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TEMPORAL CHANGES IN SOIL WATER CONTENT IN THAR DESERT: A CASE STUDY OF BIKANER DISTRICT

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ABSTRACT

Soil water wetness, also known as soil moisture content, refers to the amount of water held in the soil between soil particles. It is a crucial factor for plant growth, impacting various processes like nutrient uptake, photosynthesis, and transpiration. Measuring soil water wetness is essential for farmers, water resource managers, and researchers to make informed decisions about irrigation, water conservation, and agricultural practices. Generally, soil water is studied in three forms, such as – Surface Soil Wetness (surface to 5 cm below), Root Zone Soil Wetness (surface to 100 cm below) and Profile Soil Moisture (surface to bedrock). in the research paper presented by the researcher, the amount of water present in the soil of Bikaner district located in the Thar Desert of Rajasthan has been analyzed on the basis of data from the year 1981 to 2022.*Surface Soil Wetness, Root Zone Soil Wetness* and *Profile Soil Moisture* in the period from *1981* to *2022.* The quantity has to be analyzed on a time basis. It is clear from this study that there has been a substantial increase in the amount of middle soil water in the study area Bikaner district from the year *1981* to *2022. The main reason for which is the increase in the area irrigated by tube wells,* rain water harvesting, tree plantation, increase in irregular rainfall and slight decrease in temperature.

Keywords: *Surface Soil Wetness, Root Zone Soil Wetness, Profile Soil Moisture, Climate Change and Ground Water.*

Introduction

Soil water, also known as soil moisture, is the water held within the gaps between soil particles and is a key element for sustaining plant life, maintaining environmental balance, and supporting agricultural productivity.[i] Generally, soil water is studied in three forms, such as –

Surface soil wetness, which refers to the moisture in the top 5 cm of the soil, is critical for the germination of seeds and the initial growth stages of plants. It's highly susceptible to changes due to environmental conditions like rainfall and evaporation. This layer plays a significant role in the infiltration of water, which can percolate to deeper layers or contribute to surface runoff.[ii]

Root zone soil wetness, extending from the surface down to about 100 cm, encompasses the primary active area where plant roots absorb water and nutrients. The moisture here supports the bulk of plant growth and is a delicate balance maintained between water uptake by plants, evaporation at the surface, and deeper percolation. This zone's moisture content is a crucial determinant for irrigation practices in agriculture, especially for crops' sustenance during dry periods.[iii]

Profile soil moisture spans from the surface all the way down to the bedrock. While not all of this moisture is readily available to plants, particularly those with shallower root systems, it includes reserves that can sustain vegetation, especially deep-rooted plants like trees, during prolonged dry spells. This deeper soil moisture contributes to the water cycle by recharging groundwater and affecting the soil's capacity to hold and transfer water.[iv]

The importance of soil water is multifaceted. It's essential for the photosynthesis process in plants, nutrient transport, and overall plant health, directly impacting agricultural yields. [v]Furthermore, soil moisture levels are vital in regulating local and regional climates through their influence on humidity and

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temperature. The soil's water content also supports various organisms within the ecosystem, contributing to biodiversity and ecological health. Additionally, soil water acts as a thermal buffer, influencing soil temperature and overall environmental balance.[vi]

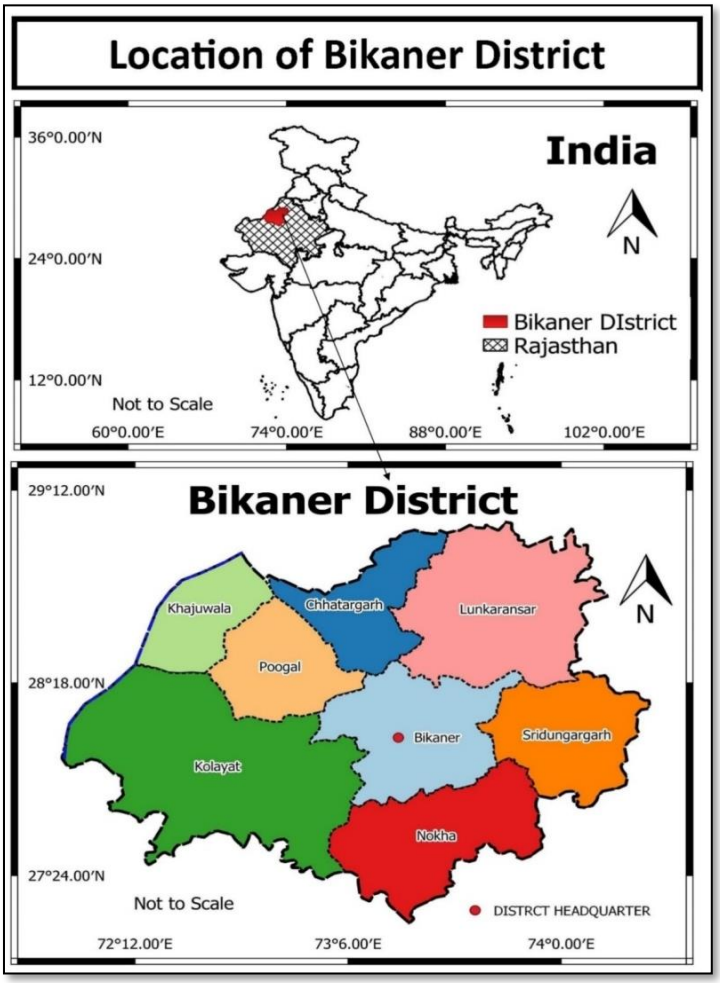
Soil water in the Thar Desert is a lifeline for its fragile ecosystem, supporting plant and animal life by enabling vegetation to grow despite scant rainfall. It aids in subsistence agriculture, allowing the cultivation of drought-resistant crops through rainfed farming and traditional water conservation practices. [vii]Soil moisture also mitigates wind erosion, contributes to soil health by aiding nutrient release, and is essential for recharging groundwater aquifers that provide drinking water. Additionally, it slightly moderates the harsh desert climate through evaporation and transpiration processes.[viii]

Keeping in view the above-mentioned facts, in the research paper presented by the researcher, the amount of water present in the soil of Bikaner district located in the Thar Desert of Rajasthan has been analyzed on the basis of data from the year 1981 to 2022.

Study Area Profile

Bikaner district is located in the northern-western part of the state. 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 in the area of 30,239 sq. km. (DCHB Bikaner, 2011).[ix]

Figure: 1



Bikaner district has total geographical area is 30,41,753 hectares. In the study area Lunakaransar tehsil is the largest tehsil according to area which is spread over 5,08,273 hectare area and Khajuwala tehsil is smallest in terms of the area it has area an 1,96,788 hectares.[x]Bikaner district has a total of 951 villages, in which the maximum number from Kolayat tehsil has 245 and the lowest is from Khajuwala tehsil which is only 58 villages. The maximum part of the district is included in desolate and dreary regions, which is a part of the Desert of Thar. [xi]Bikaner district has no one river system. Near Kolayat few little intermittent water channels can be seen during the rainy season only. The Bikaner district is remarked for the high temperature, high dryness, scarcity of precipitation, that's the major features of the desert climate. From November to March is found winter season in the district followed by the summer season in the district in April to June. The Monsoon (south-west) season is constituted from July to mid-September, while the period of mid-September to October is counted in the in-between post-monsoon.[xii]

Objectives

There are three objectives of this research work:

- To analyze the amount of Surface Soil Wetness (surface to 5 cm below) in Bikaner district on a temporal basis during the period from 1981 to 2022.
- To analyze the amount of Root Zone Soil Wetness (surface to 100 cm below) in Bikaner district on a temporal basis during the period from 1981 to 2022.
- To analyze the amount of Profile Soil Moisture (surface to bedrock) in Bikaner district on a temporal basis during the period from 1981 to 2022.

Data Source and Methodology

This research work is completely based on secondary data. In this research work, the data of the amount of soil water present in the soil of Bikaner district has been used. These figures are for the period from 1981 to 2022. These data Compiled from NASA 's ' Prediction of Worldwide Energy Resources (POWER)'s online data portal.[xiii] The data obtained has been analyzed by various statistical methods like average, standard deviation (SD), coefficient of variation (CV), linear regression etc. In the research paper, these data have been presented through tables and diagrams after analysis.

This research paper is based on 6 step descriptive research technique. In the first phase of which the objectives and questions of the research have been identified. In the second phase, the available literature related to the research problem has been reviewed. The research design has been prepared by the researcher in the third phase. Similarly, in the fourth phase, facts, information and data related to the research problem have been collected. In the fifth phase, the available facts, information and data have been analyzed and in the sixth and final phase, the writing work of this research paper has been done.

Discussion

Analyzing the data on Surface Soil Wetness in the Bikaner district from 1981 to 2022, we observe a notable fluctuation in the annual average, standard deviation (SD), and coefficient of variation (CV) over these years. The annual average soil wetness shows no clear upward or downward trend, with values ranging from a low of 0.09 g/cm³ to a high of 0.24 g/cm³. the lowest annual average was 0.09 g/cm³ in 2002, while the highest was 0.24 g/cm³ in 1982. In terms of standard deviation, the values also exhibit considerable variation across the years, ranging from as low as 0.02 to as high as 0.11. Particularly high SD values in years like 1994 and 2022 indicate greater variability within those specific years. The coefficient of variation, providing insight into the variability relative to the mean, further highlights this inconsistency, with values stretching from 23.12% to 55.15%. Years such as 1994 and 2022 are especially notable for their high CV values, signifying pronounced variability in soil wetness compared to the average. on finding the linear regression of the Surface Soil Wetness in the Bikaner district from 1981 to 2022, the value of Coefficient of determination is 0.0532, the value of y is 0.0007, and the value of

Table 1: Trends of Annual average, SD and CV of Surface Soil Wetness (surface to 5 cm below)in Bikaner district(1981-2022)

Year	Annual Average (g/cm³)	SD	CV (%)	Year	Annual Average (g/cm³)	SD	CV (%)
1981	0.22	0.10	43.91	2002	0.09	0.02	23.12
1982	0.24	0.07	27.12	2003	0.16	0.08	48.96

1983	0.19	0.07	36.70	2004	0.12	0.04	32.95
1984	0.14	0.06	43.54	2005	0.15	0.05	30.91
1985	0.13	0.05	38.45	2006	0.14	0.03	24.42
1986	0.14	0.04	31.09	2007	0.17	0.04	27.13
1987	0.12	0.04	29.46	2008	0.16	0.06	35.63
1988	0.14	0.06	41.09	2009	0.14	0.05	32.55
1989	0.13	0.05	35.53	2010	0.18	0.09	49.21
1990	0.15	0.05	35.89	2011	0.21	0.09	41.21
1991	0.10	0.03	26.85	2012	0.18	0.08	46.06
1992	0.18	0.08	46.04	2013	0.18	0.07	39.35
1993	0.13	0.05	37.12	2014	0.16	0.04	27.57
1994	0.17	0.09	55.15	2015	0.20	0.06	28.12
1995	0.19	0.08	41.66	2016	0.17	0.07	40.41
1996	0.17	0.06	35.20	2017	0.15	0.04	27.13
1997	0.18	0.06	34.66	2018	0.16	0.08	48.96
1998	0.19	0.07	36.58	2019	0.19	0.07	35.14
1999	0.11	0.05	41.75	2020	0.21	0.05	23.73
2000	0.10	0.03	32.57	2021	0.19	0.06	31.11
2021	0.13	0.04	35.61	2022	0.22	0.11	51.37

Source: NASA, Langley Research Center Prediction of Worldwide Energy Resource (POWER)

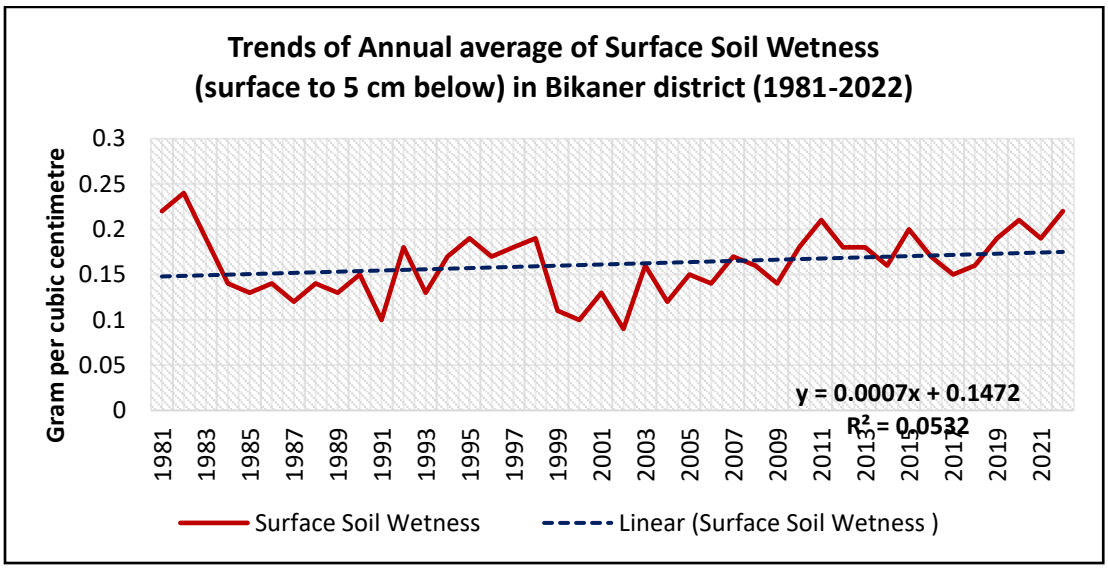


Fig. 2

The data on Root Zone Soil Wetness in Bikaner district from 1981 to 2022 exhibits an intriguing trend. Initially, from 1981 to 2000, there's an unusual pattern where the annual average, standard deviation (SD), and coefficient of variation (CV) are identical each year, fluctuating between 0.14 and 0.25 g/cm³. This pattern is atypical and might reflect specific local conditions or data recording methods of that time.

However, from 2002 onwards, the data shows more typical variability. The annual average values range from 0.14 g/cm³ in 2002, the lowest for this period, to 0.23 g/cm³ in 2022, the highest. The SD values, indicating annual variability, are generally low, with the lowest at 0.01 g/cm³ (seen in multiple years including 2002 and 2020) and peaking at 0.06 g/cm³ in 2022.

The CV values, which provide a measure of variability relative to the mean, show a broad range from 5.78% in 2002 to a high of 25.7% in 2022, indicating that the variability in soil wetness relative to the average was most pronounced in 2022 and least in 2002. This variability is essential for understanding soil moisture dynamics, which can have significant implications for agricultural practices, water management, and ecological balance in the region.

On finding the linear regression of the Root Zone Soil Wetness in the Bikaner district from 1981 to 2022, the value of Coefficient of determination is 0.0085, the value of y is 0.0002, and the value of X is 0.1868.

Table 2: Trends of Annual average, SD and CV of Root Zone Soil Wetness (surface to 100 cm below)in Bikaner district(1981-2022)

Year	Annual Average (g/cm^3)	SD	CV (%)	Year	Annual Average (g/cm^3)	SD	CV (%)
1981	0.24	0.24	0.24	2002	0.14	0.01	5.78
1982	0.25	0.25	0.25	2003	0.18	0.04	22.33
1983	0.21	0.21	0.21	2004	0.17	0.01	7.02
1984	0.18	0.18	0.18	2005	0.18	0.01	7.3
1985	0.18	0.18	0.18	2006	0.17	0.02	8.85
1986	0.18	0.18	0.18	2007	0.2	0.02	10.46
1987	0.16	0.16	0.16	2008	0.19	0.03	14.4
1988	0.17	0.17	0.17	2009	0.18	0.02	10.24
1989	0.18	0.18	0.18	2010	0.19	0.04	22.98
1990	0.19	0.19	0.19	2011	0.22	0.05	23.4
1991	0.15	0.15	0.15	2012	0.2	0.04	21.44
1992	0.2	0.2	0.2	2013	0.21	0.03	16.33
1993	0.18	0.18	0.18	2014	0.19	0.03	14.26
1994	0.2	0.2	0.2	2015	0.21	0.03	13.47
1995	0.21	0.21	0.21	2016	0.2	0.04	18.28
1996	0.2	0.2	0.2	2017	0.18	0.02	9.27
1997	0.2	0.2	0.2	2018	0.19	0.05	24.02
1998	0.22	0.22	0.22	2019	0.19	0.04	18.5
1999	0.17	0.17	0.17	2020	0.22	0.01	6.8
2000	0.14	0.14	0.14	2021	0.2	0.02	11.5
2021	0.16	0.16	0.16	2022	0.23	0.06	25.7

Source: NASA, Langley Research Center Prediction of Worldwide Energy Resource (POWER)

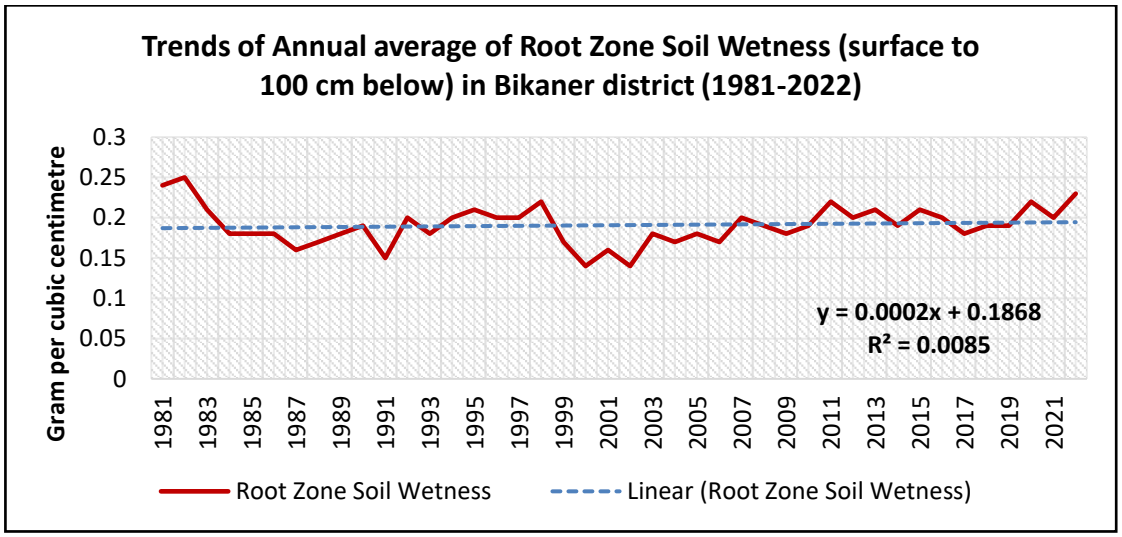


Fig. 3

From 1981 to 2022, the Profile Soil Moisture in Bikaner district displays a pattern of fluctuation without a clear long-term trend. The annual average moisture content varies considerably over these years, reaching its lowest at 0.14 g/cm^3 in 2002 and 2000, and peaking at 0.23 g/cm^3 in 1982, with a notable high of 0.22 g/cm^3 in 2022. This variability suggests changing. soil moisture conditions across the decades.

The standard deviation (SD) also shows diversity, ranging from a minimal 0.01 g/cm³ in several years including 2002, 2004, and 2020, indicating more uniform conditions, to a maximum of 0.05 g/cm³ in 1981 and 2022, reflecting greater variability. within those years. The coefficient of variation (CV) underscores this fluctuation, with the lowest CV at 5.45% in 2002, depicting minimal variability relative to the mean, and the highest at 24.01% in 2022, suggesting significant variability.

the linear regression of the Root Zone Soil Wetness in the Bikaner district from 1981 to 2022, the value of Coefficient of determination is 0.0215, the value of y is 0.0002, and the value of

Table 3: Trends of Annual average, SD and CV of Profile Soil Moisture (surface to bedrock)in Bikaner district(1981-2022)

Year	Annual Average (g/cm³)	SD	CV (%)	Year	Annual Average (g/cm³)	SD	CV (%)
1981	0.22	0.05	22.41	2002	0.14	0.01	5.45
1982	0.23	0.03	13.56	2003	0.18	0.04	20.84
1983	0.2	0.03	17.28	2004	0.16	0.01	6.1
1984	0.17	0.03	17.14	2005	0.17	0.01	7.15
1985	0.17	0.02	11.59	2006	0.17	0.01	7.36
1986	0.17	0.02	12.99	2007	0.19	0.02	9.62
1987	0.16	0.02	10.66	2008	0.18	0.02	12.92
1988	0.17	0.02	14.11	2009	0.17	0.02	9.69
1989	0.17	0.02	9.79	2010	0.19	0.04	21.12
1990	0.18	0.02	10.7	2011	0.21	0.04	21.29
1991	0.15	0.01	5.97	2012	0.19	0.04	19.22
1992	0.19	0.04	23.12	2013	0.2	0.03	14.87
1993	0.18	0.02	12.17	2014	0.18	0.02	12.88
1994	0.19	0.04	22.16	2015	0.2	0.03	13.69
1995	0.2	0.04	17.94	2016	0.19	0.03	16.91
1996	0.19	0.02	12.81	2017	0.18	0.01	8.25
1997	0.19	0.03	14.57	2018	0.18	0.04	21.7
1998	0.21	0.03	14.29	2019	0.19	0.03	18.26
1999	0.16	0.03	16.13	2020	0.21	0.01	5.77
2000	0.14	0.01	8.01	2021	0.19	0.02	11.44
2021	0.16	0.02	13.62	2022	0.22	0.05	24.01

Source: NASA, Langley Research Center Prediction of Worldwide Energy Resource (POWER)

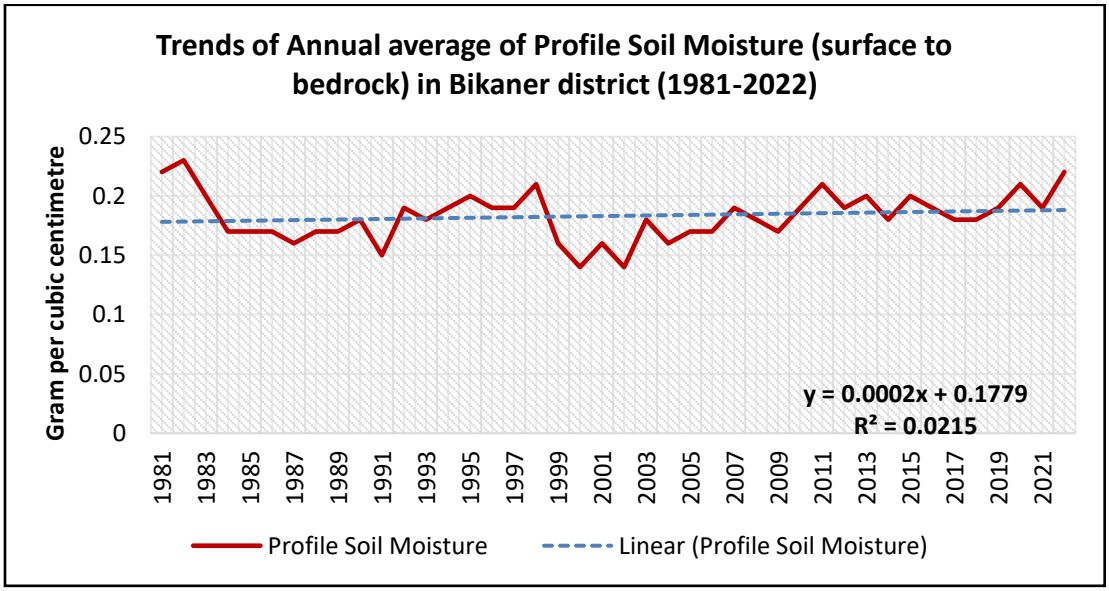


Fig. 4

Conclusion

It is clear from the above discussion that there has been a substantial increase in the amount of middle soil water in the study area Bikaner district from the year 1981 to 2022. The main reason for which is the increase in the area irrigated by tube wells in Bikaner district. Along with this, many initiatives have been taken by various government and non-government organizations in the district for rain water harvesting, such as construction of ponds, wells, and tanks etc. Along with this, tree plantation campaigns are being run by various government and non-government organizations in the district, as a result of which the forest area has increased. In recent years, there has been an increase in irregular rainfall in the Thar Desert, resulting in increased soil water levels. Similarly, slight decrease in temperature is also helping in increasing the soil water level in the district.

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