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IMPACT OF CLIMATE CHANGE ON SOIL WATER CONTENT IN THE SOIL PROFILE: A GEOGRAPHICAL STUDY OF BIKANER DISTRICT

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ABSTRACT

*The water present in the soil in the form of moisture and absorbed by the roots of plants is known as soil water. It is also referred to as film water. Soil water is normally present from the surface of the soil to a depth of **100** cm. Although many factors play a role in determining the amount of soil water in the soil profile, the most important are precipitation and temperature. The way climate change events have played out in recent decades has resulted in an undesirable deviation in the trend of precipitation and temperature distribution, which also directly affects the amount of soil water present in the soil profile. The main objective of this research is to study the decadal changes in temperature distribution, precipitation distribution and soil water content in the soil profile between **1981** and **2021** in the study area. In addition, the correlations between the above variables will be investigated. This research work is based on analytical research method. Secondary data were used for this work. These data include temperature distribution, precipitation distribution, and the amount of water present in the soil profile during the period **1981** to **2021.** From the analysis of the data, it is clear that climate change in the study area also affects the amount of soil water present in the soil profile. Due to variations in the amount of precipitation and temperature in the study area, the amount of soil water present in the soil profile also varies.*

Keywords: *Soil Water, Soil Profile, Climate Change, Average Temperature and Average Rainfall.*

Introduction

The water present in the soil in the form of moisture and absorbed by the roots of plants is called soil water. The water present in the soil is called soil water or film water. The portion of the aeration zone consisting of soil and other materials that is very close to the earth's surface and from which an accessible amount of water enters the atmosphere through plant transpiration or soil evaporation. Soil water is present in the uppermost layer of the soil. Soil water is generally present from the top of the soil to a depth of 100 cm. Soil water is very important for plant growth and development. It favours many physical, chemical and biological activities in the soil. It acts as a solvent and carrier of nutrients. Plant roots take up water from the soil to maintain tension in plant cells. Soil water acts as a factor in photosynthesis. Since the study area is an arid desert region where there is an acute shortage of surface water, soil water becomes even more important in maintaining the soil moisture necessary for plant growth and development.

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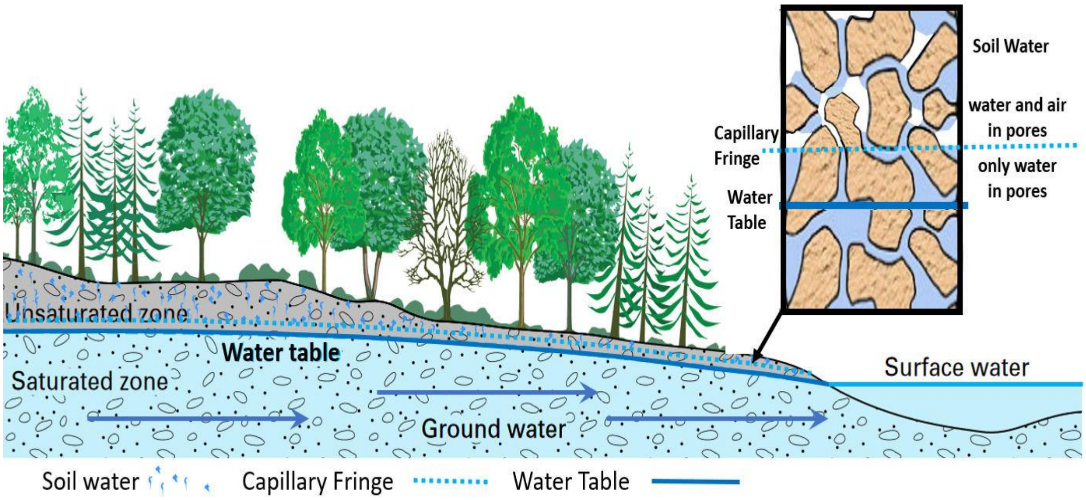


Figure 1: **The water table extends beneath the ground where the surface of a water body such as a lake or stream meets the shoreline (adapted from USGS,** 2019**a).**

Several factors play a role in determining the amount of soil water in the soil profile. The structure and texture of the soil, the slope of the land, the availability of runoff water, the amount of precipitation, temperature, evaporation, etc., all play important roles. However, the amount of precipitation and temperature play the most important role. It is worth noting that the way the events related to climate change are happening in recent decades has led to an undesirable deviation in the distribution of precipitation and temperature in many places of the world, which significantly affects the soil profile of these places. It depends on the amount of water. With this background in view, the researcher has studied the availability of soil water and its relationship with temperature and rainfall distribution in the study area in light of climate change.

Objectives

The main objectives of this research work are as follows:

- To study the decadal change in temperature distribution, precipitation distribution and amount of soil water availability in the study area between 1981 and 2021 in the study area.
- To study the correlation between temperature distribution, precipitation availability and soil water amount in the soil profile in the study area.

Research Hypothesis

The researcher hypothesized that 'when there is a change in the amount of precipitation and temperature in the study area, there will be a positive change in the amount of soil water available in the soil profile.'

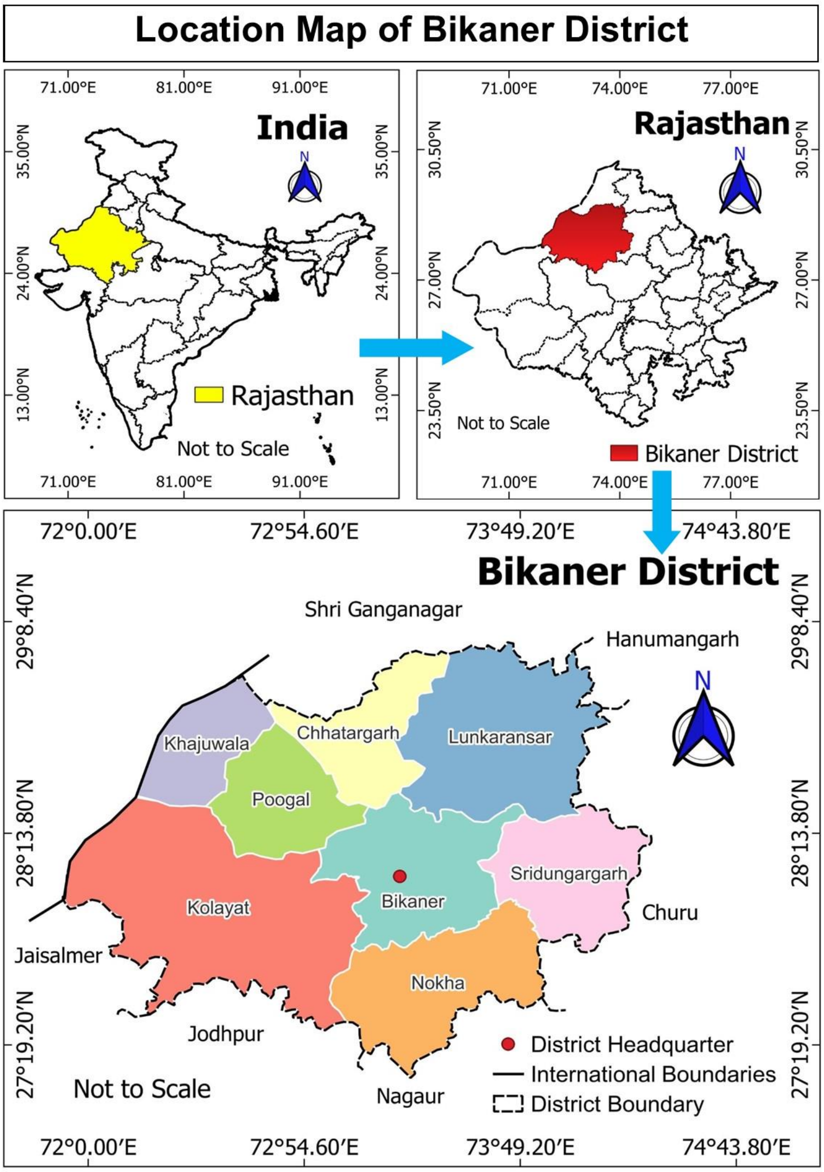
Research Methodology

This research work is based on an ‘Analytical Research Method’. Secondary data has been used for this paper. These data include the temperature distribution, rainfall distribution and the amount of soil water present in the soil profile from the year 1981 to 2021. It is noteworthy that climate change has been indicated here by the researcher based on average temperature and distribution. The data were taken from the online data portal 'https://power.larc.nasa.gov/beta/data-access-viewer/' operated by the National Aeronautics and Space Administration (NASA) Prediction of Worldwide Energy Resources (POWER). Various statistical tools such as mean, standard deviation, and multiple linear regression equations were used to analyses these data. The results obtained from the data analysis were presented in various tables and graphs.

Study Area

Bikaner district is located in the northern-western part of Rajasthanstate. It is located between 27°11’ to 29°03’ north latitude and between 71°54’ to 74°12’ east longitude. (District Statistical Outline Bikaner, 2015) Bikaner district is bounded by Sriganganagar district on the north, Churu district on the east, Jodhpur and Nagaur district on the south, Jaisalmer on the south-west and international boundary adjoining Pakistan on the west. Bikaner district is spread over 30,239 sq. km. (DCHB Bikaner, 2011). The maximum part of the district is included in desolate and dreary regions, which is a part of the Desert of Thar. Bikaner district has no one river system. Near Kolayat a few little intermittent water channels can be seen during the rainy season only. The Bikaner district is known for its high temperature, high dryness, scarcity of precipitation, that's the major features of the desert climate. From month November to March is found winter season in the district followed by the summer season in the district in April to June month. The Monsoon (south-west) season is constituted from month July to mid-September, while the period of mid-September to October is counted in the in-between post-monsoon. Bikaner District population in 2023 is 3,285,873 (estimates as per Aadhaar uidai.gov.in Dec 2023 data). As per 2011 census of India, Bikaner District has a population of 2,363,937 in 2011 out of which 1,240,801 are male and 1,123,136 are female. The population of Bikaner in 2022 is estimated to be 3,120,397 inhabitants. Literate people are 1,278,801 out of 782,399 are male and 496,402 are female.

Map 1



Finding and Discussion

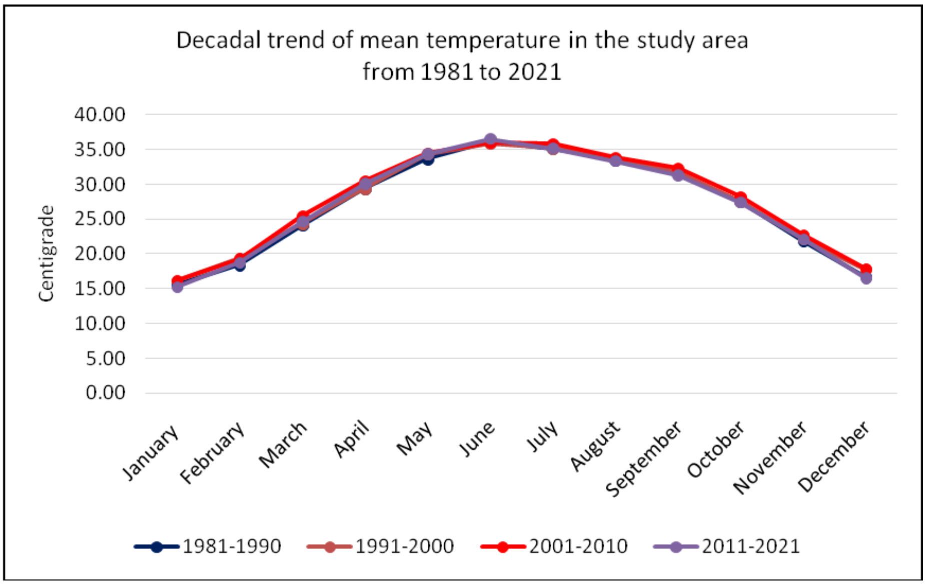
We consider temperature the most important component of climate. Changes in the long-term trend of temperature distribution in any region had been considered a sign of climate change. If we study the decadal trend of temperature distribution between the years 1981 to 2021 in the study area, then it is known that the maximum deviation in the month's temperature of January in the study area is 1.56° centigrade in the decade from 2001 to 2010, similarly in February the maximum deviation in temperature of 2.23°C in the decade from 1981 to 1990, the maximum deviation in temperature in March is 2.36°C in the decade from 1911 to 2021. The maximum deviation in temperature of the month of April is 1.71°C in the decade from 1991 to 2000. the maximum deviation in the month's temperature of May is 2.06 °C in the decade from 1981 to 1990, the maximum deviation in the month's temperature of June is 1.78 °C in the decade from 2001 to 2010, the maximum deviation in the month's temperature of July in the decade from 2011 to 2021 1.46°C, the highest temperature variation in August is 1.33°C in the decade from 1991 to 2000.The highest variation in the temperature of September is 1.68°C in the decade from 1991 to 2000. the highest variation in the temperature of October is 1.48°C in the decade from 1991 to 2000. The highest deviation in the month's temperature of November is 1.87°C in the decade 1991 to 2000 and the maximum deviation in the month's temperature of December is 1.70°C in the decade 2011 to 2021. Thus, most of the years in the study area have to be recorded in the decade from 1991 to 2000. (Table-1)

Table 1: Decadal trend of mean temperature (Centigrade) in the study area from 1981 to 2021

Months	1981-1990		1991-2000		2001-2010		2011-2021	
	Average	SD	Average	SD	Average	SD	Average	SD
January	15.55	1.32	16.15	1.48	16.16	1.56	15.29	1.20
February	18.37	2.23	19.34	1.54	19.26	2.06	18.77	1.85
March	24.10	1.84	24.32	1.93	25.42	2.14	24.65	2.36
April	29.36	1.34	29.35	1.71	30.48	1.40	30.08	1.55
May	33.63	2.06	34.30	1.53	34.44	1.94	34.35	1.00
June	36.13	1.08	35.82	1.33	35.98	1.78	36.49	1.23
July	35.13	1.07	35.15	1.40	35.87	1.23	35.20	1.46
August	33.46	1.24	33.63	1.33	33.84	1.05	33.35	0.99
September	31.62	1.11	31.64	1.68	32.27	1.21	31.29	1.61
October	27.41	1.01	27.50	1.48	28.24	1.05	27.40	0.89
November	21.78	1.17	22.07	1.87	22.71	1.50	22.12	1.31
December	16.68	1.54	17.71	1.63	17.82	1.08	16.54	1.70

Source: Prediction of Worldwide Energy Resources, NASA online data portal

Diagram 1



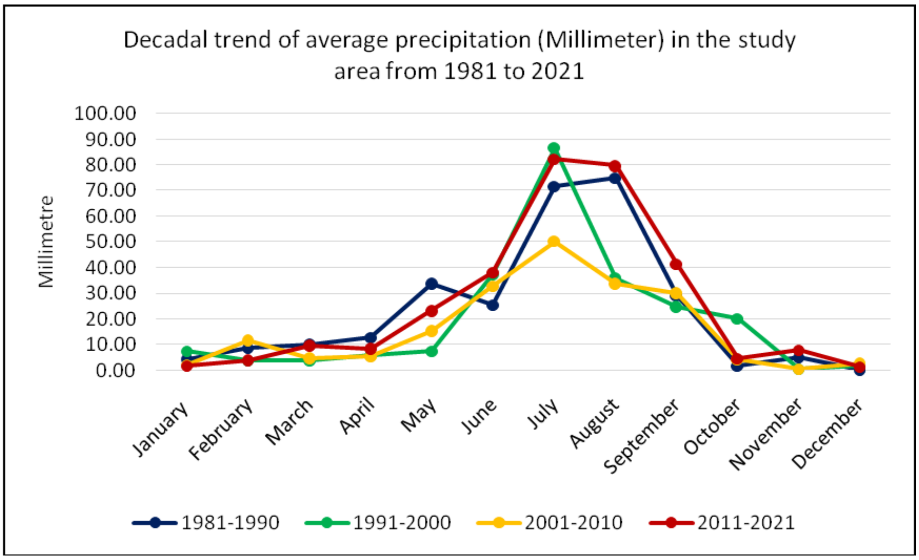
Like temperature, precipitation is also an important component of climate. Long-term changes in the distribution of precipitation in a region had been considered indicators of climate change. The distribution of precipitation significantly affects the amount of water present in the soil profile. In areas where more precipitation falls, the amount of soil water in the soil profile is also comparatively high. Considering the decadal pattern of precipitation distribution between 1981 and 2021 in the study area, the highest deviation in the distribution of precipitation in January in the decade from 1991 to 2000 is 8.24 mm. Similarly, the maximum deviation in the distribution of precipitation in February in the study area is 23.32 mm in the decade from 2001 to 2010, the maximum deviation in the distribution of precipitation in March is 16.34 mm in the decade from 2011 to 2021, in the distribution of precipitation in April, the maximum deviation in the decade from 1981 to 1990 is 23.7 mm, the maximum deviation in the distribution of precipitation in May is 36.63 mm in the decade from 1981 to 1990, the maximum deviation in the distribution of precipitation in June is 43.32 mm in the decade from 1991 to 2000, the maximum deviation in the distribution of precipitation in July is 69.29 mm in the decade from 1991 to 2000, the maximum deviation in the distribution of precipitation in August is 41.1 mm in the decade from 2011 to 2021, the maximum deviation in the distribution of precipitation in September is 41.01 mm in the decade of 2010 to 2021, the maximum variation in the distribution of precipitation in October is 32.66 mm in the decade from 1991 to 2000, the maximum variation in the distribution of precipitation in November is 18.59 mm in the decade from 2011 to 2021 and in December, the maximum variation in the distribution is 3.54 mm over the decade 2001 to 2010. (Table-2)

Table 2: Decadal trend of average precipitation (Millimeter) in the study area from 1981 to 2021

Months	1981-1990		1991-2000		2001-2010		2011-2021	
	Average	SD	Average	SD	Average	SD	Average	SD
January	4.22	6.59	7.38	8.24	2.11	3.50	1.44	3.25
February	8.44	11.11	3.69	7.48	11.60	23.32	3.84	7.82
March	10.02	10.92	3.69	5.30	4.75	8.32	9.59	16.34
April	12.66	23.37	5.80	9.27	5.27	9.43	8.37	9.99
May	33.75	36.63	7.38	9.78	15.29	15.90	23.16	15.12
June	25.31	31.71	37.44	43.32	32.70	23.56	38.18	24.72
July	71.72	59.25	86.48	69.29	50.10	45.44	82.28	59.04
August	74.88	39.24	35.86	32.49	33.75	22.65	79.64	49.82
September	29.00	36.33	24.78	24.74	30.06	29.27	41.34	41.01
October	1.58	3.38	20.04	32.66	4.22	6.15	4.52	6.69
November	4.75	14.24	0.53	1.58	0.53	1.58	7.67	18.59
December	0.00	0.00	1.58	3.38	2.64	3.54	1.22	2.08

Source: Prediction of Worldwide Energy Resources, NASA online data portal

Diagram 2



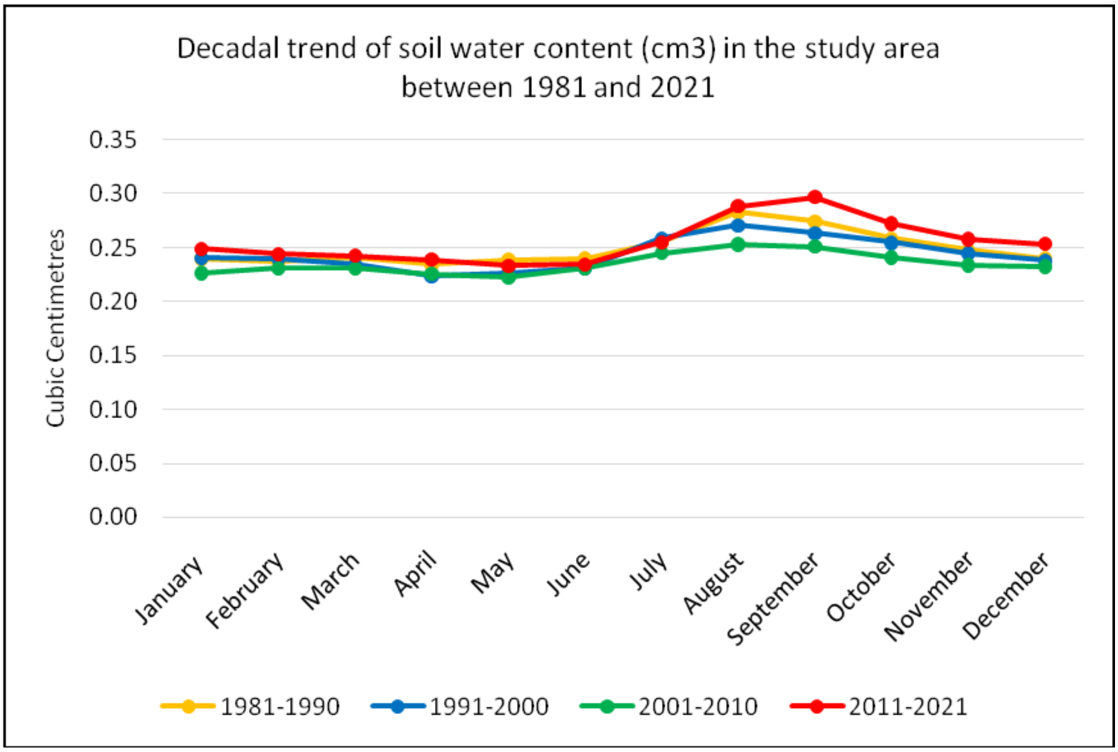
Looking at the decadal trend of the amount of Soil water present in the soil profile between the years 1981 to 2021 in the study area, we find that the maximum amount of soil water present in the soil profile in the study area is in the rainy season. In the study area, the amount of soil water in July, August, and September was 0.26, 028, and 28 cubic centimetres, respectively, during the rainy season from 1981 to 1990. It is worth noting that these months showed the greatest fluctuations in the amount of soil water. Similarly, the maximum amount of soil water under the soil profile in the study area from 1991 to 2000 was 0.27 cubic centimetres in August, and the maximum amount of soil water in the decade from 2001 to 2010 was 0.25 cubic centimetres in July, August, and September. In the decade from 2011 to 2021, the highest amount of soil water in the soil profile was measured in September at 0.30 cubic centimetres. It is noteworthy that, in these months of the rainy season, the greatest variation in the amount of soil water under the soil profile had been observed (Table-3).

Table 3: Decadal trend of soil water content (cm3) in the study area between 1981 and 2021

Months	1981-1990		1991-2000		2001-2010		2011-2021	
	Average	SD	Average	SD	Average	SD	Average	SD
January	0.24	0.02	0.24	0.02	0.23	0.01	0.25	0.02
February	0.24	0.01	0.24	0.02	0.23	0.02	0.24	0.02
March	0.24	0.02	0.24	0.02	0.23	0.02	0.24	0.02
April	0.24	0.02	0.22	0.01	0.23	0.02	0.24	0.02
May	0.24	0.04	0.23	0.01	0.22	0.01	0.23	0.01
June	0.24	0.03	0.23	0.02	0.23	0.02	0.23	0.01
July	0.26	0.03	0.26	0.03	0.25	0.02	0.26	0.02
August	0.28	0.05	0.27	0.04	0.25	0.03	0.29	0.03
September	0.28	0.03	0.26	0.04	0.25	0.02	0.30	0.03
October	0.26	0.03	0.26	0.04	0.24	0.02	0.27	0.02
November	0.25	0.03	0.25	0.03	0.23	0.02	0.26	0.02
December	0.24	0.02	0.24	0.02	0.23	0.01	0.25	0.02

Source: Prediction of Worldwide Energy Resources, NASA online data portal

Diagram 3



Testing the Validity of the Research Hypotheses

To check the validity of his hypothesis, the researcher used the "Multiple Regression Analysis". In this analysis, the amount of soil water present in the soil profile from years 1981 to 2021 was accepted as the dependent variable (Y), while the average annual temperature and the average annual rainfall from years 1981 to 2021 were accepted as independent variables (X). The results of the multiple regression analysis are shown in Table-4. The value of 'R' obtained from the multiple regression analysis for the above variables is 0.94170493, which clearly shows that there is a positive relationship between the independent variables and the dependent variable, i.e., there is a 94.17% chance that the amount of soil water will change with a change in rainfall and temperature. In this way, the researcher hypothesis that 'the amount of soil water present in the soil profile will change positively when the amount of precipitation and temperature change in the study area' is proven to be true.

Table 4: Summary of the Results of the Multiple Regression Analysis

Summary Output	
Regression Statistics	
Multiple R	0.94170493
R Square	0.88680817
Adjusted R Square	0.88085071
Standard Error	0.00617359
Observations	41
F Value	148.856646
Significance F	1.05314

Conclusion

It is clear from the above discussion that climate change in the study area also affects the amount of soil water present in the soil profile. Because of variations in rainfall and temperature in the study area, there are variations in the amount of soil water present in the soil profile. Therefore, the researcher recommends planting more and more trees in this area to maintain the amount of soil water present in the soil profile at the desired level. Trees play an important role in absorbing rainwater and surface water. If I planted more trees in the study area, it would help to maintain the required water content in the soil. Besides, traditional water harvesting techniques in the study area such as ponds, seepage pits, anicuts and puddles should also be given importance.

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