**Original Research Article**

**Farmers’ Perceptions of Climate Change and Weather Aberrations Affecting Major Crop Productivity in Haryana, India**

**Abstract:**

This study investigates farmers’ perceptions of climate change and its perceived impact on the productivity of major crops—wheat, paddy, and cotton—in Haryana, India. Conducted in Hisar and Sonipat districts, the research used a multi-stage random sampling method to survey 120 farmers through structured interviews. Perceptions were assessed using 5-point and 3-point Likert scales, supported by descriptive statistics and crop yield data from the 2022–23 season. The majority of farmers reported significant changes in climate patterns, including delayed monsoons, erratic rainfall, increased summer temperatures, prolonged winters, and declining groundwater levels. These changes were associated with delayed crop maturity, reduced yields, increased irrigation needs, and a rise in pest and disease incidence. Farmers perceived that weather aberrations such as terminal heat, excess or deficit rainfall, high wind velocity, and fog during critical growth stages led to substantial yield reductions—wheat yields declined due to terminal heat, while high temperatures during cotton flowering reduced output. The consistency between farmer perceptions and yield losses highlights the importance of local knowledge in climate impact assessment. Based on these findings, the study recommends location-specific climate-resilient strategies, improved irrigation and pest control practices, and the strengthening of extension services to enhance farmers’ adaptive responses and safeguard agricultural productivity in the face of increasing climate variability.

**Keywords: Farmers perception, Weather aberrations, Haryana agriculture**

**Introduction:**

Climate change poses a significant challenge to agricultural systems worldwide, and its repercussions are particularly pronounced in regions dependent on agriculture for sustenance and economic stability. Agriculture sector has occupied almost 43 per cent of the geographical area, it contributed 18.3 per cent of GDP to the Indian economy in the year 2022-23. As economies grow, the industrial sector's contribution increases, while the agricultural sector's share decreases (Mafi *et al.,* 2024). According to the IPCC, 2007; Fusel, 2007, climate change is any change in climate over time caused by natural variability or human activity. Climate change poses a significant threat to rural people's livelihoods (Rakib et al. 2014). Crop productivity has also declined due to inadequate soil fertility and increased disease incidence (Rawat *et al.*, 2013). In 19th century, the global average increase in temperature was 0.7°C and it is expected to increase around 1.4°C - 5.8°C by 2100 (IPCC, 2007). The Carbon dioxide (CO2), Methane (CH4) and Nitrous Oxide (N2O) concentrations are increasing during 19th to 21st century from 280 ppm to 395 ppm, 715 ppb to 1882 ppb and 227 ppb to 323 ppb respectively (Mahato, 2014). This has contributed to increase the earth’s temperature and will continue for next few decades even if the greenhouse gas emission is fully mitigated. Due to rising in temperature, agriculture production is expected to decline by 2050 in Himalaya region and will lead food insecurity (Dahal, 2008). Changes in weather patterns also result in reduction in availability of fuelwood, grass for fodder, spring water (Gene, 2012). Even extension specialists have a low to moderate understanding of how climate change affects agriculture (Ghanghas *et al.*, 2015). KVK plays a pivotal role in the agricultural landscape of India (Choudhary *et al.,* 2023 & Gautam *et al.,* 2024). Farmers' understanding of the interaction of climate and agro-ecosystem must be bridged through the inclusion of farmers' communication networks in order to support farm-level decisions and minimize losses due to adverse climatic and weather conditions (Ravikumar et al., 2015). Climate change poses a significant threat to crop productivity, which is critical for food, feed, and fodder security in dryland agriculture (Chapke *et al.,* 2018).

Haryana is one of India’s leading agricultural states, known for high productivity in wheat, rice, cotton, and mustard, supported by favourable agro-climatic conditions, irrigation infrastructure, and modern farming practices (Sardar, 2025). Although agriculture engages nearly 65% of the state’s population, its share in Haryana’s gross state domestic product (GSDP) has declined due to structural economic changes (Adhana & Yadav, 2019). Over-reliance on water-intensive crops like wheat and rice has raised sustainability concerns, particularly regarding groundwater depletion and soil health (Kumar & Singh, 2014). These challenges underscore the need to understand local agricultural dynamics and farmers’ perceptions of climate change impacts to inform resilient policy interventions.

**Methodology:**

**Study Area Selection**

The study was conducted in the state of Haryana, India, which is known for its agricultural prominence and susceptibility to climate variability. To represent regional diversity in agro-climatic conditions, two districts—Hisar and Sonipat—were purposively selected. Hisar lies in the western dry zone with relatively low rainfall and high temperature fluctuations, while Sonipat falls in the more humid eastern zone with relatively better water availability. These contrasting zones allowed for comparative assessment of climate change impacts on crop productivity across different agro-ecological contexts.

**Sampling Design**

A multi-stage random sampling technique was employed to ensure representative data collection. First, one block was randomly selected from each of the two districts. Then, two villages from each selected block were chosen at random, resulting in a total of four villages. From each village, 30 farmers were selected using a simple random sampling method, giving a total sample size of 120 respondents. Primary data were collected during the year 2023 using a structured and pre-tested interview schedule administered through face-to-face interviews.

**Data Collection Tools and Procedure**

Primary data were collected using a structured and pre-tested interview schedule through face-to-face interviews. The questionnaire was designed to capture two major aspects: (i) general perceptions of climate change and weather variability, and (ii) perceived impacts on the productivity of key crops—wheat, paddy, and cotton. Two types of Likert scales were used to collect perception data. A 5-point Likert scale (ranging from 1 = Strongly Disagree to 5 = Strongly Agree) was used to measure general perceptions related to climate change, while a 3-point Likert scale (Agree, Neutral, Disagree) was applied to assess specific perceptions regarding the effect of climate change on wheat and paddy crop productivity.

**Data Analysis**

For the perception data, mean scores were calculated from the Likert scale responses to determine the relative importance of each issue, which enabled the ranking of farmers’ concerns. Descriptive statistics such as frequencies and percentages were also used to summarize responses from the 3-point Likert scale. To assess the effect of weather aberrations on crop productivity, descriptive statistics such as mean yield were computed for different weather conditions reported by farmers. Farmers’ recall data on average yield during the 2022–23 cropping season were used to assess productivity variations under specific climate events such as excess rainfall, high temperatures, strong winds, and terminal heat stress. In addition, gross returns (Rs/ha) were estimated using the Minimum Support Price (MSP) for 2022–23 to quantify the economic impact of yield variations. This integration of qualitative perception data and quantitative yield measurements allowed for a comprehensive evaluation of the effects of climate variability on agricultural productivity in the selected districts of Haryana.

**Results and Discussion:**

**1. Farmers’ perception related to climate change in Haryana**

In Table 1, Among the various perceived indicators of climate change, farmers ranked change in rainfall patterns as the most significant concern, followed by depletion of groundwater levels. Many respondents reported that overexploitation of groundwater resources has led to a decline in water quality, with increasing salinity observed in several areas. This trend reflects both the quantitative and qualitative stress on groundwater, posing serious challenges for irrigation and crop sustainability in the region. Drastic increase in temperature during summer and increase in productivity of crops were perceived 3rd and 4th rank respectively in the study area. This result was supported by Thornton *et al.,* (2006) who found that over the time rainy season has become shorter in duration. Dhanya and Ramachandran 2016, Amir *et al.,* 2020 and Zakari *et al.,* 2022 also reported that farmers have the perception that rainy season was reducing and increasing temperature was getting excruciating.

Table 1: Farmers’ perception related to climate change in Haryana (n = 120)

|  |  |  |
| --- | --- | --- |
| **Statements** | **Mean Score** | **Rank** |
| Change in rainfall pattern | 4.42 | I |
| Depletion in ground water levels | 4.21 | II |
| Scarcity of water in surface water bodies | 3.98 | V |
| Increased occurrence of frost and frost injury | 3.85 | VII |
| Drastic risen in temperature during summer | 4.12 | III |
| No change in climate observed | 3.02 | X |
| Increased productivity of crops | 4.04 | IV |
| Reduced occurrence of dry spells | 3.62 | VIII |
| Drastic drop in temperature during winter | 3.87 | VI |
| Infestation of new pests and disease | 3.38 | IX |

A "drastic rise in summer temperature" ranked third, raising concerns about heat stress on crops, livestock, and farm operations. Interestingly, "increased crop productivity" ranked fourth, possibly linked to improved practices or favourable conditions. "Scarcity of surface water" was another major concern, affecting irrigation. Other notable perceptions included a drastic drop in winter temperatures, increased frost events, reduced dry spells, and rising pest infestations. Statistical analysis confirmed that rainfall pattern changes and groundwater depletion were the most significant concerns.

2. Perception of farmers on effect of climate change on productivity of wheat and paddy crops in Haryana

The cropping pattern of the sample farmers was dominated by paddy and wheat, Table 2 presents the perceptions of Haryana farmers regarding the effect of climate change on paddy and wheat production. The data indicates that approximately 60 per cent of the respondents agreed that climate change affects the timing of paddy crop transplantation and causes delays in crop maturity, 67 per cent agreed with the statement that climate change affects the number of irrigations, while only a small percentage disagreed. Similar results were observed by Kumar and Sidana (2018) on paddy and wheat in Punjab agriculture.

Table 2: Perception of farmers on effect of climate change on productivity of wheat and paddy crops in Haryana (n = 120)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Statement** | **Agree** | **Per**  **cent** | **Neutral** | **Per**  **cent** | **Disagree** | **Per**  **cent** | Mean Score | Rank |
| Whether climate change has led to a rise  in the usage of fertilisers in both crops | 81 | 67.50 | 37 | 30.83 | 2 | 1.67 | 1.34 | III |
| Higher incidence of diseases in paddy  and wheat crops | 86 | 71.67 | 32 | 26.66 | 2 | 1.67 | 1.30 | II |
| Whether climate variability has  affected transplantation of paddy crop | 69 | 57.50 | 42 | 35.00 | 9 | 7.50 | 1.50 | VIII |
| Delaying crop maturity of both crops | 78 | 65.00 | 35 | 29.17 | 7 | 5.83 | 1.41 | V |
| Whether the number of irrigations in  paddy or wheat crop has increased | 80 | 66.67 | 35 | 29.16 | 5 | 4.17 | 1.38 | IV |
| Quality of grain of paddy and wheat  has deteriorated | 66 | 55.00 | 49 | 40.83 | 5 | 4.17 | 1.49 | VII |
| Whether the paddy and wheat crop's net  returns have decreased | 90 | 75.00 | 26 | 21.67 | 4 | 3.33 | 1.28 | I |
| High infestation of insect pests | 79 | 65.83 | 33 | 27.50 | 8 | 6.67 | 1.41 | V |
| Leading to new weeds infestation | 41 | 34.17 | 61 | 50.83 | 18 | 15.0 | 1.81 | IX |

Around 67.50 per cent of the respondents agreed that climate change led to an increase in the use of fertilizer application, while 1.67 per cent disagreed. Additionally, 71.67 per cent of the respondents perceived a higher incidence of diseases in paddy and wheat crops due to climate change, with a small percentage (1.67 per cent) disagreeing with this statement. Barlow *et al.* (2015), found As heat stress affects the grain production and yield, cold stress result in sterility, and drought stress negatively influences the morpho-physiology of plants.

The primary impact of climate change was observed in the net returns from paddy and wheat crops, with 75.00 per cent of the respondents agreeing. Approximately one fifth of the respondents had a neutral response to the statement that weather variability affects the net returns of paddy and wheat crops.

**3. Effect of weather aberrations on productivity of paddy, cotton and wheat crops in Haryana**

The study analysed weather aberrations' impact on paddy, cotton, and wheat yields in Haryana, highlighting crop vulnerability. It also assessed yield variations and gross returns based on MSP for the 2022-23 season.

For paddy, farmers perceived that rainfall above normal during the Southwest (SW) monsoon (La Niña) resulted in an average yield of 5,401 kg/ha. compared to the average yield, which was higher by 346 kg/ha (6.84 per cent). The gross return based on the MSP for this yield was Rs 110,180 per hectare. Similar Abbas and Mayo (2021) found that number of tillers and rice plant hight increase with the positive impact of rainfall at tillering stage. Deficit rainfall during the SW monsoon (El Niño) led to an average yield of 4,182 kg/ha, which was 873 kg/ha (17.27 per cent) lower than the average. The gross return for this yield was Rs 85,312 per hectare. Similar result by Grover and Upadhya (2014), found that rainfall positive impact on paddy.

High wind velocity during the reproductive to maturity stage: farmers perceived that average yield under this condition was 3,523 kg/ha, resulting in a decrease of 1,532 kg/ha (30.31 per cent) compared to the average. The gross return for this yield was Rs 71,869 per hectare. High winds can cause the plants to bend or even break, a phenomenon known as lodging. This can be particularly damaging during the reproductive to maturity stage when the plants are heavier and more susceptible to being pushed over. Lodging reduces the plant's ability to receive sunlight, affects nutrient uptake, and can lead to reduced yields.

**Table 3: Effect of weather aberrations on productivity of paddy, cotton and wheat crops in Haryana (n = 120)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Effect of weather aberration on selected crops** | **Average yield (kg/ha)** | **Yield (kg/ha)** | **Impact of particular on yield (kg/ha)** | **Gross return (MSP 2022-23) (Rs/ha)** |
| **A.** | **Paddy** | | | | |
| 1 | Rainfall above normal during SW monsoon (La Niña) | 5055 | 5401 | 346 (6.84) | 110180 |
| 2 | Deficit rainfall during SW monsoon (El Niño) | 4182 | -873 (-17.27) | 85312 |
| 3 | High wind velocity during reproductive to maturity stage | 3523 | -1532 (-30.31) | 71869 |
| 4 | High temperature during flowering to grain development stage | 4116 | -939 (-18.58) | 83966 |
| **B.** | **Cotton** | | | | |
| 1 | Insect-pest infestation due to high relative humidity | 1976 | 1580 | -396 (-20.04) | 96064 |
| 2 | Temperature fluctuations | 1440 | -536 (-27.13) | 87552 |
| 3 | High temperature | 1214 | -762 (-38.56) | 73811 |
| 4 | Rainfall at plucking stage | 1193 | -783 (-39.63) | 72534 |
| **C.** | **Wheat** | | | | |
| 1 | Low temperature, fog and drizzling during vegetative stage | 5219 | 5582 | 363 (6.95) | 112477 |
| 2 | Hailstorm | 2914 | -2305 (-44.16) | 58717 |
| 3 | High wind velocity along with rainfall | 4067 | -1152 (-22.07) | 81950 |
| 4 | Terminal heat stress | 3194 | -2025 (-38.80) | 64359 |

Note: Figure in parenthesis indicates percentage of change in yield

High temperature during the flowering to grain development stage: Farmers perceived that average yield in this case was 4,116 kg/ha, which was 939 kg/ha (18.58per cent) lower than the average. The gross return for this yield was Rs 83,966 per hectare. Similar findings by Grover and Upadhya (2014), found that high maximum temperature negative impact on paddy crop also Abbas and Mayo (2021) found maximum temperature has negative impact on rice crop at tillering and stem elongation stages.

Regarding cotton, farmers perceived that insect-pest infestation due to high relative humidity: This condition led to an average yield of 1,976 kg/ha, resulting in a decrease of 396 kg/ha (20.04 per cent) compared to the average. The gross return for this yield was Rs 96,064 per hectare. High humidity creates favourable conditions for the proliferation of various insect pests that can feed on the leaves, stems, and reproductive structures of cotton plants. Singh *et al.,* (2015) found that the whitefly population had a positive correlation morning and evening relative humidity.

Temperature fluctuations: farmers perceived that average yield under this condition was 1,440 kg/ha, which was 536 kg/ha (27.13 per cent) lower than the average. The gross return for this yield was Rs 87,552 per hectare. High temperature: Farmers perceived that average yield in this case was 1,214 kg/ha, resulting in a decrease of 762 kg/ha (38.56 per cent) compared to the average. The gross return for this yield was Rs 73,811 per hectare.

Rainfall at the plucking stage: Farmers perceived that this condition led to an average yield of 1,193 kg/ha, which was 783 kg/ha (39.63 per cent) lower than the average. The gross return for this yield was Rs 72,534 per hectare. Similar revealed by Thakare *et al.,* (2014) discovered that maximum and lowest temperatures were higher than normal throughout crop development (June-August) and blooming (October-December), disrupting crop physiology and indirectly impacting cotton yield.

For wheat, the study identified various factors impacting the yield. Low temperature, fog, and drizzling during the vegetative stage: Farmers perceived that this condition resulted in an average yield of 5,219 kg/ha, which was 363 kg/ha (6.95 per cent) higher than the average. The gross return for this yield was Rs 112,477 per hectare. This is optimum temperature and favourable weather for wheat growth. Liu *et al.,* (2016) found that warmer regions were likely to suffer more yield loss with increasing temperature than cooler regions.

Hailstorm: Farmers perceived the average yield under this condition was 2,914 kg/ha, resulting in a decrease of 2,305 kg/ha (44.16 per cent) compared to the average. The gross return for this yield was Rs 58,717 per hectare. Hailstones have a high impact force when they fall, leading to physical damage to the wheat plants. They can break stems, leaves, and spikelets, which are vital for the wheat's growth and development. Elahi *et al.,* (2022) found that if thunderstorms and hailstorms were rated moderate or low in severity, a significant reduction in wheat yield. High wind velocity along with rainfall: Farmers perceived that this condition led to an average yield of 4,067 kg/ha, which was 1,152 kg/ha (22.07 per cent) lower than the average. The gross return for this yield was Rs 81,950 per hectare. High wind velocity can cause the wheat plants to bend or break, a phenomenon known as lodging. Wind-driven rain can facilitate the spread of fungal and bacterial diseases in wheat crops.

Terminal heat stress: Farmers perceived that the average yield in this case was 3,194 kg/ha, resulting in a decrease of 2,025 kg/ha (38.80 per cent) compared to the average. The gross return for this yield was Rs 64,359 per hectare. Terminal heat stress in wheat arises when the average temperature during the grain filling phase exceeds 31 °C. According to the IPCC (2014), temperatures in India are expected to rise by 0.7–2.0 °C by the 2030s and by 3.3–4.8 °C by the 2080s. Shew *et al.,* (2020) reported that a 1 °C temperature increase could lead to an average wheat yield decline of 8.5%, escalating to 18.4% and 28.5% under 2 °C and 3 °C warming scenarios, respectively. These impacts are likely to be more severe in northern India and during the rabi season (November to March). A temperature rise of 0.5–1.56 °C between 2080 and 2100 is projected to negatively affect food production, potentially reducing India’s food grain output by 10–40% (Parry *et al.*, 2004; IPCC, 2007). Heat stress disrupts the metabolic processes involved in grain filling, affecting the accumulation of starch and proteins in the grains.

**Conclusion and policy implications:**

This study explored farmers’ perceptions of climate change and its perceived impact on the productivity of major crops—wheat, paddy, and cotton—in Haryana. The findings show that farmers are acutely aware of changing weather patterns, including delayed monsoons, erratic rainfall, rising summer temperatures, prolonged winters, and declining groundwater levels. These climatic changes were commonly associated, in farmers' views, with delayed crop maturity, increased irrigation needs, rising pest and disease incidence, and ultimately, reduced yields. Farmers identified specific weather aberrations such as terminal heat, high wind velocity, unseasonal rainfall, and fog as key stressors affecting different stages of crop growth. For example, many reported that terminal heat led to poor grain filling in wheat, while high temperatures and untimely rainfall affected cotton during flowering and plucking stages. Similarly, paddy yields were said to benefit from well-timed monsoons but suffered under excess or deficient rainfall and strong winds.

These perception-based insights provide a valuable understanding of how climate variability is experienced at the grassroots level. While the study did not include direct measurement of yields or weather data, the consistency and detail in farmers’ responses reflect a strong experiential knowledge of local climate impacts. The findings underscore the need for location-specific climate-resilient strategies, improved irrigation and pest management practices, and the strengthening of agricultural extension services to better equip farmers to cope with ongoing climatic challenges.

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**Competing Interests Disclaimer:**

Authors have declared that they have no known competing financial interests or non-financial interests or personal relationships that could have appeared to influence the work reported in this paper.

**Disclaimer (Artificial intelligence)**

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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