Adoption of Climate-Smart Technologies in Agriculture: Evidence from an Eastern Indian State

by Purna Chandra Tanti and Dr. Pradyot Ranjan Jena

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Abstract:

Climate change threatens rural livelihoods by adversely affecting crop yields. However, resource-poor farmers often face financial constraints to adopt practices that could sustainably increase their crop yields. Climate-smart agricultural (CSA) practices are advanced as a possible solution. 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 [2]adopted practices such as rescheduling planting (79%), crop rotation (50%), micro-irrigation (19%), and early maturity seeds (18%). A Probit model is estimated to explore the key determinants of the adoption of these five major practices. The result shows that factors such as government extension service, 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. Region-specific policies such as farmers' field schools, subsidies on farm machinery, and resource endowments can upscale CSA adoption in the region.

Keywords: Climate Smart Agriculture, Agricultural Extension, Perception of climate change, Probit model, Odisha

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1. Introduction

The anthropogenic emission of greenhouse gases is alarmingly rising, causing a widespread impact on human and natural systems (IPCC, 2014). According to the IPCC report 2014, the global surface temperature will rise by 2.5^{0} C at the end of the 21st century, which may cause extreme events, including a decrease in cold temperature extremes, rise in the warm temperature extremes, changes in the extreme of high sea level and change in the precipitation extremes in several regions(Calzadilla et al., 2013; IPCC, 2014; Karki et al., 2020). Several studies have established that developing countries are the most vulnerable to climate change due to their lack of adaptive capacity (Mertz et al., 2009; Taraz, 2017). Sub-Saharan Africa and South Asia are the most vulnerable regions to climate change among the developing countries (Banerjee et al., 2013; Eckstein et al., 2020). According to the Global Climate Risk Index (CRI), India is ranked seventh in climate vulnerability (Swami & Parthasarathy, 2021). Climate change effects are continuously threatening many agricultural systems, and studies have confirmed it. A comparable magnitude increase in temperature may have caused a reduction in yield of 5–7 per cent in the eastern and western regions, 8 per cent in the western regions and 17 per cent in Southern India (Kalli & Jena, 2020; Mendelsohn, 2000).

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; Jena & Majhi, 2021.). Climate-smart agriculture (CSA) technologies have been advocated as a solution for the challenges posed by climate change (FAO, 2010). 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).

Adaptation to climate change is highly region-specific as it depends on the target region's climatic, environmental, socio-economic, and political conditions. Smallholder farming households need both technical know-how and financial support to consistently follow the new technologies. Studies have shown that capacity building at a micro-level can trigger farmers' adaptation efforts and considerably improve their ability to engage in adaptation action (Khatri-Chhetri et al., 2017). (Bhatta et al., 2016) show that better financial inclusion and access to formal financial systems are necessary to increase households' overall adaptive capacity.

One of the biggest constraints about CSA technology adoption for the resource-poor smallholder farmers in the developing countries apart from financial and technical support is the awareness and knowledge about CSA. Farming households typically have a short time horizon meaning that they value the short-term gains more than longer-term gains. Some of the benefits from CSA, like soil quality improvement and reduction of GHG gas emission, require a longer time horizon. Farmers 'perceived risk about climate change induces them to take action. Several studies have found that farmers having indigenous knowledge perceive climate change accurately and argue that adaptation policy should be designed based on the conditions prevailing at the regional or local level for its better implementation(A. S. Singh et al., 2020; C. Singh et al., 2016; Srivastava et al., 2017; Tripathi & Mishra, 2017).

Agricultural extension is a vital component of climate adaptation strategy. The interaction between local extension officials and farmers creates a long-term communication network that enhances farmers' technical knowledge regarding CSA technologies. The existing studies on the adoption of CSA technologies have not explicitly studied the role of extension in CSA adoption's success. While analysing the determining factors of CSA technologies, the current study explicitly discusses the role of agricultural extension.

The study is based on a primary questionnaire survey conducted among the farm households of an Eastern Indian state, namely Odisha. The state is selected for analyzing the perception of farming households regarding climate change and its likely impact on their livelihood. Further, the study aims to understand the prevailing practices of climate change adaptation in agriculture and to quantitatively estimate the key factors that influence the adoption behaviour of farming households in the state. Being a climatically vulnerable region, Odisha faces frequent bout of flood and drought, especially the coastal districts of the state face flood on a yearly basis, and the in-land districts face droughts. The current paper purposively selects a district from the coastal and inland regions to understand the farmers' perception and agricultural technology adoption behaviour. The questionnaire used for the study is an extensive instrument having sections of demographic characteristics; landholding and cropping patterns of the households; perception about different climate events; adoption of soil, water, fertilizer, and farm machinery; access to credit and institutional support such as extension service; household incomes from different sources; and intra-household gender perspectives. The major objective of the study has been to understand the motivation and constraints behind technology adoption and to what extent institutional support plays a role to enhance farm households' adoption capacity.

2. Materials and Methods:

This section covers the study area, survey design, dependent and independent variables, econometrics method used in the study.

2.1 Study Area

The present study has covered two districts of Odisha, namely Balangir and Kendrapara. The state has a wide heterogeneity in its climate. Drought, flood, and cyclones are recurrent calamities that have devastated the core of the state economy for decades. Balangir district is one of the most vulnerable districts to drought in the state(Sahoo & Bhaskaran, 2018). Further, the east coast of Odisha has experienced the highest number of cyclones (6 cyclones in the last two decades) compared to some of the other coastal states of the country, namely, West Bengal. Tamandu and Andhra Pradesh (Maharjan, 2018; Sam et al., 2020).

2.1.1 Balangir District

Balangir district is situated in the western part of Odisha. Geographically the district lies between 82^{o} 41' to 83^{o} 42’ East longitudes and between 20^{o} 9' to 21^{o} 05’ North latitude. This district is located under the western central tableland agro-climatic zone. The climate of the area is hot and sub-humid (Sam et al., 2020). The district has faced more than thirteen times drought in the last three decades, making the district into a hotspot of lack (Below et al., 2012). In the last five years, the district had three times drought. The district's irrigation area is negligible; the district has only 10.9% irrigation covered area during Kharif season and 5% during Rabi season. The district is mainly dependent upon rainfed agriculture. The drought is inducing the farmers to do interstate and intrastate migration. The major crops grown in the region are paddy, cotton, pulses, and oilseeds. Farmers grow potatoes, onion, and vegetables as significant horticulture crops.

2.1.2 Kendrapara District:

Kendrapara district is on the coast of the Bay of Bengal, an area of 2644 km. The district is generally hot with high humidity. It comes under the east and south-eastern coastal plain zone. The district has 77% of the rainfed area and 23% of irrigated area. The major crops cultivated in the districts are paddy, green gram, black gram, groundnut, jute, and sunflower. Farmers also grow vegetables and fruits as a horticultural crop. The district has been graded as a high-risk zone for sea erosion, salination of soil, and flood in disaster occurrence.

2.2 Survey Design The current study is based on cross-sectional household survey data of 248

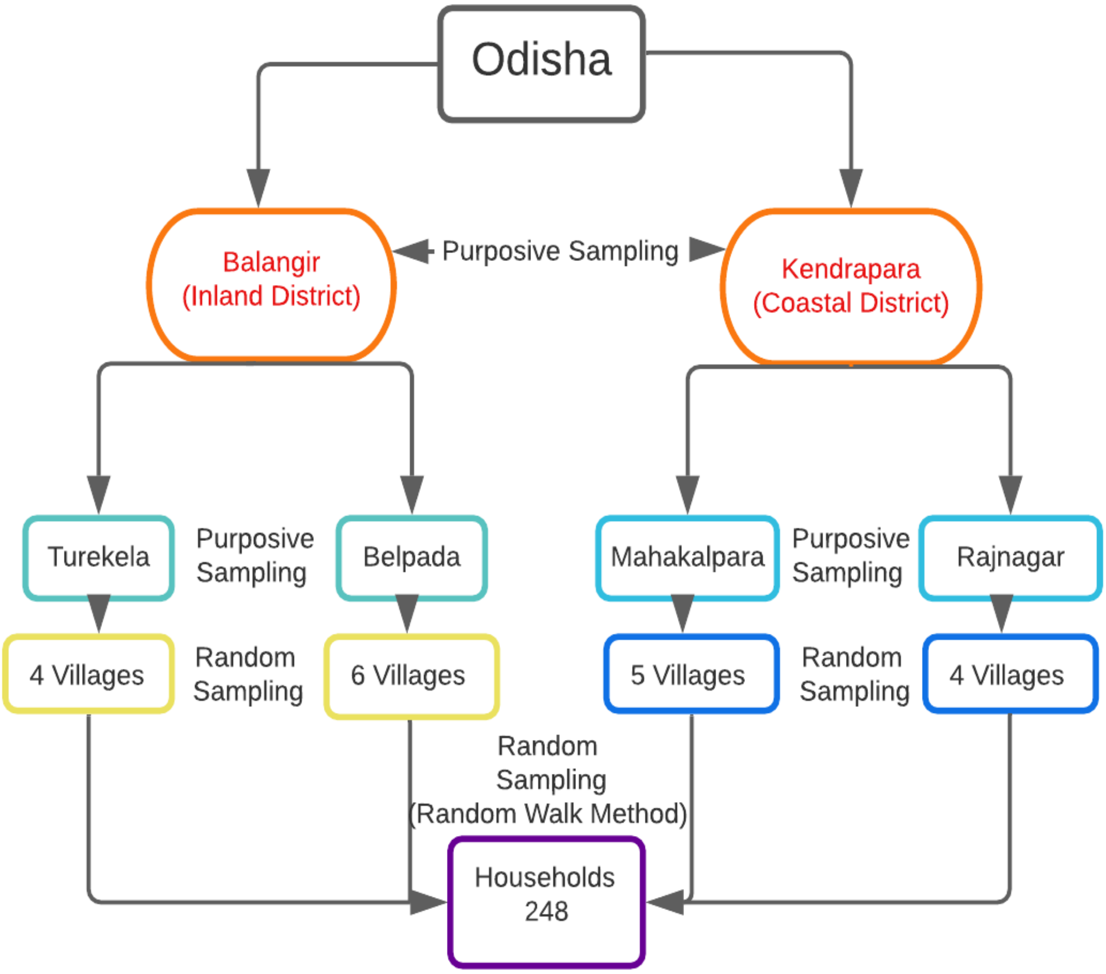


Figure 1 Sampling Design

(Source: Authors own Creation)

rural farmers collected during the 2019-20 production year in Odisha. The Multistage Stratified sampling has been carried out to collect the samples from the state. After a comprehensive discussion with the state agricultural officer, we selected two vulnerable climatic districts: Balangir and Kendrapara. In the third stage of sampling, four blocks have been chosen from each district by looking at the vulnerability level. Villages are randomly selected using the constant population proportion factor in the fourth stage of sampling. Finally, the households within the selected villages are chosen by following a random walk method. The primary survey is administered with a structured questionnaire. The questionnaire comprises a wide range of household farm characteristics, the household's income, primary and secondary occupation of the household head, cropping pattern and production, various government extension services, and various climate-smart agriculture adaptation strategies. The interview was administered in the local language for a better understanding of the farmers. Focus Group Discussion was carried out to gather in-depth knowledge of the study area and gender role of adaption to agriculture. Interviews were organized with various stakeholders of the government organization, head of the village, and panchayat

2.3 Analytical and Econometrics Model:

In this study, the dependent variable has a dichotomous outcome. The dummy dependent variable responded with one of the farmers adopting adaptation practices in response to climate change and 0 otherwise. The probit model has been used for the analysis. The basic difference between the probit and logit model is in the assumption of the distribution of the error term ε, the error term in the logit model assumed to have standard logistic distribution, and the error term in the probit model believed to have a standard normal distribution. Economists are more likely to use the probit model due to the normality assumption of the error term. (Bryan et al., 2009; Wooldridge, 2010). The explanatory variables are both dummies and continue in nature.

Two specifications of the model have used in the study. The first specification is the quadratic form of the independent variable. The quadratic form of age has been used in the model to know the impact of age square on the dependent variables. In the second model, both the quadratic independent variable and interaction between total landholdings and total credit has used. The probit model is expressed in the following equation (Greene 2008, Bryan et al. 2008)

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

Here y* = dependent variable, explanatory variable is defined by X, β is the parameter that has to be estimated, ϵ is the error term. y=1[y*>0] is refers to the binary outcome of the dependent variable. The estimated parameters (β) of the probit model only give the independent variables' direction on the binary dependent variable and statistically significant direction with independent variables like Ordinary Least Square coefficients. A positive coefficient (β) shows an increase in the independent variable's coefficient likely to increase the adoption that Y=1(Adoption of particular adaptation strategy in our case). But this coefficient fails to express how much the probability of household adopting a specific adaptation (y=1) will change if a change in the explanatory variable (X) (Abid et al., 2015b) So, logit/Probit models fail to show the magnitude of the effect of change in explanatory variable x on probability (y=1). So, to interpret the result in a better way, we need to calculate the marginal effect. The marginal effect describes a unit change in the independent variable on the probability of change of a dependent variable. The following two-equation gives the marginal effect of a variable (Greene, 2000).

$$\frac{dp(y=1)}{dx_J} = \emptyset(\beta_X) + \beta_J \quad (2)$$

The marginal effect of the j[th] continues variable, where $\emptyset$ is a cumulative normal density function.

The marginal effect for a binary variable model can be written as equation (3)

$$\Delta P(y = 1) = \emptyset(\beta_1) - \emptyset(\beta_0) \quad (3)$$

Bootstrap sampling has been used before doing the probit model. The bootstrap sample is a procedure to resample the small size samples where large numbers of smaller samples of the same size are repeatedly drawn with replacement from a single original sample. The bootstrap uses the data and computer power to estimate that unknown sampling distribution.

2.4 Conceptual Framework: The study carries out the empirical analysis following a conceptual framework developed by us in selected previous studies. The conceptual framework shows the factor that influences the adaptation of CSA practises. The explanatory variables have been classified into five categories such as household attributes, economic, social, institutional and climatic shock. These factors directly or indirectly affect the adaptation among the local farmers. The conceptual framework is also derived from (IPCC,2001) which describes

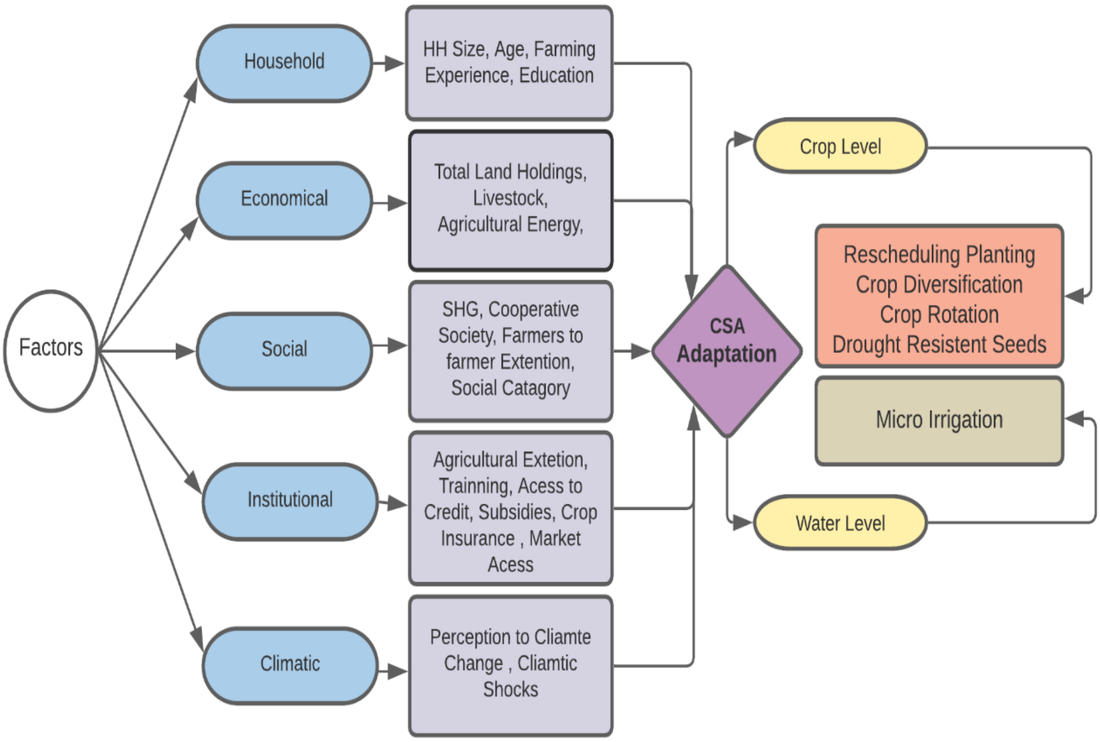


Figure 2 Conceptual Framework,

(Source: Authors Own Creation)

adaption at the individual, community, and institutional levels. The process of adaptation is different at different level(Swami & Parthasarathy, 2020). The institutional level adaptation depends on effective policy implementation and the relationship between the government and the farmers. Household-level adaption depends upon the physical and economic infrastructure and awareness of the community. The individual or household level adaption is associated with the household attributes such as age, sex, education, years of farming, household size. The economic factors associated with total land holdings, livestock and other assets. The membership in social groups and cooperatives also has an impact on adaptation. The household associated with a different organization, institution and their services also determine the individual adaptation. The local climatic conditions, perception of the farmer towards the climate change and experienced natural shocks impact the local adaptation. The integration of individual attributes and institutional factors magnifies the adaptive capacity of an individual farmer.

2.5 Description of the Adaptations Strategies:

The dependent variables have been chosen by following the literature (FAO, 2010; 2011; McCarthy et al., 2011), observing the farms' preference for agricultural practices and discussing with the agriculture extension officers. Farmers prefer Climate-smart practices to combat the climate change issues in the study area. The description of the dependent variables or climate-smart adaptation strategies has been incorporated in Table 1. The respondents have adopted practices such as rescheduling planting (79%), crop rotation (50%), micro-irrigation (19%), and early maturity seeds (18%).

Table 1: Description of the Adaptations Strategies or Dependent Variables:

Adaptation Strategies	Description
Rescheduling Planting	Rescheduling planting is changing the date of planting to avoid the delayed onset and irregular monsoon. Earlier in Odisha, farmers used to plant Kharif crop in early June, but gradually they have rescheduled planting to July due to lack of onset monsoon.
Crop Diversification	Farmers do multiple crops in a field to maintain the nutrition level of the soil and increases productivity. It increases income and reduces poverty. Crop diversification helps to reduce the risk of a single crop. In the study region, farmers do cotton crop, oilseeds, sugarcane, horticultural crop, and livestock production, including fisheries with the main crop.
Drought Resistant Seeds	Farmers use drought-resistant seeds and an early maturity variety of seeds to avoid water stress conditions. Early maturity varieties seeds are also known as short-duration paddy varieties.
Crop Rotation	Crop rotation is to grow a series of crops in the same land. Farmers grow Paddy and Cotton in Kharif Season, Vegetables in the Winter season, and Pulses in Rabi Season.
Micro Irrigation	Micro Irrigation is a Climate-smart irrigation system where water is irrigated through drippers, sprinklers, forgers, and other emitters on the land's surface or subsurface. Two prime micro-irrigation system drip and sprinkle have been taken for the study.

Source: Authors Own Creation

2.6 Description of Explanatory Variables

Following Fig. 2, the outcome and explanatory variables are constructed and given in Table 2.

Table 2 Explanatory Variables

	Explanatory Variables	Sources
Household Attributes	Age of the Household Head, Education of the Household Head, Years of Farming, Household Size, Social Category	(Abid et al., 2015a; Bryan et al., 2009; Tripathi & Mishra, 2017b; Yang-jie et al., 2014)
Economic Factors	Total Landholdings, livestock, migration. Access energy for irrigation	(Jain et al., 2015; Khanal et al., 2018)
Social Capital	NGO Extension, membership in Self Help Group, membership in Cooperative Society, Farmers to farmer extensions	(Burnham & Ma, 2017; Dang et al., 2019; Islam & Nursey-Bray, 2017; Paudel et al., 2020; Swami et al., 2020)
Institutional	Govt. Extension, Training, TV and Media, Access to credit, Access to subsidy, Direct transfer of cash, Distance to input market, Crop Insurance	(Azadi et al., 2019; Bryan et al., 2013a; Khanal et al., 2018a; Jena, 2021)
Climatic Factors	Climate is changing; Temperature is increasing, Rainfall is decreasing, drought and flood is increasing Experienced drought and flood in last five years	(Carlton et al., 2016; Swami & Parthasarathy, 2020; Zheng & Dallimer, 2016) (Aryal, Sapkota, Khurana, et al., 2020; Funk et al., 2020; Hirpha et al., 2020)

Source: Authors Own Creation

3. Descriptive Results:

3.1 Socio-Demographic Characteristics:

Table 1 shows the socio-economic characteristics of the sample household. The average age of interviewed farmers was 51 years. The youngest farmer in the sample is 23 years old, and the farmer's highest age is 82 years old. It shows that there is a wide distribution of age groups among farmers. The major group is between 40 to 65 years old are actively engaged in agriculture. We didn't find the women head farmers in our random sample. The small sample size or the proportion of female head farmers are less in the study area. The average family size in the study region is approximately five members. Farmers have an average of 24 years of farming experience. The surveyed household keep, on average, 2 to 3 livestock. Few farmers do not have livestock, and the maximum numbers of livestock are 46 in a family. The farmers' average landholding is 3.63 acres, where the minimum land holdings are 0 acres, and the maximum is 20 acres—the farmers who do not have their land take a lease from other farmers. The average size of the leased land is 2-3 acres. The land's topography shows that 43% of the farmland is upland, where farmers barely get irrigation facilities. Farmers have 18% of medium land and 39% of low land.

There is heterogeneity in farmers' social category; 29% are from the General category,44% are from Other Backward Caste categories,7% fare from Scheduled Caste, and 18% are from Scheduled Tribe. The average years of schooling of the household head are seven years shows that the average level of education is upper primary among the region's farmers.

When asked about access to the extension services, 56% of farmers have responded in affirmation. The allied department of state agriculture provides regular training to the farmers. In this sample, 15 % of farmers get training. KVK (*Krishi Vigyan Kendra*), AATMA (*Agricultural Technology Management Agency*), and NGOs provide Odisha farmers training.

These agencies control and manage different extension services at the district level. Farmers do collaborative and participatory farming in Odisha. The peer and neighbour activities and information influence the other farmer. The percentage of farmers who follow their peers and neighbours is 27%. Farmers use different media to access information; 40% of farmers watch television to get information on agricultural activities.

The government promotes *Pradhan Mantri Phasal Bima Yojana* (PMPBY*)* to get compensation if farmers lost their crops due to natural shocks. Farmers are having crop insurance are 39% of the sample. Subsidies have been given to 35% of the farmers in the form of seed, fertilizer, and farm machinery by the government. Farmers get on an average 47000 rupees loan from the Public bank, cooperatives and Private banks. The average distance to the input markets from home is 4-5 K.M. The minimum distance is 1 K.M., and the Maximum distance is 10 K.M. The farmer who has a maximum distance of 10 K.M. faces difficulties in marketing and transportation. 42% of farmers do not use any sources of energy for their agricultural operation. 23% use electricity,14 % diesel and 11% use multiple sources of energy.

3.2 Perceptions of climate change and Climatic Shocks:

The survey data shows that many farmers perceive climate change from their last 15 years of experience. 95% of farmers perceive that climate is changing in their area. Only 2% of farmers believe there are no changes, and 3% do not know about climate Variability. 85% of farmers noted that Temperature is increasing over the year, and 75% of farmers believe rainfall decreases. Since the survey area is drought and flood-prone districts, 79% of farmers perceive an increase in the frequency of drought in their region, and 47% of farmers perceive that flood frequently occurs. 96% of farmers reported on the change in the timing of monsoon rainfall. 77% of farmers get regular updates on weather report and information on Climate Change.

Table 3 Descriptive Statistics

Variables		Mean	Std. Dev.	Min	Max
Dependent Variables	If adopted=1, 0 otherwise				
Rescheduling Planting		0.782	0.414	0	1
Crop Diversification		0.355	0.479	0	1
Crop Rotation		0.565	0.497	0	1
Drought Resistant Seeds		0.169	0.376	0	1
Micro Irrigation		0.173	0.379	0	1
Independent Variables					
Age	Continues: in year	51.19	10.367	23	82
HH Size	Continues: in number	4.948	1.664	2	11
Years of farming	Continues: in numbers	24.242	11.098	2	50
Years of Schooling	Continues: in numbers	7.806	5.517	0	17
SHG	Binary: 1 If farmer is member of SHG ,0 otherwise	0.665	0.473	0	1
Coop member	Binary	0.415	0.494	0	1
Govt. Extn.	Binary	0.565	0.497	0	1
Training	Binary	0.153	0.361	0	1
Neighbor	Binary	0.27	0.445	0	1
Television	Binary	0.403	0.492	0	1
Perception to increase Temperature					
Doesn’t know	Binary	0.077	0.267	0	1
Constant	Binary	0.069	0.253	0	1
Increasing	Binary	0.855	0.353	0	1
Perception to decrease in Rainfall.					
Doesn’t Know	Binary	0.181	0.386	0	1
No	Binary	0.06	0.239	0	1
Yes	Binary	0.758	0.429	0	1
Perception to Increase drought	Binary	0.512	0.501	0	1
Perception to Increase flood	Binary	0.242	0.429	0	1
Gets climate change Information	Binary	0.774	0.419	0	1
Crop Insurance	Binary	0.399	0.491	0	1
Livestock Numbers	Continues: number of Livestock	2.698	4.579	0	46
Machinery Subsidy	Binary	0.351	0.478	0	1
Direct Transfer of Cash	Binary	0.234	0.424	0	1
Drought Shock	Binary	0.431	0.496	0	1
Flood /Submergence shock	Binary	0.355	0.479	0	1
Migration	Binary	0.25	0.434	0	1
Distance to Market	Continues Distance in K.M.	4.653	2.689	1	10
Districts		.	.	.	.
Balangir	Binary	0.435	0.497	0	1
Kendrapada	Binary	0.565	0.497	0	1
Topography		.	.	.	.
Upland	Binary	0.431	0.496	0	1
Medium	Binary	0.181	0.386	0	1
Lowland	Binary	0.387	0.488	0	1
Sources of Energy				.	.
No Energy	Binary	0.423	0.495	0	1
Electrical	Binary	0.234	0.424	0	1
Diesel	Binary	0.149	0.357	0	1
Kerosine	Binary	0.077	0.267	0	1
Multiple	Binary	0.117	0.322	0	1
Total area Owned	Continues: in acre	3.635	3.527	0	20
Total Credit (Log)	Continues: in Rupee’s	47662.9	106024	0	62200
Caste			.	.	.
General	Binary	0.294	0.457	0	1
OBC	Binary	0.448	0.498	0	1
SC	Binary	0.077	0.267	0	1
ST	Binary	0.181	0.386	0	1
		Total Sample 248			

Shock in the last five years, 43% of farmers have experienced drought, and 35% of farmers have experienced flood and submergence.

3.3 Difference between Adopters and Non-Adopters:

The Kernel density graph 3.1 to 3.25 showed the difference between adopter and non-adopters by their age, education level, total land holdings, primary income, and total production. This density plot visualizes the distribution of data over a continuous interval or period. This KD graphs plot values by smoothing out the noise. The peaks of the Density Plot help to know where the values are concentrated over the interval. The overlap regions show the common characteristics between the adopters and non-adopters. The older farmers are adopters of rescheduling planting and micro-irrigation. The other three adaptions (crop diversification, crop rotation, and drought-resistant seeds) have the density of adopters on the left it means the adopters are younger. The majority of the adopters lies the age of 35 to 65years. There are two peaks of education distribution among adopters and non-adopters. One height is around class 5th, and another is around class 10th. Farmers get updates on climate variability by text messages and short voice calls. As climatic distribution of Landholdings of adopters is rightly skewed refers to the size of their landholding is more than non-adopters. The primary income is rightly skewed for adopters, showing that adopters have a higher income than non-adopters. The density graph for the production of major crops among the adopters is rightly skewed, shows that productivity is more for the adopters than non-adopters.

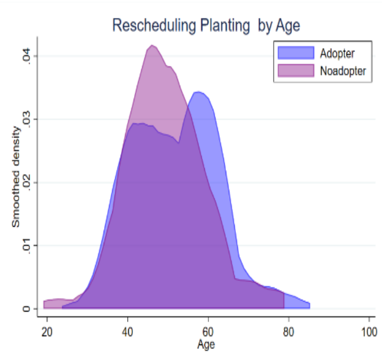


Figure 3.1

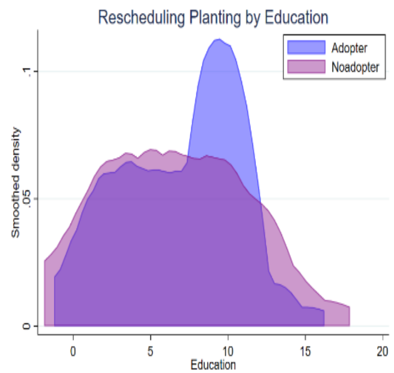
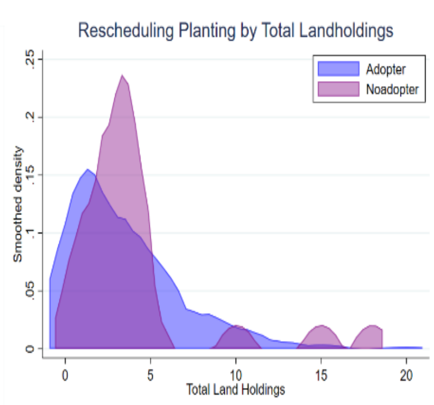


Figure 3.2



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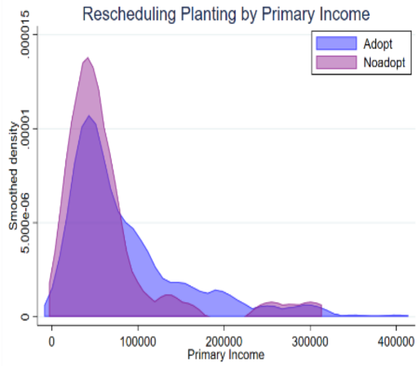

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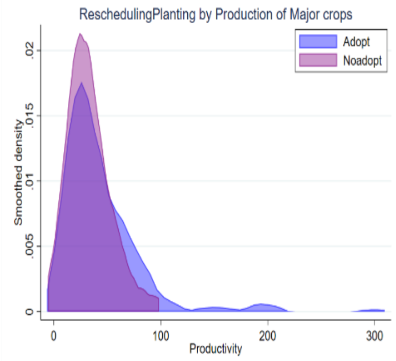

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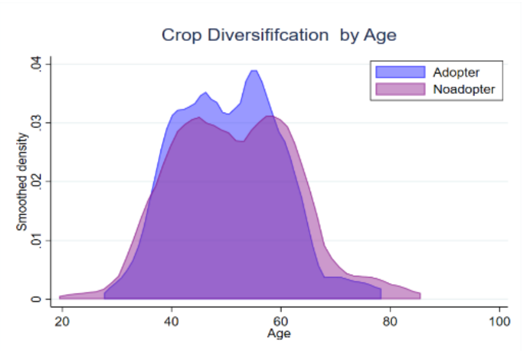

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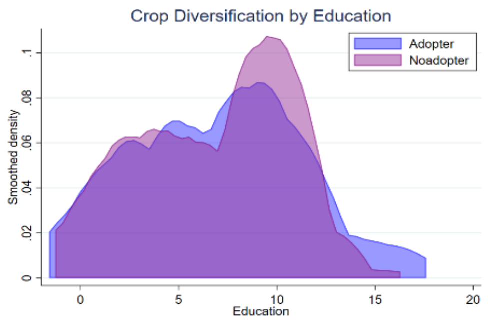

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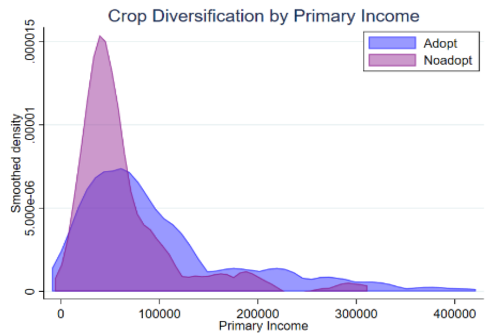
Figure 3.8



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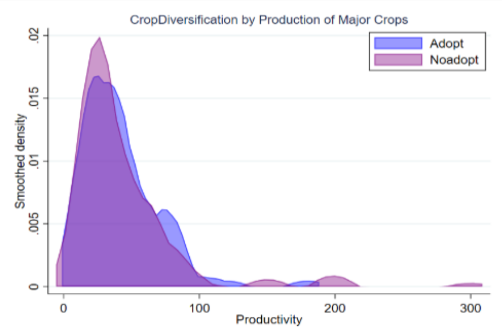
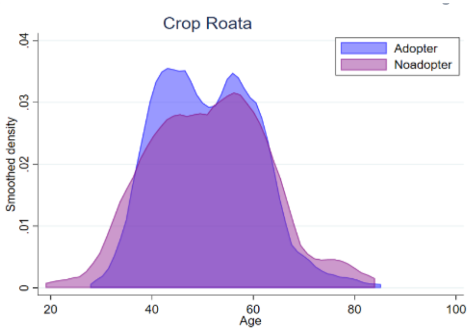


Figure 3.10



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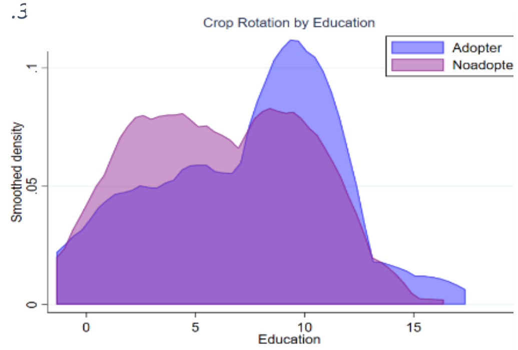


Figure 3.12

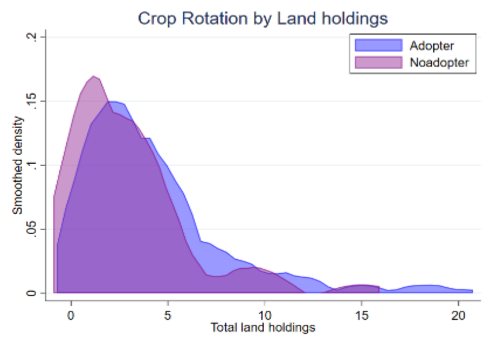


Figure 3.13

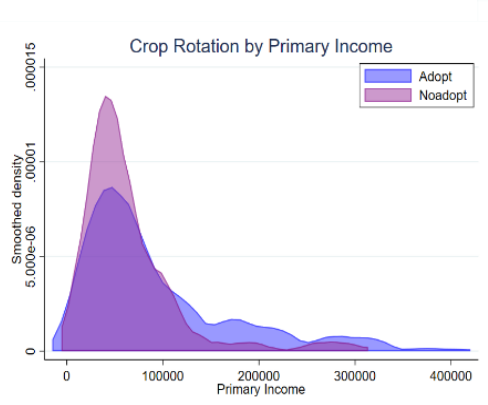


Figure 3.14

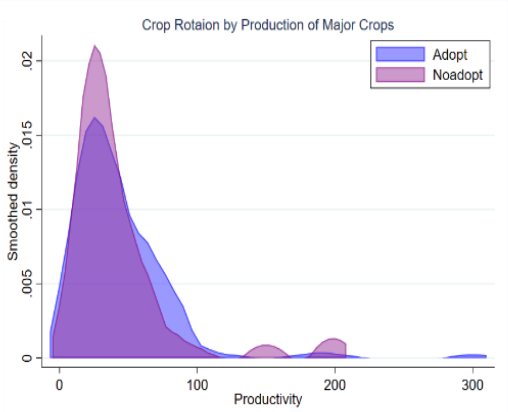


Figure 3.15

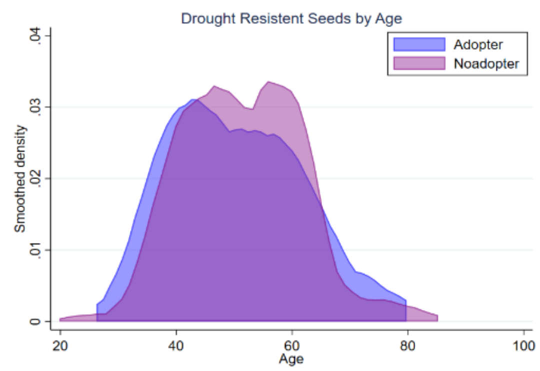
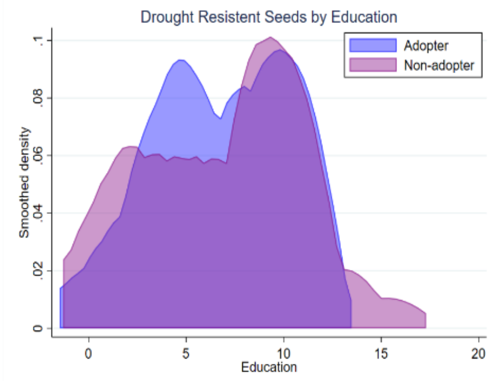


Figure 3.16



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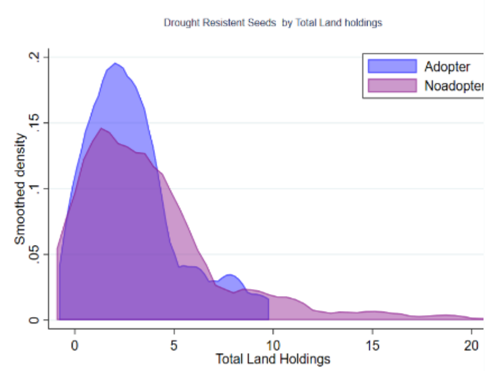

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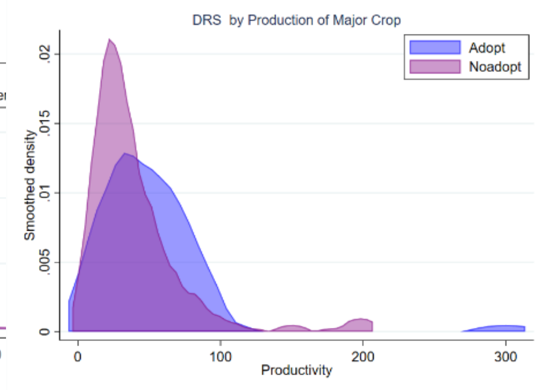

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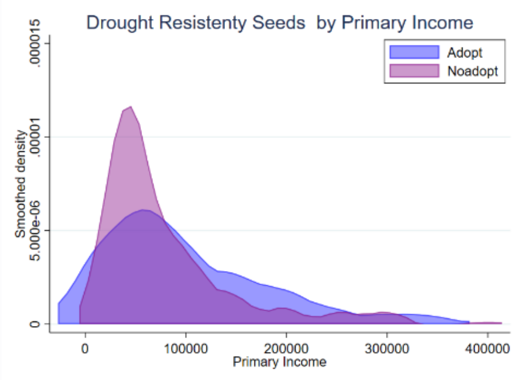

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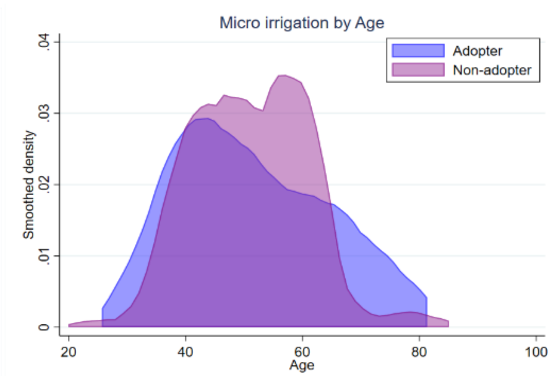
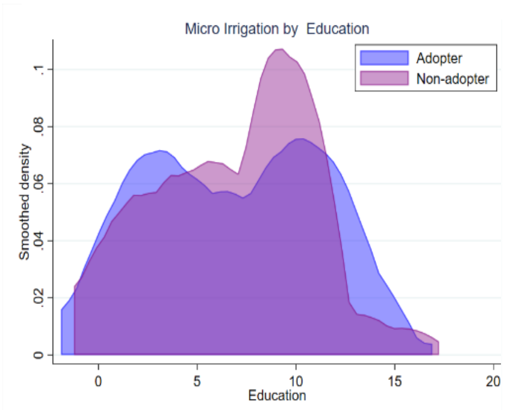


Figure 3.21



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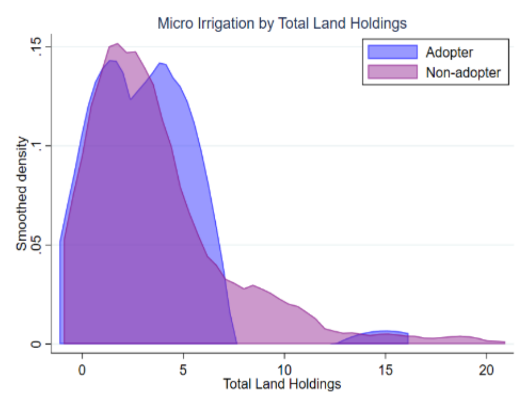

Figure 3.23

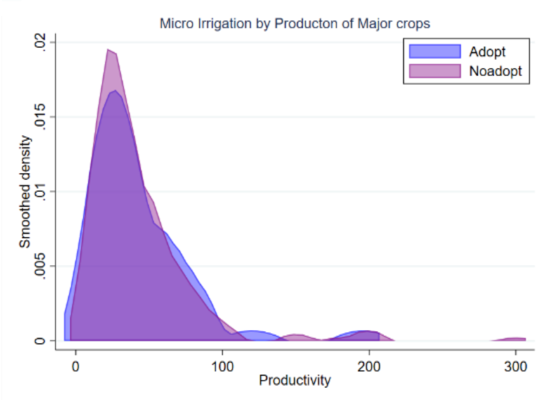

Figure 3.24

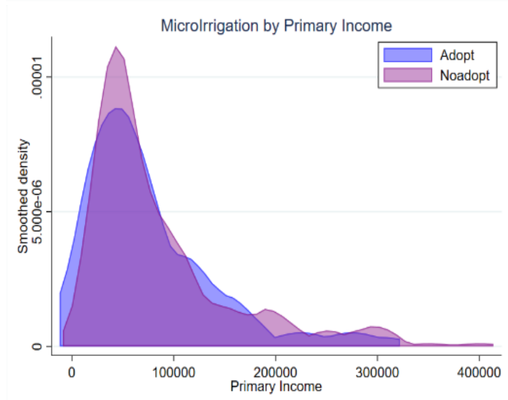

Figure 3.25

Figure 3.1 to 3.25: K Density graphs between adopter and non-adopter

3.4 Regional difference between two Districts:

Figure 4 to 7 shows the regional difference between two study area on different parameter. There is a difference in institutional access between the two districts of farmers. 54 % of farmers had crop insurance in Kendrapara, and 49% in Balangir. Kendrapara district has 40% credit cooperative societies called Primary Agricultural Credit Society (PACS). There is a smaller number of credit cooperatives in the Balangir district called LAMPS. Farmers take the highest amount of loans from a cooperative society, followed by a public bank and a private bank. Figure 6 shows the occupational distribution among the farmers between the two districts. Farmers do secondary activities apart from agricultural activities. Salaried Job holders are more in the Balangir district. Kendrapara farmers do fishing as an important secondary occupation to diversify their income because the Kendrapara district is situated on Bengal's shore. Figure 7 shows that farmers from the Kendrapara district are more educated than the Balangir district. Higher education (Graduation and more) is high among the farmers of Balangir, and school education is high among the Kendrapara district farmers. The farmers who do not have formal education are double in Balangir than Kendrapara.

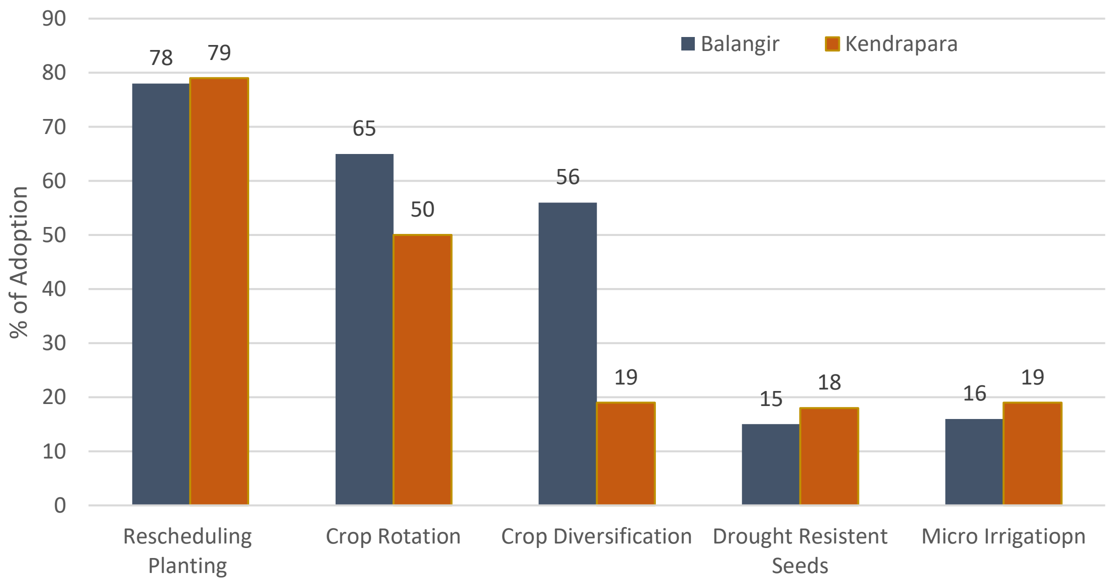

Figure 4 Difference in Adaptations between two districts

There is also a difference in landholdings between the two districts. In Balangir, small, medium

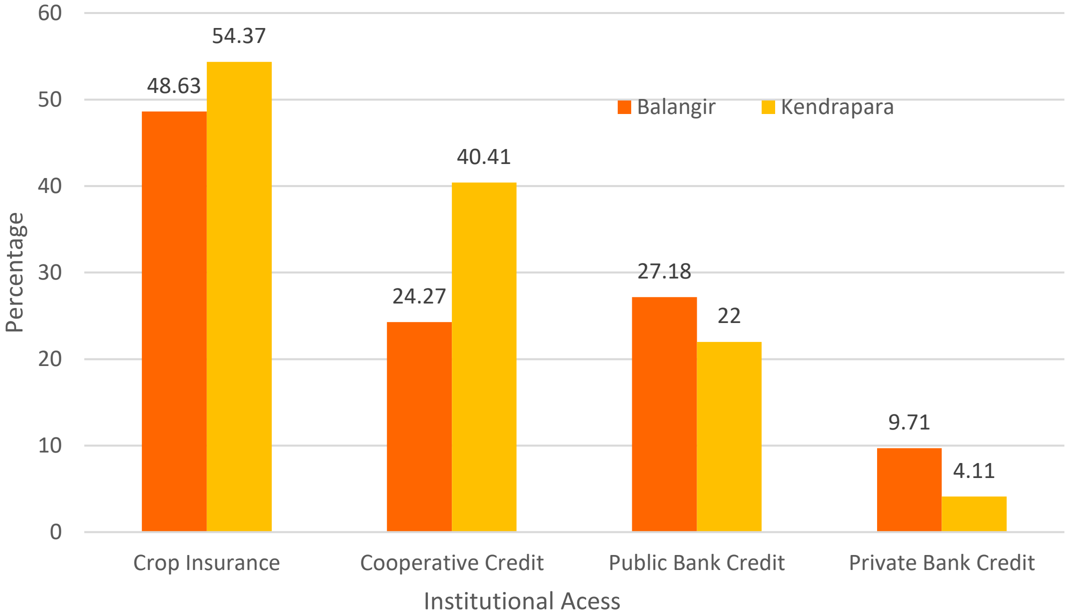

Figure 5 Institutional Access

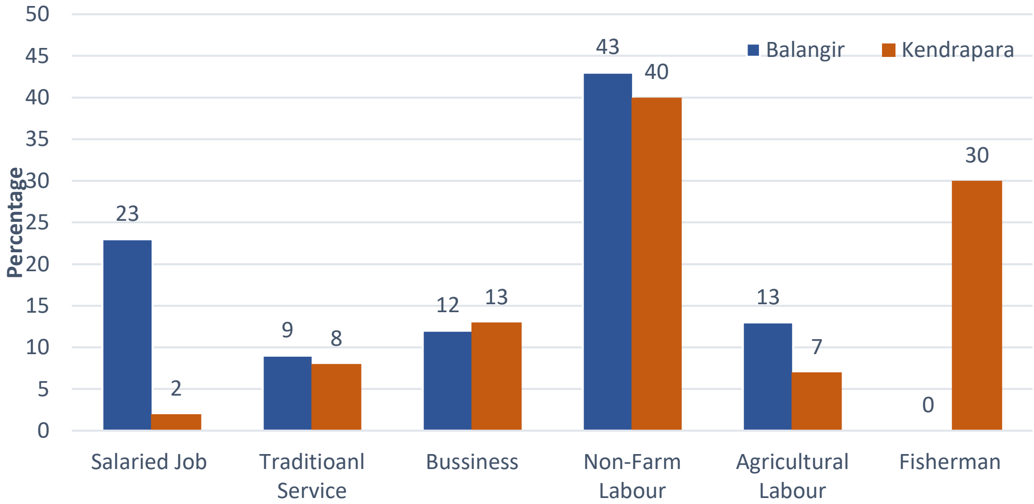

Figure 6 Occupation Secondary

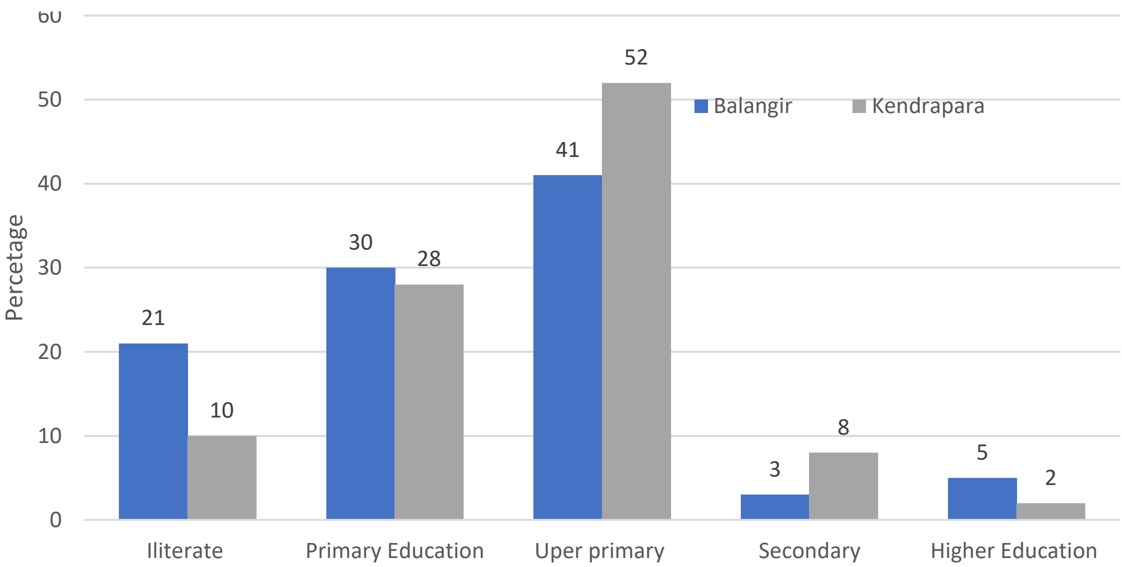

Figure 7 Education of the Household Head

and large farmers are more. In Kendrapara, the number of marginal farmers is more. There is a difference in the level of adaptation for both districts. Balangir district has more percentage of crop rotation and crop diversification. Farmers do rice and cotton as a complementary crop in Balangir. If one crop is damaged, then it can recover from another crop. The percentage of rescheduling planting is relatively more in the Kendrapara district. The irrigation system in the Kendrapara district is insufficient, so the delayed monsoon makes the farmer reschedule their plantation: micro-irrigation and drought-resistant seeds more in the Kendrapara district. Farmers do horticulture crops in Kendrapara, so they use drip and sprinkle more.

4. Factors affecting the adoption of CSA technologies

Table 4 shows the probit model's result and the significant impact of the independent variables on the dependent variables, and Table 5 shows the marginal effect. We have done the post estimation evaluation of our models by ROC curves showed in Appendix figure A1 to A5. In this study, the ROC curve values for all models range from 0.85 to 0.95, showing that all models fitted well. This range reflects the proportion of correctly estimated positive and negative events out of the total number of events. It means that all our models can predict the success rate of more than 85 % when a household adopts or doesn't adopt a particular adaptation to mitigate climate variability.

4.1 Household Attributes

We have taken both age and age square in our model to show the natural effect of age on dependent variables. If there is a positive effect of age and the negative effect of age squared, as people get older, it negatively impacts dependent variables that are an adaptation. If age and age square both have a positive coefficient, it shows that farmers get more senior, positively impacting adoption. This study age has a significantly positive effect (0.184) on crop rotation, and age square has a highly negative impact (-0.002) on crop rotation. The marginal impact shows that a unit increase in the household head's age would increase an 4% increase in crop rotation probability.

The farmers' total landholding has a significantly negative impact on the adoption of Rescheduling planting (0.176) and drought-resistant seeds (-0.387). A unit increase in landholding size tends to decrease the rescheduling planting by around 3 % and decrease drought-resistant seeds by about 5%. Livestock acts as a financial asset for the farmers during their vulnerable period. Farmers having livestock has a significantly positive impact on adaption to rescheduling planting (0.116), crop diversification (0.043) and drought-resistant seeds (0.056. A unit increase in the livestock is likely to increase 2% of Rescheduling Planting, 0.8% of crop diversification, and 0.7% of drought-resistant seeds. Years of farming negatively impact crop rotation (0.093) and drought-resistant seeds (-0.005). A year increase in the farming activities decreases the amount of 0.05 % of crop rotation and a 0.09% decrease in the drought-resistant seeds. The farmers new to farming are more likely to use drought-resistant seeds and make crop rotation. Education of household head has been taken as years of schooling. Our study reflects a significantly negative impact on crop rotation at (-0.010) and a positive impact on rescheduling planting.

4.3 Institutional Factors

Access to Government Extension service has a highly significant and positive impact on all the adoption practises except the adaptation of micro-irrigation. The farmer receiving government extension has a significantly positive effect on Rescheduling planting at (0.793), Crop diversification is at (*0.723*), crop rotation at (*0.737)*, using drought-resistant seeds at (2.116). Farmer provided with Government extension service has a likelihood to reschedule planting by 11 %, crop diversification by 14 %, crop rotation by 18 %, use of drought-tolerant seeds by 28 %. Farmers to farmer extension services include knowledge sharing and motivating among

Table 4 Regression Results

	1		2		3		4		5	
	Rescheduling Planting		Diversified crop		Crop Rotation		Drought resistant Seeds		Micro Irrigation	
	QM	FM	QD	FM	QM	FM	QM	FM	QM	FM
Age	0.065	0.113	0.112	0.124	0.198**	0.209**	-0.048	-0.032	-0.136	-0.127
	(0.540)	(0.292)	(0.257)	(0.214)	(0.024)	(0.018)	(0.670)	(0.781)	(0.179)	(0.229)
age2	-0.000	-0.001	-0.001	-0.001	-0.002**	-0.002**	0.001	0.001	0.001	0.001
	(0.771)	(0.438)	(0.363)	(0.305)	(0.030)	(0.024)	(0.422)	(0.451)	(0.170)	(0.232)
HH Size	-0.001	-0.019	-0.020	-0.036	0.043	0.037	0.065	0.043	-0.135	-0.116
	(0.995)	(0.826)	(0.786)	(0.631)	(0.505)	(0.574)	(0.481)	(0.656)	(0.128)	(0.199)
Years of farming	-0.002	-0.006	-0.005	-0.008	-0.016	-0.018	-0.053**	-0.063**	0.024	0.025
	(0.898)	(0.743)	(0.727)	(0.603)	(0.187)	(0.162)	(0.009)	(0.005)	(0.170)	(0.162)
Years of Schooling	0.041	0.045*	-0.011	-0.007	-0.049*	-0.048**	-0.003	0.011	-0.025	-0.030
	(0.126)	(0.088)	(0.612)	(0.761)	(0.013)	(0.015)	(0.931)	(0.738)	(0.284)	(0.219)
SHG	-0.456	-0.452	-0.255	-0.289	0.458	0.439*	-0.282	-0.395	-0.808**	-0.756**
	(0.247)	(0.249)	(0.375)	(0.320)	(0.067)	(0.081)	(0.409)	(0.257)	(0.011)	(0.018)
Cooperative member	-0.437	-0.464	0.811**	0.835**	-0.118	-0.118	-0.546	-0.766	0.156	0.265
	(0.286)	(0.271)	(0.009)	(0.008)	(0.663)	(0.664)	(0.228)	(0.126)	(0.661)	(0.464)
Govt. Extn.	0.706**	0.793**	0.711**	0.723**	0.701**	0.737**	1.734***	2.116***	0.513	0.498
	(0.032)	(0.019)	(0.007)	(0.006)	(0.004)	(0.003)	(0.000)	(0.000)	(0.138)	(0.148)
Training	0.512	0.483	0.704	0.701*	-0.002	-0.025	0.036	-0.013	0.701	0.777*
	(0.299)	(0.325)	(0.072)	(0.077)	(0.996)	(0.940)	(0.934)	(0.977)	(0.076)	(0.057)
Peer Effect	0.665*	0.717*	0.263	0.296	-0.302	-0.295	0.068	-0.034	-0.818	-0.810*
	(0.077)	(0.061)	(0.373)	(0.321)	(0.262)	(0.275)	(0.854)	(0.930)	(0.055)	(0.061)
Television	0.208	0.192	0.844**	0.825**	0.934***	0.910***	-0.101	-0.077	-0.068	0.006
	(0.520)	(0.558)	(0.001)	(0.002)	(0.000)	(0.000)	(0.763)	(0.817)	(0.820)	(0.984)
Perception of Change in Temperature										
Doesn't know	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Constant	1.742**	1.888**	0.154	0.145	-1.966**	-1.888**	-0.261	0.254	-0.596	-0.896
	(0.012)	(0.009)	(0.796)	(0.811)	(0.004)	(0.006)	(0.755)	(0.781)	(0.454)	(0.318)
Increasing	2.673***	2.635***	-0.064	-0.081	-2.022**	-2.010**	-0.758	-0.559	-0.239	-0.342
	(0.000)	(0.000)	(0.910)	(0.887)	(0.001)	(0.002)	(0.252)	(0.407)	(0.675)	(0.559)
Perception to decrease Rainfall										
Doesn't know	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Yes	-1.508*	-1.193	-0.453	-0.459	0.747	0.763	-1.262*	-1.097	0.220	0.177
	(0.061)	(0.135)	(0.421)	(0.421)	(0.171)	(0.165)	(0.091)	(0.164)	(0.732)	(0.788)
No	-1.352**	-1.148**	0.124	0.128	0.504	0.509	-0.609	-0.616	0.209	0.272
	(0.025)	(0.047)	(0.745)	(0.742)	(0.195)	(0.197)	(0.234)	(0.255)	(0.642)	(0.558)
Perception on Drought	-0.155	-0.097	0.715**	0.716**	0.182	0.169	0.165	0.184	-0.189	-0.144
	(0.660)	(0.787)	(0.018)	(0.019)	(0.514)	(0.544)	(0.706)	(0.684)	(0.621)	(0.711)
Perception to flood	1.182**	1.084*	-0.014	-0.053	0.848**	0.846**	0.925**	0.809*	0.924**	0.923**

	(0.026)	(0.052)	(0.964)	(0.865)	(0.006)	(0.006)	(0.041)	(0.094)	(0.017)	(0.021)
Awareness to CC	1.176**	1.230**	-0.171	-0.176	-0.339	-0.335	-0.367	-0.250	-0.853*	-0.798
	(0.003)	(0.003)	(0.637)	(0.629)	(0.302)	(0.309)	(0.457)	(0.636)	(0.040)	(0.060)
Crop Insurance	0.027	0.276	-0.768**	-0.714**	0.740**	0.785**	0.221	0.520	-0.285	-0.402
	(0.943)	(0.487)	(0.008)	(0.016)	(0.006)	(0.004)	(0.560)	(0.234)	(0.425)	(0.268)
Own Livestock	0.124**	0.116**	0.045*	0.043*	0.034	0.034	0.052	0.056*	0.038	0.037
	(0.013)	(0.022)	(0.051)	(0.067)	(0.182)	(0.176)	(0.086)	(0.084)	(0.175)	(0.188)
Subsidies	-0.518	-0.328	0.402	0.465*	0.370	0.409	1.374**	1.430***	1.145**	1.051**
	(0.139)	(0.368)	(0.124)	(0.084)	(0.157)	(0.124)	(0.001)	(0.001)	(0.002)	(0.006)
DTC	0.009	-0.151	-0.556	-0.622*	-0.492	-0.522*	-0.303	-0.376	-0.710	-0.696*
	(0.985)	(0.759)	(0.112)	(0.079)	(0.101)	(0.084)	(0.438)	(0.344)	(0.077)	(0.091)
Drought	0.728*	0.763**	-0.640*	-0.638*	-0.228	-0.228	0.929**	0.965**	0.349	0.346
	(0.037)	(0.035)	(0.046)	(0.048)	(0.387)	(0.389)	(0.017)	(0.020)	(0.308)	(0.322)
Flood	0.336	0.267	-0.586*	-0.584*	0.133	0.139	-0.777**	-0.803*	-0.424	-0.441
	(0.384)	(0.498)	(0.070)	(0.071)	(0.634)	(0.620)	(0.044)	(0.046)	(0.301)	(0.296)
Migration	-0.195	-0.137	0.099	0.077	0.732**	0.708**	0.832**	0.731**	-0.171	-0.093
	(0.605)	(0.723)	(0.739)	(0.794)	(0.007)	(0.010)	(0.013)	(0.032)	(0.628)	(0.799)
Distance to Market	-0.138*	-0.139*	-0.025	-0.024	0.020	0.022	-0.118	-0.122	-0.144**	-0.162**
	(0.057)	(0.059)	(0.638)	(0.659)	(0.699)	(0.672)	(0.142)	(0.138)	(0.021)	(0.012)
Balangir District	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Kendrapara District	0.296	0.484	-0.810	-0.757	-0.242	-0.223	1.388*	1.531*	1.115*	1.127*
	(0.590)	(0.392)	(0.125)	(0.152)	(0.584)	(0.617)	(0.063)	(0.054)	(0.082)	(0.085)
High Land	0.567	0.648*	-0.373	0.000	0.316	0.000	-1.000	0.000	-0.093	0.000
	(0.142)	(0.095)	(0.300)	(.)	(0.337)	(.)	(0.058)	(.)	(0.825)	(.)
Medium Land	0.000	0.000	0.000	0.356	0.000	-0.287	0.000	1.224**	0.000	0.018
	(.)	(.)	(.)	(0.320)	(.)	(0.383)	(.)	(0.032)	(.)	(0.966)
Low Land	0.967**	1.061*	0.185	0.567**	-0.086	-0.361	-0.963*	0.227	-0.055	-0.051
	(0.024)	(0.013)	(0.606)	(0.039)	(0.798)	(0.139)	(0.051)	(0.567)	(0.902)	(0.876)
No Energy	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Electrical	1.226**	1.144**	0.697*	0.661*	0.669*	0.597	0.317	0.239	0.646	0.950*
	(0.016)	(0.030)	(0.055)	(0.074)	(0.070)	(0.116)	(0.533)	(0.650)	(0.163)	(0.068)
Diesel	0.041	0.011	0.375	0.380	0.535	0.495	1.749***	1.816***	-0.244	-0.212
	(0.931)	(0.981)	(0.317)	(0.310)	(0.110)	(0.141)	(0.000)	(0.000)	(0.628)	(0.679)
Kerosine	-0.946*	-0.932*	-0.705	-0.700	-0.388	-0.389	0.605	0.722	0.672	0.735
	(0.067)	(0.073)	(0.182)	(0.190)	(0.390)	(0.392)	(0.425)	(0.361)	(0.184)	(0.159)
Multiple	-0.068	-0.087	-0.443	-0.470	1.025**	1.021**	1.528**	1.636**	0.328	0.361
	(0.898)	(0.869)	(0.356)	(0.331)	(0.008)	(0.008)	(0.007)	(0.007)	(0.520)	(0.484)
Total area Owned	-0.086**	-0.176**	0.021	-0.034	0.102**	0.057	-0.126*	-0.387**	-0.095**	-0.022
	(0.029)	(0.005)	(0.533)	(0.503)	(0.009)	(0.338)	(0.048)	(0.010)	(0.046)	(0.725)
Total Credit (Log)	0.021	-0.055	0.025	-0.012	-0.020	-0.043	-0.025	-0.139*	-0.043	0.001
	(0.551)	(0.282)	(0.403)	(0.769)	(0.478)	(0.242)	(0.504)	(0.018)	(0.216)	(0.981)
Total area*Total Credit (Log)	*****	0.017**	*****	0.009	*****	0.007	*****	0.036**	*****	-0.016

	*****	(0.041)	*****	(0.155)	*****	(0.327)	*****	(0.015)	*****	(0.130)
General	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
OBC	0.044	0.126	-0.271	-0.254	-0.117	-0.078	-0.123	-0.156	-0.294	-0.313
	(0.919)	(0.774)	(0.451)	(0.476)	(0.694)	(0.796)	(0.764)	(0.713)	(0.477)	(0.462)
SC	-0.475	-0.414	0.083	0.035	0.138	0.121	-0.125	-0.028	-0.770	-0.704
	(0.388)	(0.450)	(0.863)	(0.943)	(0.728)	(0.760)	(0.851)	(0.967)	(0.178)	(0.221)
ST	0.287	0.489	-0.754	-0.699	-0.156	-0.093	-0.688	-0.559	-0.279	-0.384
	(0.646)	(0.457)	(0.137)	(0.170)	(0.709)	(0.826)	(0.230)	(0.350)	(0.578)	(0.449)
_cons	-4.812	-5.939*	-3.845	-4.177	-4.971**	-4.847**	-0.255	-1.703	3.719	3.186
	(0.110)	(0.052)	(0.158)	(0.124)	(0.043)	(0.048)	(0.935)	(0.595)	(0.182)	(0.260)
Pseudo R2	0.48	0.50	0.42	0.42	0.34	0.34	0.44	0.48	0.47	0.36
ROC Value	0.91	0.91	0.89	0.90	0.86	0.86	0.92	0.93	0.93	0.86
Total Sample	248		248		248		248		248	

(QM: Quadratic Model, FM: Full Model, SHG: Self Help Group, DTC: Direct Transfer Cash, OBC: Other Backward Class, SC: Scheduled Caste, ST: Scheduled Tribe)

p-values in parentheses

*Significant at 10% level; **Significant at 5% level; ***Significant at 1% level

Table 5 Marginal Effect of Full Model

	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

themselves. The peer effect has a significantly positive impact (0.105) on the farmers' rescheduling planting. Having a peer effect increases the likelihood of doing reschedule planting by 11 %. The farmers receive training and demonstrations from various sources have significantly positive impact (*0.701)* on crop diversification and (0.777). A farmer gets training to have the likelihood to adopt micro-irrigation by 12% and crop diversification by 14 %. Exposure to media has a highly statistically significant and positive impact on adopting crop diversification *(0.825*) and crop rotation (*0.910*). A farmer who watches TV tends to adopt crop diversification by 17 % and crop rotation by 22 %.

Subsidies such as input, machinery, and fertilizers significantly impact the farmers' various adaption strategies. It has a positive effect on the adaption of crop diversification at (0.0963), drought-resistant seeds *(0.189)* and micro-irrigation *(0.1738)*. Suppose a farmer gets subsidies from the government likely to increase the probability of crop diversification by 10%, crop rotation by 19% and micro-irrigation by 17 %. The total Credit doesn't have a significant impact on adaptation practices. It has a statistically significant negative effect (-*0.156)* on the adaptation practices. Financial Institutes provides the credit based on the size of the landholdings, so we have used an interaction variable between the total credit amount and total landholdings. The interaction between these two variables significantly impacts adopting rescheduling planting *(0.017)* and drought-resistant seeds *(0.036*). If a farmer has more land and his access to credit is likely to increase. This interaction term tends to reschedule their planting by 0.03 % and drought-resistant seeds by 0.04 %—distance to the input and output market influences farming activities. The distance to market has a significantly negative impact on the Micro Irrigation system (-0.131) and rescheduling planting (-0.139). If one unit decreases in the market's distance, it can increase micro-irrigation and rescheduling planting by 1%. Crop Insurance encourages farmer the adapt to agriculture. Farmers who purchase crop insurance are positively adopted crop rotation.

4.4: Perception of Climate Change and Awareness

Farmers have a different perception of climate change and climate variability. Farmers who are updated with climate change information are positively rescheduling planting (1.230). They are likely to increase the rescheduling plantings by 18%. Farmers Perceived to decrease in the Rainfall doesn't have an impact on adoption. If farmers perceive a constant temperature for the last 15 years, it significantly impacts rescheduling planting (*1.888*) and a negative effect (-*1.888*) on crop rotation. Farmers perceive constant temperature for the last 15 years to do rescheduling painting by 38% % and decrease crop rotation by 35 %. Framers perceived that an increase in temperature has more likely to do rescheduling planting by 50% and less likely to do crop rotation by 39%. Perception to grow in the drought in the previous 15 years have a statistically significant and positive impact (*0.716*) on crop diversification. They are likely to do more crop diversification by 14%. Perception to increase flood has a positive impact on the rescheduling painting (*1.084*), crop rotation by (*0.846*), drought-resistant seeds (0.809) and micro-irrigation (0.923). These farmers are likely to increase rescheduling painting by 15%, crop rotation by 21%, drought-resistant seeds by 10% and micro-irrigation by 12%.

Farmers who experienced climate shocks in the last few years have a significantly positive impact on the adoptions. If a farmer had experienced the drought, they are more likely to do rescheduling planting (0.763) and drought-resistant seeds *(0.965).* Drought experienced farmers tend to increase rescheduling by 11% and early maturity variety seeds by 12%. Experienced lack has a negatively significant impact on crop diversification. Experienced

4.5 Agricultural Infrastructure:

The agricultural system being rainfed in the area under consideration, the water crisis is the primary problem among the farmers. Access to electricity has a positive effect on the adaption of rescheduling planting, crop diversification and micro-irrigation. If a farmer 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 who use diesel as a source of energy for farming operations are more likely to use drought-resistant seeds by 26%. Farmers use multiple energy sources to do crop rotation by 25% and drought-resistant seeds by 23%.

4.6 Social Capital and Other factors:

Members in the SHG group have a significantly positive impact on crop rotation (0.439) and negatively impact Micro-irrigation. Membership in SHG increases the likelihood to adopt crop rotation by 10%. Membership in a cooperative society has a positive impact on the adoption of crop diversification. Memberships in cooperative society increase the likelihood to do crop diversification by 17 %. Migration plays a vital role to adapt to resilient climate strategies. Migration helps a farmer to access and save their capital and invest for the next season. Rural farmers move to urban setups to get good work and earn more. Migration is appositely significant with crop rotation and drought-resistant seeds (0.965) and (*0.731*). The farmers who migrate likely to adopt crop rotation by 17 % and drought resident seeds by 10 % more.

5. Discussion and Concluding Observations

The study's empirical findings reveal that the significant explanatory variables that influence the adoption of specific CSA technologies are – the household head's age, education, access to extension service, training, livestock ownership, agricultural subsidies, awareness of climate change, and agricultural infrastructure. This finding suggests that the rural farming households in Eastern India do not have the intent to go for autonomous adaptation. Very few farmers draw upon their resources for the required investment —the major group of farmers depends on public or private organizations' support. This is known as planned adaptation in the literature

(Malik et al.,2010). In planned adaptation, the government or non-government agencies do intervention of different policies. So, modern agricultural technologies' adoption depends on government support such as access to agricultural extension, subsidies, training, and government credit program.

Farmers linked with government policies and programs are more likely to adopt multiple CSA practices such as crop diversification and crop rotation. Crop diversification is quite popular in the Balangir district, where farmers cultivate multiple crops like paddy, cotton and vegetables. Adopting multiple crops is a risk-hedging strategy in which if the climate variability adversely affects one crop, other crops can still produce income. It has been understood that farmers in the Balangir district shifted to cotton from paddy after frequent bouts of droughts are experienced. Low input cost, easy procurement of cotton in the local market, the establishment of cotton mills nearby, and high selling price has attracted the farmers to shift to cotton cultivation. It is observed that farmers do integrated farming with crop diversification in the Kendrapara district. Farmers usually construct a small pond in their field for fish cultivation. This small fish pond can help them to generate off-farm income and to irrigate during water stress. Farmers who get access to extension services also integrate horticultural crops to diversify their farm income. Farmer's field school and government extension outreach are instrumental in higher adoption rates. Our findings are in line with other studies (Abid et al., 2015a; Aryal, Sapkota, Rahut, et al., 2020; Khan et al., 2020; Tripathi & Mishra, 2017) who observed the positive impact of extension service on CSA adoption. Farmers to farmer extension include collective action, social networking, learning, updated technology, and peer farmers' information. This study is in line with studies of (Bryan et al., 2013).

The awareness about climate change and regular information on climate variability have a positive association with adaptation. Similar results are reported from (Jha et al., 2018; Zamasiya et al., 2017). Those farmers that get regular updates from the regional meteorological centres are more likely to adopt modern practices. Other literature has also found a similar result(Belay et al., 2017; S. Singh, 2020). Migration has a positive and significant impact on crop rotation and the use of drought-resistant seeds. Farmers do not migrate in the *Kharif* season due to high value-added crop and more labour requirements. They migrate in the *Rabi* season to earn off-farm income in the urban centres. These findings are in line with studies of (Belay et al., 2017).

The interaction between access to credit and landholding increases the probability of adopting practices such as rescheduling planting and drought-resistant seeds. This finding corroborates the results from(Belay et al., 2017). Farmers get credit from the banks based on their landholding size, so the higher the landholding, the more significant the amount can be accessed as credit. Small farmers generally divert their small amount loan to other activities, but the large farmer may be using his credit for the changing seed varieties and planting dates.

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 kick-start the adoption mission among resource-poor farmers, public 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. However, agricultural extension services will remain the most vital determining factor in the sustenance of CSA adoption in India.

Acknowledgements:

This work is supported by the Indian Council of Social Science Research, Ministry of Education, Government of India, Grant Number (F.No.-02/25/GEN/2017-18/RP/Major)

References and Bibliography:

Abid, M., Scheffran, J., Schneider, U. A., & Ashfaq, M. (2015a). Farmers' perceptions of and adaptation strategies to climate change and their determinants: The case of Punjab province, Pakistan. *Earth System Dynamics*, *6*(1), 225–243. https://doi.org/10.5194/esd-6-225-2015

Arora, N. K. (2019). Impact of climate change on agriculture production and its sustainable solutions. *Environmental Sustainability*, *2*(2), 95–96. https://doi.org/10.1007/s42398-019-00078-w

Aryal, J. P., Sapkota, T. B., Khurana, R., Khatri-Chhetri, A., Rahut, D. B., & Jat, M. L. (2020). Climate change and agriculture in South Asia: adaptation options in smallholder production systems. In *Environment, Development and Sustainability* (Vol. 22, Issue 6). Springer Netherlands. https://doi.org/10.1007/s10668-019-00414-4

Aryal, J. P., Sapkota, T. B., Rahut, D. B., Krupnik, T. J., Shahrin, S., Jat, M. L., & Stirling, C. M. (2020). Major Climate risks and Adaptation Strategies of Smallholder Farmers in Coastal Bangladesh. *Environmental Management*, *66*(1), 105–120. https://doi.org/10.1007/s00267-020-01291-8

Azadi, Y., Yazdanpanah, M., & Mahmoudi, H. (2019). Understanding smallholder farmers' adaptation behaviours through climate change beliefs, risk perception, trust, and psychological distance: Evidence from wheat growers in Iran. *Journal of Environmental Management*, *250*(August), 109456. https://doi.org/10.1016/j.jenvman.2019.109456

Banerjee, R., Kamanda, J., Bantilan, C., & Singh, N. P. (2013). Exploring the relationship between local institutions in SAT India and adaptation to climate variability. *Natural Hazards*, *65*(3), 1443–1464. https://doi.org/10.1007/s11069-012-0417-9

Belay, A., Recha, J. W., Woldeamanuel, T., & Morton, J. F. (2017). Smallholder farmers' adaptation to climate change and determinants of their adaptation decisions in the Central Rift Valley of Ethiopia. *Agriculture and Food Security*, *6*(1), 1–13. https://doi.org/10.1186/s40066-017-0100-1

Below, T. B., Mutabazi, K. D., Kirschke, D., Franke, C., Sieber, S., Siebert, R., & Tscherning, K. (2012). Can farmers' adaptation to climate change be explained by socio-economic household-level variables? *Global Environmental Change*, *22*(1), 223–235. https://doi.org/10.1016/j.gloenvcha.2011.11.012

Bhatta, G. D., Aggarwal, P. K., Shrivastava, A. K., & Sproule, L. (2016). Is rainfall gradient a factor of livelihood diversification? Empirical evidence from around climatic hotspots in Indo-Gangetic Plains. *Environment, Development and Sustainability*, *18*(6), 1657–1678. https://doi.org/10.1007/s10668-015-9710-6

Bryan, E., Deressa, T. T., Gbetibouo, G. A., & Ringler, C. (2009). Adaptation to climate change in Ethiopia and South Africa: options and constraints. *Environmental Science and Policy*, *12*(4), 413–426. https://doi.org/10.1016/j.envsci.2008.11.002

Bryan, E., Ringler, C., Okoba, B., Roncoli, C., Silvestri, S., & Herrero, M. (2013). Adapting agriculture to climate change in Kenya: Household strategies and determinants. *Journal of Environmental Management*, *114*, 26–35. https://doi.org/10.1016/j.jenvman.2012.10.036

Burnham, M., & Ma, Z. (2017). Climate change adaptation: factors influencing Chinese smallholder farmers perceived self-efficacy and adaptation intent. *Regional Environmental Change*, *17*(1), 171–186. https://doi.org/10.1007/s10113-016-0975-6

Calzadilla, A., Rehdanz, K., Betts, R., Falloon, P., Wiltshire, A., & Tol, R. S. J. (2013). Climate change impacts on global agriculture. *Climatic Change*, *120*(1–2), 357–374. https://doi.org/10.1007/s10584-013-0822-4

Carlton, J. S., Mase, A. S., Knutson, C. L., Lemos, M. C., Haigh, T., Todey, D. P., & Prokopy, L. S. (2016). The effects of extreme drought on climate change beliefs, risk perceptions, and adaptation attitudes. *Climatic Change*, *135*(2), 211–226. https://doi.org/10.1007/s10584-015-1561-5

Connolly-Boutin, L., & Smit, B. (2016). Climate change, food security, and livelihoods in sub-Saharan Africa. *Regional Environmental Change*, *16*(2), 385–399. https://doi.org/10.1007/s10113-015-0761-x

Dang, H. le, Li, E., Nuberg, I., & Bruwer, J. (2019). Factors influencing the adaptation of farmers in response to climate change: a review. *Climate and Development*, *11*(9), 765–774. https://doi.org/10.1080/17565529.2018.1562866

Eckstein, D., Künzel, V., & Schäfer, L. (2020). *Global climate risk index 2021*. http://germanwatch.org/en/download/8551.pdf

FAO (Food and Agriculture Organisation of the United Nations). (2010). Climate-Smart Agriculture: Policies, practices and financing for food security, adaptation and mitigation. *Fao*, 49. https://doi.org/10.1111/j.1467-6346.2009.02662.x

Food and Agriculture Organization of the United Nations. (2011). *FAO- Adapt: Framework Programme on Climate Change Adaptation*. 38.

Funk, C., Raghavan Sathyan, A., Winker, P., & Breuer, L. (2020). Changing climate - Changing livelihood: Smallholder's perceptions and adaption strategies. *Journal of Environmental Management*, *259*(October), 109702. https://doi.org/10.1016/j.jenvman.2019.109702

Gebrehiwot, T., & van der Veen, A. (2015). Farmers Prone to Drought Risk: Why Some Farmers Undertake Farm-Level Risk-Reduction Measures While Others Not? *Environmental Management*, *55*(3), 588–602. https://doi.org/10.1007/s00267-014-0415-7

Greene, W. H. (2000). *Econometric Analysis 4th Ed.*

Hirpha, H. H., Mpandeli, S., & Bantider, A. (2020). Determinants of adaptation strategies to climate change among the smallholder farmers in Adama District, Ethiopia. *International Journal of Climate Change Strategies and Management*, *12*(4), 463–476. https://doi.org/10.1108/IJCCSM-01-2019-0002

International Protocol on Climate Change. (2014). Climate Change 2014 Synthesis Report: Summary Chapter for Policymakers. *Ipcc*, 31.

Islam, M. T., & Nursey-Bray, M. (2017). Adaptation to climate change in agriculture in Bangladesh: The role of formal institutions. *Journal of Environmental Management*, *200*, 347–358. https://doi.org/10.1016/j.jenvman.2017.05.092

Jain, M., Naeem, S., Orlove, B., Modi, V., & DeFries, R. S. (2015). Understanding the causes and consequences of differential decision-making in adaptation research: Adapting to a delayed monsoon onset in Gujarat, India. *Global Environmental Change*, *31*, 98–109. https://doi.org/10.1016/j.gloenvcha.2014.12.008

Jena, P. R. (2019). Can minimum tillage enhance productivity? Evidence from smallholder farmers in Kenya. *Journal of Cleaner Production, 218,* 465–475. https://doi.org/10.1016/j.jclepro.2019.01.278

Jena, P. R. (2021) Extension services as key determining factor for adoption of minimum tillage practice in Kenya: A plot level analysis. Journal of Public Affairs. https://doi.org/10.1002/pa.2724

Jena, P. R., & Majhi, R. (2021). An application of artificial neural network classifier to analyze the behavioural traits of smallholder farmers in Kenya. *Evolutionary Intelligence*, *14*(2), 281-291.

Jha, C. K., Gupta, V., Chattopadhyay, U., & Amarayil Sreeraman, B. (2018). Migration as adaptation strategy to cope with climate change: A study of farmers' migration in rural India. *International Journal of Climate Change Strategies and Management*, *10*(1), 121–141. https://doi.org/10.1108/IJCCSM-03-2017-0059

Kalli, R., & Jena, P. R. (2020). Impact of climate change on crop yields: Evidence from irrigated and dry land cultivation in semi-arid region of India. *Journal of Environmental Accounting and Management*, *8*(1), 19–30. https://doi.org/10.5890/JEAM.2020.03.002

Karki, S., Burton, P., & Mackey, B. (2020). The experiences and perceptions of farmers about the impacts of climate change and variability on crop production: a review. *Climate and Development*, *12*(1), 80–95. https://doi.org/10.1080/17565529.2019.1603096

Khanal, U., Wilson, C., Hoang, V. N., & Lee, B. (2018). Farmers' Adaptation to Climate Change, Its Determinants and Impacts on Rice Yield in Nepal. *Ecological Economics*, *144*(February 2017), 139–147. https://doi.org/10.1016/j.ecolecon.2017.08.006

Khan, I., Lei, H., Shah, I. A., Ali, I., Khan, I., Muhammad, I., Huo, X., & Javed, T. (2020). Farm households' risk perception, attitude and adaptation strategies in dealing with climate change: Promise and perils from rural Pakistan. *Land Use Policy*, *91*(October 2019), 104395. https://doi.org/10.1016/j.landusepol.2019.104395

Khatri-Chhetri, A., Aggarwal, P. K., Joshi, P. K., & Vyas, S. (2017). Farmers' prioritization of climate-smart agriculture (CSA) technologies. *Agricultural Systems*, *151*, 184–191. https://doi.org/10.1016/j.agsy.2016.10.005

Lipper, L. (2014). *Climate Smart Agriculture for Food Security*. *November*. https://doi.org/10.1038/nclimate2437

Maharjan, S. (2018). *Adoption of multiple climate- smart agricultural practices in the Gangetic plains of Bihar, India*. https://doi.org/10.1108/IJCCSM-02-2017-0025

McCarthy, N., Lipper, L., Branca, G., & Security, F. (2011). Climate-Smart Agriculture: Smallholder Adoption and Implications for Climate Change Adaptation and Mitigation. *Organization*, *October*, 1–37. https://doi.org/FAO Mitigation of Climate Change in Agriculture Series 4

Mendelsohn, R. (2000). Efficient adaptation to climate change. *Climatic Change*, *45*(3–4), 583–600. https://doi.org/10.1023/a:1005507810350

Mertz, O., Mbow, C., Reenberg, A., & Diouf, A. (2009). Farmers' perceptions of climate change and agricultural adaptation strategies in rural sahel. *Environmental Management*, *43*(5), 804–816. https://doi.org/10.1007/s00267-008-9197-0

Paudel, B., Zhang, Y., Yan, J., Rai, R., Li, L., Wu, X., Chapagain, P. S., & Khanal, N. R. (2020). Farmers' understanding of climate change in Nepal Himalayas: important determinants and implications for developing adaptation strategies. *Climatic Change*, *158*(3–4), 485–502. https://doi.org/10.1007/s10584-019-02607-2

Report, A. (n.d.). *Climate Change 2001: Synthesis Report*.

Sahoo, B., & Bhaskaran, P. K. (2018). Multi-hazard risk assessment of coastal vulnerability from tropical cyclones – A GIS based approach for the Odisha coast. *Journal of Environmental Management*, *206*, 1166–1178. https://doi.org/10.1016/j.jenvman.2017.10.075

Sam, A. S., Padmaja, S. S., Kächele, H., Kumar, R., & Müller, K. (2020). Climate change, drought and rural communities: Understanding people's perceptions and adaptations in rural eastern India. *International Journal of Disaster Risk Reduction*, *44*, 101436. https://doi.org/10.1016/j.ijdrr.2019.101436

Singh, A. S., Eanes, F., & Prokopy, L. S. (2020). Climate change uncertainty among American farmers: an examination of multi-dimensional uncertainty and attitudes towards agricultural adaptation to climate change. *Climatic Change*. https://doi.org/10.1007/s10584-020-02860-w

Singh, C., Dorward, P., & Osbahr, H. (2016). Developing a holistic approach to the analysis of farmer decision-making: Implications for adaptation policy and practice in developing countries. *Land Use Policy*, *59*, 329–343. https://doi.org/10.1016/j.landusepol.2016.06.041

Singh, S. (2020). Farmers' perception of climate change and adaptation decisions: A micro-level evidence from Bundelkhand Region, India. *Ecological Indicators*, *116*, 106475. https://doi.org/10.1016/j.ecolind.2020.106475

Srivastava, S. K. K., Chand, R., & Singh, J. (2017). Changing Crop Production Cost in India: Input Prices, Substitution and Technological Effects. *Agricultural Economics Research Review*, *30*(conf), 171. https://doi.org/10.5958/0974-0279.2017.00032.5

Swami, D., & Parthasarathy, D. (2020). A multidimensional perspective to farmers' decision making determines the adaptation of the farming community. *Journal of Environmental Management*,*264*(October2019),110487. https://doi.org/10.1016/j.jenvman.2020.110487

Swami, D., & Parthasarathy, D. (2021). Dynamics of exposure, sensitivity, adaptive capacity and agricultural vulnerability at district scale for Maharashtra, India. *Ecological Indicators*, *121*, 107206. https://doi.org/10.1016/j.ecolind.2020.107206

Taraz, V. (2017). Adaptation to climate change: Historical evidence from the Indian monsoon. *Environment and Development Economics*, *22*(5), 517–545. https://doi.org/10.1017/S1355770X17000195

Tripathi, A., & Mishra, A. K. (2017). Knowledge and passive adaptation to climate change: An example from Indian farmers. *Climate Risk Management*, *16*(2017), 195–207. https://doi.org/10.1016/j.crm.2016.11.002

Vermeulen, S. J., Aggarwal, P. K., Ainslie, A., Angelone, C., Campbell, B. M., Challinor, A. J., Hansen, J. W., Ingram, J. S. I., Jarvis, A., Kristjanson, P., Lau, C., Nelson, G. C., Thornton, P. K., & Wollenberg, E. (2012). Options for support to agriculture and food security under climate change. In *Environmental Science and Policy* (Vol. 15, Issue 1, pp. 136–144). Elsevier. https://doi.org/10.1016/j.envsci.2011.09.003

Wooldridge, J. M. (2010). *Econometric analysis of cross section and panel data* (Vol. 1). MIT Press.

Yang-jie, W., Ji-kun, H., & Jin-xia, W. (2014). Household and Community Assets and Farmers ' Adaptation to Extreme Weather Event : the Case of Drought in China. *Journal of Integrative Agriculture*, *13*(4), 687–697. https://doi.org/10.1016/S2095-3119(13)60697-8

Zamasiya, B., Nyikahadzoi, K., & Mukamuri, B. B. (2017). Factors influencing smallholder farmers' behavioural intention towards adaptation to climate change in transitional climatic zones: A case study of Hwedza District in Zimbabwe. *Journal of Environmental Management*, *198*, 233–239. https://doi.org/10.1016/j.jenvman.2017.04.073

Zheng, Y., & Dallimer, M. (2016). What motivates rural households to adapt to climate change? *Climate and Development*, *8*(2), 110–121. https://doi.org/10.1080/17565529.2015.1005037

Appendix:

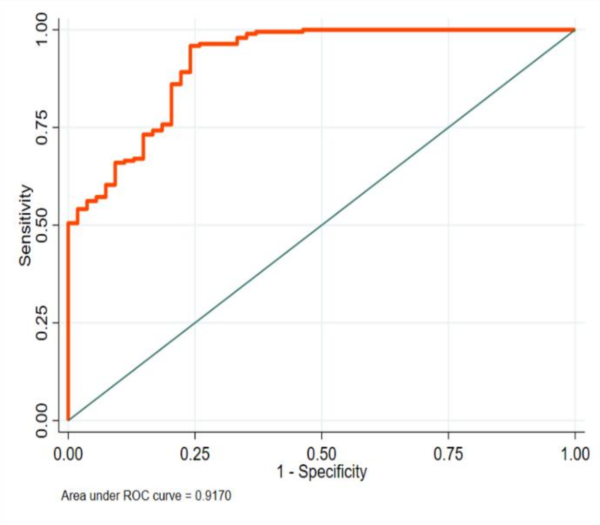

Figure A.1 ROC curve of Rescheduling Planting Model

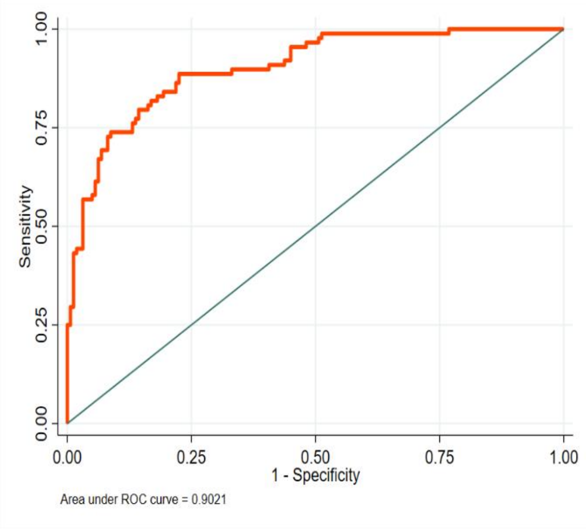

Figure A.2 ROC curve of Crop Diversification Model

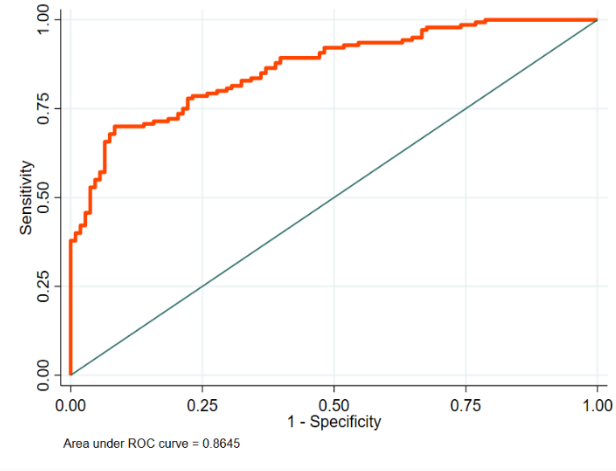

Figure A.3 ROC curve of Crop Rotation Model

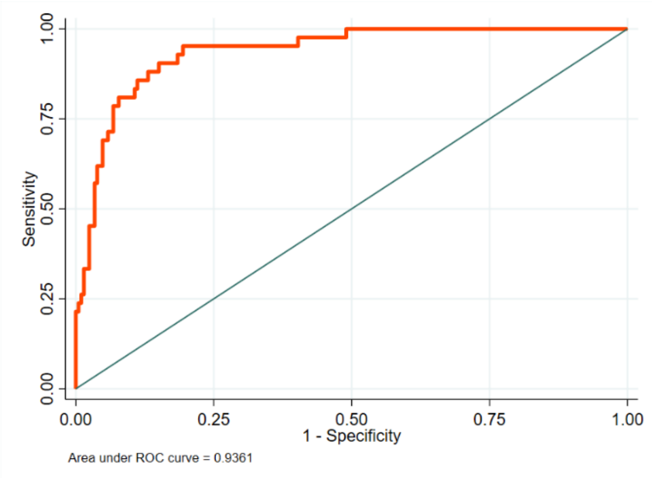

Figure A.4 ROC curve of Crop Rotation Model

Figure A.4 ROC curve of Drought Resistant Seeds

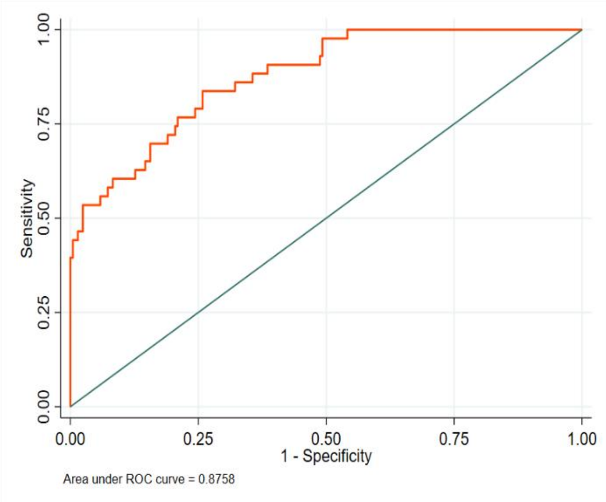

Figure A.5 ROC curve of Micro Irrigation