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Adoption of Climate-Resilient Technology by smallholder farmers in Rice-Based Cropping System in Western Central Table Zone of Odisha

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HIGHLIGHTS

- Intervention farmers showed higher technology adoption than control farmers and Annual income was significantly higher among intervention farmers.
- Innovativeness and occupation were the strongest direct predictors of climate-resilient technology adoption.
- Social participation exerted the highest indirect influence on adoption, mediated through innovativeness.
- Institutional access crop insurance and custom hiring centres significantly widened the intervention–control adoption gap.

ARTICLE INFO

Keywords: Climate-resilient technologies, Smallholder farmers, Technology adoption, Rice-based cropping systems, Extension services, Innovativeness, Odisha.

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ABSTRACT

Rice cultivation in rain-fed systems of Odisha is highly vulnerable to climate variability, threatening the livelihoods of smallholder farmers. This study assessed the adoption of Climate Resilient Technologies (CRTs) among smallholder farmers during Kharif 2023-24 in Jharsuguda district under the Western Central Table Land Zone of Odisha. A multi-stage sampling technique was employed to select respondents from intervention and control villages, with 60 farmers selected from each group. Adoption was evaluated across four modules: natural resource management, crop production, livestock and fisheries, and institutional interventions. Results showed that intervention farmers had significantly higher overall adoption levels than control farmers ($Z = 11.34$, $p < 0.01$). Adoption rates for drought-tolerant varieties, seed treatment, and crop insurance were notably higher among intervention farmers (86.67%) compared to control farmers (43.33%). Intervention farmers also recorded significantly higher annual income ($U = 5306$, $p < 0.05$). Multiple linear regression and path analysis identified innovativeness, occupation, farming experience, age, social participation, and farm size as key determinants of adoption. The study highlights the importance of ICT-based participatory approaches and strengthened institutional access for enhancing resilience in rice-based farming systems in Odisha.

INTRODUCTION

Rice (*Oryza Sativa* L.) is the main staple crop and a significant contributor to the agricultural economy of Odisha, grown on 4.61 million ha and produced 9.21 million tonnes in 2022–23 (Directorate of Agriculture, Govt. of Odisha, 2023). The state is predominantly an agricultural state with a share of almost 70% of Gross Cropped

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Area under rice cropping system and plays a significant role in rural livelihoods (Directorate of Agriculture, Government of Odisha, 2023). In less productive areas, diversified agriculture, like rice-pulse and rice-vegetables, has been encouraged to increase the income stability of farmers (Naik et al., 2025b; Rao et al., 2016). Rice production, however, has been impacted by the growing climate variability in Odisha, such as irregular rainfall, droughts, floods and long spells of dry weather (Lenka, 2023). In India, agriculture losses due to climate change in 2016-21 have been estimated at US$ 3.75 billion, and losses in agrarian productivity in the drought prone districts of Odisha could be as much as 40% less than the state average (Odisha Economic Survey 2023-24). In high temperature stress districts like Jharsuguda, there is likely to be an increase in production risks due to higher temperature (IPCC, 2021). In response to these challenges, the National Innovations on Climate Resilient Agriculture (NICRA) has encouraged the adoption of climate-resilient technologies such as drought-tolerant varieties, integrated nutrient management, and moisture conservation methods (National Innovations on Climate Resilient Agriculture, 2021). Previous research indicated that these technologies are effective in promoting productivity and income generation; with social participation, extension contact, and demonstration learning effecting adoption behaviour (Rogers, 2003; Sultana et al., 2020; Harikrishna & Naberia, 2021; Shanabhoga et al., 2023).

The study examined the status of adoption of 30 climate-resistant technology (CRT) across four modules (Reddy et al., 2025), its economic implications, and factors associated with the adoption behaviour of rice farmers in Jharsuguda based on correlation analysis, regression analysis and path analysis. Despite growing evidence on CRT adoption under NICRA, comparative empirical studies examining both adoption levels and their determinants across intervention and control groups within a single agro-climatic zone remain limited in Odisha (Naik et al., 2025b). This study, therefore, aimed to (i) assess the status of CRT adoption across four modules in Jharsuguda district during Kharif 2023–24, (ii) examine the economic implications of adoption on annual farm income, and (iii) identify key socio-personal, economic, communicational, and psychological determinants of CRT adoption among smallholder rice farmers. Two null hypotheses on adoption and income differences between intervention and control groups were tested.

METHODOLOGY

This study was carried out, in the Western Central Table Zone of Odisha in Jharsuguda district between 21°-22° N latitude and 83°-84° E longitude at an altitude of 225-280 m above mean sea level. The district is a kharif rice monoculture system where almost 78% of the gross cropped area is under Kharif rice production and is highly sensitive to rainfall deficiency in the critical growth stage of the rice crop (mid-July to mid-August), as reported by Mansingh et al. (2024). The respondents were selected using a multistage sampling design. The district of Jharsuguda was purposively selected as the district was considered to be more vulnerable in climatic condition and intervention and control villages under the National Innovations on Climate Resilient Agriculture programme were present there. Two intervention villages (Tharkuspur and Bhoimunda) and two similar non-intervention villages Telidihi and Luisingha located under Krishi Vigyan Kendra Jharsuguda and Odisha University of Agriculture and Technology were selected. One hundred and twenty farming households were randomly selected across two groups (intervention and control) with 60 farming households selected in each group. Primary data was gathered by conducting interviews, using a structured and face-to-face approach during kharif 2023-24. Adoption was measured using a three-point scale (0 = non-adoption, 1 = partial, 2 = full adoption) across 30 CRT practices (maximum score = 60). Categories were derived using the mean ± SD method. Content validity was ensured through expert validation and pilot testing with 20 farmers from an excluded village. A total of 14 independent variables were explored in four dimensions (socio-personal, socio-economic, socio-communication and socio-psychological) with over 30 Climate Resilient Technology (CRT) practices across four Modules (natural resource management, crop production, livestock and fisheries, and institutional interventions) (Sarkar et al., 2022; Sodhi et al., 2023). Both null hypotheses are now explicitly stated at the end of the Introduction/Methodology transition: H_1 (no significant difference in CRT adoption between groups) and H_2 (no significant difference in annual income).

The study employed descriptive and inferential statistics to analyse the relationship between the factors of the farmers' profile and the adoption of the technologies and practices of adaptation to climate change. All association and differences between variables were statistically analysed using Pearson's correlation and Z-test, and for ordinal income data the Mann–Whitney U test was performed. The effect of all 14 predictors was investigated by Multiple Linear Regression with enter and stepwise procedure (Yadav & Gosh, 2023). Both direct and indirect effects were estimated and Variance Inflation Factor (VIF) was used to check multicollinearity with all values being below 5. IBM SPSS Statistics was used for statistical analysis.

RESULTS

The implementation of technologies promoting resilience to climate change were covered under every module

The complete 30 adopted CRT Practices by Module is shown in Table 1. During Module I (Natural Resource Management), the intervention farmers reported significantly high percentage for full adoption of crop residue incorporation (56.67% vs 35.00%), soil sample collection and testing (48.34% vs 30.00%) and green manuring with Dhaincha in rice (38.33% vs 23.33%). Regarding Module II (Crop Production), the system that showed that the biggest difference (51.67% vs. 31.67%) was for the varieties of Drought-tolerant Rice. Adoption of individual intervention practices has significantly varied between intervention and non-intervention farms, with the adoption rate of 55.00%, 56.67% and 50.00% for weeding, seed treatment and intercropping, respectively. In Module IV (Institutional Interventions), village weather station access was reported by 45.00% of intervention farmers compared to 0.00% of control farmers, consistent with NICRA programme objectives. Crop insurance coverage under the *Pradhan Mantri Fasal Bima Yojana* (PMFBY) was also significantly higher in case of intervention farmers compared to the control farmers (86.67% vs. 43.3).

Table 1. Major climate-resilient technology interventions under different modules implemented among smallholder farmers in the study area

Module	Technologies/Practices
I: Natural Resource Management (In-situ Moisture Conservation)	Green manuring (Dhaincha) in rice, enriching soil by incorporating crop residues, renovation of community/ farm ponds, soil sample collection and testing, use of vermicomposting, mulching in vegetable crops
II: Crop Production	Drought-tolerant/disease-resistant rice variety, inter-cropping, hybrid maize/sweet corn variety cultivation, integrated nutrient and crop management, high-yielding disease-resistant vegetable growing, crop diversification, micronutrient application in cauliflower, seed treatment, paddy straw mushroom cultivation, micro-irrigation (drip and sprinkler), sowing of latest released varieties, weed management practices
III: Livestock and Fisheries	Urea treatment of fodder, deworming and vaccination, mineral mixture feed, fodder production and silage making, low-cost goat shed/cattle shed, integrated farming approach (fodder production)
IV: Institutional Interventions	Village fodder bank/seed bank, climate literacy via village weather station, custom hiring centre, use of ICT tools for climate risk mitigation, crop insurance through PMFBY

Table 2. Annual income distribution of intervention and control farmers (Jharsuguda district)

S. No.	Income category	Intervention (%)	Control (%)
1	Below Rs. 1,20,000	23.33	38.34
2	Rs. 1,20,001 to Rs. 2,40,000	46.67	43.33
3	Above Rs. 2,40,000	30.00	18.33
	Test Statistic	Value	
	Mann-Whitney U	5306.00	
	Wilcoxon W	124.00	
	Z Value	–1.54	
	Asymptotic Significance (2-tailed)	p < 0.05	

Note: Mann–Whitney U = 5306; p < 0.05.

Annual income distribution and economic implications

Table 2 reveals, that the proportion of the farmers in intervention group who got income above Rs. 2.40 lakh per year was 30.00% as against 18.33% of the control farmers. On the other hand, the proportion of farmers who became less than Rs. 1.20 lakh was 38.34% for the control farmers while it was 23.33% for the intervention farmers only. The Mann–Whitney U test showed that the income difference between the two groups was statistically significant ($U = 5306, p < 0.05$), allowing H_2 to be rejected and a measurable economic benefit of CRT adoption established.

Overall adoption level

Table 3 shows that 53.34% of intervention farmers were categorised as high adopters compared to 16.66% of control farmers, a difference of 36.68 percentage points. The Z-test value ($Z = 11.34$, $p < 0.01$) far exceeded the critical value of ±1.96, firmly rejecting H_o. The mean adoption score of intervention farmers (60.73) was 21.6% higher than that of control farmers (49.95).

Table 3. Distribution of respondents by overall adoption level of technologies

Category	Intervention (%)	Control (%)	Z-value
Low	20.00	46.67	
Medium	26.67	36.67	11.34**
High	53.34	16.66	
Mean	60.73	49.95	
SD	4.86	5.53	

Note: **Significant at p=0.01; critical Z = ±1.96; SD = standard deviation

Determinants of adoption: Correlation, regression, and path analyses

Table 4 shows the results of bivariate correlation. The strongest negative association was with age (r = "0.392, p < 0.01) and strong positive correlations were with innovativeness. The narrative has been corrected to read "strong positive correlations were with innovativeness (r = 0.386) and occupation (r = 0.363). Farm size ($r = 0.281, p < 0.01$), livelihood diversification ($r = 0.268, p < 0.01$), and economic motivation ($r = 0.250, p < 0.01$) also recorded significant positive associations No significant relationships were found between mass media exposure (r = 0.175), farming experience (r = 0.168) and education (r = 0.014) and adoption.

The Multiple Linear Regression (MLR) model (Table 5) explained 59.0% of the variance in adoption ($R^2 = 0.590$, $F = 10.778$, $p < 0.01$). Occupation ($b = 3.599, p < 0.001$), farming experience ($b = 2.304, p < 0.01$), and innovativeness ($b = 0.788, p < 0.01$) were significant positive predictors, while age exerted a strong negative effect ($b = –3.832, p < 0.01$). Table 6. Showed six variables namely occupation (X_4), innovativeness (X_{14}), age (X_1),

Table 4. Bivariate correlation of profile characteristics with adoption of technologies

Code	Variable	r-value	p-value
X_1	Age	–0.392**	0.000
X_2	Education	0.014NS	0.877
X_3	Farm size	0.281**	0.002
X_4	Occupation	0.363**	0.000
X_5	Annual income	0.194*	0.033
X_6	Farming experience	0.168NS	0.066
X_7	Irrigation status	0.209*	0.021
X_8	Livelihood diversification	0.268**	0.003
X_9	Social participation	0.234*	0.011
X_{10}	Mass media exposure	0.175NS	0.054
X_{11}	Extension contact	0.234*	0.011
X_{12}	Economic motivation	0.250**	0.006
X_{13}	Risk orientation	0.223*	0.014
X_{14}	Innovativeness	0.386**	0.000

Note: *Significant at p < 0.05; **Significant at p < 0.01; NS = Non-significant

Table 5. Multiple linear regression: Predictors of technology adoption

Code	Variable	b	SE	t-value	p-value
X_1	Age	−3.832**	1.029	−3.724	0.000
X_2	Education	−0.005NS	0.444	−0.010	0.992
X_3	Farm size	1.129*	0.467	2.416	0.017
X_4	Occupation	3.599***	0.876	4.109	0.000
X_5	Annual income	0.064NS	0.922	0.070	0.945
X_6	Farming experience	2.304**	0.818	2.816	0.006
X_7	Irrigation status	0.649NS	0.818	0.794	0.429
X_8	Livelihood diversification	1.047NS	0.834	1.255	0.212
X_9	Social participation	0.653*	0.294	2.222	0.028
X_{10}	Mass media exposure	0.193NS	0.230	0.838	0.404
X_{11}	Extension contact	0.195NS	0.189	1.033	0.304
X_{12}	Economic motivation	0.255NS	0.149	1.716	0.089
X_{13}	Risk orientation	0.028NS	0.147	0.192	0.848
X_{14}	Innovativeness	0.788**	0.253	3.117	0.002

Model fit: R = 0.768; R^2 = 0.590; Adjusted R^2 = 0.535; F = 10.778; $p < 0.01$.
Note: *p < 0.05; **p < 0.01; ***p < 0.001; NS = Non-Significant, b: Beta Co-efficient, SE: Standard error.

Table 6. Stepwise Regression- Parsimonious Predictors of CRT Adoption

Model	Predictors in Model	R	R²	Adj.R²	Std. Err.	New Predictor	B	β	t	Sig.
1	X_4	0.363	0.132	0.125	7.22	X_4	3.599	0.363	4.109	<.001
2	X_4-X_{14}	0.503	0.253	0.240	6.78	X_{14}	0.788	0.304	3.117	0.002
3	X_4-X_{14}-X_1	0.617	0.381	0.363	6.22	X_1	−3.832	−0.287	−3.724	<.001
4	X_4-X_{14}-X_1-X_6	0.679	0.462	0.440	5.84	X_6	2.304	0.245	2.816	0.006
5	X_4-X_{14}-X_1-X_6-X_9	0.713	0.509	0.484	5.61	X_9	0.653	0.192	2.222	0.028
6	X_4-X_{14}-X_1-X_6-X_9X_3	0.736	0.541	0.512	5.46	X_3	1.129	0.175	2.416	0.017

Final model: R = 0.736; R^2 = 0.541; Adj. R^2 = 0.512; F = 13.02; $p < 0.01$. All VIF values < 1.3.

Table 7. Path coefficients: Direct, indirect, and residual effects on adoption

Variable	Direct effect	Indirect effect	Sub-effect I	Sub-effect II	Sub-effect III
Age (X_1)	−3.832**	−0.620	0.376 (X_6)	0.020 (X_{14})	0.006 (X_9)
Education (X_2)	0.014NS	0.044	0.044 (X_{11})	0.026 (X_6)	0.016 (X_5)
Farm size (X_3)	1.129*	0.212	0.039 (X_7)	0.022 (X_8)	0.019 (X_{14})
Occupation (X_4)	3.599**	0.179	0.058 (X_{11})	0.049 (X_9)	0.032 (X_{14})
Annual income (X_5)	0.064NS	0.087	0.119 (X_6)	0.071 (X_2)	0.045 (X_{14})
Farming experience (X_6)	2.304**	0.098	0.008 (X_7)	0.005 (X_8)	0.003 (X_{14})
Irrigation status (X_7)	0.649NS	0.024	0.087 (X_9)	0.032 (X_{14})	0.021 (X_{12})
Livelihood diversification (X_8)	1.047NS	0.022	0.048 (X_4)	0.039 (X_{11})	0.025 (X_{14})
Social participation (X_9)	0.653*	0.458	0.176 (X_{14})	0.051 (X_{10})	0.040 (X_{12})
Mass media exposure (X_{10})	0.193NS	0.038	0.067 (X_{14})	0.037 (X_{11})	0.030 (X_9)
Extension contact (X_{11})	0.195NS	0.151	0.058 (X_{14})	0.055 (X_4)	0.033 (X_9)
Economic motivation (X_{12})	0.255NS	0.034	0.031 (X_{14})	0.030 (X_9)	0.025 (X_6)
Risk orientation (X_{13})	0.028NS	0.224	0.140 (X_{14})	0.050 (X_9)	0.040 (X_2)
Innovativeness (X_{14})	0.788**	0.058	0.036 (X_9)	0.035 (X_4)	0.028 (X_{11})

Note: *p < 0.05; **p < 0.01; NS = Non-Significant. Highest direct effect: Innovativeness (X_{14}). Highest indirect effect: Social participation (X_9).

farming experience (X_6), social participation (X_9) and farm size (X_3) were selected by stepwise regression to explain 54.1% of variance in adoption (Adjusted R^2 = 0.512, and F = 13.02, $p < 0.01$). All the Variance Inflation Factor (VIF) values were less than 1.3 and thus no multicollinearity was found.

The path analysis (Table 7) showed that the variable with the greatest direct effect on the adoption of technologies was innovativeness (X_{14}; 0.788), while the top indirect effect was provided by social participation (X_9; 0.458), followed by innovativeness (X_{14}; 0.176), and economic motivation (X_{12}; 0.040). Farming experience (X_6) and occupation (X_4) also had significantly direct effects. To capture the variance in adoption account for by factors not included in the model, the residual path coefficient was 0.641, which represented about 41% of the variance in adoption.

DISCUSSION

The foregoing shows that there was a positive contribution to technology adoption through structured extension support provided under the NICRA programme, as the higher adoption of Climate Resilient Technologies (CRTs) by intervention farmers (Oraon et al., 2020; Meena et al., 2023). Crop residue incorporation and soil testing rates are on the rise, aligning with the soil health management guidelines recommended by the National Food Security Mission (Government of India, 2023). The same results were found by Nyasimi et al. (2017) who found that extension-based interventions increased NRM adoption by smallholders.

The fact that intervention farmers have also accepted the use of drought-tolerant varieties of rice also attests the success of demonstration-based varietal promotion from KVK Jharsuguda. In Odisha, improved varieties like Sahabhagi Dhan, Swarna Sub-1 and other drought stress tolerant varieties have recorded better yield performance during drought (Directorate of Agriculture, Government of Odisha, 2023; Odisha Economic Survey, 2023-24). Crop insurance enrolment, custom hiring centres etc. further reinforced the uptake of technologies, as noted by Pabba et al. (2022) and Sodhi et al. (2023). The economic analysis showed that the annual farm income of the CRT adopters was relatively high, and a significant portion of intervention farmers fell in the Rs. 2.40 lakh income bracket, which suggests a gradual shift towards diversification and enhancing livelihood stability (Odisha Economic Survey, 2023–24). The same positive gains in income are found in Assam and Rajasthan, thanks to climate-resilient practices (Sultana et al., 2020; Kalash et al., 2023; Yadav & Ghosh, 2034).

Socio-psychological variables identified, as the strongest predictor of adoption was the innovativeness which is in accordance with Rogers' (2003) Diffusion of Innovations theory. Direct and indirect effects were estimated through path analysis by decomposing standardised regression coefficients; indirect effects were computed as the product of standardised path coefficients along each causal pathway (Das et al., 2020).Innovativeness is linked to information-seeking behaviour and risk tolerance (Rogers, 2003); age is associated with cognitive inertia and physical constraints; social participation enhances adoption indirectly through peer learning and confidence-building. However, occupation had a positive effect on adoption, while age had a negative effect, suggesting that the farmers' age is associated with lower adoption rates (Harikrishna & Naberia, 2021; Bodsa & Chavda, 2024). No significant direct effects were found for education, farming experience and mass media exposure, indicating that passive access to information is not sufficient for adoption. Jena et al. (2023) have found that demonstration-based and personalised extension methods are effective in increasing the awareness of farmers and users, whereas using the media alone is ineffective. Increased innovativeness and economic motivation due to social participation contributed to indirect impact on adoption, suggesting the importance of farmer groups and local institutions in promoting peer learning and technology acceptance (Nyasimi et al., 2017; Kakoti et al., 2026). Other unexplained variations imply that other factors, including market access, credit availability, and input supply systems, also have an impact on adoption behaviour and need to be explored further (Naik et al., 2025a; Rahmawati et al., 2026).

CONCLUSION

The study revealed significant positive effects of structured exposure to climate-resilient technologies on both adoption behaviour and annual income of smallholder rice farmers in the Western Central Table Zone of Odisha. The strongest direct influences were found for innovativeness, while the strongest indirect influences were found for social participation and its association with innovativeness. The results underline the importance of participatory and farmer-to-farmer and community-based extension, instead of the more traditional passive dissemination. The policy recommendations are covering more farmers under crop insurance schemes, improving custom hiring centres, setting up of village level weather stations connected with mobile advisory services and integration of climate literacy aspects in the training at Krishi Vigyan Kendra. Building the capacity of farmer producer organisations and self-help groups can further contribute to social inclusion, climate resilience and livelihood security of smallholder rice farming households in Odisha.

DECLARATIONS

Ethics approval and informed consent: Informed consent was obtained from all farmer respondents participating in the study during the course of the research. The study was conducted in accordance with ethical research standards and with the voluntary participation of the respondents.

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REFERENCES

Bodsa, D. M., & Chavda, V. N. (2024). Climate change impact on socio-economic constraints faced by respondents for adoption of climate-resilient technologies in Amreli and Rajkot district. *International Journal of Innovative Research and Advanced Studies, 11*(9), 15–18.

Das, U., Ansari, M. A., & Ghosh, S. (2020). Does climate knowledge act as a shield for farm livelihoods? Empirical analysis from the coastal and non-coastal ecosystems of India. *Theoretical and Applied Climatology, 150*(3–4), 1627–1642. https://doi.org/10.1007/s00704-020-03141-9

Directorate of Agriculture, Government of Odisha. (2023). *Season and crop report 2022–23.* Department of Agriculture and Farmers' Empowerment, Government of Odisha.

Government of India. (2023). *National Food Security Mission: Annual report 2022–23.* Ministry of Agriculture and Farmers' Welfare.

Harikrishna, Y. V., & Naberia, S. (2021). Adoption of climate resilient technologies by farmers. *Gujarat Journal of Extension Education, 32*(1), 49–52.

Intergovernmental Panel on Climate Change. (2021). *Climate change 2021: The physical science basis.* Cambridge University Press. https://doi.org/10.1017/9781009157896

Jena, P. R., Tanti, P. C., & Maharjan, K. L. (2023). Determinants of adoption of climate resilient practices and their impact on yield and household income. *Journal of Agriculture and Food Research, 14,* 100736. https://doi.org/10.1016/j.jafr.2023.100736

Kakoti, D., Gogoi, M., Boro, Y. K., Buragohain, P. P., & Debnath, A. (2026). Assessment of impact, vulnerability, and farm households' adaptation in the context of climate change: A study on six agro-climatic zones of Assam, India. *Agricultural & Rural Studies, 4*(1), 14. https://doi.org/10.59978/ar04010002

Kalash, P., Kachhawaha, S., Rathore, B. S., Meghwal, R. R., & Kumar, M. (2023). Impact of climate resilient technological interventions in Jodhpur district of Rajasthan. *Indian Journal of Extension Education, 59*(2), 26–29.

Lenka, S. (2023). Impact of NICRA project on knowledge, skill, and attitude (KSA) of farmers on climate resilient agro-technologies in Odisha. *International Journal of Bio-Resource and Stress Management, 14*(1), 132–136.

Mansingh, A., Kujur, M., Sahoo, S., Rath, L. P., & Ikka, N. J. (2024). Monitoring land use land cover transformations and effects on land surface temperature in Jharsuguda District, Odisha. *Environment and Conservation, 30*(Suppl.), S219–S226. http://doi.org/10.53550/EEC.2023.v30i01s.045

Meena, D. C., Kumari, M., Kishore, P., Bangararaja, S. V., & Bishnai, R. (2023). Do Socio-economic Conditions and Personal Behaviour Influence the Adoption of Climate Change Mitigating Measures. *Indian Journal of Extension Education, 59*(2), 22-25. http://doi.org/10.48165/IJEE.2023.59205

Naik, A., Das, K. S., Mohanty, P., Naik, A. Y., & Kumar, V. (2025a). Transforming smallholder livelihoods: A case study on integrated farm planning in Subalaya village, Sundargarh district, Odisha. *International Journal of Agriculture Extension and Social Development, 8*(Special Issue 2), 1–6.

Naik, A., Dash, S. R., Das, K. S., Sahoo, S. K., & Baral, P. (2025b). Empowering farmers through climate resilience: A socio-economic study of farmers under the NICRA project in Jharsuguda district of Odisha, India. *International Journal of Environment and Climate Change, 15*(3), 464–480.

Naik, B. M., Singh, A. K., Roy, H., & Maji, S. (2023). Assessing adoption of climate resilient agricultural technologies by farmers of Telangana State. *Indian Journal of Extension Education, 59*(1), 81–85.

National Innovations on Climate Resilient Agriculture. (2021). *Annual report 2021–22.* ICAR-ATARI, Kolkata.

Nyasimi, M., Kimeli, P., Sayula, G., Radeny, M., Kinyangi, J., & Mungai, C. (2017). Adoption and dissemination pathways for climate-smart agriculture technologies for climate-resilient livelihoods in Lushoto, Northeast Tanzania. *Climate, 5*(3), 63. https://doi.org/10.3390/cli5030063

Odisha Economic Survey. (2023–24). *Odisha economic survey 2023–24*. Planning and Convergence Department, Government of Odisha.

Oraon, D., Kumar, A., Singh, R. K., Singh, U. K., & Alam, Z. (2020). Adoption level of soil and water conservation technology under NICRA in Chatra District in Jharkhand. *Indian Journal of Extension Education, 56*(2), 35-38.

Pabba, A. S., Naik, R. V., & Sudharani, V. (2022). Adoption of climate resilient agricultural technologies by farmers in Nalgonda district of Telangana State. *Indian Journal of Extension Education, 58*(2), 30–34.

Rahmawati, N., Anindita, C., Rozaki, Z., & Triyono. (2026). The welfare level of rice farmers in the Bengawan Solo Watershed, Indonesia. *Agricultural & Rural Studies, 4*(1), 17. https://doi.org/10.59978/ar04010001

Rao, C. S., Gopinath, K. A., Prasad, J. V. N. S., & Singh, A. K. (2016). Climate resilient villages for sustainable food security in tropical India: Concept, process, technologies, institutions, and impacts. *Advances in Agronomy, 140*, 101–214.

Reddy, M. P. S., Nair, J. G., & Somanath, G. (2025). Scale to measure farmers' perception of capacity needs under NICRA. *Indian Journal of Extension Education, 16*(4), 176-179. https://doi.org/10.48165/IJEE.2025.614RT04

Rogers, E. M. (2003). *Diffusion of innovations* (5th ed.). Free Press.

Sarkar, S., Padaria, R. N., Das, N., Das, B., Biswas, G., Roy, D., & Sarkar, A. (2022). Conceptualizing and validating a framework of climate smart village in flood affected ecosystem of West Bengal. *Indian Journal of Extension Education, 58*(2), 1-7. http://doi.org/10.48165/IJEE.2022.58201

Shanabhoga, M. B., Krishnamurthy, B., Suresh, S. V., Deehamna, S., & Kumar, R. V. (2023). Climate change adoption constraints among paddy growing farmers in Karnataka State. *Indian Journal of Extension Education, 59*(2), 124–127.

Sodhi, G. P. S., Singh, P. K., Dhillon, G. S., Ahuja, S., Kaur, A., Kaur, T., Murai, A. S., Singh, R., & Kaur, S. (2023). Adoption behavior of climate-smart agriculture practices in Punjab under NICRA. *Indian Journal of Extension Education, 59*(2), 46–50.

Sultana, S., Das, P. K., Saikia, D., & Barman, I. (2020). Impact of NICRA project on farm income and productivity of participant farmers in Assam. *Current Journal of Applied Science and Technology, 39*(11), 38–42.

The Hindu. (2021, July 14). India suffered an income loss of $159 billion in key sectors due to extreme heat. *The Hindu.*

Yadav, P. K., & Ghosh, S. (2023). Effectiveness of adaptation mechanisms of farmers in flood prone area of Bihar. *Indian Journal of Extension Education, 59*(3), 32-37. http://doi.org/10.48165/IJEE.2023.59306