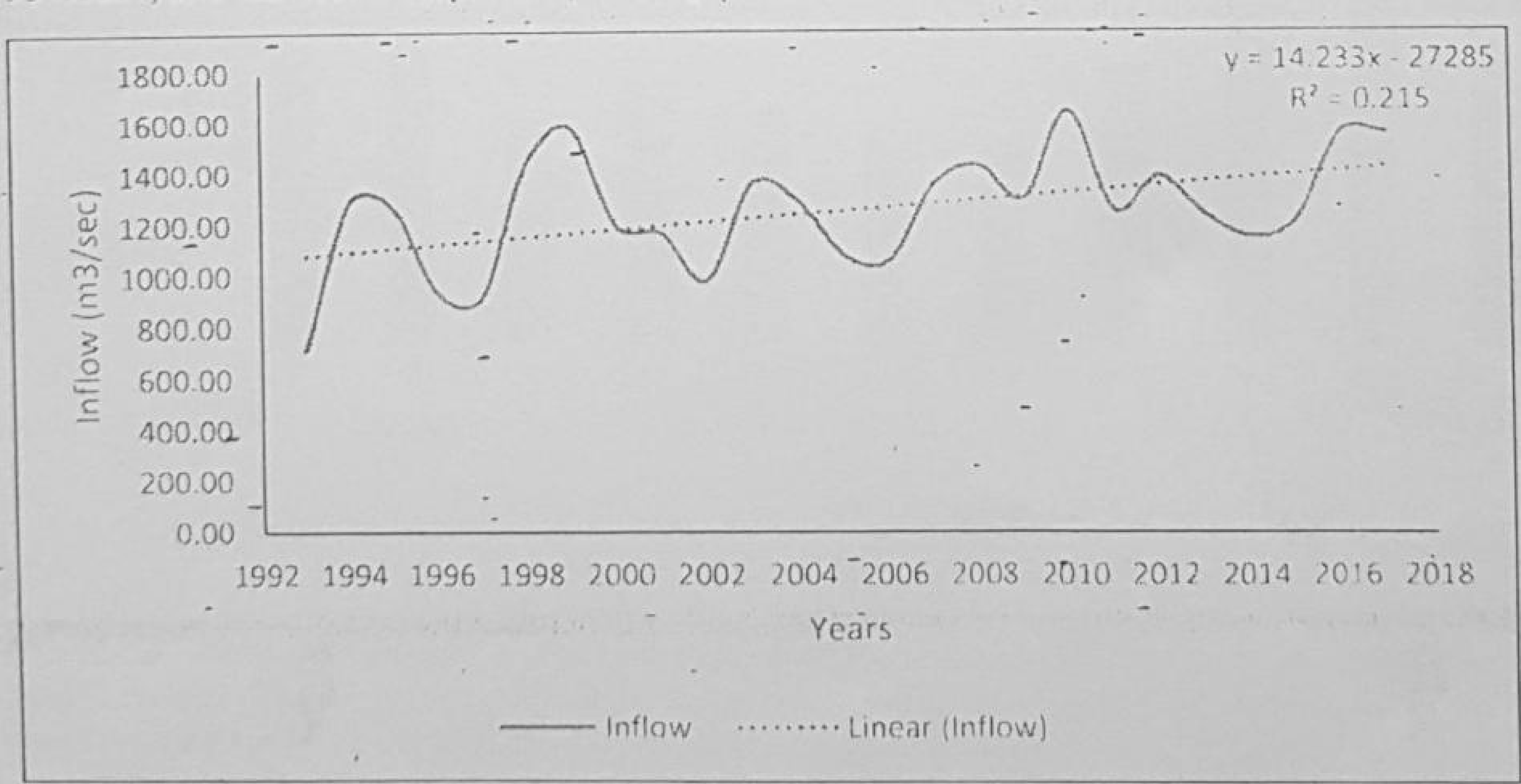

Figure 4.Mean Annual Trend of Reservoir Inflow in Jebba Dam (1993 to 2017)
Source: Authors' Data Analysis, 2019.

4.5 *Analysis on the Effect of Weather Variables (Evaporation, Rainfall, and Temperature) on the Reservoir Inflow Pattern*

Table 1: Correlation between Rainfall, Temperature and Evaporation on Reservoir Inflow

Variables		Rainfall	Temperature	Evaporation
Reservoir Inflow	Pearson Correlation	.467*	.301	-.326
	Sig. (2-tailed)	.019	.144	.112
	N	25	25	25

*. Correlation is significant at the 0.05 level (2-tailed).

Table 1 show that the correlation between rainfall and reservoir inflow is 0.467* this shows that there is a positive significant relationship between rainfall and reservoir inflow which signify that an increase in rainfall will lead to increase in the amount of water which will be available for energy generated and vice versa.

Temperature also shows it in positive direction with the r value between temperature and reservoir inflow in the study area been 0.301. This implies that it is positive but not very strong at 0.05 level of significant. since climate change will certainly increase global air temperature, At first glance, increased global precipitation would appear to suggest more water available for hydroelectric power production. However, higher temperatures will lead to increased evapotranspiration levels thus reducing the runoff (Harrison *et al.*, 1998).

evaporation shows it have strong negative correlation relationship with reservoir inflow at 0.05 level significant as the r value between them is -0.326 which indicate a strong negative relationship between evaporation and reservoir inflow. This means an increased in the amount of evaporation will lead to decrease in the reservoir inflow but not statistically significant.

4.6 Analysis of mean monthly inflow and mean monthly outflow

The summary of mean monthly reservoir inflow, and outflow on the study area is presented in figure 5 and figure 6 respectively during the 25years of the study. The peak reservoir inflow occur during the month of September which is 2058.2 m3/s and October with 1989.84m3/s, and the low flow occur during the months of July and June with values of 843.16m3/s and 897.28 m3/s respectively, also from January to may, august and November, December exhibit fluctuations across the months

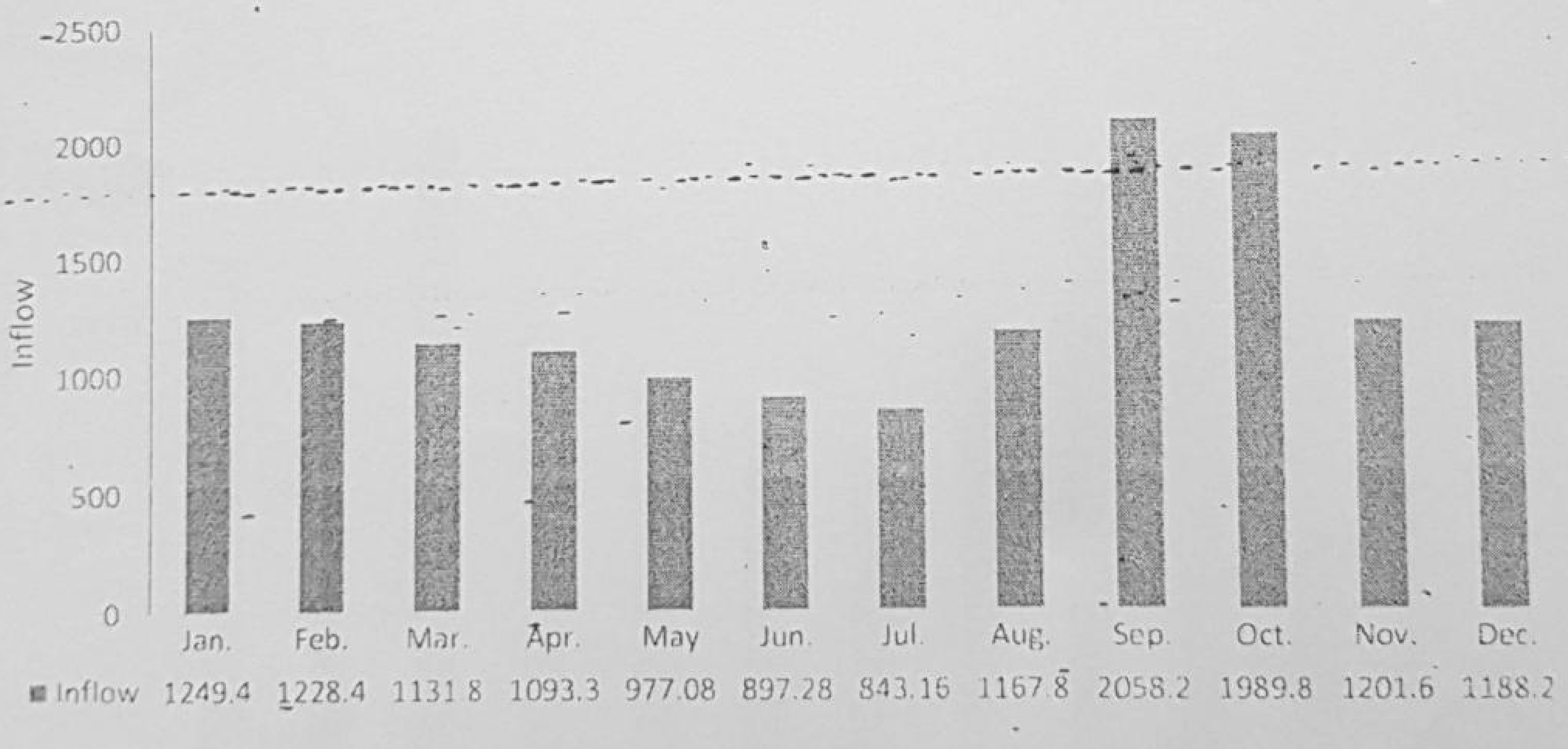

Figure 5: Mean Monthly Trend of Reservoir Inflow in Jebba Dam (1993 to 2017)
Source: Authors' Data Analysis, 2019.

While reservoir out flow record it peak in the month of October with 2037.04 m3/s and September 1949.24 m3/s respectively and the lowest reservoir out flow was on the month of July 842.88m3/s and various fluctuation across the remaining months from January, to December as shown in figure 6

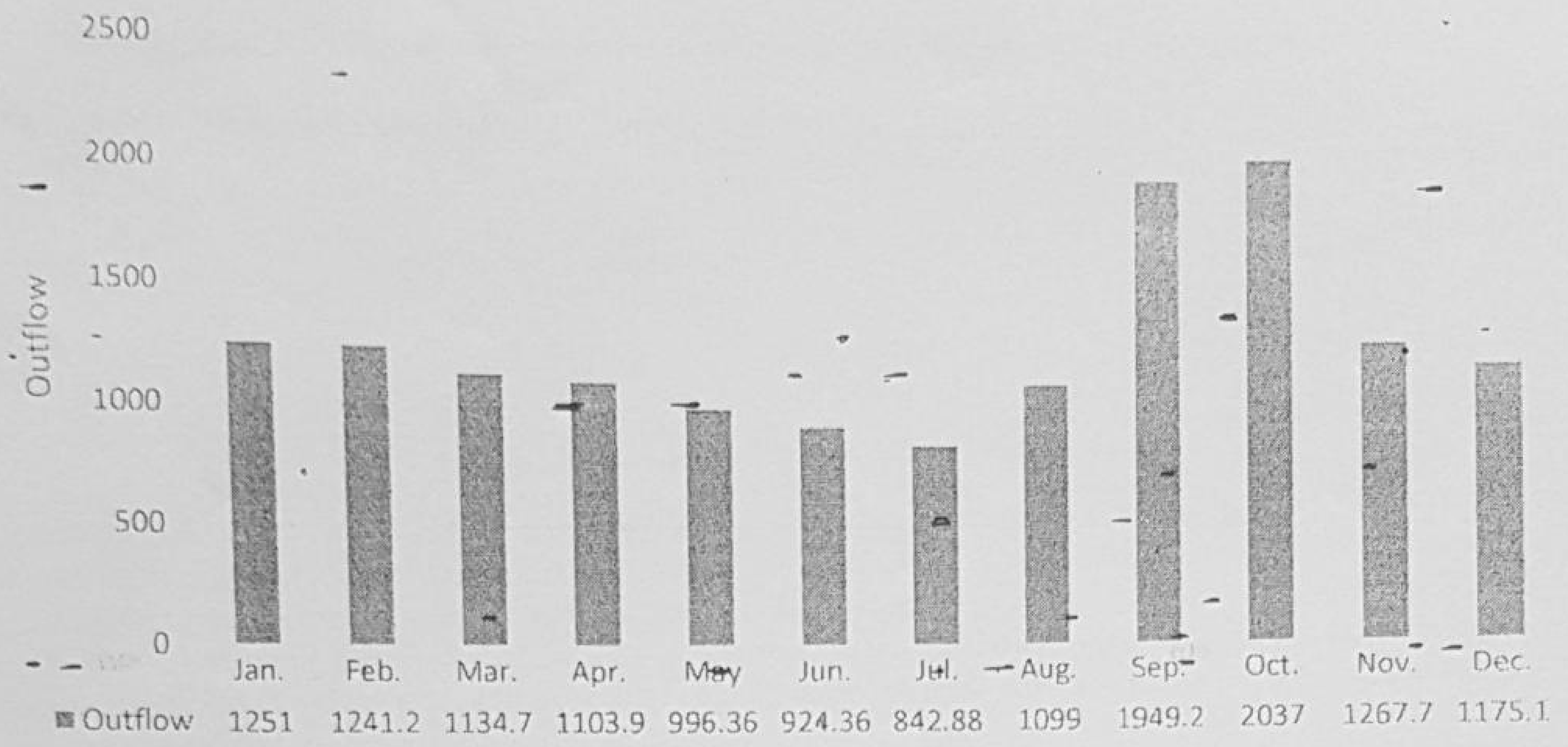

Figure 6: Mean Monthly Trend of Reservoir Outflow in Jebba Dam (1993 to 2017)
Source: Authors' Data Analysis, 2019

4.7 Analysis of mean monthly energy generated

Various degree of fluctuation are observed. From January to February, March and April with an average mean of 226278mwh, 207603mwh, 273724mwh, and 197979mwh, respectively. The month of May with 183595mwh, marks the period of decline in the amount of energy generated to the month of July with an average of 155098mwh which is the lowest as the study reveals. While the month of June generates 162045mwh Although the month of August with a mean of 195274mwh marks the period of increase in energy generation and this increase continues to September, October, and a down word decrease from November to December having an average of 249887wmwh, 266122mwh, 223790mwh, and 218711 respectively. And the months with highest amount of energy generation are march, October, September, November, January, This is so because of the inflow pattern of the Jebba reservoir which is as a result of the river flow regime characterized by two distinct flood periods occurring annually, namely the white and black floods.

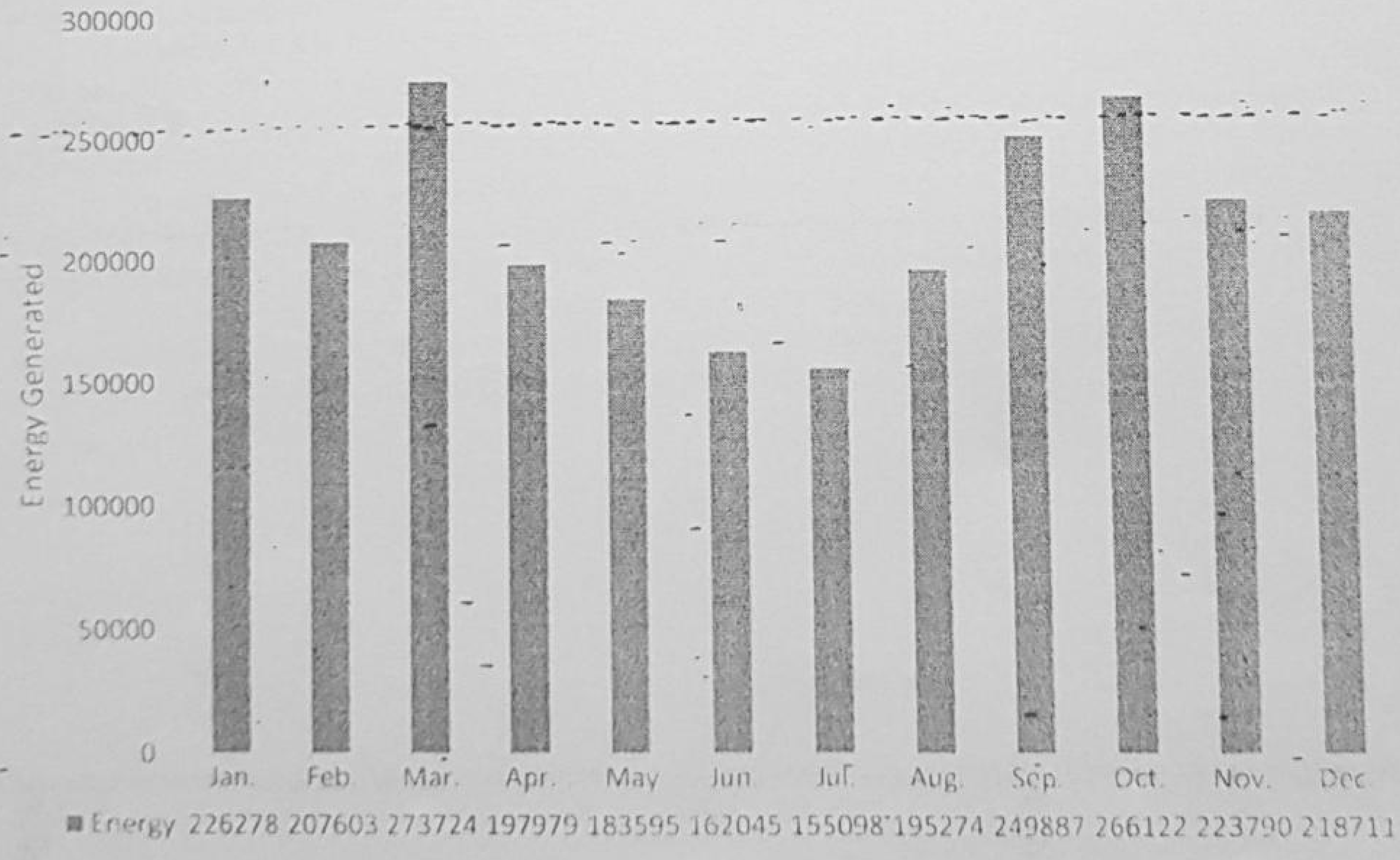

Figure 7: Mean Monthly Trend of Energy Generated in Jebba Dam (1993 to 2017)

Source: Authors' Data Analysis, 2019

4.7 *Correlation Between Reservoir Inflow and Outflow on the amount of energy generated*

Table 2: Correlation Between Reservoir Inflow and Outflow on the amount of power generated

Variables		Reservoir Inflow	Reservoir Outflow
Energy	Pearson Correlation	.637*	.634*
	Sig. (2-tailed)	.001	.001
	N	25	25

* .Correlation is significant at the 0.05 level (2-tailed).

Table 2 shows that reservoir inflow and the amount of energy generated have correlation of 0.637* The result shows a significant positive relationship at 0.05 level of significance. This implies that a change in reservoir inflow will definitely affect the amount of energy generated. This findings is in agreement with Jimoh (2008), who revealed that reservoir inflow in Kainji dam is a major factor that determines the amount of energy generated because rainfall and inflow covering over nine countries across West Africa is being received at the dam.
The r value between the reservoir outflow and amount of energy generated is 0.634* the result shows a significant positive relationship at 0.05 level of significance which means that it is a strong positive relationship, that implies the more the reservoir outflow the more amount of energy generated since the reservoir outflows is crucial to reservoir balance, the reservoir useful life, as well as reservoir discharge. And the amount of electricity to be produced by a hydropower facility will mainly depend on the volume of water passing through the turbine in a given amount of time,

5. Conclusion

Hydropower generation is highly dependent on available water resources. The impact of rainfall, temperature, evaporation, variability has a direct impact on reservoir inflow which in turn have much effect on amount of electricity generation. This study examined the historical rainfall, temperature, evaporation, reservoir inflow, and outflow data across twenty five years in jebba reservoir to understand specific trends over time. The study also examined the discharge irregularities of the Jebba Reservoir from 1993-2017 as way to contextualize the implications of climate variability on the performance of hydropower plants.

Weather variables (rainfall, temperature, evaporation,) and the hydro meteorological parameters (reservoir inflow, reservoir outflow) within Jebba Dam were subjected to multiple analyses. The trends of the weather variables and hydro parameters for the time frame of study were shown using trend line. Rainfall, temperature, shows an increasing trend, except for evaporation which shows a downward decrease while the reservoir inflow and outflow pattern show a steady fluctuation in the movement of the flow sometimes increase and decrease trend. Mean while all the variables and the parameters exhibit fluctuations at various levels while statistical analysis revealed that there is increased electricity generation during the dry season than the rainy season. However, the amount of energy generated in March, August, September, and October is high and can be comparable to the amount generated in the dry season months. Pearson correlation co-efficient shows that reservoir inflow and outflow have significant relationship with the amount of energy generated, while rainfall also have a significant relationship with the amount of reservoir inflow temperature have little significant relationship with the amount of reservoir inflow and evaporation have negative relationship to reservoir