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RESEARCH PAPER

Impact of Climate Change on Agriculture for Paddy Farmers in Gajapati District

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ABSTRACT

Climate change is one of the most important challenges for agricultural production, particularly in rain-fed irrigations such as Gajapati district of Odisha, where in the people mostly depend on paddy cultivation. The study used purposive sampling impact of irregular rainfall, hot temperatures, cyclones and low moisture in soils and farmer well-being. Used purposive sampling, collected data from 52 paddy farmers through structured questionnaires and personal interviews. The study used descriptive statistics, chi-square tests and multiple regression analysis to find climate impacts and adaptation responses. The Results reveal that erratic rainfall and heat stress significantly reduce yields, while extreme weather it causes crop losses. While occupation had no clear impact on subsidy, gender was found to influence the adoption of new practices. The most important factor influencing farmer income, according to regression analysis, is the size of the landholding. Despite emerging adaptation strategies such as drought-tolerant varieties, mixed cropping and community water management, limited access to irrigation, credit and institutional support hinders resilience. The study concludes that strengthening irrigation infrastructure, promoting climate-smart agriculture and enhancing institutional interventions are essential to safeguard paddy farming and improve adaptive capacity in Gajapati district. The study finds a significant impact of climate change on paddy farming in Gajapati district, Odisha. The study shows erratic rainfall, rising temperature and extreme weather are directly affecting crop growth, yield and farmers' livelihood.

HIGHLIGHTS

- 86.5% of farmers reported paddy yield decline due to irregular rainfall, heat stress, and extreme weather.
- 40.38% farmers demand improved irrigation support to cope with climate change impacts.
- Improved irrigation, climate-smart agriculture, and institutional support are essential for farmer resilience.
- 82.69% of farmers are aware of climate change impacts, but only 54% adopted adaptation strategies.

Keywords: Climate change, Paddy farmers, Awareness, Adoption, Practices

Climate change is a significant challenge to agriculture worldwide particularly for farmers involved in paddy cultivation. Rice cultivation depends heavily on regular rainfall from monsoons, suitable temperatures and sufficient availability of water. Even in conditions of minor modification in climate, yields are reduced, food security is threatened and this situates rural livelihoods in disorder. Across Asia the rising temperatures, irregular rainfall, frequent floods and droughts and pest and disease problems are already changing

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rice farming practices. In Odisha, paddy is the staple food and a major source of income for rural households, farmers are finding it increasingly difficult to maintain crop productivity while adapting to changing environmental conditions. Gajapati district falls in the southern part of the Eastern Ghats of Odisha. It is a predominantly hilly and tribal area where agriculture is not only an occupation but a way of life. Paddy crop is the predominant crop and it has closely integrated with the local culture, traditions and different seasons. During the last two decades, Gajapati district has witnessed remarkable climate change as erratic rainfall, delayed receipt of the monsoon, increased temperatures and frequent extreme weather events became common. Unpredictable rains greatly affect sowing and transplantation schedules, which result in poor germination and low yield. Heavy rainfall causes flash floods and soil erosion due to the loss of fertile upper layer of the soil, while a rise in temperature during the most sensitive crop stages of growth results in crop stress, poor grain formation and increased pest attacks. The scarcity of water has also cropped up because most of the farmers depend on rainfed agriculture and rarely have access to irrigation facilities. These climatic changes seriously affect the socioeconomic factors for farmers aspect of farming communities in Gajapati. Crop loss, decreasing productivity and household income create food insecurity-forcing families to migrate in search of work, especially during agricultural off-seasons. Women farmers, who are cultivating for paddy crop, have limited accessibility to land, amount of inputs and extension services, which affect the level of their challenges. Extreme effects such as cyclones and unseasonal rains further damage crops and infrastructure while, access to crop insurance and compensation remains low for many small and tribal farmers. Despite these difficulties, farmers are adopting adaptive measures such as the use of short-duration and drought-tolerant paddy varieties, mixed cropping, farmer producer organizations and community-based water and soil conservation. Government initiatives, non-government organizations and research institutions are promoting climate-resilient agriculture in the district, there is an emergent need to scale up and strengthen these initiatives to ensure sustainable livelihoods among paddy farmers.

LITERATURE REVIEW

Several studies have demonstrated the significant impacts of climate changing patterns on Odisha's agricultural output, with temperature and rainfall emerging as important factors influencing crop performance. Using a Ricardian approach, Mishra, Sahoo, and Sahu (2015) found that rising temperatures and erratic rainfall reduce farm income, with the extent and type of climate change effects the crop in Odisha. Their findings highlight the need for strong water resource management policies and better crop insurance in order to increase adaptability. Accordingly, Swain and Pradhan (2021) examined 40 years of data and showed that rainfall irregularities further postponed sowing and harvesting, while a 1.2°C increase in temperature led to a 10% decrease in paddy crop productivity in the districts of Balasore and Puri. A call for the widespread adoption of climate-resilient paddy varieties was sparked by the observed warming trend and changing rainfall patterns.

Climate Change Effects of Agriculture and Paddy in Odisha

It has been found that there are intense climatic effects on paddy in Odisha. Mishra, Sahoo, and Sahu (2015) stated that temperature increase and rainfall unpredictability negatively affected agricultural income. Swain and Pradhan (2021) mentioned that a 1.2°c temperature increase resulted in a 10% decrease in rice production in Balasore and Puri due to rainfall unpredictability in crop activities. Yield losses are accentuated by the increase in temperatures. Das and Behera (2023) demonstrated that if the temperature rises by 1°C, the yields will decrease by 7.5%, but irrigated areas will experience reduced damages. Panda *et al.* (2019) revealed that the MU (monsoon union) rainfall variability is the parameter that influences the change of rice yields for the KBK region. Sahoo and Roul (2021) presented that there will be potential losses of 12-18% for the rice. Coastal hazards are more serious. Dar *et al.* (2017) observed an increase in yield and decrease in losses for flood-resilient varieties, while Pani and Mishra (2018) observed a 25% decrease in rice productivity affected by salinity and sea-level rise.

Vulnerability, Livelihoods and Adapt

Vulnerability is socioeconomic. Panda, J. (2016) argues that vulnerability to climate change correlates with poverty, debt, and crop diversity. Sethi & Dash (2020) observe the vulnerability of the tribal farmers in Gajapati & Rayagada due to monocrop practices. Hussain *et al.* (2016) observed a decrease in food security & migration to other jobs. Adaptation requires resources. In determining adaptation, Mohapatra and Rout (2022) considered credit access, whereas education/institutional assistance was found to improve adaptation by Sahu and Mishra (2013). In contrast, Pradhan and Singh (2020) emphasized factors of gender, which suppress women farmers' adaptation.

Climate-Smart Agriculture and Conservation Practices

Climate-smart practices enhance benefits. Results from Tanti *et al.* (2024) demonstrated that CSA deployment elevates productivity and earnings. Ajatasatru *et al.* (2024), in turn, demonstrated that the System of Rice Intensification provides greater benefits while reducing water use and emissions. It also proves successful in rain-fed conditions. According to Chan *et al.* (2017), there was an increase of 60-70% yield while Pradhan, Idol, and Roul (2016) verified better yield, soil fertility, and profit in case of intercrops and much retention.

Farmer-Led Innovations and Local Practices

Farmers have been actively managing the stress created by climate change. Mixed cropping, organics, and community irrigation practices have been reported by Nayak *et al.* (2019), while water harvesting practices that raised productivity by 30% have been conducted by Behera and Tripathy (2017).

National and Regional Context

It At the national scale, the impacts of rising temperatures on reduced productivity in crops are found to be consistent by Praveen and Sharma (2019). The findings are similar to Hussain *et al.* (2016).

RESEARCH GAP

Previous research for Odisha and paddy cultivation relies heavily upon general climate change models and ignores microclimates and the processes of groundwater and pests. Socioeconomic factors fail to take account of gender and market access to an appropriate extent. Barriers to adoption of climate-smart agriculture and its present lack of integration of local innovations point to the need for adapted research.

RESEARCH QUESTIONS

1. How is climate change affecting the growth and yield of paddy crops in Gajapati district?
2. What is the key climate-related challenges (such as drought, irregular rainfall, floods, pests) faced by paddy farmers in the region?
3. What adaptation strategies are currently being used by paddy farmers to cope with climate variability and change?
4. What climate-smart agricultural practices or technologies can be introduced or supported to help farmers overcome climate risks?
5. What role can local institutions, government, and extension services play in supporting paddy farmers to adapt to climate change effectively?

RESEARCH OBJECTIVES

1. To understand how climate change is affecting paddy farming in terms of crop growth, yield and quality in Gajapati district.
2. Identify the main climate risks such as irregular rainfall, drought, floods and rising temperatures that directly impact paddy farmers.
3. To examine how these changing climate conditions affect the crops and farmers.

RESEARCH METHODOLOGY

Descriptive research design was used in this research to analyze the effects of climate change on the production of rice in the Gajapati district of Odisha. Through the method of purposive sampling, 52 paddy farmers were chosen from Gosani and Rayagada blocks. The study used purposive sampling to select paddy farmers from the required areas in Gajapati district of Odisha. These farmers were chosen because they directly engage in rice farming and, thus, have been victims

of climate change. Data from them were collected through discussion in surveys and interviews. The questions highlighted farming methods, the problems faced due to shifting weather and how they cope. The research collected data on the socioeconomic factors, awareness and effects of climate change through interviews and structured questionnaires. The data was processed by the use of descriptive statistics, multiple regression analysis and thematic analysis. Climate information and rice production secondary data validated the results.

DATA ANALYSIS

The collected data was analysed using both quantitative and qualitative methods. Survey responses were studied using basic statistical tools to find patterns in climate effects on crop yield and farmer income. Interview answers were carefully read and grouped into themes to understand farmers' views, experiences, and the ways they are coping with climate change. This helped to get a clear picture of the challenges faced and the strategies used by paddy farmers in Gajapati district.

Analysis of Secondary Data

Secondary data from national and state agricultural reports show that climate change has been causing fluctuations in paddy production due to irregular rainfall and extreme weather events. In Odisha, paddy output has declined in recent years especially in rain-fed districts like Gajapati which have been repeatedly affected by cyclones such as Titli and Gulab.

Table 1: Paddy Area and Production in India

Year	Paddy Area (million ha)	Paddy Production (million tonnes)
2015–16	43.5	104.4
2016–17	43.8	109.7
2017–18	44	112.8
2018–19	44.5	116.5
2019–20	45	118.9
2020–21	45.8	122.3
2021-22	45.3	129.66
2022-23	46.0	135.76
2023-24	46.3	132.00

Although some climate-smart practices are being

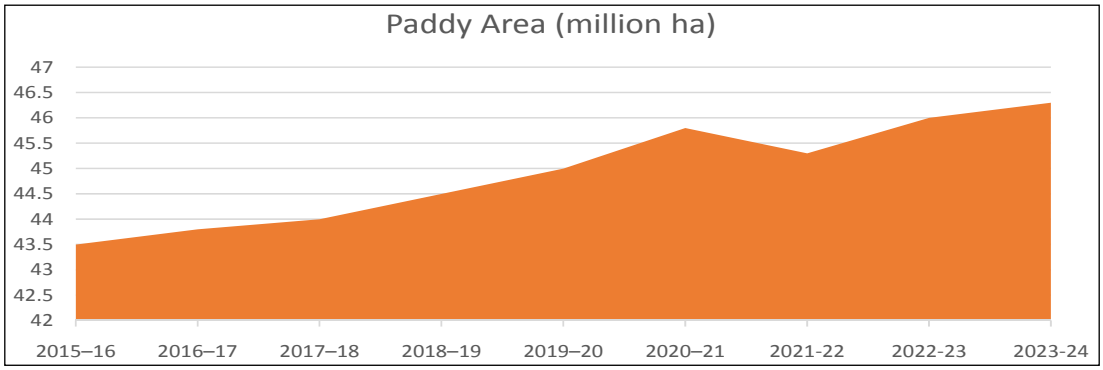

Fig. 1: Paddy Area in India (Million Hectares)

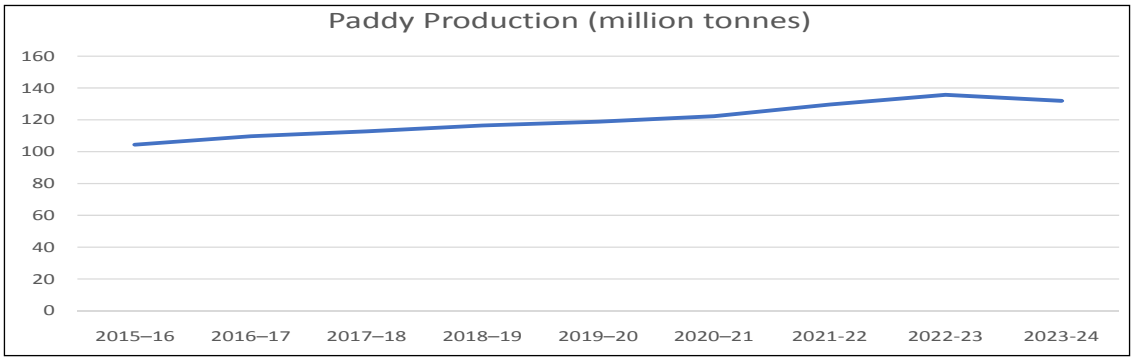

Fig. 2: Paddy Production in India (Million Tonnes)

Source: *Directorate of Economics & Statistics (DES), Department of Agriculture & Farmers Welfare, Agricultural Statistics at a Glance 2023.*

adopted by farmers the overall support and awareness levels are still limited. These trends strongly align with the challenges reported by farmers in this study.

Descriptive Statistics of Primary Data:

The data shows that the respondents have an average of 7 years of schooling, reflecting moderate literacy levels. However, only 54% of the respondents have adapted in order to cope with the effects of climate change and only 33% have benefited from government subsidies for lost crops. The median and mode reflect limited government assistance, in contrast to moderate awareness and adaptation.

Farmer's Awareness of Climate Change and Its Effect on Paddy Crops

The results show that over 80% of farmers are aware of climate variability impacts on paddy, mainly erratic rainfall and strong winds. However, only a few show high awareness, indicating limited depth of knowledge on adaptation strategies.

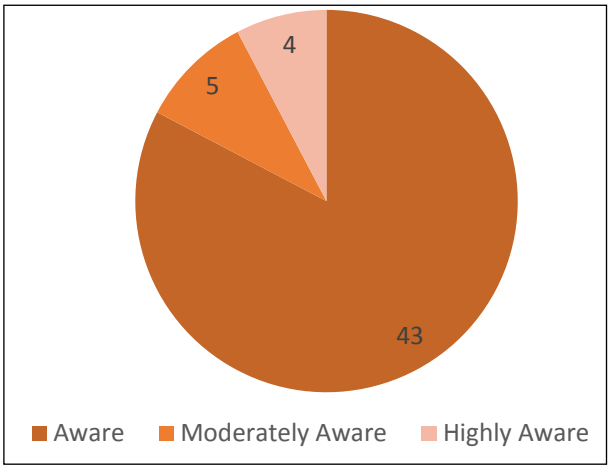

Fig. 3: Farmer's Awareness of Climate Change and Its Effect on Paddy Crops

Farmer's Expectations of Government Support for Climate Change Impacts

It is evident from the findings that a major portion of farmers, which is 40%, require irrigation support in view of their high rainfall dependence and rising duration of arid periods. About 27% require

Table 2: Farmer's Awareness of Climate Change and Its Effect on Paddy Crops

Awareness Level	Number of Farmers	Percentage (%)	Interpretation
Aware	43	82.69	Majority of farmers are aware that changes in rainfall and wind patterns affect crop productivity.
Moderately Aware	5	9.62	A small group shows limited awareness or general understanding of climate effects.
Highly Aware	4	7.69	Few farmers demonstrate strong understanding and detailed awareness of climate change impacts.

Table 3: Farmer's Expectations of Government Support for Climate Change Impacts

Type of Support Expected	Number of Farmers	Percentage (%)	Interpretation
Irrigation Support	21	40.38	Most farmers expect better irrigation facilities and water management systems.
Financial Subsidy	14	26.92	Around one-fourth of farmers seek direct financial aid or subsidy schemes.
Input Support	9	17.31	Many farmers want support in the form of seeds, fertilizers, and other inputs.
Other Support	7	13.46	A few farmers mentioned other types of help such as marketing or infrastructure.
Crop Insurance	1	1.92	Very few farmers requested crop insurance or risk protection.

financial subsidies, while 17% require input subsidies in view of rising costs, whereas very few farmers raised the issue of crop insurance.

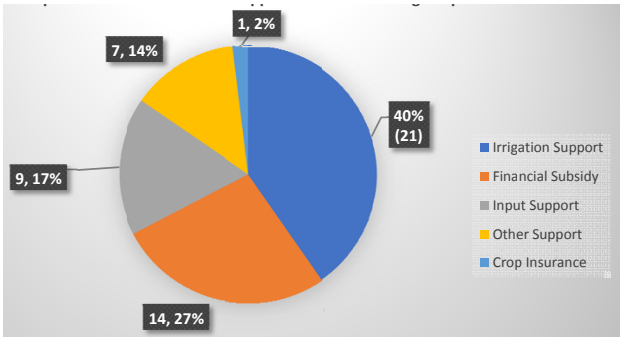

Fig. 4: Farmer's Expectations of Government Support for Climate Change Impacts

Table 4: Social and Livelihood Effects of Climate Change on Farmers (*N* = 52)

Sl. No.	Social Impact	Effect on Farmers' Livelihood
1	Income insecurity	Difficulty in meeting household expenses
2	Reduced savings	Majority farmers unable to save due to crop losses
3	Mental stress	Uncertainty in farming activities
4	Reduced interest in farming	Some farmers considering alternative livelihoods

The findings indicate that while more than half of the farmers have begun adapting to climate change, a considerable proportion still remain highly vulnerable. Strengthening extension services, training programmes, financial assistance, and policy support is essential to encourage wider adoption of climate-resilient farming practices among paddy farmers in Gajapati district.

Table 5: Impact of Climate Change on Paddy Farming in Gajapati District (N = 52)

Sl. No.	Impact on Paddy Farming	Number of Farmers	Percentage (%)
1	Poor crop growth due to irregular rainfall and drought	41	78.8
2	Delay in sowing/ transplanting	38	73.1
3	Decrease in paddy yield	45	86.5
4	Increased pest and disease incidence	45	86.5
5	Decline in grain quality	36	69.2
6	Crop damage due to floods/waterlogging	22	42.3
7	Increased cost of cultivation	40	76.9

Interpretation: The table shows that climate change has significantly affected paddy farming in Gajapati district. A majority of farmers (86.5%) reported a decline in paddy yield and increased pest and disease incidence. Poor crop growth and delayed sowing were also widely reported due to irregular rainfall and drought. Additionally, 69.2% of farmers observed deterioration in grain quality, while increased cost of cultivation was reported by 76.9% of farmers. These findings clearly indicate that climate change adversely affects crop growth, yield and quality, thereby threatening the sustainability of paddy farming in the study area.

Regression Analysis

Multiple regression analysis also showed that education, size of landholding, and adoption of new practices were significant factors in explaining variations in income ($F = 9.93$, $p < 0.001$), with an R-squared value of 0.344. In this analysis, size of landholding had a positive impact on income ($p < 0.001$), whereas education and adoption of new practices had no significance in this context.

Table 6: Regression Coefficients Showing the Influence of Educational Qualification, Landholding Size, and Adoption of New Farming Practices on Farmers' Income

Variable	Coefficient (B)	Std. Error	t-Value	p-Value	Significance
Educational Qualification	0.004	0.055	0.080	0.936	Not Significant
Landholding Size	**1.338**	0.271	4.946	**0.000**	**Significant**
Adoption of New Practices	0.565	0.407	1.388	0.171	Not Significant

Interpretation: presents the results of the multiple linear regression analysis examining the effect of educational qualification, landholding size, and adoption of new practices on farmers' income. The model was found to be statistically significant ($p <$

0.001). Among the predictors, only landholding size showed a significant positive influence on income, indicating that farmers with larger holdings tend to have higher earnings.

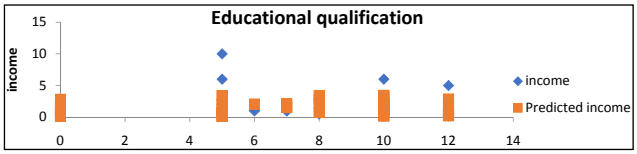

Fig. 5: Effect of educational qualification on Farmers' Income

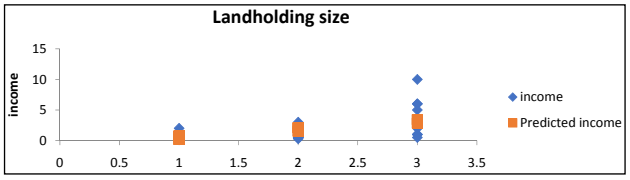

Fig. 6: Effect of Landholding Size on Farmers' Income

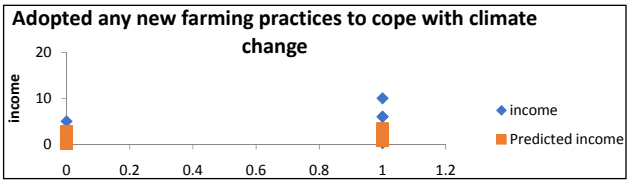

Fig. 7: Effect of Adopted any new farming practices to cope with climate change on Farmers' Income

To analyse whether the adoption of new farming practices to cope with climate change is influenced by the gender of the respondents (Table 8).

Table 8: Gender vs. Adoption of New Farming Practices

Variable	Type	Categories
Gender	Categorical	Female, Male
Adopted new farming practices	Categorical	Yes (1), No (0)

Table 9: Gender-wise Distribution of Adoption of New Farming Practices to Cope with Climate Change

Gender	No (0)	Yes (1)	Total
Female	7	0	7
Male	17	28	45
Total	**24**	**28**	**52**

The table Table 9 presents the observed frequency distribution of respondents by gender and their adoption of new farming practices to cope with climate change. Out of the 7 female respondents, none reported adopting new farming practices, but all were non-adopters. However, a high proportion of the male respondents exhibited adoption behavior, with 28 out of 45 males reporting the adoption of new farming practices, as compared to 17 non-adopters. In all, out of the total of 52 respondents, 28 adopted new farming practices, while 24 were non-adopters. This table reveals that there is a remarkable gender difference in the adoption of climate-resilient farming practices, where male respondents are relatively higher in adopting the practice, compared to female respondents.

DISCUSSION

From the data analysis, it is clear that climate change has impacted paddy crop cultivation in Gajapati district significantly, primarily due to climate variability, late monsoon arrival, and an increase in temperatures. Even as over 80% of farmers are aware that paddy crop cultivation has been impacted by the prevailing climatic changes, no more than half of them are practicing any form of adaptation strategies. This difference between awareness and adaptation reveals that farmers are impacted by some real-life limitations concerning irrigation requirements and lack of institutional support. This is clearly evident from the descriptive statistics, which indicates that a small section of farmers has derived benefit from any form of government assistance or compensation, thereby making them climate change vulnerable to crop damage.

Expectations of government assistance: Expectations of government assistance reflect the major needs of farmers, of which irrigation stands out as the most important, with more than 40% of the respondents emphasizing better irrigation facilities. Subsidies on finance and inputs and crop insurance, are of less importance, with crop insurance being mentioned by few farmers, reflecting their lack of awareness and confidence in crop insurance programs. The regression analysis verifies that the size of land possession has a highly significant positive effect on farmer's income, while educational qualifications and new agricultural practices are not significant. This makes it clear that farmers owning larger land resources are better adapted to resist climatic risks, while small and marginal farmers are more vulnerable to fluctuations in their income due to climatic changes.

The table shows that climate change has significantly affected paddy farming in Gajapati district. A majority of farmers (86.5%) reported a decline in paddy yield and increased pest and disease incidence. Poor crop growth and delayed sowing were also widely reported due to irregular rainfall and drought. Additionally, 69.2% of farmers observed deterioration in grain quality, while increased cost of cultivation was reported by 76.9% of farmers. These findings clearly indicate that climate change adversely affects crop growth, yield and quality, thereby threatening the sustainability of paddy farming in the study area

CONCLUSION

However, the impact of climate change on paddy cultivation in Gajapati district, as concluded in the study, is substantial and significant, especially in the context of unpredictable rainfall, late monsoon arrival, rise in temperatures, and occurrences of natural disasters. It can be observed that the awareness level of the farmers in respect to the change in the climatic conditions prevails in major numbers; however, the resolution to implement adapted strategies in practical contexts remains meager to measure.

Moreover, the data analysis shows that land holding size has been the most important factor that impacts the farmer's income, which clearly indicates a higher risk associated with smaller farmers due to the impacts of climate change. Education level and the adoption of new farming practices have not been observed to have a significant effect on income, which clearly indicates that the results of adaptation are more resource-dependent than the level of education, which might be lacking. There has been less demand for crop insurance and subsidy accessibility.

On the whole, it is highlighted in the study how the need must be met for improving irrigation infrastructure, extending climate-resilient agriculture practices, and providing greater access to government programs and institutional services in the Gajapati district of Odisha. It is required to improve resilience and maintain paddy yield with greater focus on small and marginal farmers, along with improvements in extension and community management of resources amidst the present challenges of climate change.

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