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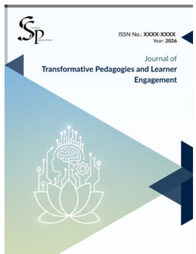

Article

Withstanding the Storm: Farmers' Insights on Climate Change and Sustainable Agriculture in Murshidabad, India

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Abstract:

In this mixed-methods study, the researcher investigates farmers' perceptions of climate change, how this change affects their agricultural activities, and the measures they take to mitigate its impacts in Murshidabad District, West Bengal, eastern India. Data were gathered from 300 farmers across all 26 administrative blocks of the study area. A structured questionnaire combining Likert-scale and open-ended questions was used to collect both quantitative and qualitative data. Statistical and inferential analysis of the quantitative data, including a one-sample Chi-Square goodness-of-fit test ($p < .001$), showed respondents' strong awareness of climate change, such as rising summer temperatures, erratic monsoon onset and withdrawal, and declining rainfall patterns. Surprisingly, 80% of respondents reported decreasing agricultural incomes despite adopting short-duration and stress-tolerant crop varieties. Thematic analysis of qualitative data revealed their understanding of altered phenological cues, such as changing flowering times, and the emergence of new pest species and crop diseases. As adaptation strategies, they adjusted sowing and harvesting schedules, diversified crops, and shared irrigation systems. However, their vulnerability remains due to delayed crop insurance payments, limited access to timely weather information, and high agricultural costs. The study concludes that although farmers exhibit locally-based ecological knowledge and resilience, they require government support to sustain sustainable farming practices. Policy reforms should incorporate farmers' experiential observations into early-warning systems, decentralize irrigation infrastructure, ensure timely crop insurance payouts, and implement capacity-building programs to strengthen climate-resilient agricultural livelihoods.

Keywords: Climate change perception; Indigenous ecological knowledge; Farmers' ecological awareness; Government support

1. INTRODUCTION

Global climate patterns have been experiencing profound changes as a result of shifts in key climate variables (Wright et al., 2023; Intergovernmental Panel on Climate Change [IPCC], 2021). This change occurs mostly due to various types of human activities, that produce increasing level of greenhouse gases (GHGs), such as methane (CH_4), carbon dioxide (CO_2), nitrous oxide (N_2O), and chlorofluorocarbons (CFCs). Since the birth of Industrial Revolution in Europe in the mid-18th century, human activities, particularly burning of fossil fuels, deforestation, and various developmental processes, have escalated CO_2 levels in the atmosphere from 289 ppm to 379 ppm by 2005 (Karmouche, 2024). These gases trap the heat caused by the sunlight, absorb and re-emit infrared radiation, that in turn, result in increasing global temperatures by approximately 33°C, compared to a scenario without GHGs (NASA, 2020a). This phenomenon has led to a global mean rise in surface temperature by approximately 1.2°C since the late 19th century (NASA, 2020b). The 2010s was notably 0.8°C warmer than the 1910s, and the period between 1990–2000 was the warmest in the last 300 years (Zheng, 2024).

Global warming impacts the hydrological cycle, causing more frequent rainfall, flooding, and droughts. Coastal pockets and island-nations, such as Tuvalu, the Maldives, Lakshadweep, and the Andaman and Nicobar Islands are experiencing existential threats. They could become submerged with an extra 2°C temperature hike to the existing one (Mansoor & Inam, 2025). All these climatic shifts also threaten agricultural activities with impacts varying significantly by regions round the globe. At this juncture, understanding perception of farmers about climatic change is very important, as many individuals, in general, perceive this change as a distant issue (Spence et al., 2012). As climate change impacts agricultural activities directly in an agri-based society like India, exploration of farmers' perception of this change may determine strategies for coping and adaptation – to foster resilience towards a sustainable farming (Dhanya et al.,2022; Das & Ansari, 2021), and to determine suitable policy-mechanisms by the government.

Thus, the objectives of the present study were to:

1. gather insights into farmers' perceptions of climate changes, how these changes impact their agricultural practices and what adaptive measures they take up to minimise its negative impact; and

2. propose practical policy recommendations and interventions that could assist farmers in both mitigating and adapting to the consequences of climate change on agricultural activities.

2. CONTEXT OF THE STUDY

Global perspective of climate change impact on agriculture

Climate change – through slow but steady rising temperature, changed precipitation patterns, and recurrence of extreme weather, such as droughts, floods, and storms – poses a significant threat to global agriculture. Especially in the developing countries, where access to adaptive agricultural technologies – such as access to advanced irrigation system or drought-resistant crop varieties – is limited, changes in climate disrupt agricultural output (Abebaw, 2025). Increase in global temperature and precipitation variability severely impact food production across the globe. And the phenomenon is quite relevant for five major agricultural hubs in the continents of America, Europe, Asia, and Australia, that collectively account for approximately 60% of global grain production (Sivakumar, 2020). Take for example – a 1°C rise in temperature above a critical threshold of 24°C could reduce rice yields by 10% in South and Southeast Asia by 2030 (De Nardi et al., 2024). In India, a similar 1°C increase could lead to annual loss of wheat production by a hefty 6 million tons – valued at US $20 billion per annum (Adom, 2024)! More to worry, meteorological predictions reveal that crop productivity might come down by 16–40% between 2080–2100 due to global warming (Farooq et al., 2023; Deryng et al., 2014).

Erratic behaviour pattern in climate also disrupts crop physiology. It could shorten plants' growth periods, increase respiration rates, alter photosynthesis process, reduce efficacy of fertiliser used, and increase evaporation rates (Brouder & Volenec, 2008). Escalated rate of snow-melting, frequent droughts and floods – further jeopardise agri-productivity. Attacks of unknown species of pests and insects and proliferation of pathogens and weeds are results of rising temperatures and humidity (Kumar & Mukhopadhyay, 2025). For example, outbreak of bacterial leaf blight is directly related with increased rainfall (Duku et al., 2016). Again, heat stress during reproductive stages can degrade quality of grains, thus reducing both its market as well as nutritional value (Farooq et al., 2017). Heavy rainfall causes soil erosion, nutrient leaching, and degraded soil health. On the contrary, prolonged droughts impair microbial activities in plants (De Silva et al., 2025). Increased level of carbon dioxide may boost up the ratio of carbon-to-nitrogen in crop residues, and it slows down decomposition and limits nutrient availability (Patel et al., 2024).

Perspective in India

The agricultural sustainability and productivity in India – like other regions of the globe – is heavily impacted by the trend of rising temperature, volatile monsoon, and higher incidents of extreme weather conditions. The agricultural sector that engages about 44% of the population and contributes to 14% to the GDP in India,

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faces threats due such climatic whims (Hassan, 2025). A close analysis of the national mean annual surface air temperature for the period 1901–2018 shows an alarming rate of approximately 0.7°C rise in temperature (Gaston et al., 2023; Meteorological Department of India [MDI], 2020). These data align closely with the contemporary global average increase (Hingane et al., 1985). However, further analysis showed that the rate of warming was not uniform across seasons. The rate was most evident during winter season – 0.04°C per decade. During the post-monsoon seasons, it was 0.05°C per decade. On the contrary, the monsoon period saw a minimal increase of 0.01°C per decade (Mahapara et al., 2025). Rainfall pattern – another important component of climate – across India shows a spatially heterogeneous variability. An in-depth analysis of a 176-year rainfall series reveals substantial regional variability. It shows a declining trend in central India, the southern states, and some pockets of the north-east India. Conversely, some states, such as Maharashtra, Gujarat, Odisha and coastal Andhra Pradesh witnessed sumptuous rainfall (Chakra, 2024). Such variability could be seen at the district level also. In some rain-fed regions, 40% stations experienced less than average rainfall, while 48% ones reported excess of the same. Punjab witnessed such contradictory trends. Districts like Amritsar and Bathinda saw reduced rainfall of 5.5–7.1 mm/year over five decades, while Ludhiana got increased one (Kaur, 2020). Research by Varikoden and Revadekar (2020) found decreasing rainfall trends in central and northern India during north-east and south-west monsoon seasons. On the other hand, peninsular regions saw an upward trend during the north-east monsoon.

Research studies (Amale et al., 2023; Falga & Wang, 2022; Lal, 2003) found that the summer monsoon, which contributes approximately 70% of the annual rainfall in India, has grown increasingly erratic. More often than not, it shows delayed onset, uneven distribution, and early withdrawal. Indian agriculture depends heavily on monsoon rains (Sharma et al., 2010, and the cultivation of all crops throughout the year, especially *kharif* (the autumn crop, sown at the beginning of the summer rains) crops, may be negatively impacted by the whimsical trend of the monsoon. To add to the worry, projections indicate that atmospheric CO_2 levels may soar up 605–755 ppm by 2070, which can alter precipitation patterns by 5–25% by the end of the present century. As a result, rainfall in winter season may become more severe than that in summer (Dore, 2005). The unpredictable nature of the monsoon invites drought conditions, while conversely, excessive rainfall in eastern states like Bihar, Assam, and West Bengal leads to devastating flood, waterlogging, and soil erosion (Banerjee et al., 2025; Charak et al., 2024).). Water availability for irrigation in some regions– particularly in the agriculturally rich Indo-Gangetic Plains – faces increasing threat due to increased evapotranspiration rates and whimsical river flows. It adversely affects irrigation-dependant crops, such as sugarcane and rice (Kar et al., 2024). Besides, the coastal agricultural zones, including West Bengal, Odisha, and Andhra Pradesh, face compounded risks from intensified storms, and rising sea levels. Such incidents cause salty sea water intrusion into aquifers and top soils, that spoil traditional agricultural activities (Das, 2024; Das & Swain, 2024).

Perspective in West Bengal

The multi-pronged impacts of climate change could be seen in the agricultural sector of West Bengal – the prime source of its economy and livelihood. The mosaic geographical profile and topographical diversity of the state, spanning the Himalayan foothills in the north, the fertile Gangetic Plains in the middle part, and the low-lying Sundarbans delta at south, make it easily vulnerable to climatic shifts (Mandal et al., 2013). Prominent volatility in climatic behaviours – be it unforeseen heat stress, unpredictable rainfall, or increased frequency of storms – has been observed during the last few decades. The agri-activities in the state primarily depend on the monsoon rains. Production of the prime crops, including paddy, wheat, jute, potatoes, oilseeds, vegetables and mangoes depends on major climatic shifts. Paddy cultivation faces yield reductions due to heat stress. The impact might worsen by irregular monsoon patterns that disrupt flowering and grain filling in paddy (Wassmann et al., 2009). Jute cultivation, one of the major economic crops produced by the state, dependents on timely water supply. Interestingly, less water and more water – both are harmful for jute cultivation, lowering productivity and fibre quality. Yet both the extremes are increasing in the state due to erratic monsoons (Rahman & Rahman, 2024). Similarly, dry spell and water logging due to heavy rainfall – both affect tuber quality and yield of potato cultivation (Pathak et al., 2025). A study by Ghosh and Ghosal (2021) showed that yield and quality of tea plantations in the northern Himalayan foothills, and Darjeeling is negatively impacted by alterations in temperature and precipitation. The Gangetic delta districts also bear the brunt of climatic upheavals, disrupting farming calendars, and degrading soil fertility (Sultana & Ahmad, 2025). Mango cultivation in the Gangetic Plains is highly sensitive to temperature extremes and unseasonal rains. Both affect flowering and fruit-setting stages (Halder et al., 2024). The agricultural activities in Sundarbans also suffer due to soil and water salinity – a direct effect of rising sea levels. Both the mangrove ecosystems and agricultural viability of the area are affected by frequent cyclones like *Amphan* and *Yaas* (Mandal et al., 2019).

3. REVIEW OF RELATED LITERATURE IN INDIA

Studies have documented Indian farmers' perceptions of climatic change and its effect on agricultural activities, and the measures they have adopted to combat such change. Datta and Behera (2022a), in a systematic review, concluded that most of the farmers perceive the trend of erratic rainfall and gradually rising temperature. And surprisingly, their perceptions align with meteorological records. Another qualitative study by Banerjee (2015) in Maharashtra and Andhra Pradesh, revealed farmers' perceived changes in rainfall and temperature. This study also showed a close relation between farmers' lived experiences and recorded meteorological data. Jatav (2024) attributed agricultural vulnerability in Bundelkhand and the Central region directly to farmers' greater exposure to climatic change. How farmers perceived climate variability in the form of rising temperature, delayed monsoon, and reduced soil moisture, was revealed in a study, conducted in the semi-arid areas of South India (Dhanya & Ramachandran, 2016). The study added that farmers had responded to such change by shifting to cultivation of short-duration crops, such as vegetables and pulses. In more severe cases, they would leave their land fallow. In another study in the coastal state of Goa, Reddy et al. (2022) found that farmers believed in the impact of climate change on their agricultural activities, as they experienced water depletion and less crop yield. They adopted crop diversification, trying improved varieties of seeds, and integrated farming systems. In the same line, a study by Govindbhai (2019) found that most of the farmers in North Gujarat possessed a medium to high level of awareness on climate change, and adaptation literacy. On the contrary, farmers in the Chhattisgarh Plains could recognise the trend of increasing temperature and inconsistent rainfall. However, their adaptive capacity to such climatic whims was found to be limited (Parganiha, 2016).

In West Bengal also, the effects of climate change on agricultural activities are increasingly felt (Datta & Behera, 2022a). In a study by the same authors (2022b), farmers reported their perception of climate change in sub-Himalayan tract. Here –as found in the study of Banerjee (2015) – the respondents' perceptions aligned with meteorological records on summer temperature and monsoon rainfall for the period 1991–2020. Another study (Datta & Behera, 2022c) confirmed that farmers perceived increased temperature and reduced precipitation in the sub-Himalayan region. As adaptative strategies, they took recourse to sowing high-yielding crops, and expanding irrigation infrastructure. Similarly, a study in the Cooch Behar Sadar sub-division, Das and Paul (2021) found that farmers had adopted high-yielding crop varieties to combat climatic whims. A study in Jhargram district (Biswas et al. (2020), revealed that farmers' perception of climate change influenced their readiness to adapt alternative cultivation practices. The study, most importantly, added that the farmers could cope better with climate-related challenges if they had received adequate government support. Yet, another study by Sarkar and Padaria (2010) in the coastal areas of South 24 Pargana district, found the farmers' awareness of rising temperature, reduced crop and livestock yields. Interestingly, the incidence of increased plant diseases emerged as a significant climate-related risk in this study.

While all the research studies, discussed in the previous section, provide valuable perceptual insights of the farmers into the impacts of climate change on agriculture and their adaptation strategies in several pockets of West Bengal, there remains a scarcity of such study in Murshidabad district. The area has its unique riverine geography and agri-based economy. Therefore, a study exploring farmers' perception of climate change and the resultant impact on their livelihood in this district will definitely help clarify the local dimensions of the problem. It will also contribute to formulation of necessary response strategies and policy formulation by the government.

4. METHODS AND MATERIALS

Area of study

Murshidabad district, covering an area of 5,324 square kilometres, is geographically located between 23°43'30"N–24°50'20"N latitude and 87°49'17"E–88°46'00"E longitude. It is set against the backdrop of lower Gangetic valley. The district consists of 26 administrative blocks, as shown in Figure 1.

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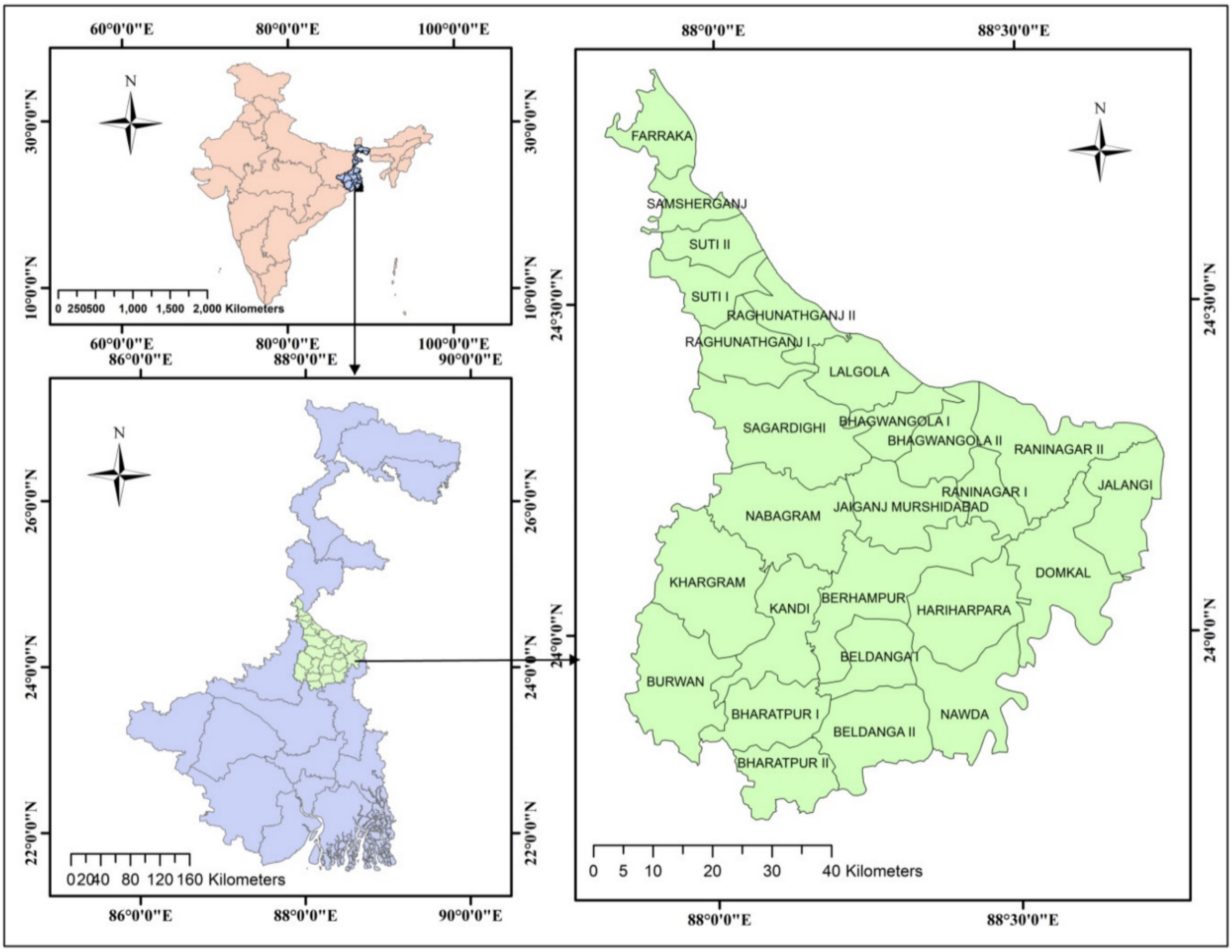

Figure 1: *Geographical location of the study area*

Source: *Mondal et al. (2022)*

Climate and agricultural overview of the study area

The Bhagirathi River bisects Murshidabad district from north to south into the western *Rarh* area, known for its reddish, clayey, and lateritic soils, and the eastern *Bagri*, famous for its fertile plains with its alluvial, loamy-sandy soil. With a remarkable net cultivated area of 399,793 hectares and a gross cropped area of 9,77,493 hectares, the high cropping intensity of the district underscores its significance in the agricultural landscape of West Bengal (Murshidabad – PLP, 2020-21). Rainfall in the south-west monsoon season from June to September, contributes to about 74% of the average annual rainfall of 1,328 mm. The summer season is hot and humid, with temperature sometimes exceeding 40^{0}C in May and June, while winters are mild, with temperature dipping to around 9^{0}C–11^{0}C in December and January (District Census Handbook [series 20, Part-XII-A], 2011). This climatic condition of the district is ideal for cultivation of a variety of crops (Table 1).

Table 1: *Region-wise staple agricultural crops of the study area*

Crop	***Rarh* (western part)**	***Bagri* (eastern part)**
Paddy (*Aman/Aus/Boro*)	Grown in irrigated tracts	Major crop
Jute	Limited	Prominent in alluvial tracts
Wheat	Grown in smaller areas	Grown in *Rabi* (crop sown in September and reaped in the spring) areas
Barley	Limited	Limited
Mustard/Sesame	Cultivated in mixed zones	Prominent in irrigated areas

Pulses (gram, lentils, grass pea etc.)	Cultivated in smaller scale	Prominent
Potato	Grown in rainfed/irrigated pockets	Prominent in irrigated areas
Sugarcane	Limited	Present in irrigated tracts
Maize	Limited	Cultivated in mixed zones
Vegetables	Grown in hillock areas	Prominent in irrigated areas
Spices/Condiments (chilli, ginger, etc.)	Small-scale cultivation	Cultivated in irrigated pockets
Mulberry cultivation	Concentrated in selected areas	Limited
Mango/Other fruits (orchards)	Pocket orchards	Prominent

Source: *Collected from the respondents*

Murshidabad district lies very close to the Ganga-Padma-Bhagirathi river system. Such proximity makes the area prone to flooding and riverbank erosion. The district often gets inundated during rainy season, devastating standing crops, and accelerating loss of top soil. Most of the farmers in this socio-economically less advanced district are smallholders. They lack access to advanced agri-knowledge, resilient seed varieties, and up-to-date irrigation technologies which are necessary for sustainable agriculture amidst climatic shifts.

Research design, population, and sample

The present study employed a mixed-method descriptive survey research design to explore farmers' perception of climate change and its impact on their agricultural practices. Such a design is very useful in collecting and analysing both quantitative and qualitative data, to explore any research issue comprehensively (Creswell & Clark, 2017).

All the active farmers, residing in Murshidabad district of West Bengal, was taken as population of this study. The researcher used purposive sampling technique to select a sample of 300 farmers. Such a sample could provide information-rich data, based on their personal experiences (Etikan et al., 2016). The sampling technique maintained two criteria to ensure relevance and depth of the data obtained. First, to fulfil geographical representation across the diverse agri-ecological zones of the district, the sample included a minimum of ten farmers from each of the 26 administrative blocks. Second, to capture perceptions on the basis of long-term practical experiences, only those farmers aged between 35–50 years, with a minimum of 15 years of agricultural practices on their own land, were included in the sample.

Tool used

The researcher collected primary data, using a structured questionnaire. It was developed in Bengali language to ensure comprehensibility of the respondents, most of whom were illiterate or semi-literate. The questionnaire consisted of 14 questions, divided into two distinct sections. Section A included ten closed-ended questions, and their responses rated on a 3-point Likert scale as 'No', 'Cannot say', and 'Yes'. Here the items aimed at quantitative assessment of climate-related experiences and adaptation strategies among the respondents. Section B consisted of four open-ended qualitative questions. These items were designed to elicit the respondents' insights into the effect of climate change on their agri-practices, their adaptation strategies, perceived future risks, and desired government support. This approach of selecting both quantitative as well as qualitative items in the tool aligns with the principles of mixed-method study. Such a method narrows down the limitations inherent in each approach when utilised independently (Tashakkori & Teddlie, 2010). This approach enabled the researcher to validate and analyse the broader trends and real-life experiences of the respondents.

Data collection was done through one-on-one interviews. By engaging the respondents directly, the study ensured that all participants could express their perceptions and experiences freely. No time restriction was imposed during interviews. Typically, each session took 20–25 minutes.

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5. RESULTS AND DISCUSSION

Descriptive data analysis

Table 2: *Counts of responses on quantitative items (N=300)*

Q. No.	No	Can not say	Yes
1	72	36	192
2	36	60	204
3	90	90	120
4	54	102	144
5	168	54	78
6	36	120	144
7	12	120	168
8	54	6	240
9	18	108	174
10	54	6	240

Source: *Field data*

Table 3: *Percentage counts of responses on quantitative questions (N=300)*

Q. No.	No	Can not say	Yes
1.	24%	12%	64%
2.	12%	20%	68%
3.	30%	30%	40%
4.	18%	34%	48%
5.	56%	18%	26%
6.	12%	40%	48%
7.	4%	40%	56 %
8.	18%	2%	80%
9.	6%	36%	58%
10.	18%	2%	80%

Source: *Field data*

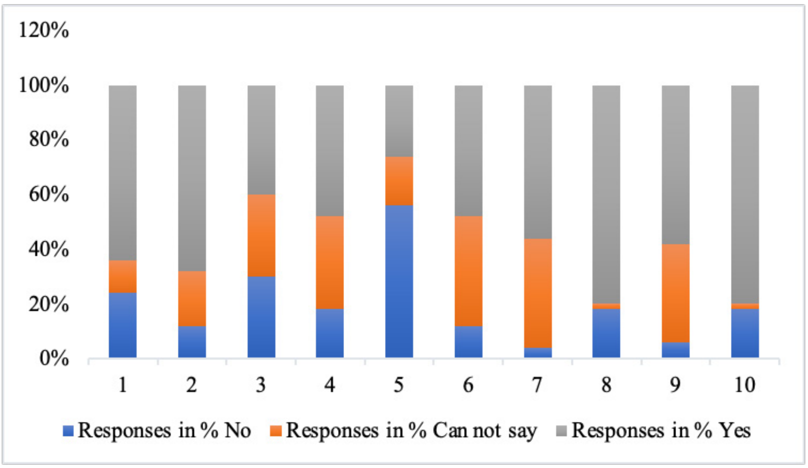

Figure 2: *Percentage of responses on quantitative questions*

Source: *Field data*

Table 2, 3 and Figure 2 show questions with maximum 'Yes' (question numbers 8 and 10) versus those with 'Cannot say' (question numbers 6 and 7) – expressing uncertainty – and question number 5 with high 'No'. These responses help identify which specific phenomena of climate change impact agricultural activities, as perceived by the respondents.

Table 4: *Ranked table of 'Yes' responses on quantitative questions*

Rank	Q. No.	Questions (abbreviated)	% of 'Yes'
1	8	Using new crop varieties/seeds	80%
2	10	Earning less from agriculture	80%
3	2	More severe summer heat	68%
	1	Changed monsoon rainfall	64%
5	9	Weather affects planting/harvesting	58%
6	7	Soil less fertile	56%
7	4	Lower crop yields	48%
8	6	More pests/crop diseases	48%
9	3	Floods/soil erosion damage	40%
10	5	Spending more on water pumps/canals	26%

Source: *Field data*

Table 4 shows that farmers strongly perceived the need to adopt new crop varieties. They also experienced reduced earnings from agriculture due to climate change. Responses to question numbers 7, 9, 1, and 2 (56–68% 'Yes') reflect most of the respondents' perception of changing climatic patterns. On the other hand, responses to question numbers 5, 3, 6, and 4 (26–48% 'Yes') show less consensus. Increased spending on water pumps/canals shows the least 'Yes', possibly due to farmers' access to various resources of irrigation across the district.

Statistical analysis of data

One-sample Chi-Square goodness-of-fit test was done to examine if the distribution of farmers' responses in 'Yes' for each quantitative question was significantly different from a uniform or equal distribution. A significant result indicates that their opinions are not evenly split, and that there is a clear preference in one direction. The results of this test – using degrees of freedom (df) 2, and an alpha (α) level of 0.05 – are presented in Table 5.

Table 5: *One-sample Chi-Square goodness-of-fit test of 'Yes' responses on quantitative questions*

Q. No.	% of 'Yes'	Chi-Square value (χ^2)	df	p-value	Result (α = 0.05)
1	64%	108.00	2	< 0.001	Significant
2	68%	141.12	2	< 0.001	Significant
3	40%	12.00	2	< 0.002	Significant
4	48%	38.16	2	< 0.001	Significant
5	26%	70.32	2	< 0.001	Significant
6	48%	58.56	2	< 0.001	Significant
7	56%	97.92	2	< 0.001	Significant
8	80%	370.80	2	< 0.001	Significant
9	58%	135.36	2	< 0.001	Significant
10	80%	370.80	2	< 0.001	Significant

Source: *Author's calculation*

Table 5 shows statistically significant results for all 10 quantitative questions, confirming that 'Yes' response distributions are clearly different from an even split. This allows to conclude that the observed climatic patterns by the respondents are genuine. The most prominent consensus – indicated by the highest χ^2 values –is about the

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need to adopt new varieties of crops, and the experience of less earning from agriculture. Following these two, a very strong consensus exists on the respondents' perception of more severe summer heat, changed monsoon rainfall, and the impact of weather on planting and harvesting calendar. Notably, even the question with the lowest 'Yes' (increased spending on irrigation) shows a significant result, which in this case, reveals consensus against the phenomenon being a universal experience.

Table 6: *Farmers' common responses on qualitative questions*

Q. No.	Questions	Common responses
11	What signs in nature – such as changes in bird behaviour, tree growth patterns, or river conditions – have you observed that clearly indicate shifting weather patterns?	i) Decline or change in bird migration; ii) Early or late flowering/fruiting in plants; iii) Drying of ponds; iv) Irregular river flow; v) Appearance of new insect species and plant diseases; vi) Shifts in timing of fog, heat, or rain
12	What proactive measures have you or your neighbours taken to adapt to the increasingly unpredictable weather, such as extreme heat or flooding?	i) Altering crop calendars, such as sowing and harvesting earlier or later; ii) Switching to short-duration or heat-tolerant crop varieties; ii) Constructing small embankments or raised seed beds; iii) Using pumps, deep tube wells, or canals for irrigation; iv) Temporarily taking up non-agricultural works elsewhere
13	What critical issues do you expect farming to encounter due to ongoing climate change?	i) Unpredictable monsoon and heat stress; ii) Increased attacks of unknown pests and diseases; iii) Soil getting less productive; iv) Crop failures; v) Declining interest in the younger generation in agriculture
14	What specific support would you like to receive from the government or other organisations to ensure the sustainability of your farming practices?	1) Timely release of crop insurance money by the government; ii) Installation of irrigation facilities; iii) Taking up flood control measures; iv) Subsidies for seeds, fertilisers, diesel; v) Fair prices of crops; vi) Training on climate-resilient practices

Source: *Field data*

Table 7: *Thematic analysis and interpretation of farmers' responses on qualitative questions*

Major themes	Ecological and phenological changes	Local practices towards adaptation	Anxiety and perceived risks in future	Expectation from government and trust deficit
Description	Observable shifts in nature and seasonal cycles	Community-level adjustments to unpredictable climatic changes	Climatic caprices may increase in future	Release crop insurance money timely; Train up-to-date agricultural skills; Come up with plans to stop seasonal out-migration
Key links with other themes	Directly influences adaptive behaviour and anxiety about future	Mediates between environmental shocks and livelihood outcomes	Worsened by ecological uncertainty and institutional failure	Shapes adaptation, resilience, and future planning
Underlying concept	Perception of climatic changes, rooted in age-old close observation	Adaptive capacity	Emotional response to climatic vulnerability	Governance and policy interference
Key expressions	"Cuckoo calls later now"; "Migratory birds do not come to that number as seen before; "River flows unpredictably"	"We plant *Aman* paddy earlier"; "Share one pump among several farmers"	"The soil is getting barren"; "Young people don't want to take up agriculture"	"Crop insurance comes late"; "Need training on pest control"
Interpretive meaning	farmers' perception of climate instability	Indigenous ways of adaptation	Emotional distress and generational disillusionment	Desire for government policy interference to combat negative impact of climatic changes on agriculture

As seen in Tables 6 and 7, farmers are keenly aware of the ecological changes, based on their long interaction with environment. Many of them reported significant changes in birds' behaviour, particularly in the calling time of the cuckoo and arrival patterns of seasonal migratory birds. Additionally, notable changes in plant and water systems – as reported by many – include plants flowering earlier or later than usual, village ponds drying up, and erratic flow of local rivers. They are also worried about strange species of pests and diseases attacking their crops. It hints at broader shifts in the local ecosystem. They try to adapt their agricultural practices to changing climatic conditions with ingenuity that stems from their traditional knowledge. A very common response expressed by them was to adjust sowing or harvesting time, depending on rainfall variability. They also adopt short-duration and heat-tolerant varieties of crops to cope with unpredictable monsoon patterns. However, they often get worried about the future of their livelihood. Whimsical monsoon trend, prolonged heatwaves, increased attacks of pests and diseases, gradually declining soil fertility, and reduced water resources are the causes of their apprehension. Repeated crop failures invite not only their economic strain but also emotional torment. Moreover, they worry about the disinterest of the later generation in agriculture –potentially threatening the generational bond and cultural identity. In the same vein they reveal a yawning gap between their expectation from the government to tackle such challenges, and the delivery, delay or failure on the part of the same. They expect timely financial aid as a quick compensation for crop losses. They also feel a crying need of improved irrigation infrastructure, flood control, and fair procurement prices of their crops for navigating the uncertainties of climate change. Additionally, they need training in climate-resilient practices and integrated pest management to boost up long-term resilience. However, there exists a trust deficit due to delays in government help, underscoring the need of responsive governance and suitable policies that value their expectations. Thus, the core thematic model of

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farmers' responses on qualitative questions may be shown as in figure 3.

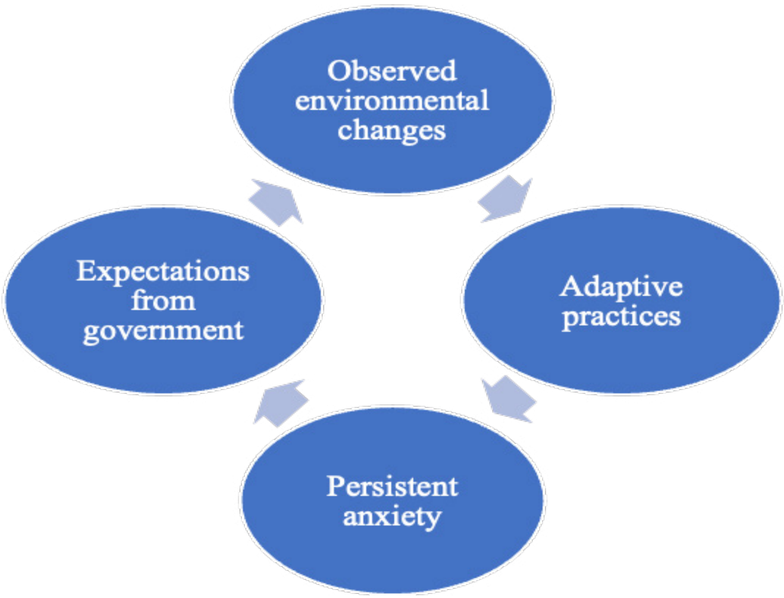

Figure 3: *Core thematic model of the responses on qualitative questions*

6. DISCUSSION ON FINDINGS

A close examination of the findings of this study reveals both significant alignment with and remarkable divergence from the existing literature regarding farmers' perceptions of climate change, impact of this change on their agricultural activities, and their adaptive behaviours in response to such changes in Murshidabad district. The precision with which the farmers recognised the trend of rising temperature, erratic monsoon patterns, and the related ecological disturbances – aligns with documented trends across various regions in India, such as alluvial plains and sub-Himalayan districts of West Bengal (Datta & Behera, 2022a, 2022b; Das & Paul, 2021; Biswas et al., 2020), coastal Goa (Reddy et al., 2022), North Gujarat (Govindbhai, 2019), and semi-arid South India (Dhanya & Ramachandran, 2016). Their observations, such as delayed cuckoo calls, changes in the arrival time of the seasonal migratory birds, irregular blossoming patterns of plants and crops, ponds getting dry in summer, and attacks of new varieties of plant pests and diseases – bear testimony to their reliance on indigenous phenological knowledge as valid indicators of climatic changes. All these findings have already been echoed in other studies (Jatav, 2024; Datta & Behera, 2022a). Besides, their resilience and adaptation mechanism, such as altered sowing and harvesting calendars, utilisation of short-duration and stress-tolerant crop varieties, small-scale water harvesting, and taking recourse to off-time short-term jobs beyond agriculture to eke out their livelihood – match with strategies taken up by farmers, as revealed in the studies in coastal Goa (Reddy et al., 2022), the Chhattisgarh Plains (Parganiha, 2016), and Maharashtra, Andhra Pradesh (Banerjee, 2015). However, the findings in this study raise a critical concern regarding the monetary returns of these adaptive strategies. In spite of an 80% of the farmers adopting new varieties of crops, the same number of them reported declining income from farming. It indicates that local innovations – though widespread – fail them to ensure economic sustainability. This economic vulnerability is compounded by their anxiety over loss of interest of the later generations in agriculture. Such agony is more intense than one found in other studies conducted in West Bengal (Das & Paul, 2021; Datta & Behera, 2022b). Another point of crucial importance is that, while previous studies recognised the necessity of institutional support to the farmers to fight the whims of climate (Parganiha, 2016; Biswas et al., 2020), the respondents in the present study expressed a profound trust deficit in government endeavours to alleviate their misery. It is, most possibly, due to delays in crop insurance payments, and inadequate irrigation support. The repairment of this gap requires an urgent necessary policy intervention.

7. IMPLICATION OF THE STUDY

The present study bears important implications for adaptation policy in agricultural eco-system amidst the increasing trend of climate change. It encourages future research studies in eastern India to explore the interconnection among indigenous ecological knowledge, environmental resilience, and effectiveness of governmental policy intervention. The study shows that farmers in Murshidabad district are blessed with perception of climatic variability. Their perception is evidenced by their consciousness about untimely call of native birds and altered time-patterns of migratory birds. They are also aware about phenological changes in plants, and emergence of unknown varieties of pests and crop diseases. Such ecological literacy validates indigenous knowledge as a robust, particular area-based approach to interpret climate phenomena. Moreover, these insights make a strong case for incorporating farmers' experiential observations into formal climate monitoring and regional forecast systems.

Methodologically, the mixed-methods approach utilised in this study, provides a replicable blueprint for conducting farmers' climatic perception-related studies in other riverine and flood-prone agri-ecological settings. The findings also reveal a notable paradox that has not been adequately addressed in any of the previous researches conducted in India. It shows that while 80% of farmers adopted new crop varieties – a very useful proactive adaptation effort – the same number of them reported declining agricultural incomes. This revelation testifies to the limitations of incremental adaptation strategies of the farmers who lack timely support from institutional mechanisms.

Beyond economic factors, the study reveals a significant socio-psychological aspect of climate vulnerability. Farmers voiced apprehension regarding the potential discontinuity of the later generation in agricultural activities. Such perceived disinterest of the next generation towards agriculture might hamper the transfer of traditional agronomic knowledge, hinting at the region's gradual shift of the region's economy from agricultural to non-agricultural sectors. Does this phenomenon not imply future food insecurity, and reorientation of the socio-cultural fabric of the district?

Another implication of the study lies in the finding that, there remains trust deficit between farmers and governmental institutions due to the latter's failure to stand by the sufferers in time. Such an air of mistrust may hinder collaborative resilience-building. This very finding implies that only policy or programme design may not be enough to bring desired result, timely and transparent delivery of government services are essential.

8. LIMITATIONS OF THE STUDY

The present study is not free from some methodological limitations. The purposive sampling technique - employed in this study – might limit the generalisability of the findings to the greater agrarian population of Murshidabad, because only the farmers in 35–50 years age-group, with at least 15 years of continuous agricultural experience on their own land, were included in the sample. Perspectives from farmers having upper, if not lower age-limit, sharecroppers, and those who left agricultural livelihoods might have added to diverse perceptions, vulnerabilities, and adaptation behaviours. Besides, the study's cross-sectional design is a limitation in itself because such a design can provide only a snapshot of perceptions and practices of a sample at a single point of time (Cohen et al., 2017). As climatic conditions have been changing, a longitudinal approach would have been more effective in exploring farmers' perceptions of, and coping responses that might develop over time towards this change. Moreover, sole reliance on farmers' self-reported data might lack objectivity, and right information. These data might also suffer from potential recall biases, and social desirability effects. Though the sampling units included all the 26 administrative blocks of Murshidabad district to ensure geographical coverage, intensive block-specific, long-term data might boost up the robustness of the findings. And finally, while the qualitative aspect of the study enhances its analytical depth, prolonged participant observation or repeated field engagement would have provided a more rigorous triangulation between reported and real adaptation practices by the farmers.

9. CONCLUSION AND RECOMMENDATIONS

This study explores perception of farmers about climate change, how this change impacts their agricultural activities, and the measures they adopt to fight such impacts in Murshidabad. The findings reveal that farmers possess ecological awareness, developed through their long-term intense interactions with environment. Such indigenous climate intelligence, functions as an early-warning system. To alleviate the negative effects of climatic change on their agricultural practices, they adopt innovative measures. While grappling with shifting monsoon patterns and heat stress, many of them reschedule seed-sowing and harvesting calendar, use stress-tolerant crop varieties, and construct small-scale embankments. All these adaptive strategies show their resilience. Unfortunately, despite these proactive efforts, they face reduced economic returns from agriculture. Such contradiction may be attributed to the fact that individual or collective adaptation strategies are insufficient to sustain their livelihood without systematic support by the government. No doubt, the farmers express concerns over increased climatic volatility, declining soil fertility, and uncertain financial returns from agriculture. Yet

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what torments them most is disinterest of younger generations in pursuing agricultural activities, signalling a crisis for transfer of agrarian knowledge and culture to the progeny. They expect from the government timely release of crop insurance money, extended irrigation facilities, introduction of fair crop procurement systems, and access to sustainable agricultural skills. However, delays in governmental responses have bred deficit of trust in them. As a result, otherwise manageable climatic challenges sometimes turn into their out-migration in search of alternative sources of livelihood. Thus, sustainable agricultural futures in Murshidabad rests on proactive government policies and programmes and materialisation of the same. Climate resilient agricultural practices in this district must be a collaborative enterprise between farmers and the government – rooted in mutual trust and prompt pro-active measures. Towards this end, a few recommendations may be put forward. First, steps should be taken to integrate phenological intelligence of the farmers into state-level climate monitoring and early-warning systems. It is expected that their local insights can enhance the accuracy and reliability of official forecasts. Secondly, sustained investment on setting up of decentralised irrigation system by the government is essential. Community-managed initiatives, including micro-embankments, shallow pumps etc., should be supported by subsidised solar pumping technology and less-costly energy tariffs to reduce over-dependency of farmers on erratic rainfall. Thirdly, crop insurance facilities require substantial reform to guarantee prompt and transparent compensation for crop loss. And last but not the least, it is crucial to strengthen adaptive capabilities of the farmers by upskilling them in up-to-date agricultural practices. District and state level training programmes and extension services should be taken up by the government periodically to update farmers' knowledge on crop-varieties, alternative farming, and pest control. By prioritising these recommendations, it is possible to build a sustainable agricultural eco-system that supports the current generation while preserving agricultural heritage for the future.

DECLARATIONS

Author(s) Contribution

The author conceptualised the study, conducted the literature review, collected and analysed data, and prepared the manuscript.

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Availability of Data and Materials

The data available at the request of the author.

Declaration of Conflict of Interest

The author declares no conflict of interest related to this research. All analyses and interpretations were conducted independently, without influence from external organizations or stakeholders.

Clinical Trial Registration (if applicable)

Not Applicable

Human Ethics and Consent to Participate

This study is based on primary data. Informed verbal consent was obtained from all individual participants included in the study. Besides, all sources of information have been appropriately cited, and care has been taken to ensure accuracy, transparency, and respect for intellectual property.

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