Climate Change Impacts and Adaptation Strategies in Rural Indian Agriculture: A Case Study of Sonarpur, West Bengal

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Abstract

This research delves into how climate change is affecting farmers' perception in the Sonarpur district of West Bengal (India), focusing on the challenges local farmers are grappling with. Previous studies have underscored the impact of urban expansion and human activities on climate change stressing the need for sustainable farming methods. Through a primary survey, this study finds that while farmers may not be fully aware of climate change, they are experiencing its effects on their farming practices. This study also aims to understand their perceptions and the effectiveness of adaptation efforts. The findings reveal farmers' perception about unpredictable weather patterns that are disrupting crop yields prompting them to adjust their methods. While farmers generally appreciate government support, there are ongoing struggles with accessing timely assistance and adopting new technologies. Many farmers are hesitant about using genetically modified crops citing concerns about biodiversity loss and economic dependencies. However, they show interest in innovative farming techniques such as hydroponics indicating a potential shift towards technological solutions to reduce credit dependency and improve resilience in farming practices.

Keywords: Climate change, Agricultural practices, Drought resistant crops, Crop failure insurance

JEL Classification Codes: Q10, Q18, Q54, Q56, Q57, R11

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1. Introduction

The renowned agricultural scientist M.S. Swaminathan once aptly remarked, "If agriculture goes wrong, nothing else will go right."[2] This succinctly captures the pivotal role that agriculture plays in the socio-economic fabric of India. From providing sustenance to millions to driving economic growth, the significance of agriculture cannot be overstated. India's cropping pattern has evolved considerably over the years. Prior to the Green Revolution, the majority of cultivated land was dedicated to foodgrains with minimal diversification in crop types.[3] During the Green Revolution, the introduction of the Minimum Support Price (MSP) and other government support measures encouraged farmers to primarily grow wheat and paddy. However, the economic reforms initiated in 1991 exposed domestic agricultural products to the global market, creating new export opportunities and leading to a greater diversification in cropping patterns towards non-food crops.[4]Yet, despite its crucial importance, rural Indian agriculture has long grappled with a multitude of challenges, ranging from structural issues like informal credit systems and poor infrastructure to inherent problems like low productivity and disguised unemployment.[5]

However, amidst these persistent challenges, a new and formidable threat has emerged in recent years — climate change. The impacts of climate change on agriculture are increasingly evident, with erratic weather patterns, shifting rainfall distribution, and rising temperatures posing significant risks to crop yields and livelihoods. Nowhere is this more apparent than in regions like West Bengal, where the effects of global warming have been accompanied by excessive rainfall, exacerbating existing vulnerabilities.[6]

In the face of this looming crisis, it has become imperative to understand the specific impacts of climate change on rural Indian agriculture and identify effective measures to mitigate its adverse effects. This paper is an attempt to address this pressing issue. Drawing upon insights from the data collected from these farmers and available literature, the study draws conclusions to explore the multifaceted dimensions of climate change-

[2](Swaminathan 2017)
[3](Economic Survey, 2019–20).
[4](National Bank for Agricultural and Rural Development 2005)
[5](National Bank for Agriculture and Rural Development 2022)
[6](Bidur Paria. Pulak Mishra 2022)

induced challenges in agriculture and assesses the potential of various adaptation strategies, by virtue of prioritizing the farmers' perception about the same.

Central to this endeavour is an examination of the role of technological innovations in bolstering the resilience of agricultural systems. From heat-resistant crop varieties to precision farming techniques, genetic modification, and hydroponics, there exists a spectrum of innovative approaches that hold promise in mitigating the impacts of climate change on agriculture.[7] However, the adoption and uptake of these technologies by farmers remain contingent upon various factors, including their awareness, access to resources, and perceived benefits.[8]

To delve deeper into these dynamics, this paper employs a door-to-door survey conducted in Sonarpur, a rural village located in close proximity to Kolkata, West Bengal. Moreover, the survey was designed not merely as a data-gathering exercise but as an opportunity for meaningful engagement and dialogue with farmers. Beyond the structured questionnaire, efforts were made to foster genuine conversations, allowing for the exploration of nuanced perspectives and insights. These qualitative inputs were subsequently synthesized and incorporated into an 'Additional Comments' section, enriching the overall analysis.

While the study acknowledges the inherent limitations stemming from its constrained sample size and scope, it aspires to contribute meaningfully to the discourse on climate change adaptation in rural Indian agriculture. By shedding light on the challenges faced by farmers and exploring avenues for innovative solutions, the research endeavours to inform policy interventions and community-led initiatives aimed at building climate-resilient agricultural systems. The study's primary aim is to bring forward the perception of the farmers on impact of climate change on agricultural practices in Sonarpur district, an otherwise less talked about and less explored subject in climate cum agricultural research.

[7](Tétédé Rodrigue Christian Konfo March 2024)
[8](Tingting Liu 2018)

2. Literature Review

The complex relationship between climate change and agricultural practices has garnered significant scholarly attention, particularly in developing economies like India where agriculture remains a crucial economic sector. Previous research has examined this relationship through various lenses, from broad impact assessments to specific adaptation strategies.

Studies focusing on the West Bengal region have highlighted certain particular vulnerabilities of agricultural systems to climate variability. For example, Bandyopadhyay's research in South 24 Parganas district revealed that only 13.08 percent of cultivated land is irrigated, indicating high rainfall dependence and climate vulnerability.[9] This limited irrigation infrastructure, combined with seasonal employment patterns, has led to significant agricultural labour migration during non-Kharif seasons, highlighting the socio-economic implications of climate-dependent agriculture. Roy's investigation into the North 24-Parganas further identified key obstacles to agricultural development, including small landholdings, natural calamities, and limited mechanization due to cheap labour availability, factors that collectively hamper farmers' ability to adapt to changing climatic conditions.[10]

The role of financial institutions and credit accessibility in climate adaptation has been extensively studied. Jana's research in the 24 Parganas district revealed that approximately one-third of farmers lack access to credit facilities, with 63.6% of available credit coming from informal sources.[11] This finding aligns with broader literature on agricultural finance in developing regions, where informal lending often dominates despite high interest rates. Recent studies have noted the emergence of self-help groups and microfinance institutions as crucial intermediaries in rural credit markets, particularly in supporting climate adaptation strategies.[12]

Technological innovations in agriculture have been proposed as potential solutions to climate-related challenges. Research by Konfo emphasizes the importance of climate-smart innovations in enhancing producer incomes through sustainable solutions. These

[9](Mausumi Bandyopadhyay 2017)
[10](Sanjoy Roy 2021)
[11](Jana n.d.)
[12](Neha Kumar 2018)

include precision farming techniques, which involve site-specific variable recognition and monitoring of soil and temperature conditions for increased flexibility and better yields.[13] However, as Liu notes, the implementation of such technologies faces significant barriers in developing regions, particularly due to small landholdings and underdeveloped agricultural infrastructure.[14]

The debate surrounding genetically modified crops as a climate adaptation strategy has also received scholarly attention. Bhattacharjee's analysis highlights the cautious approach toward genetically modified crops due to limited research on long-term effects on health and climate. This uncertainty has influenced both policy decisions and farmer attitudes, particularly in regions like West Bengal where market acceptance remains a significant concern. The regulatory environment, as discussed by Phillips[15], further complicates the adoption of genetically modified technologies as a climate adaptation strategy.

Recent scholars have increasingly focused on integrating traditional knowledge with modern adaptation strategies. Kumar and Khanna[16] emphasize the importance of understanding local farming communities' perceptions and practices in developing effective climate adaptation policies. This approach recognizes that successful adaptation strategies must consider both technological innovations and local socio-economic contexts, particularly in regions with strong traditional agricultural practices. Datta, Behera, and Rahut[17] systematically reviewed literature on farmers' perceptions and adaptations in India, finding that the majority of farmers have observed rising temperatures and erratic rainfall, aligning with meteorological data. They also identified a wide range of adaptation measures, including both incremental and transformational changes in land use, cropping systems, and labor allocation. However, the analysis shows that adoption of the measures is not determined by a farmer's perception of climate change but rather determined by factors such as access to information or credit for that matter, the level of household income, and farm size. The authors point out that there is a need for large-scale investments in the agricultural sector and capacity-building efforts to

[13](Tétédé Rodrigue Christian Konfo March 2024)
[14](Tingting Liu 2018)
[15](Phillips 2008)
[16](Surender Kumar, Madhu Khanna 2023)
[17](Pritha Datta 2022)

support effective adaptation, which they suggest an integrated approach to ensure sustainable policymaking and enhance the resilience of farmers to climate impacts. This calls for both local knowledge and systemic challenges to be addressed when developing climate adaptation strategies.

Our study adds to the existing literature by reviewing not only farmers' perception on concurrent climate change, but also their awareness about existing solutions such as heat-resistant crops and hydroponic techniques. We identify the heavy dependence of Sonarpur's farmers on government crop insurance and suggest an improvement to this policy to the Government of West Bengal.

3. Methodology and Data Sources

This study employs a survey-based research design to investigate the farmers' perception of climate change on agriculture in the Sonarpur district of West Bengal, with a special focus on improvement measures. A convenience sampling technique is employed to select participants for the study. Despite the inherent challenges of resource constraints and logistical limitations, efforts were made to ensure a representative sample across diverse demographic categories, including age, gender, and income levels.

A structured questionnaire is developed to collect data on farmers' perceptions of climate change, adaptation strategies, awareness of government policies, willingness to adopt new technologies, and other relevant variables. The questionnaire is designed to elicit both qualitative and quantitative responses, allowing for a comprehensive analysis of the research questions. A copy of the questionnaire has been attached in the appendix.

Data collection is conducted through face-to-face in-person interviews with the selected participants. The authors solely conducted these interviews ensuring consistency and clarity in data collection. Respondents were briefed about the purpose of the study and their privacy and confidentiality were protected by anonymizing response data and storing it securely. For open-ended questions included in the survey, thematic analysis has been employed to identify recurring themes and patterns in respondents' narratives regarding climate change impacts and adaptation strategies.

In particular, primary data were extracted from a cross section of 30 individuals after elimination of cases of missing data and extreme outliers. To ensure qualitative soundness of the data, only in-person in-depth interviews were conducted with efforts to understand their current situation through the survey. It was ensured that compliance with ethical guidelines for research involving human participants was present. Table 1 shows the descriptive statistics of the data at hand. Figure 1 gives the geographical map of Sonarpur district.

Table 1: Demographics of the Survey Population (by age, gender and annual income)

Age		Gender		Income	
Category	**No. of Individuals**	**Category**	**No. of Individuals**	**Category**	**No. of Individuals**
0 - 25	10	Male	14	INR 0 –INR 1,00,000	7
25 - 40	14	Female	16	INR 1,00,000 -INR 3,00,000	19
40 and above	6	Others	0	INR 3,00,000 and above	4

Source: Authors' survey data

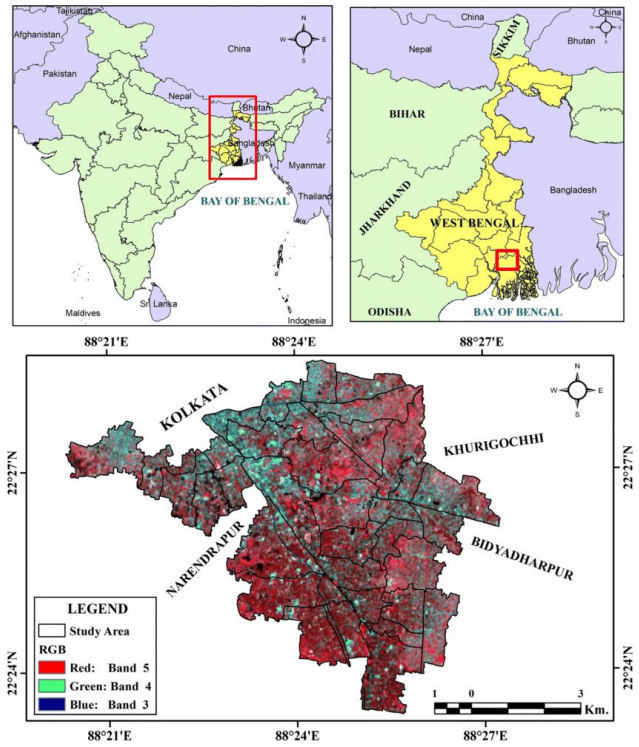
4. Results and Analysis

The study yielded mixed results on people's perception on the impact of climate change on their yield. However, remarkably all respondents agreed that there had been a noticeable impact and change on their cultivation practices, half of them believing that there had been a drastic negative impact leading to crop losses and hence a shifting in cropping patterns.[18] These observations can be attributed to events which occurred in Sonarpur around the survey period. In the early weeks of December 2023, Sonarpur observed sudden bursts of heavy rainfall which spoiled the rice harvest. Farmers never anticipated these showers.[19] Figure 1 shows the geographical location of Sonarpur district within the state of West Bengal.

Figure 2 reveals the average weather patterns in Sonarpur over the years. The sudden rainfall in December 2023 disrupted this pattern. Our study has been conducted post this event, so that farmers can refer to a recent context such as rainfall while answering open ended questions on climate change and relief measures.

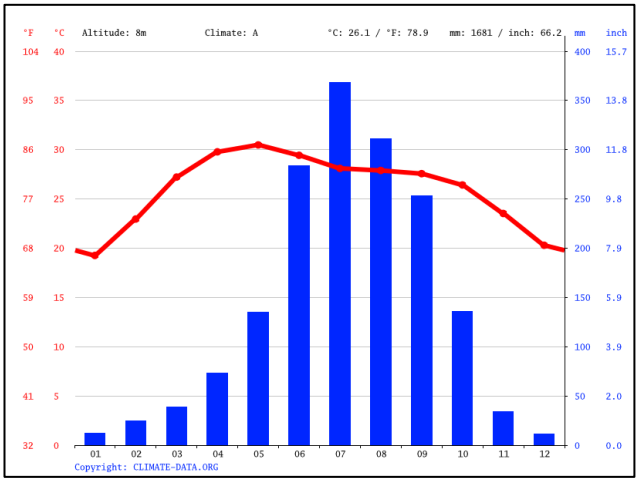
[18]Survey Result
[19](The Times of India 2023)

Figure 1: Geographical Location Map of Sonarpur, West Bengal



Source: https://www.researchgate.net/figure/Location-map-of-the-Rajpur-Sonarpur-Municipality-area_fig1_342472046 *(Accessed on 27 June 2024)*

Figure 2: Climate Graph/Weather by Month of Sonarpur on Average over the Years



Source: https://en.climate-data.org/asia/india/west-bengal/rajpur-sonarpur-59999/

Our survey also revealed that cultivators in Sonarpur have been forced to tweak their cultivation practices due to changing temperatures. An overwhelming majority of farmers observed a negative impact on the growth of rice and wheat due to changed precipitation levels (irregular and extreme patterns) fuelled by changing temperatures. Although both rice and wheat show insignificant adaptations to rising temperatures, wheat has been able to adapt to changes in precipitation.[20] About 40% of the sample has no experience with heat-resistant crop seed varieties. The rest are aware of the development of such crop and seed varieties but most only aspire to use them. A few farmers have heard of these varieties but are apprehensive of introducing them into their cultivation practices due to the high working cost. The effort of the government in developing effective crop species is commendable. However, these efforts can only bring real-world benefits when implemented in cultivation practices. Since, the effects of global warming cannot be reversed (in an outright manner) over a short period of time, drought-resistant and heat-resistant crop varieties must be encouraged in the same manner as the high yielding seed varieties in the 1960s.

Farmers also believe that the government's constant support and cash transfers have been beneficial. Ironically almost half of them have not directly benefited from government schemes; they believe that certain initiatives have been effective. Most appreciated efforts of the government's help during the time the Amphan super cyclone in 2020. Table 2 shows the average weather patterns for Sonarpur by month which reveals high precipitation from June – October. The Amphan was the fourth super cyclone that hit West Bengal and Kolkata since 2015, all of which led to major damage to life, property and agricultural yield.[21] Amphan made landfall on 20 May 2020 which drastically changed the weather averages displayed in Table 2 not just for May 2020 but for the entire year as well. In these cases, the government stepped in to provide food grains from its buffer stock to the residents, said the farmers. They also recounted incidents of financial assistance during this period. Few mentioned that the government helped them set up irrigation facilities over their land-holdings which these farmers periodically shared with other sharecroppers during times of erratic rainfall.

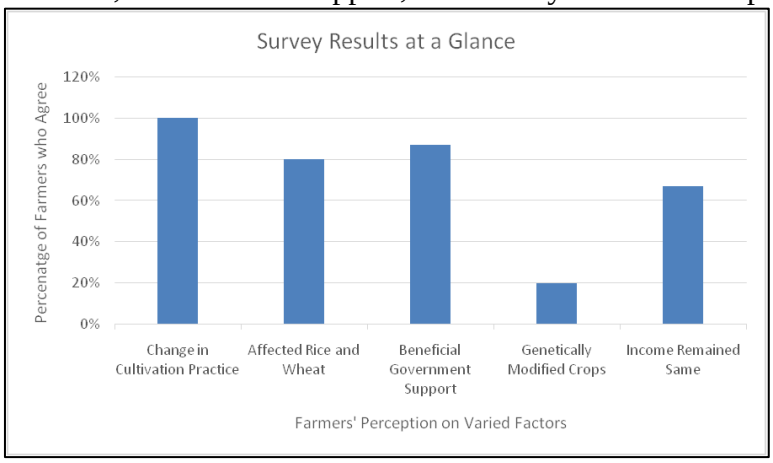
[20](Surender Kumar, Madhu Khanna 2023)
[21](PRABIR KUMAR DAS 2021)

Table 2: Data on Average Weather Patterns by Month for Sonarpur over the years

Weather Parameter / Month (on average)	January	February	March	April	May	June	July	August	September	October	November	December
Avg. Temperature °C (°F)	19.3 °C (66.7 °F)	22.3 °C (72.1 °F)	27.2 °C (81 °F)	29.8 °C (85.6 °F)	30.5 °C (86.9 °F)	29.4 °C (84.9 °F)	28.1 °C (82.6 °F)	27.9 °C (82.2 °F)	26.7 °C (80.1 °F)	26.4 °C (79.6 °F)	23.5 °C (74.3 °F)	20.3 °C (68.5 °F)
Min. Temperature °C (°F)	13.3 °C (55.9 °F)	17.1 °C (62.8 °F)	21.9 °C (71.4 °F)	25.7 °C (78.3 °F)	27.1 °C (80.8 °F)	26.2 °C (79.2 °F)	25.2 °C (77.4 °F)	24.6 °C (76.3 °F)	23.1 °C (73.6 °F)	21.8 °C (71.2 °F)	18.6 °C (65.5 °F)	14.8 °C (58.6 °F)
Max. Temperature °C (°F)	25.5 °C (77.9 °F)	27.5 °C (81.5 °F)	33.2 °C (91.8 °F)	36.3 °C (97.3 °F)	35.9 °C (96.6 °F)	34.8 °C (94.6 °F)	31.0 °C (87.7 °F)	30.6 °C (87.5 °F)	30.2 °C (86.4 °F)	30.1 °C (86.2 °F)	28.4 °C (83.5 °F)	25.6 °C (78.9 °F)
Precipitation / Rainfall mm (in)	12 (0)	25 (1)	39 (2)	26 (1)	54 (2)	185 (7)	284 (11)	368 (14)	311 (12)	253 (10)	36 (1)	34 (1)
Humidity(%)	64%	61%	64%	69%	74%	76%	86%	88%	81%	69%	64%	64%
Rainy days (d)	1	2	4	2	4	9	16	21	16	2	1	1
Avg. Sun hours (hours)	9.1	9.3	9.7	9.4	8.6	8.5	8.1	7.8	7.8	8.3	8.9	8.7

Link to excel: Corrected_Exact_Styled_Climate_Data.xlsx
Source:https://en.climate-data.org/asia/india/west-bengal/rajpur-sonarpur-59999/

Figure 3: Survey Results at a Glance: Farmers' Perception on Varied Factors such as Temperature, Cultivation, Government Support, Genetically Modified Crops and Income



Source: Authors' survey data

Another mentioned the effectiveness of the 'Bangla Shasya Bima' Insurance scheme. Bangla Shasya Bima aims at supporting sustainable production in agriculture sector byway of -

- providing financial support to farmers suffering crop loss/damage arising out of unforeseen events; and,
- stabilizing the income of farmers to ensure their continuance in farming.[22]

Figure 3 presents the survey results at a glance. It is important to note that most farmers are apprehensive about the idea of sowing Genetically Modified crops on their land. Primarily due to the lack of conclusive judgement on the use of Genetically Modified

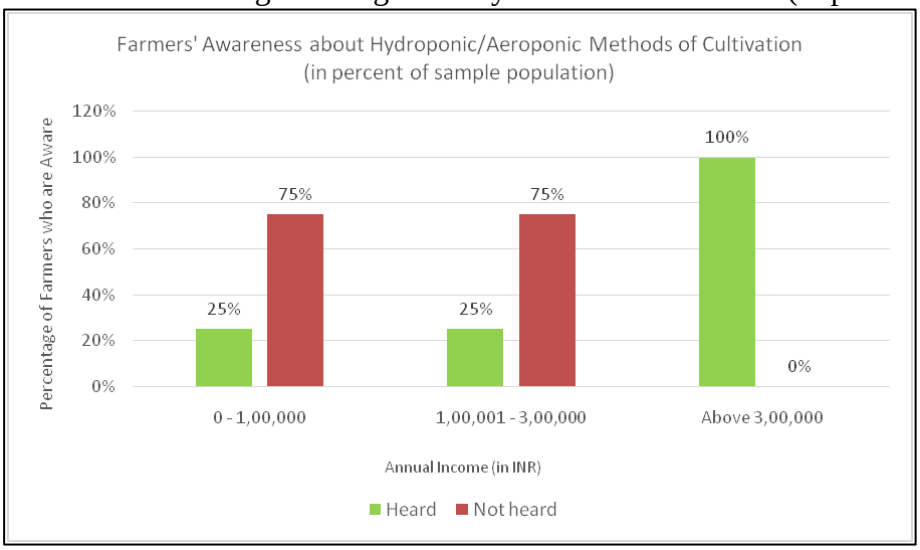
[22](Government of West Bengal 2024)

crops by the Supreme Court, the farmers retained a negative outlook. The Supreme Court had appointed a Technical committee to provide their report. The committee expressed the need for realignment of Genetically Modified crops regulations and suggested a complete ban on herbicide tolerant crops. On January 9, 2024, the Supreme Court resumed hearing petitioner's arguments which challenged the government's approval (in October 2022) of indigenously developed HT Mustard DMH-11.[23] Experts believe that Genetically Modified seeds threaten crop biodiversity, especially indigenous crop varieties which are crucial to fight climate change. They believe that the loss of these varieties would constitute a huge risk in the face of worsening effects of climate change.[24] Furthermore, the development of Genetically Modified seeds is concentrated in the hands of a few private firms. This must be considered when assessing Genetically Modified crops in the context of implementing it in agricultural practices in villages like Sonarpur. An approval on Genetically Modified seeds would make working capital more expensive for farmers. This is because these few private firms could monopolise the Genetically Modified seed market and become price-setters for the period until competitors attempt to rise.[25] Two-thirds of the survey sample size has never heard of hydroponic/aeroponic systems. Figure 4 below sorts the awareness of farmers about such systems based on their income. Our study reveals that farmers have become used to traditional subsistence methods of farming. Although these methods have clearly reached the end of their usefulness, there have been negligible changes in overturning such systems. The lack of initiative on the part of these farmers is distressing. Once given factual explanations by us who were taking interviews on field, an overwhelming majority of people were willing to set up hydroponic/aeroponic systems. Clearly, the sweeping advent of the internet has made people living in rural regions more accepting and receptive towards innovation. The government has introduced several schemes to introduce new technology into agriculture.[26] Although, the technology might not have effectively reached Sonarpur yet, its news definitely has. Through interactions with all farmers, a common link lay in their desire to fund their own working capital instead of relying on credit. A lot of these farmers envision these technologies as a method of breaking the vicious credit cycle and taking control of the entire production process. Farmers believe that the ability to take

[23](Centre for Civil Society 2022) (Nitnaware, Down to Earth 2024)
[24](Nitnaware, Down to Earth 2022)
[25](Phillips 2008)
[26](Government of West Bengal n.d.)

control over their process of production is a cost-cutting panacea, combined with new agricultural techniques and better resource management. This can help them cut significant costs, thereby increasing productivity and allowing them to finance their own working capital, subsequently improving their financial independence and reducing the dependency on precarious lending arrangements. This phase has been identified as a crucial milestone toward sustainable agriculture because it would not only increase the resilience of farm income and thus better financial stability for farmers but also stimulate more resilience against external financial shocks.[27] It will further be pivotal in increasing self-sufficiency and reducing reliance on credit, thereby contributing to larger socio-economic payoffs through improved food security and enhanced rural development.[28]

Figure 4: Farmers' Awareness about Hydroponics, Aeroponics, Precision Agriculture or Greenhouse Technologies Categorised by their Annual Income (in percent).



Source: Authors' survey data

Government schemes have focused on bringing farmers into the institutional credit sector.[29] The respondents reported that they had created bank accounts in the past five years. They mentioned that it was easier and more affordable to secure bank loans now. However, a majority of the farmers still prefer the informal sector: a field in which Self-Help Groups have proved outstanding. Farmers have actively welcomed the foundation of

[27](Kirsten 2009)
[28](Chatterjee 2016)
[29](National Bank for Agricultural and Rural Development 2023-24)

self-help groups. In Sonarpur, most of these groups collect INR 50 from each farmer per month which is used to help farmers in raising credit, and in times of need like marriages and funerals. Self-help groups provide these funds at near-negligible rates of interest and the borrowers are held to account by close members of their own community.[30] Additionally, a shocking trend has been seen in Sonarpur recently. Due to the influx of banking facilities, moneylenders have faced stiff competition and decreasing demand for loans. They have adapted through two methods: (i) providing loans at lower rates of interest compared to banks and (ii) providing loans in kind to eliminate a step (securing working capital) in the agricultural process, said the respondents.

However, these positive developments may not sound enough when it comes to the impact of climate change on credit needs of farmers. Due to unpredictable yields, farmers in our study reveal that they often lose existing savings or are unable to repay previously withdrawn loans. This plunges them in a vicious debt cycle which is difficult to escape since farming, as a field, has a considerable maturation period between the investment and its return. Taking the example of the recent rice crop failure in 2022, several farmers said that they plan on funding the next year's cultivation on credit facilities.

Our study finally reveals that a majority of farmers believe that their income levels have remained the same relatively, while a few believe that it has declined. Most farmers believe that their standard of living has declined over the years. These results raise concerns for the future as bad yields due to changing climates are only expected to push incomes lower.

5. Conclusion and Policy Recommendations

The survey revealed mixed perceptions among farmers regarding the impact of climate change on their yield, with all respondents agreeing on noticeable changes in cultivation practices. Farmers in Sonarpur have been compelled to adjust their cultivation practices in response to changing temperatures and precipitation patterns. Notably, rice and wheat cultivation exhibit varying levels of adaptation to rising temperatures and altered precipitation. While a significant portion of farmers lack experience with heat-resistant

[30](Neha Kumar 2018)

crop and seed varieties, there is some awareness of these coming up. However, apprehensions regarding implementation, potentially due to high costs, hinder widespread adoption of these varieties.

Farmers generally perceive government policies positively, particularly initiatives such as the 'Bangla Shasya Bima' Insurance scheme. However, there are concerns regarding the timeliness and effectiveness of government assistance, with a preference for proactive support rather than reactive measures during crises. Farmers overwhelmingly reject the idea of sowing Genetically Modified crops on their land, partly influenced by legal uncertainties and concerns about biodiversity loss. The debate around Genetically Modified crops underscores the need for comprehensive regulations and considerations of socio-economic impacts. Despite limited awareness initially, farmers exhibit receptiveness towards innovative farming technologies like hydroponic/aeroponic systems, especially after receiving factual explanations. There is a growing recognition of technology as a means to enhance self-sufficiency and break free from reliance on credit.

While there have been improvements in access to institutional credit, many farmers still rely on informal sources due to perceived benefits such as lower interest rates and community support. Climate change-induced yield fluctuations exacerbate existing challenges, leading to increased reliance on credit and concerns about income stability.

With a vision to solve this, the following is a policy recommendation to improve the already existing ‘Bangla Shasya Bima’ Insurance scheme. The ‘Bangla Shasya Bima’ Insurance scheme, aimed at providing insurance coverage to farmers in West Bengal, represents a significant step towards safeguarding the agricultural sector against risks and uncertainties. However, upon critical analysis, one area for improvement emerges as crucial for enhancing the effectiveness and utility of the policy: the incorporation of comprehensive weather index-based insurance. Currently, the scheme primarily relies on traditional yield-based insurance, which indemnifies farmers based on actual yield losses. While yield-based insurance has its merits, it often faces challenges related to accurate yield assessment, especially in regions with diverse cropping patterns and varying agronomic practices. By integrating weather index-based insurance into the ‘Bangla

Shasya Bima' scheme, the government can address these challenges and provide more timely and reliable compensation to farmers in the event of adverse weather events.[31]

In refining the 'Bangla Shasya Bima' Insurance scheme, it's essential to explore a hybrid approach that integrates both crop yield-based and weather index-based measurements. Such a comprehensive strategy would harness the strengths of each method while mitigating their respective limitations, thereby offering farmers more robust protection against diverse agricultural risks.

Firstly, the existing crop yield-based insurance component could be retained but with improvements in data collection and assessment methodologies. This could involve leveraging advancements in remote sensing technologies, such as satellite imagery and drones, to accurately monitor crop health, growth stages, and yield potential. By incorporating these high-resolution data sources, insurers can enhance the precision of yield assessments, reducing the potential for disputes and delays in claims processing. Additionally, investing in training programs for local agronomists to better interpret and validate field-level data would further bolster the accuracy of yield estimates.[32]

Simultaneously, integrating weather index-based insurance into the scheme would provide an additional layer of protection against weather-related risks. Weather index insurance operates by establishing predetermined thresholds for key meteorological variables, such as rainfall, temperature, and humidity. When these thresholds are exceeded, payouts are triggered automatically, without the need for individual farm assessments. This streamlined approach significantly reduces administrative burdens and accelerates claims processing, ensuring timely assistance to affected farmers.[33] Furthermore, weather index insurance can cover a broader spectrum of perils beyond yield losses, including droughts, floods, and heat waves, thereby offering more comprehensive risk coverage.

To implement this hybrid approach effectively, the government of West Bengal already has a robust infrastructure for weather monitoring and data dissemination for the Bay of

[31](Government of West Bengal 2024)
[32](Afshar, M. H., Foster, T., Higginbottom, T. P., Parkes, B., Hufkens, K., Mansabdar, S., Ceballos, F., & Kramer, B. 2021)
[33](Sun 2022)

Bengal observatory. There is a network of weather stations equipped with sensors for real-time data collection and transmission.

Furthermore, policy to policy partnerships could play a pivotal role in scaling up the adoption of weather index-based insurance among farmers. By integrating the insurance dissemination with other agricultural policy schemes and conditional cash transfers like Krishak Bondhu, Duare Sarkar, Matir Katha, etc. would reduce the apprehension of farmers from availing the scheme. Having banked and paperwork done only once while registering for the policy may enhance the accessibility of all such policies combined.

In conclusion, the successful integration of crop yield-based and weather index-based measurements within the 'Bangla Shasya Bima' Insurance scheme requires a multifaceted approach encompassing technological innovation, data analytics, stakeholder engagement, and capacity-building initiatives. By embracing complexity and embracing a holistic perspective, policymakers can develop insurance products that are not only robust and effective but also inclusive and empowering for the farming communities they serve. This comprehensive strategy reflects a commitment to harnessing the transformative potential of insurance as a catalyst for sustainable agricultural development and poverty alleviation in West Bengal.

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Appendix: **Questionnaire**

1. Do you believe climate change has a direct impact on your lives and cultivation practices?
   a. Significantly
   b. Not significantly, but noticeable
   c. No noticeable observation
   d. None of these options describe my condition
2. Have there been instances when you have had to change cropping patterns or your original plans were not followed because of climate change?
   a. Yes, I had to adapt them considerably.
   b. Yes, I had to make some adjustments.
   c. No changes had to be made.
   d. None of these options describe my condition
3. Have you observed a difference in the impact of changing temperatures on rice and wheat?
   a. Yes, they respond differently.
   b. No, I have not observed a characteristic difference
   c. I don’t cultivate both of these
   d. None of these options describe my condition

4. Are you aware that the government has launched several drought- and heat wave-resistant varieties of crops? (DBW187, DBW222)
   a. Yes, I am using them.
   b. Yes, I wish to use them.
   c. No, I have not heard of them.
   d. None of these options describe my condition
5. How effective do you think the government's policies have been in taking measures to mitigate the impact of climate change on the agricultural sector?
   a. Highly Effective: I have benefited from them.
   b. Effective: I have not directly benefited, but it has improved the situation.
   c. Ineffective: They have not improved the situation.
   d. None of these options describe my condition
6. Would you be willing to grow Genetically Modified crops that ensure good yields but are not yet popular and preferred among people (trials are underway)?
   a. Yes, I would be open to trying.
   b. No, I will stick to non-modified crops.
   c. Too early to say
   d. None of these options describe my condition
7. Have you ever heard of hydroponic or aeroponic systems, precision agriculture, or greenhouse technologies?
   a. Yes
   b. No
   c. Maybe
   d. None of these options describe my condition
8. Would you be willing to set up such systems?
   a. Yes
   b. No
   c. Maybe
   d. None of these options describe my condition
9. What has been the state of credit facilities for agriculture?
   a. I only borrow from the formal sector.
   b. I borrow partly from the formal and the informal sector.

c. I only borrow from the informal sector.

d. None of these options describe my condition

10. How would you judge the trajectory of your income from agriculture over 10 years?

a. It has jumped considerably.

b. It has only improved to keep track with rising prices.

c. It has remained relatively the same.

d. It has declined.