


RESEARCH ARTICLE | MARCH 31 2025

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AIP Conf. Proc. 3303, 050005 (2025)

<https://doi.org/10.1063/5.0264494>



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Impact of Climate Change on Evaporation in Mosul Dam Reservoir-Iraq

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Abstract. Water resources in Iraq are considered one of the elements most affected by climate change, especially water bodies, and the loss of water from reservoirs by evaporation is one of the most losses that occur in semi-arid countries. Hence, a study of a subject in this regard is very necessary, so the Mosul Dam reservoir was taken to study the effects of change. So we researched this with a detailed analysis of climatic data from 1990-2020. We found the reality of the effect of each climatic element on the evaporation element. We linked five of the climatic elements to one mathematical model to find the value of evaporation from them, and finally we made predictions for some main climatic elements. The results showed that the reservoir loses about 0.9 billion cubic meters annually through evaporation, and the results of the analysis of evaporation data indicated that its rates were increasing and reached a difference of 13.6% over 30 years, and from the results of the strength of the correlation between the climatic elements with evaporation by the SPSS program, it was found that temperature represents the greatest effect on evaporation in a direct way, then the inverse effect of humidity, and the direct effect of the number of hours of sunshine, and the effect of the rain was inverse of medium intensity, after that a mathematical model of evaporation was made in Mosul Dam Reservoir and its R-square was 95.6%, and the results also showed that the storage volume was decreasing during the study years. Due to the great importance of the two elements of temperature and rain, a prediction was made for the data of temperature rates through the SDSM program, and it found that it continues to rise, so about 2050 it will reach an average temperature that is 0.3C⁰ higher than the average in the year 2023, the data that was predicted for rain recorded a continued decrease in its quantities, as it will be 4.9% less than it is in 2023, and less than about 50% compared to what it was in 1990.

Keywords: Climate change, water resources, evaporation in reservoirs, Mosul Dam Reservoir, the Middle East, SDSM, SPSS

INTRODUCTION

The Earth's climate changes from time to time. This climate change may be due to causes outside the Earth system, such as a change in solar radiation or due to the spread of ash after volcanic eruptions. For reasons from within the Earth system due to human activities, such as the release of some greenhouse gases into the atmosphere,

the concentration of these gases has increased compared to what it was before the industrial renaissance. Climate change and the accompanying acceleration and unprecedented change in temperature rise, “the average temperature increased by 0.76 degrees Celsius during the twentieth century,” and the sea level rose by 17 cm during the same period, all these changes led to an imbalance in temperatures the heat. climate system and directly affected water resources [1,2].

What concerns us here is the impact of climate change on the sources of water resources, which are among the most sensitive systems to this change. All studies on climate change in the world confirm the impact of climate change on the quantity and quality of water resources, as well as the increase in extreme weather events such as droughts, floods, avalanches, and hurricanes. Surface water bodies are usually dynamic because they decrease, increase, and change their appearance or course over time, due to many of natural and human-caused factors [3]. These changes usually cause severe consequences. In extreme cases, they can cause floods and droughts. Therefore, it is necessary to study the state of water bodies in terms of their behavior considering climate change.

It is expected that both surface and groundwater resources will suffer from severe shortages in the future in the Middle East [8]. Average temperatures in the region are expected to increase by 3 to 5 °C by the end of the century, while precipitation is expected to decrease by approximately 20% and runoff by more than 25% by 2050 [4,5].

The Mosul Dam Reservoir (MDR), which was chosen as a case study of the effects of climate change on evapotranspiration in it, is one of the most important initiatives in Iraq to manage its water resources. It is the largest man-made reservoir in Iraq. [5,6] which was constructed after the Mosul Dam provided an important primary water source for Mosul, Baghdad, and other towns along the river's path. In addition, the North Jazeera Irrigation Project, an important irrigation project located west of Nineveh Governorate in northern Iraq, receives irrigation water from the Mosul Dam reservoir [5]. This massive reservoir is becoming more sensitive to changes due to increased human activity, climate change, and unexpected monthly flows from the Tigris River. This has resulted in a lower potential return on investment in the reservoir [7].

EFFECT OF CLIMATE CHANGE ON RESERVOIRS

Significant impacts of climate change on reservoirs include:

- Warming water conditions: As the world's temperatures rise, so do reservoir temperatures. This may result in a drop in the concentration of dissolved oxygen, which might harm aquatic life [8].
- Changes in reservoir ice cover: Warmer temperatures may also result in a reduction in reservoir ice cover, which may have a variety of effects on reservoir ecosystems, such as modifications to the water temperature and mixing patterns. Changes in reservoir water levels can influence the coastline and the plants and animals that depend on the reservoir for habitat due to changes in precipitation patterns. A shift in the timing of seasonal occurrences, such as the time of ice breakup or the start of spring blossoms, can also be brought on by a change in the climate. The timing of crucial biological processes in the reservoir environment may be thrown off by these changes. With consequences for water quality, aquatic life, and human activities that rely on reservoirs for drinking water, leisure, and other uses, climate change is anticipated to have a substantial and complicated impact on reservoirs, especially on evaporation and increasing water penetration into the ground in semi-arid areas [9].

STUDY AREA DESCRIPTION

The Mosul Dam Reservoir (M.D.R.) is essentially an artificial reservoir that was established following the construction of the Mosul Dam, which is located on the Tigris River precisely about 60 kilometers northwest of Mosul City and 80 kilometers from the Turkish and Syrian borders, as well as 500 kilometers to the north from Baghdad, the capital of Iraq. Dam coordinates are (42o49') longitude and (36o37') latitude, as illustrated in Figure 1.

Due to the reservoir's capacity at a maximum operation level of 335 meters above sea level, with a maximum storage volume of 11.13 km³ and a maximum water depth of 80 meters [10]. it is one of the largest dams in the world, the second-largest dam in the Middle East, and the largest dam in Iraq. The reservoir's WSA is 380 km² in Highest operational elevation, its length is around 45 km, and its top width is between 2 and 14 km [11]. On the left abutment, there is a concrete spillway for the dam. The spillway is 680 m long and has a crest elevation of 317.5 meters above.



FIGURE 1. Mosul Dam, using google earth

METHODOLOGY

The work methodology that we used in this study consisted of a series of scientific steps that would fulfill the purpose of the study as required. The steps were as follows; after completing the description of the study area, necessary aerial maps were made to accurately describe the area through the QGIS program.

After that, we started preparing the data, classifying it according to its sources, and processing it for the accounts.

Then, a detailed analysis of the climatic data available for the years of the study was made, which are evaporation data, precipitation, temperatures, relative humidity, wind speed, and the number of hours of sunshine for the meteorological station in Mosul Dam, which were obtained from the Meteorological and Seismic Monitoring Authority - Ministry of Transport (13). Then an accurate mathematical model was developed that describes the relationship between evaporation in the Mosul Dam reservoir and the climatic elements that affect its value, by entering the values of evaporation and the values of the rest of the climatic elements once through the SPSS program, which provides data analysis and finding mathematical models among the variables. We also include in this program the strength of the impact of each of the climatic elements on evaporation, which has a significant impact, and which has a lesser impact than the rest.

Finally, the SDSM program was used, to predict the values of some climatic elements that have a significant direct impact on evapotranspiration values, until the year 2050 to complete the objectives of this research, which is the study. The effect of climate change on evaporation at present, as well as its impact on evaporation values in the Mosul Dam reservoir in the near and medium future by predicting some values of basic climate elements that give an idea of the nature of the climate of the Mosul Dam area.

First, a map was made describing the study area and the elements in it in detail, using the QGIS program, as shown in Figure 2.

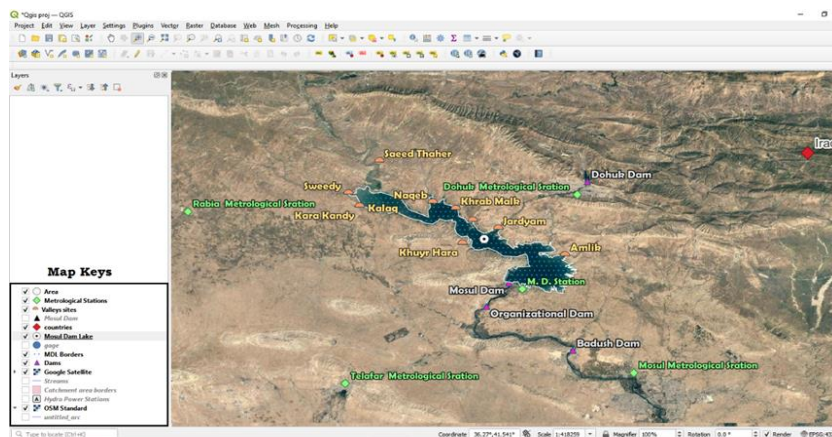


FIGURE 2. The study area and the landmarks put in it, using Qgis

Climate Data Analysis

The climatic data of the meteorological station in the Mosul Dam project, all of which were obtained from the Meteorology and Seismic Monitoring Center - the Iraqi Ministry of Transport in the Iraqi capital, Baghdad, were used to understand the effects of climate change that were recorded near the Mosul Dam reservoir. Some data were in a daily format, and some were in a format Monthly, all of them were analyzed using methods that meet the purposes of the study, and according to the application of the principles of descriptive statistics, they were divided into three groups, namely:

1. The values of the mean, Maximum and the Minimum value, and the standard deviation.
2. Analysis according to time periods by dividing the total period into a group of similar smaller periods.
3. Analysis according to the comprehensive time trend.

The series of steps that we followed in preparing and analyzing climate data are illustrated in the work mechanism diagram below:

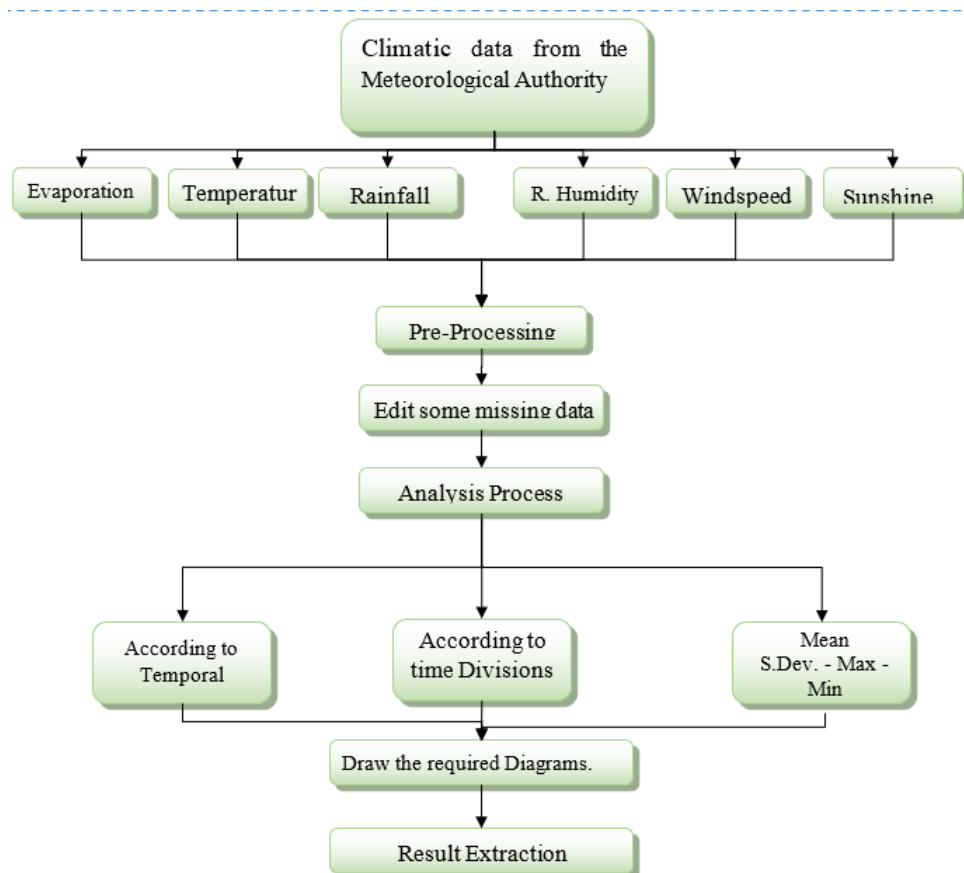


FIGURE 3. Steps of analyzing the climatic data

SPSS Program Working

This program was used to find the strength of the correlation between the dependent element, which is evaporation, with the rest of the independent climatic elements, and to determine who is the most influential element and the rest gradually, then a mathematical model was made through which we can find the value of evaporation depending on the five climatic elements.

Where data for 372 months were entered, which is the most famous number of study years of 31 years from 1990 to 2020, data for the seven climatic elements were entered, which are rain, temperature, evaporation, wind speed,

relative humidity, and rising dust, and Correlation analysis was used to find the strength of the correlation between evaporation and the rest elements, then Non-Leaner Regression analysis was used to make the mathematical model of evaporation.

Finally, the SDSM program was used, with the aim of predicting the values of some climatic elements that have a significant direct impact on evapotranspiration values, until the year 2050 to complete the objectives of this research, which is the study. The effect of climate change on evaporation at the present time, as well as its impact on evaporation values in the Mosul Dam reservoir in the near and medium future by predicting some values of basic climate elements that give an idea of the nature of the climate of the Mosul Dam area.

The daily data was entered in the format that the program receives, which is DOC. For the maximum temperature data first, and its results were extracted, then the minimum temperature data, and its results were extracted, after that the rates between them were found, then the process was carried out for the rain data as well, and its values were predicted until the end of 2050.

RESULT

The results were arranged as hydrological data results, then climatic data results, then SPSS program results, then SDSM program results.

Descriptive statistics results for Hydrologic elements.

They are the values of the standard deviation, the average, the Maximum, and the Minimum value for each element. We summarized them in the following two tables:

TABLE 1. Mean and Standard Deviation for climate variables for the years (1990-2019)

	Variable	Unit	Mean	Std. Deviation
1	Inflow	MCM/Month	1343.5	1268.9
2	Outflow	MCM/Month	1302	791.9
3	Water volume	M ³ /Month	6853836968	2243723638

TABLE 2. Maximum and Minimum value for climate variables for the years (1990-2019)

	Variable	Unit	Max	Year	Min	Year
1	Inflow	MCM/Month	8732	1993	158	1991
2	Outflow	MCM/Month	6455	1993	267	2001
3	Water volume	M ³ /Month	12062668500	1997	2443735850	2011

Inflow Water

We clearly notice through the data analysis chart of the inflow water in Mosul dam reservoir from 1990 to 2019 that the quantities are decreasing, see Figure 4

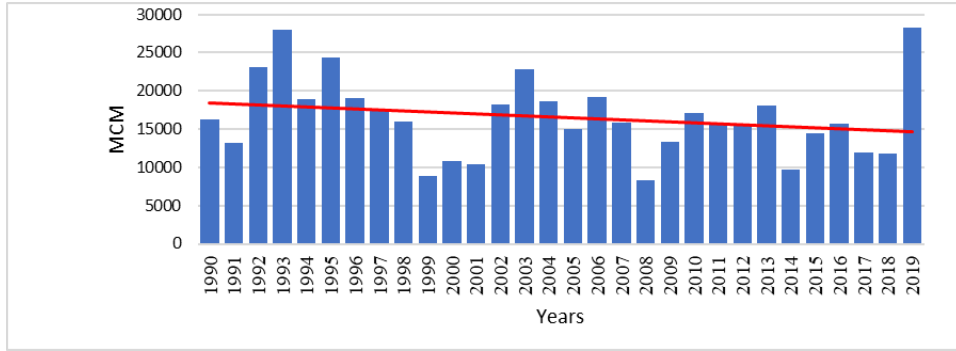


FIGURE 4. Annual inflow from M.D.R in MCM for years 1990-2019

To find the incremental difference in the change in the inflow values for the apportioned time periods, we found the percentage change in the inflow values between each period and the first period spanning from 1990-1999, by applying the following mathematical formula:

$$\% \text{ changing in inflow} = \left(\frac{\text{Value of First Period}}{\text{Value of current period}} \right) * 100$$

The following results were obtained, as shown in TABLE 3. Percentage change in inflow value of evaporation for the years (1990-2019). It is noted that the inflow rate was gradually decreasing, and the percentage for the last period decreased by 14.5% compared to the first period:

TABLE 3. Percentage change in inflow value of evaporation for the years (1990-2019)

	Period	Total inflow for this period MCM	% Changing in total inflow compared to the period 1990-1994
1	1990-1999	185265.8	0.0
2	2000-2009	152264.6	-17.8
3	2010-2019	158433.4	-14.5

Outflow Water

We notice through the data analysis chart of Outflow water that the quantities of outflow are decreasing, see the Figure5.

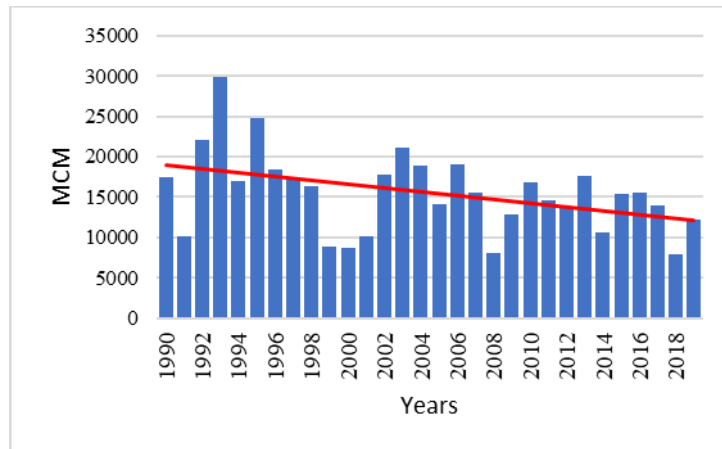


FIGURE 5. Annual outflow from M.D.R in MCM for years 1990-2019

To find the incremental difference in the change in the outflow we used the same formula that we used it in finding incremental difference in the change in the inflow. we noted that the outflow rate was gradually decreasing, and the percentage for the last period decreased by 24.3% compared to the first period:

TABLE 4. Percentage change in outflow value of evaporation for the years (1990-2019)

	Period	Total outflow for this period MCM	% Changing in total outflow compared to the period 1990-1994
1	1990-1999	182482.0	0.0
2	2000-2009	146303.4	-19.8
3	2010-2019	138196.5	-24.3

Water Volume

We notice through the data analysis chart of the water volume is decreasing, see Figure 6.

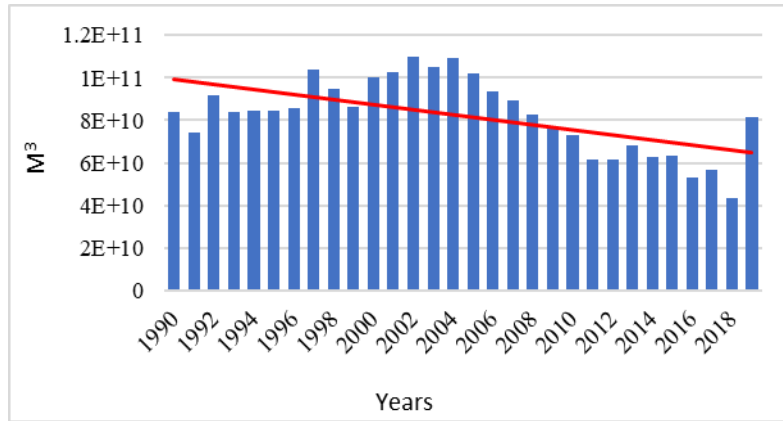


FIGURE 6. Annual Water Volume in M.D.R in M3

To find the incremental difference in the change in the water volume we used the same formula that we used it in finding incremental difference in the change in the inflow. We noted that the water volume rate was gradually decreasing, and the percentage for the last period decreased by 28.4% compared to the first period:

TABLE 5. Percentage change in Realistic Water Volume value of evaporation for the years (1990-2019)

	Period	Total Vol. for this period MCM	% Changing in total Realistic Water Volume compared to the period 1990- 1994
1	1990-1999	872786517325.0	0.0
2	2000-2009	971288739100.0	11.3
3	2010-2019	625010844435.1	-28.4

Descriptive Statistics Results for Climate Elements

They are the values of the standard deviation, the average, the Maximum, and the Minimum value for each climatic element. We summarized them in the following two tables:

TABLE 6. Mean and Standard Deviation for climate variables for the years (1990-2020)

	Variable	Unit	Mean	Std. Deviation
1	Evaporation	M ³ /Year	908169770	189.4
2	Mean Air Temperature	C ⁰ /Year	21.1	2.7
3	Rainfall	Mm/Year	346	43.9
4	Windspeed	(M/Sec)/Year	1.4	10.0
5	Sunshine	Hr./Day	8.2	0.5
6	hum	%	51.6	20.1

TABLE 7. Maximum and Minimum value for climate variables for the years (1990-2020)

	Variable	Unit	Max	Year	Min	Year
1	Evaporation	M ³ /Year	1197588589	2002	588418890	1991
2	Mean Air Temperature	C ⁰ /Year	22.9	2010	18.6	1993
3	Annual Rain	Mm/Year	797.5	1996	129	1999
4	Wind Speed	(M/Sec)/Year	2.0	2002	0.9	2008
5	sunshine	Hr./Day	8.7	1995	7.7	2015
6	Relative Humidity	%	58.3	2019	45.75	1999

Evaporation Data

For the analysis of the temporal trend of evaporation data in Mosul dam reservoir, we did it for all the years of the study for one time as shown in Figure 7, which we can clearly notice the trend of evaporation values toward the increase depending on the data included.

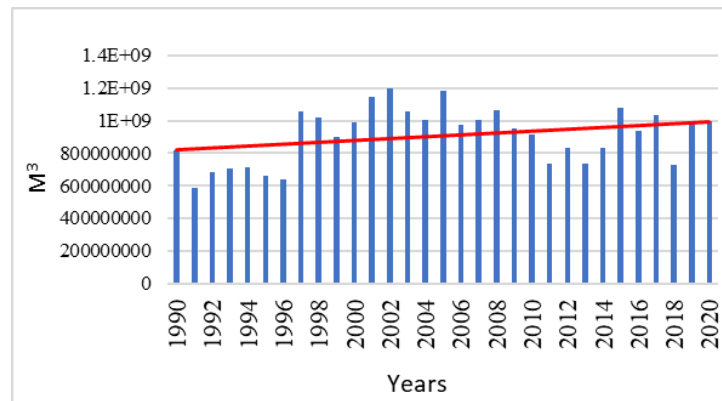


FIGURE 7. Mean annual Evaporation (M3) in MDR for years (1990-2020)

To find the incremental difference in the change in the water volume we used the same formula that we used it in finding incremental difference in the change in the inflow. we noted that the water volume rate was gradually decreasing, and the percentage for the last period increased by 13.6% compared to the first period:

TABLE 8. Percentage change in the value of evaporation for the years (1990-2020)

	Period	Evaporation rate for this period	% Changing in evaporation rate compared to the period 1990-1994
1	1990-1999	778117456.8	0.0
2	2000-2009	1057309316.7	35.9
3	2010-2020	883967819.3	13.6

Temperature

For the analysis of the temporal trend of temperature data in Mosul dam reservoir, we did it for all the years of the study for one time as shown in Figure 8, which we can clearly notice the trend of evaporation values toward the increase depending on the data included.

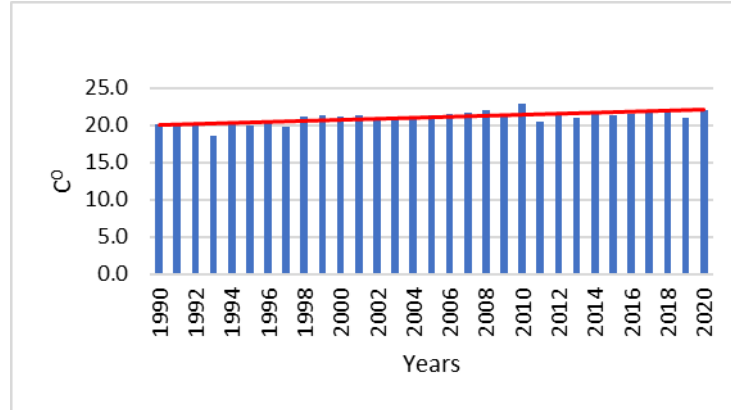


FIGURE 8. Mean annual Temperature in (C0) in MDMS for years (1990-2020)

To find the incremental difference in the change in the Temperature we used the same formula that we used it in finding incremental difference in the change in the inflow, from we noted that the Temperature rate was gradually decreasing, and the percentage for the last period increased by 6.9% compared to the first period:

TABLE 9. Percentage change in the value of Temperature for the years (1990-2020)

	Period	Temperature rate for this period	% Changing in Temperature rate compared to the period 1990-1994
1	1990-1999	20.2	0.0
2	2000-2009	21.3	5.6
3	2010-2020	21.6	6.9

Rainfall Data

For the analysis of the temporal trend of Rainfall data on the Mosul dam reservoir, we did it for all the years of the study for one time as shown in Figure 9, in which we can notice the trend of Rainfall values toward the decrease depending on the data included.

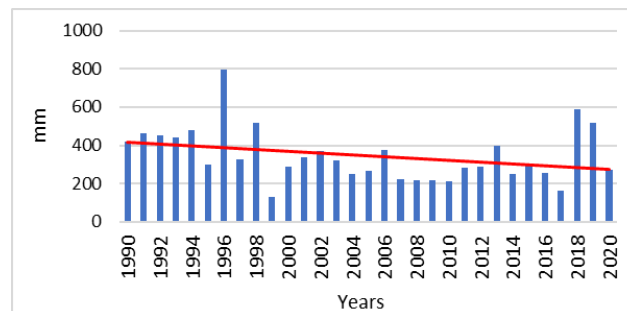


FIGURE 9. Annual Rainfall (mm) in MDMS for years (1990-2020)

To find the incremental difference in the change in the Rainfall we used the same formula that we used it in finding incremental difference in the change in the inflow. We noted that the Rainfall rate was gradually decreasing, and the percentage for the last period decreased by 25.7% compared to the first period:

TABLE 10. Percentage change in the value of Rainfall rate for the years (1990-2020)

	Period	Rainfall rate for this period	% Changing in Rainfall n rate compared to the period 1990-1994
1	1990-1999	432.0	0.0
2	2000-2009	286.8	-33.6
3	2010-2020	320.8	-25.7

MODEL MAKING THROUGH SPSS

We summarized the results of this program in the most important four tables, the first is the Pearson Correlation Value for the Variable table, which shows the strength of the influence of each element on evaporation and whether the effect is direct or inverse, and the second is the ANOVA^a Values table, which shows the strength of evaporation representation by all the entered climatic elements, the third table It is The Suggested Formulas table, in which we collected the models that we proposed for the program and gave us an R-square value for each one, and the other table is the successful model information table.

Pearson Correlation Value Table

TABLE 11. Pearson Correlation Value for the Variable

	Variable	Pearson Correlation Value	significance status	Pear. Corr. Zone	Effect
1	Temperature	0.956	affective	Strong	Positive
2	Relative Humidity	-0.915	affective	Strong	Inverse
3	Sunshine	0.902	affective	Strong	Positive
4	Rainfall	-0.562	affective	Moderate	Inverse
5	Windspeed	0.306	affective	Weak	Positive
6	Dust	0.075	Not affective	Neglectable	Positive

The most correlated Variable to the evaporation is the temperature with Pearson Correlation value equal to 0.956 (95.6%), this means a large direct correlation between the two elements, and the table also shows that the weakest effect among the six climatic elements is the effect of rising dust, with a Pearson correlated value of 0.075 (7.5%)

ANOVA^a Table

This table is considered the most important table SPSS results, as it shows the accuracy of the results extracted from the mod inverse: determines its acceptability or not by estimating the value of R squared, which means the analysis coefficient that gives us a percentage that explains the strength of the independent variables' contribution to the value of the variance of the dependent variable, and its value is between -1 And +1, where the closer it is to zero, the independent element affects less the value of the variance of the dependent variable, and the higher the value and closer to 1, this indicates the strength of the independent variable's interpretation of the variance value of the dependent variable, the negative sign means that the effect is opposite and the positive sign means that the effect direct not inverse :

TABLE 12. ANOVA^a Values

Source	Sum of Squares	df	Mean Squares
Regression	22056943.298	6	3676157.216
Residual	333789.702	234	1426.452
Uncorrected Total	22390733.000	240	
Corrected Total	7624316.496	239	

Dependent variable: Evaporation (mm/day)

a. R squared = 1 - (Residual Sum of Squares) / (Corrected Sum of Squares) = 0.956 (95.6%)

We can clearly notice the large R-square value, which is close to 1. This ratio indicates the strength of the influence of the independent variables placed in the model that we made on the variation in the dependent variable. Therefore, the empirical model is very expressive and gave us ideal values to represent the value of evaporation in Mosul Dam reservoir. Through the five climatic elements affecting the value of evaporation, which are according to the strength of influence, temperature, relative humidity, solar radiation, precipitation, and wind speed.

So, the ideal model to represent the value of evaporation according to the most important climatic elements in the Mosul Dam area in northern Iraq, according to data for more than thirty years from 1990 to 2020, is the following empirical formula:

$$\text{Eva.} = a (T^b)(S^c)(W^d)(H^e)+(R^f)$$

Our Using for the criterion of obtaining the highest value of R square was done to choose the best empirical model to explain the variation in evapotranspiration through the five climatic elements.

By including the values of the parameters in the equation, we get the following ready model:

$$\text{Eva.} = 0.293 (T^{1.571}) (S^{0.528}) (W^{0.020}) (H^{0.180}) +(R^{0.561})$$

As we tried many models, as shown below, but we chose the best and most accurate among them:

TABLE 13. The Suggested Formulas

	R ² Value	The Suggested Formula
1	0.905 (90.5%)	Eva. =0.096[(T ^{2.39}) +(S ^{2.898}) +(W ^{4.494}) +(H ^{1.366}) +(R ^{-3x10^-6})]
2	0.93.8 (93.8%)	Eva. = 0.604 [(T ^{1.874}) +(S ^{1.881}) +(W ^{3.131}) +(H ^{0.589})]
3	93.8 (93.8%)	Eva. = 0.75 [(T ^{1.813}) +(S ^{1.803}) +(W ^{2.992})]
4	0.924 (92.4%)	Eva. = 1.451 (T ^{1.473}) (S ^{0.24}) (W ^{0.17}) (H ^{0.001}) (R ^{0.000001})
5	0.956 (95.6%)	Eva. = 0.293 (T ^{1.571}) (S ^{0.528}) (W ^{0.02}) (H ^{0.18}) +(R ^{0.561})

Details of the best model are listed in the table below:

TABLE 14. Best Model Details

Best Model		
Suggested Formula		Eva. = a (T ^b)(S ^c)(W ^d)(H ^e)+(R ^f)
Parameter	Initial Value	Last approved value
a	0.001	0.293
b	0.001	1.571
c	0.001	0.528
d	0.001	0.02
e	0.001	0.18
f	0.001	0.561
Completed Formula		Eva. = 0.293 (T ^{1.571}) (S ^{0.528}) (W ^{0.02}) (H ^{0.18}) +(R ^{0.561})
R ²	0.956 (95.6%)	

This empirical model is completely ready to estimate a very close approximate value of evaporation in the Mosul Dam reservoir once we substitute the values of the climatic elements in the model with the units mentioned for it and we will get the monthly evaporation values in the Mosul Dam reservoir in mm, as well as the area close to the Mosul Dam reservoir we can rely on this formula For the same purpose being of a very similar climatic nature.

Experimenting several formulas, made us reach the optimal formula, which combined five climatic elements in one formula and with the highest possible interpretation of the variance value of evaporation through the five largest climatic elements affecting the Mosul Dam area, where the R-square value reached (95.6%), which is an ideal formula with very high accuracy.

SDSM RESULTS

The results of this program included two types of forecasts, temperature, and rain forecasts.

Temperature Forecast Results

The forecast results showed that average temperatures will continue to increase until the year 2050, and the estimated average temperature for the years (2044-2050) has increased by about 0.3 C⁰ over the average temperature for the years (2024-2033), as shown in the following table:

TABLE 15. Percentage change in the value of Temperature rate for the years (2024-2050)

	Period	Temperature rate for this period	% Changing in Temperature rate compared to the period 2024-2033
1	2024-2033	21.69	0.0
2	2034-2043	21.71	0.1
3	2044-2050	21.99	1.4

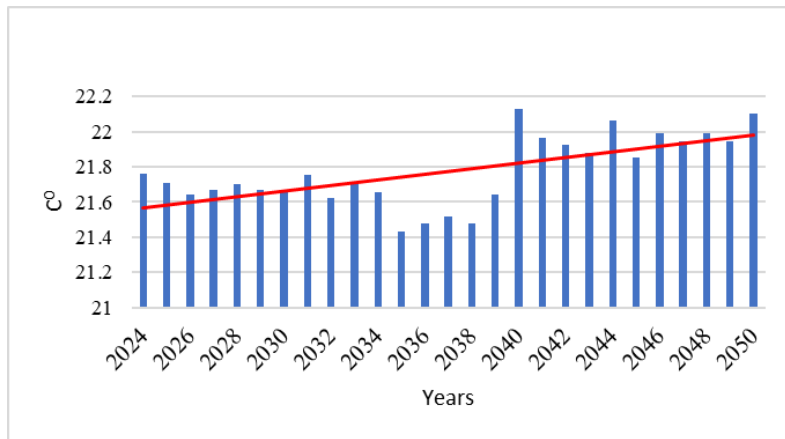


FIGURE 10. Forecasted Mean annual Temperature in (C⁰) in MDMS for years (2024-2050)

Rain Forecast Results

The forecast results showed that the rainfall rates will continue to decrease until the year 2050, and the estimated annual rainfall rate for the years (2044-2050) was 4.9% lower than the rainfall rate for the years (2024-2033), as shown in the following table:

TABLE 16. Percentage change in the value of Rainfall rate for the years (2024-2050)

	Period	Rainfall rate for this period	% Changing in Rainfall rate compared to the period 2024-2033
1	2024-2033	237.5	0.0
2	2034-2043	235.8	-0.7
3	2044-2050	225.7	-4.9

The time trend analysis table showed the clear gradual decrease in the forecasted rainfall values for the years (2024-2050).

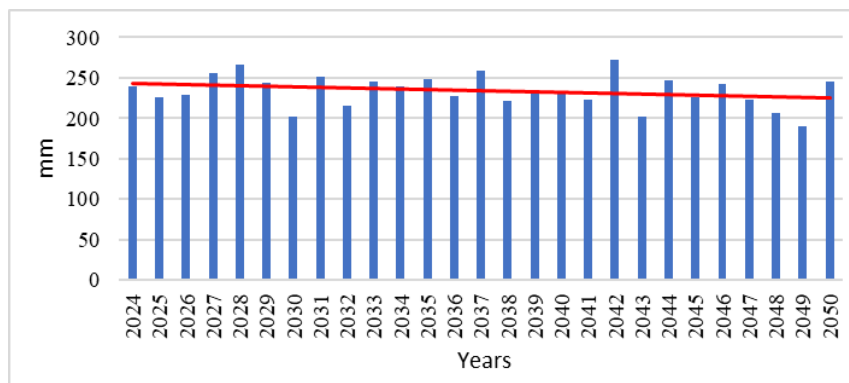


FIGURE 11. Forecasted Annual Rainfall (mm) in MDMS for years (2024-2050)

CONCLUSION

Analyzes of basic climatic elements such as temperature, precipitation, and other elements indicated that the characteristics of climate change showed a significant impact over the past years on the Mosul Dam reservoir, in terms of a rise in temperatures that rose during the study period (1990-2020) by about 1.4 degrees Celsius. While the rain decreased by about 25.7%, the amount of evaporated water from the Mosul Dam reservoir increased by 13.6% in 31 years. It was 0.9 billion cubic meters annually, and this indicates that the effects of climate change are becoming more obvious and accelerating. The volume of reservoirs in the reservoir decreased by 28.4%, The rate of water discharge from the Mosul Dam reservoir to the areas below it through the body of the dam decreased by 24.3%, and the water supply from the Tigris River to the reservoir decreased by 14.5% during the years of the study.

The decrease in water supply to the reservoir and subtraction from the dam and the decrease in its water level will prompt the dam project management to change the operating strategy so that the focus is on filling basic needs For the cities located below the dam, and this will be at the expense of the water of the irrigation project built on the reservoir, which will lead to damage to agriculture in northern Iraq, especially with the increase in the water need for crops due to the increase in temperature. The climatic factor most directly affecting evaporation in Mosul Dam Reservoir was the temperature factor with a correlation of 95.6%, then the sun radiation with a correlation of 91.5%, and finally the wind speed with a correlation of 30.6%.

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