International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

A Study on Climate Change Scenario in Haryana: Trends, Impacts, and Adaptation Strategies

Pawan Kumar[1], Dr. Pinki Kumari[2]

[1]Ph.D. Scholar, Shri JJT University Jhununu, Rajasthan
[2]Guide

Abstract

The average temperature in Haryana has increased over the last few decades, resulting in heatwaves that have a negative impact on agricultural output and human health. Crop yields and the management of water resources have been impacted by the worsening of water scarcity caused by altered rainfall patterns, which are typified by unpredictable monsoons and protracted droughts. Examining precipitation trends is important for a country. Such as India, whose economy and food security depend on optimal water accessibility. Using a month-to-month information set spanning two years (2022–2023) for 22 locations in Haryana, India, this study focuses on monthly precipitation trends. The yearly rainfall trended upward in half of the districts, although it was statistically significant in just two (Kurukshetra and Yammunagar). Similarly, among the 22 districts exhibiting a declining tendency in yearly rainfall, five districts (Jind, Fatehabad, Bhiwani, Hisar, and Rohtak) showed a substantial declining trend. Rainstorms that last from June to September account for more than 80% of India's annual precipitation. The number of subdivisions exhibiting expanding precipitation in June and July is nearly equal to those demonstrating a decline in precipitation. The number of locations exhibiting a rising pattern is more than those exhibiting a decreasing pattern in August, while the situation is reversed in September. In months without rainstorms, the majority of the subdivisions displayed almost no change in precipitation. In the great majority of the months, there was no discernible trend in the monthly precipitation across India's five main regions. No significant trend in annual, sporadic, or monthly precipitation was identified for the whole of India. June, July, and September saw a decrease in precipitation, however August and September saw an increase in the pattern. This study emphasizes how urgently comprehensive climate action strategies are needed to guarantee the sustainability and resilience of Haryana's economy and environment.

Keywords: Climate Change, Haryana, Agriculture, Water Stress, Temperature Trends, Adaptation, IPCC, Geospatial Analysis

Introduction

The majority of Haryana is dry to semi-bone-dry, with only 300 mm of precipitation in the southwest. in the upper east to 1100 mm. There are no long-lasting streams in the state, and natural drainage covers around 66% of the land. Understanding the characteristics of the factors that could alter the climate and eventually have an impact on water supplies is crucial before beginning any research. Depletion of groundwater levels, changes in water quality, and decreased discharge are some manifestations of these

consequences. It is important to consider Haryana's environment, groundwater, and surface water arrangement separately before relating them to the problem of changes in the environment.

Study Area:

Haryana is situated in northwest India between latitudes 27°37' and 30°35' and longitudes 74°28' and 77°36', with an elevation of 700–3600 feet over the ocean floor. In terms of agroecological conditions, groundwater and surface water quality, and quantity, Haryana exhibits a great deal of spatial variation. The geographic area and rainfall analysis for each of Haryana's districts are displayed in Figure 1. The surface water network is also incredibly diverse and expansive. The state is located in the basins of the Yamuna and Indus rivers, and it gets its share of surplus water from the Ravi and Beas rivers in addition to water from the Sutlej and Yamuna rivers. Haryana state mainly occupies the Indo-Gangetic water divide and forms a part of the Indo-Gangetic plain.

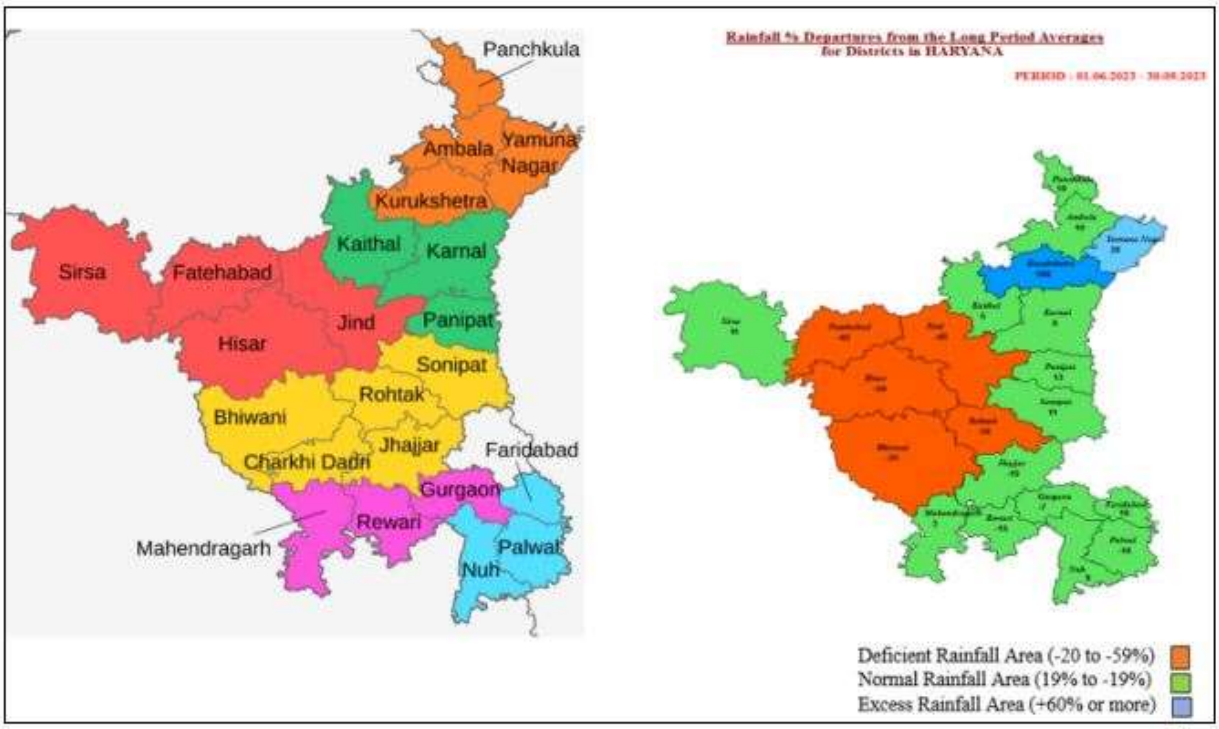

Fig 1: Rainfall pattern in Haryana during the year 2023 (IMD)

The current seasonal rivers, the Ghagger, Tangri, Markanda, and Chautang, start in the northeastern portion of the Shiwaliks and flow in a southwest direction. The Dohan, Krishanawati, and Sahibi are the few ephemeral streams that run from south to north. In the south, northwest, and western regions, where the Aravalli slopes' outcrops occur irregularly, aeolian lots with sandy exercises are typical. In a similar vein, many regions of the world experience significant rains. They are usually not disastrous occurrences, but if precautions are not followed and the precipitation is greater than anticipated, a catastrophic event may occur.

Methodology

Data source gathering of relevant information and data via accessible reports, questionnaires, and field research is a requirement to ascertain how Haryana's water resources are affected by climate change.

Numerous hints regarding the hydrological and geohydrological conditions in the research area can be gleaned from conversations with the local population. These kinds of investigations are useful for using questionnaires to extract historical data. As a result, this study attempts to gather as much information as possible via field research, reports from various sources, and individual questionnaires. However, no single model or methodology is suitable for all socioeconomic analyses of the effects of climate change. Primary data for this study comes from in-person surveys conducted in the villages that were sampled. The purpose of this survey is to gather data about the socioeconomic characteristics of the population. According to the report, the biophysical elements, including changes in water quality, slope, drainage pattern, rock type, and their structure that regulate surface runoff and surface water percolation were all assessed and mapped, as well as the impact of changes in water quality on human health .

Objectives

- To assess temperature and precipitation trends over 40 years.
- To examine the impact of climate change on agriculture and water resources.
- To evaluate adaptation strategies adopted by farmers and institutions.
- To propose policy recommendations for sustainable climate resilience.

Results and Discussion

Temperature and Rainfall Trends

- Mean annual temperature increased by 1.4°C from 1980 to 2023.
- Rise in frequency of heatwaves: 12 days/year (1980s) to 30 days/year (2020s).
- Rainfall decreased by 10–15% in southwestern districts; increased unpredictability in monsoon onset.

Agricultural Impact

- Delayed sowing of rabi crops due to late withdrawal of monsoon.
- Decline in wheat productivity by 4–6 quintals/ha in southwestern Haryana (2010–2020).
- Increase in pest attacks due to warmer winters (especially white grub, stem borers in sugarcane and paddy).

Water Stress

- Over 60% of blocks fall under overexploited category for groundwater.
- Aquifer depletion in Sonipat, Karnal, and Kurukshetra exceeds 4 m/decade.
- Water table in Mahendragarh and Bhiwani has declined by more than 20 meters since 1990.

Urban Impact

- Urban heat island effects observed in Gurugram and Faridabad.
- Rise in vector-borne diseases like dengue and chikungunya due to humid microclimates.
- Urban floods in Rohtak and Gurugram after intense rainfall events.

People's Perception (Survey Highlights)

- 80% farmers noticed changes in rainfall and sowing patterns.
- 60% adopted groundwater-saving methods like sprinklers or drip irrigation.
- 45% preferred heat-tolerant and early maturing seed varieties.

Rainfall Analysis in Various Haryana Districts (2023)

Haryana state had 80.7 mm (48%) of rainfall in June 2023. Rainfall of 54.7 mm, which was more than the average amount. The years 1936 and 2008 saw the highest rainfall in Haryana throughout the previous

121 years (1901–2023), with 162.1 mm, or 230.8% more than usual, followed by 2001 and 2008 with 155.1 mm and 150.6 mm, respectively.

Table 2: Rainfall Analysis of Haryana during the year 2023

District/State	Actual Rainfall (mm)	Normal Rainfall (mm)	DEP (Departure %)
Ambala	899.8	819.9	10
Bhiwani	201.7	292.1	-31
Chandigarh	1227.1	844.8	45
Charkhi Dadri	316.3	400	-21
Faridabad	646.4	558.7	16
Fatehabad	151.5	261.6	-42
Gurugram	457.2	489.1	-7
Hisar	138	299.3	-54
Jhajjar	343	380.5	-10
Jind	217.6	394	-45
Kaithal	384.1	365.1	5
Karnal	568.7	521.9	9
Kurukshetra	826	413.6	100
Mahendragrh	406.4	394.4	3
Nuh	519.3	477.2	9
Palwal	334.8	399.3	-16
Panchkula	1018.1	859.6	18
Panipat	514.9	455.8	13
Rewari	406.1	478.5	-15
Rohtak	309.3	466	-34
Sirsa	235.1	210.8	12
Sonipat	533.5	475.3	12

Yamunanagr	1143.2	895.2	28
Subdivision	421.5	430.1	-2

Table 3: Annual Rainfall Data Analysis for the Years 2022 and 2023

District	Annual Rainfall 2022 (mm)	Annual Rainfall 2023 (mm)	Difference (mm)	Percentage Change (%)
Ambala	646.5	899.8	253.0	39.17
Bhiwani	323.0	201.7	-121.3	-37.56
Charkhi Dadri	551.9	316.3	-235.6	-42.69
Faridabad	638.0	646.4	8.4	1.32
Fatehabad	647.4	151.5	-495.9	-76.58
Gurgaon	851.1	457.2	-393.9	-46.29
Hisar	535.9	138.0	-397.9	-74.22
Jhajjar	700.8	343.0	-357.8	-51.06
Jind	567.0	217.6	-349.4	-61.61
Kaithal	589.6	384.1	-205.5	-34.86
Karnal	859.7	568.7	-291.0	-33.86
Kurukshetra	777.9	826.0	48.1	6.18
Mahendragh	617.7	406.4	-211.3	-34.22
Nuh	813.5	519.3	-294.2	-36.16
Palwal	690.0	334.8	-355.2	-51.45
Panchkula	1058.9	1018.1	-40.8	-3.85
Panipat	754.8	514.9	-239.9	-31.78
Rewari	560.6	366.8	-193.8	-34.57
Rohtak	626.4	309.3	-317.1	-50.62
Sirsa	361.4	235.1	-126.3	-34.94
Sonepat	585.0	533.5	-51.5	-8.80

Yamuna Nagar	941.5	1143.2	201.7	21.42
Chandigarh	1195.1	1227.1	32.0	2.68

Adaptation and Mitigation Strategies

Policy and Institutional Interventions

- Haryana's SAPCC (2021) identifies agriculture, water, and energy as priority sectors.
- Crop diversification incentives (millets, pulses, horticulture) in Mewat and Mahendragarh.
- Solar-powered irrigation pumps under PM-KUSUM scheme.

Technological Solutions

- Remote sensing for drought and crop monitoring.
- Promotion of zero tillage and conservation agriculture.
- AI-based weather forecasting apps (e.g., Meghdoot) to aid in decision-making.

Community-Level Resilience

- Capacity-building programs for climate-smart agriculture.
- Formation of Farmer Producer Organisations (FPOs).
- Agroforestry along degraded canal banks in Hisar and Sirsa.

Conclusion

The northern Indian state of Haryana is suffering greatly from the consequences of climate change because endanger its general development and agricultural economy. Frequent heatwaves brought on by rising average temperatures have a negative impact on both agricultural productivity and human health. Crop yields and water management have been impacted by the worsening water scarcity caused by irregular rainfall patterns, which are typified by irregular monsoons and protracted droughts. In addition, infrastructural damage and disruption of livelihoods have resulted from the increased frequency of extreme weather events like storms and floods. Because Haryana depends so heavily on agriculture, especially water-intensive crops like wheat and rice, the state is especially susceptible to disruptions brought on by the climate. In order to lessen these negative impacts, it is imperative that adaption plans that include water-saving methods, sustainable farming methods, and strong legislative frameworks. To improve the sustainability and resilience of Haryana's economy and environment, comprehensive climate action strategies are required. The need for localized water resource management and agricultural planning to overcome the discrepancies and guarantee efficient use of water resources is further highlighted by the state's uneven rainfall distribution. It is impossible to overestimate how urgently such actions are required if Haryana is to successfully traverse the difficulties presented by climate change and ensure its continued growth.

Climate change is no longer a distant threat for Haryana. The clear evidence of rising temperatures, falling groundwater, erratic rainfall, and socio-economic distress in farming communities demands urgent attention. While Haryana has made strides in solar energy and irrigation reforms, a more inclusive, climate-resilient development model is crucial. Strengthening climate services, decentralizing water governance, and mainstreaming climate adaptation in all development planning are the way forward.

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