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Prediction of the Key Determinants of Climate-Resilient Technology Adoption: A Case study of Odisha

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Abstract

Climate change, poverty, and inequality are the major issues of developing countries. Climate change threatens rural livelihoods by adversely affecting crop yields. Developing countries are the most vulnerable to climate change due to their lack of adaptive capacity. Climate-smart agricultural (CSA) practices are advanced as a possible solution. However, resource-poor farmers often face financial constraints to adopt practices that could sustainably increase their crop yields. The current paper using a structured questionnaire survey among the farming households of an Eastern Indian state, namely, Odisha, explores the key determinants of CSA adoption. Two districts with one each from the coastal and the inland regions of the state are chosen for the study. The majority of the respondents (95%) perceive the effects of climate change in the region. The respondents have adopted practices such as rescheduling planting (79%), crop rotation (50%), micro-irrigation (19%), and early maturity seeds (18%). Farmer's perception of climate change has been analysed to assess the knowledge of farmers on climate change. To explore the key determinants of adopting these five major practices, a probit model is estimated. Understanding the role of women farmers to upscale the CSA practices has been described qualitatively. The result shows that factors such as farmer field school participation, subsidies, access to energy use, and perception of climate shocks are the major determinants. Further, the interaction between landholding and credit availability has positively affected the decision to adopt. Government extension services have a substantial impact on various adaptation practices. Farmers' access to govt extension is more likely to do rescheduling planting by 11%, crop diversification by 14%, and crop rotation by 18%, and early maturity variety seeds by 28%. Lack of training, poor access to the market, lack of land rights to females, and resource constraints are barriers for women to adopt CSA. Region-specific policies such as farmers' field schools, subsidies on farm machinery, and resource endowments can upscale CSA adoption in the region.

Keywords: Agricultural extension, climate-smart agriculture, perception of climate change, probit model

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Introduction

Adapting to climate change in agriculture requires an integrated approach where the precise application of inputs, climate-resilient seeds, and appropriate tillage methods hold significance (Arora, 2019; Connolly-Boutin & Smit, 2016; FAO, 2011; Jena, 2019). Climate-smart agriculture (CSA) technologies have been advocated as a solution to cope with the challenges posed by climate change (FAO, 2010). The examples of some of the CSA technologies/practices are drip irrigation, rainwater harvesting, laser land levelling, crop rotation, minimum tillage of land, retaining crop residues at the plots, planting early maturing crop cultivars, drought or disease-resistant crops and cultivars, and using more organic manures. Broadly, CSA focuses on developing resilient food production systems that lead to food and income security under progressive climate change and variability (Lipper, 2014; Vermeulen et al., 2012). Agricultural extension is a vital component of climate adaptation strategy (Jena, 2021). The interaction between local extension officials and farmers creates a long-term communication network that enhances farmers' technical knowledge about CSA technologies. The existing studies on the adoption of CSA technologies have not explicitly studied the role of extension in the success of CSA adoption. While analysing the determining factors of CSA technologies, the current study explicitly discusses the role of agricultural extension. Furthermore, the role of gender in CSA adoption is vital in understanding the climate change adaptation mechanism in developing countries. A study by FAO (2011) shows that women farmers can increase productivity by 30% if they were provided with the resources similar to those that men possess. There is limited research on this aspect, which the current study seeks to redress. The major objective of the study has been to understand the motivation and constraints behind technology adoption and the extent to which institutional support like extension services and gender play a role in enhancing farm households' adoption capacity.

Data and Methodology

The current study is based on cross-sectional household survey data of 248 rural farmers in Odisha, collected during the 2019-20 production year. Multistage Stratified Sampling has been carried out to collect the samples from the state. The dependent variable has a dichotomous outcome. The dependent variable takes the value 1 if a farmer adopts the CSA practices and 0 otherwise. The probit model has been used for the analysis. The explanatory variables are both continuous and categorical in nature. The estimated model is expressed in the following equation (Greene, 2008; Bryan, et al. 2009).

$$y^* = \beta_0 + \beta X + \epsilon, \; y=1[y^*>0] \quad (1)$$

Where, y* is the adoption decision and the dependent variable, X contain the explanatory variables, β is the parameter that has to be estimated, and ϵ is the error term. y=1[y* > 0] refers to the binary outcome of the dependent variable. The coefficient, β shows the odds of an independent variable's influence on the adoption decision, however, the marginal effect provides the magnitude of the change in probability of the adoption decision (Greene, 2000; Abid et al., 2015)

Results and Discussion

Table 1 explains the independent variable's influence on the adoption decision. The marginal effect provides the magnitude of the change in probability of the adoption decision. A unit increase in the household head's age would increase the probability of crop rotation by 4%. But after the margin with relatively older farmers, a unit increase in age reduces the probability by 0.05%. A farmer having livestock has a significantly positive impact on adaption to rescheduling planting, crop diversification, and drought-resistant seeds. The farmers new to farming are more likely to use drought-resistant seeds and practice crop rotation. The farmer receiving government extension has a significantly positive effect on rescheduling planting (11%), crop diversification (14%), crop rotation (18%), and drought-resistant seeds (28%). Farmer to farmer extension services includes knowledge sharing and motivating one another. The peer effect has a significantly positive impact on the farmers' rescheduling planting. A farmer having access to media extension tends to adopt crop diversification by 17% and crop rotation by 22% more.

Subsidies on input, machinery, and fertilizers significantly impact the various adoption strategies by farmers. It has a positive effect on the adoption of crop diversification, drought-resistant seeds, and micro-irrigation. The interaction between access to credit and landholding increases the probability of adopting practices such as rescheduling planting and drought-resistant seeds. A decrease in distance to the inputs market by 1 km increases the adoption of micro-irrigation and rescheduling planting by 1%. Farmers perceiving an increase in temperature are 50% more likely to reschedule their planting. Perception of a rise in floods impacts the adoption of rescheduling planting, crop rotation, drought-resistant seeds, and micro-irrigation. Farmers that get regular updates from the regional meteorological centers are more likely to adopt modern practices.

If farmers can access multiple energy sources, they are more likely to adopt crop rotation and drought-resistant seeds. Farmers who have access to electricity are more likely to do rescheduling planting by 14%, crop diversification by 15%, and micro-irrigation by 17%. Farmers using multiple energy sources are more likely to do crop rotation by 25% and drought-resistant seeds by 23%. Membership in SHG increases the likelihood of adopting crop rotation by 10%. Membership in a cooperative society has a positive impact on the adoption of crop diversification (by 17%).

Table 1 Marginal Effect

	Rescheduling Planting	Diversified crop	Crop Rotation	Drought resistant Seeds	Micro Irrigation
Age	0.0166	0.0256	0.0520**	-0.0043	-0.0210
	(0.2872)	(0.2100)	(0.0149)	(0.7815)	(0.2248)
age2	-0.0001	-0.0002	-0.0005**	0.0001	0.0002
	(0.4351)	(0.3016)	(0.0195)	(0.4515)	(0.2276)
HH Size	-0.0028	-0.0074	0.0091	0.0058	-0.0191
	(0.8255)	(0.6308)	(0.5733)	(0.6557)	(0.1934)
Years of farming	-0.0009	-0.0016	-0.0044	-0.0084**	0.0041
	(0.7429)	(0.6032)	(0.1570)	(0.0024)	(0.1575)
Schooling	0.0066**	-0.0014	-0.0119**	0.0014	-0.0049
	(0.0803)	(0.7606)	(0.0121)	(0.7372)	(0.2161)
SHG	-0.0664	-0.0598	0.1094**	-0.0523	-0.1250**
	(0.2445)	(0.3169)	(0.0760)	(0.2563)	(0.0139)
Coop member	-0.0680	0.1732**	-0.0293	-0.1014	0.0439
	(0.2666)	(0.0062)	(0.6633)	(0.1216)	(0.4630)
Govt. Extension	0.1164**	0.1498**	0.1836**	0.2802***	0.0824
	(0.0171)	(0.0045)	(0.0020)	(0.0001)	(0.1442)
Training	0.0709	0.1452*	-0.0063	-0.0017	0.1284*
	(0.3213)	(0.0722)	(0.9398)	(0.9772)	(0.0510)
Peer Effect	0.1052*	0.0613	-0.0735	-0.0044	-0.1339*
	(0.0557)	(0.3189)	(0.2709)	(0.9300)	(0.0576)
Television	0.0282	0.1709***	0.2267***	-0.0101	0.0010
	(0.5569)	(0.0007)	(0.0001)	(0.8169)	(0.9837)
Perception of Change in Temperature					
Doesn’t know	0.0000	0.0000	0.0000	0.0000	0.0000
Constant	0.3807**	0.0312	-0.3594**	0.0431	-0.1374
	(0.0024)	(0.8099)	(0.0043)	(0.7833)	(0.2905)
Increasing	0.4980***	-0.0169	-0.3913***	-0.0814	-0.0615
	(0.0000)	(0.8877)	(0.0000)	(0.4462)	(0.5825)
Perception to decrease Rainfall					
Doesn’t Know	0.0000	0.0000	0.0000	0.0000	0.0000
No	-0.1467	-0.0846	0.1882	-0.1467	0.0272
	(0.1500)	(0.4048)	(0.1534)	(0.1447)	(0.7912)
Yes	-0.1397**	0.0264	0.1258	-0.0923	0.0430
	(0.0107)	(0.7382)	(0.1819)	(0.2881)	(0.5367)
Perception to drought	-0.0143	0.1485**	0.0422	0.0244	-0.0237
	(0.7863)	(0.0161)	(0.5434)	(0.6840)	(0.7106)
Perception to flood	0.1591*	-0.0110	0.2108**	0.1071*	0.1527**
	(0.0496)	(0.8646)	(0.0041)	(0.0903)	(0.0169)
Awareness to CC	0.1805**	-0.0365	-0.0835	-0.0331	-0.1319
	(0.0011)	(0.6295)	(0.3060)	(0.6367)	(0.0549)
Crop insurance	0.0405	-0.1480*	0.1955**	0.0689	-0.0665
	(0.4862)	(0.0139)	(0.0025)	(0.2314)	(0.2646)
Livestock Numbers	0.0170**	0.0088*	0.0084	0.0074*	0.0061
	(0.0170)	(0.0604)	(0.1704)	(0.0786)	(0.1838)
Subsidy	-0.0482	0.0963*	0.1019	0.1894***	0.1738**
	(0.3657)	(0.0787)	(0.1187)	(0.0003)	(0.0039)
DTC	-0.0221	-0.1289	-0.1300	-0.0498	-0.1152*
	(0.7586)	(0.0731)	(0.0781)	(0.3434)	(0.0849)
Drought (Shock)	0.1119**	-0.1322**	-0.0568	0.1278**	0.0572

	(0.0303)	(0.0424)	(0.3867)	(0.0148)	(0.3190)
Flood/submergence(shock)	0.0391	-0.1211*	0.0346	-0.1063*	-0.0730
	(0.4967)	(0.0673)	(0.6191)	(0.0421)	(0.2904)
Migration	-0.0202	0.0160	0.1762**	0.0968**	-0.0154
	(0.7228)	(0.7945)	(0.0077)	(0.0264)	(0.7991)
Distance to Market	-0.0205*	-0.0050	0.0054	-0.0162	-0.0268**
	(0.0538)	(0.6595)	(0.6721)	(0.1332)	(0.0091)
Balangir	0.0000	0.0000	0.0000	0.0000	0.0000
Kendrapada	0.0735	-0.1747	-0.0558	0.1805**	0.1761*
	(0.4058)	(0.1776)	(0.6186)	(0.0154)	(0.0554)
Upland	0.1127	-0.0713	0.0706	-0.1835*	-0.0031
	(0.1044)	(0.3317)	(0.3802)	(0.0325)	(0.9661)
Medium	0.0000	0.0000	0.0000	0.0000	0.0000
Lowland	0.1689**	0.0461	-0.0184	-0.1566*	-0.0114
	(0.0153)	(0.5517)	(0.8256)	(0.0633)	(0.8821)
No Energy	0.0000	0.0000	0.0000	0.0000	0.0000
Electrical	0.1431**	0.1555*	0.1531	0.0242	0.1745*
	(0.0128)	(0.0952)	(0.1183)	(0.6576)	(0.0804)
Diesel	0.0018	0.0869	0.1274	0.2686***	-0.0278
	(0.9814)	(0.3122)	(0.1334)	(0.0002)	(0.6644)
Kerosine	-0.1717*	-0.1333	-0.0979	0.0846	0.1287
	(0.0942)	(0.1307)	(0.3788)	(0.4279)	(0.1973)
Multiple	-0.0141	-0.0938	0.2529**	0.2349**	0.0572
	(0.8697)	(0.3082)	(0.0027)	(0.0079)	(0.5153)
Total area Owned	-0.0258**	-0.0070	0.0141	-0.0512**	-0.0036
	(0.0028)	(0.5018)	(0.3359)	(0.0060)	(0.7249)
Total Credit (log)	-0.0081	-0.0024	-0.0106	-0.0184*	0.0002
	(0.2781)	(0.7692)	(0.2386)	(0.0128)	(0.9806)
Interaction1	0.0025**	0.0018	0.0016	0.0048**	-0.0026
	(0.0361)	(0.1508)	(0.3238)	(0.0108)	(0.1251)
General	0.0000	0.0000	0.0000	0.0000	0.0000
OBC	0.0187	-0.0515	-0.0192	-0.0213	-0.0559
	(0.7760)	(0.4655)	(0.7953)	(0.7145)	(0.4664)
SC	-0.0692	0.0073	0.0298	-0.0040	-0.1122
	(0.4682)	(0.9428)	(0.7593)	(0.9666)	(0.1533)
ST	0.0666	-0.1308	-0.0232	-0.0689	-0.0672
	(0.4381)	(0.1284)	(0.8251)	(0.3220)	(0.4362)
N	248	248	248	248	248

p-values in parentheses
*Significant at 10% level; **Significant at 5% level; ***Significant at 1% level

Female member is generally not considered the household head due to patriarchal cultural practices typical to developing countries. The wage gap between male and female acts as an entry barrier for women in the agricultural sector. Further, physical access to the market is low among the women farmers in Odisha. From the FGDs, it is observed that 72% of male members make major decisions about farming activities; in 8% of the households, it is the female members, whereas in the remaining 20% of the households, both male and female members decide on major agricultural activities. There are some major differences in perspectives between male and female members: while the former is more inclined towards generating higher income, it is food balance and food security that the latter focus on. Women farmers from Balangir district knew about crop diversification and its likely benefits. In fact, they motivate their spouses to cultivate cotton crops along with paddy to minimize the risk of crop loss and increase the diversified income. Similarly, women farmers from Kendrapara do integrated farming. They engage in activities such as livestock rearing, fisheries, and growing horticultural crops along with paddy.

Conclusion and outlook:

The study's empirical findings reveal that the key determinants of adopting specific CSA technologies are: household attributes, access to extension service, training, livestock ownership, agricultural subsidies, awareness of climate change, and agricultural infrastructure. We observe that most adopters are beneficiaries of the public-funded agricultural programmes that provide subsidies in the form of direct cash transfer and subsidized inputs. the access to agricultural extension variable measures the number of times that a respondent had interacted with the extension officers. The higher the number of interactions, the more likely the adoption of CSA practices. Gender plays an important role in household decision making. Although there exist several bottlenecks for women farmers in developing countries, the FGD findings show that women farmers take a keen interest in technology adoption. In the households where decision making is done by both male and female members, the adoption probability is higher. Based on these findings, it can be concluded that government support in terms of extension services and subsidies are vital components of the climate change adaptation strategy of rural farming households. To foster the adoption mission among resource-poor farmers, government support may be necessary for the short run, but there should be more bottom-up efforts from the grassroots level to sustain a climate-smart agricultural system.

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