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Climate Change Vulnerability and Adaptation Strategies of Rice Cultivators in Odisha, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

In the present era, climate change is the biggest challenge for the world. The vulnerability of climate change to India's agriculture sector is quite evident. Due to its geographical existence, climate change is creating a vulnerable situation in the eastern part of India. Odisha's economy is one of the most affected in this regard. The agriculture sector, being the common practice of livelihood, is always sensitive to climate change. The unpredictable rainfall patterns, floods, droughts, and frequent cyclones have caused severe damage to crops and livestock, leading to a lack of employment and a vulnerable situation for farmer households. Therefore, this study employed the LVI approach to evaluate farmers' climate change vulnerability and used the probit model to identify the factors influencing farmers' adaptation options. To accomplish the stated objective, both primary and secondary data have been used. Primary data have been collected from four blocks (Athagarh, Cuttack Sadar, Barang, and Banki) of Cuttack districts, Odisha, where most of the farmers are marginal farmers. The LVI combined nine major components and 33

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subcomponents under it, which establishes a specific functional relationship with vulnerability. The vulnerability assessment indicates that Cuttack district is moderately vulnerable to climate change, with a 0.41 vulnerability score. Social network and livelihood strategies are the major scoring indices in this regard, with 0.90 and 0.65 LVI values, respectively. The probit model found that farming experience and non-farm income are detrimental factors for adopting any strategies to combat climate change. The policy options are precautionary measures that are required to withstand the negative effects of climate change. Therefore, effective government steps required in creating an awareness program, extending training facilities to the farmers, and proper provisioning of irrigation and credit facilities are highly essential for increasing crop productivity and reducing the vulnerability of the farmer household.

Keywords: Climate change; vulnerability; adaptation strategies; agriculture; Odisha.

1. INTRODUCTION

Climate change to poses a serious threat that affects livelihood, human health, settlements, biodiversity in forests, and food production. Climate change causes continuous change in frequency and intensity of some extreme climate phenomena [1]. Climate change also induced shocks that are increasing day by day, and intensifying droughts, floods, storms, and rising sea levels and thereby impacting the world irrespective of any continent or country [2]. Livelihoods like agriculture, fishing, and tourism are severely affected by climate extremes. Moreover, in the case of agriculture, climate change poses serious risks like crop losses, low productivity, and high operational costs. Climate vulnerability can cause low income for farmers and thereby lead to poverty and income inequality for agriculture-dependent people [3].

As agriculture is the major source of occupation in the Indian economy, it is always vulnerable to climate change. Due to its geographical existence, India faces extreme natural events every year, particularly in the eastern region [4]. Therefore, the present study is conducted in Odisha, which is situated on the eastern side of India with 480 kilometers of long coastline. The climate changes are evident in the form of rising temperatures, changing rainfall patterns, and a rise in climate extremes, of which Odisha is no exception. Odisha is an agriculturally predominated state, contributes about 18 percent to the net state domestic product (NSDP) [5], and is the second major sector after the service sector. Rice, the main crop of the state, heavily depends on monsoon rainfall. The scanty of rainfall often causes drought and flood situations in the state. Rising climate extremes pose serious threats to agriculture and the population. With the high level of natural calamities, the implications of climate change and its impact on agricultural activities and farmer livelihoods are essential to understand. Due to climate change, major problems farmers have been facing are the loss of crop production, a lack of employment opportunities, and the deterioration of health conditions. By keeping all the difficulties and inconclusive statements of literature, this study aims to assess the vulnerability of farmer households to climate change and tries to identify the factors that determine the adaptation strategies of rice-growing farmers to climate change in Odisha.

Vulnerability is a multidimensional concept that varies across temporal and spatial scales and depends on economic, social, geographic, demographic, cultural, institutional, governance, and environmental factors [6]. One of the main aspects of any climate change adaptation is the ‘vulnerability assessment’ [7,8,9]. Vulnerability assessment requires the identification of who and what is most vulnerable and why. Biophysical factors such as rainfall variability, land slope, and drought intensity, as well as socioeconomic factors such as low irrigation development, low crop insurance coverage, and smaller forest areas, are primarily responsible for drought vulnerability [10]. Sahoo [11] studied the socio-economic vulnerability of farmer groups to climate change [12,13] and found that, compared to small farmer groups, medium-sized and big farmer groups are capable of incurring a significant cost of irrigation. Districts with poor infrastructure and a high-density of population are severely vulnerable to climatic shocks [14] [15,16]. If we talk about agriculture, there is no positive correlation between temperature and agricultural output, or productivity [17,18,19]. Farmers in areas with high susceptibility to extreme weather and climate change suffer significant financial losses, including low productivity and little variety in crops [20,21]. Climate change also hampers economic growth extensively, i.e., temperature increases and rainfall affect agricultural production, which may be distributed to economic growth [22]. Mishra [23] the study results found that seasonal variables such as rainfall and average temperature adversely affect kharif and rabi crop production.

Climate change and its multiple impacts need to be addressed by suitable coping strategies. To cope with climate change vulnerability farmers are using indigenous adaptation strategies. Adaptation options are the array of strategies and measures available and appropriate to address needs [24]. Adaptation involves reducing risk and vulnerability; seeking opportunities; and building the capacity of nations, regions, cities, the private sector, communities, individuals, and natural systems to cope with climate impacts, as well as mobilizing that capacity by implementing decisions and actions [25]. The area where institutional support is very poor, farmers usually adopt temporary coping strategies [26]. Therefore, climate change adaptation should be viewed in the context of a broader development strategy and rural poverty reduction. In rainfed regions generally, those who have better access to irrigation facilities are adapting to the greatest extent possible and vice-versa [27]. On the other hand, lack of credit is a key impediment to poor adaption options [28]. Adeoti [29] found that, lack of information, climate change, water scarcity, small farm size, limited laboratory capacity, and insufficient irrigation facilities are important variables affecting farmers' crop productivity as well as adaption capacity in response to climate change. Keeping the above aspects, the present study therefore intends to assess the climate change vulnerability and adaptation strategy of rice-growing farmers in Odisha, India.

2. METHODOLOGY

2.1 Study Area and Data Collection

This study is based on both primary and secondary data. Secondary data was collected from international, national, and regional agencies. Secondary data on monthly rainfall, minimum, and maximum temperature were collected from the 'Indian Metrological Department, (IMD) BBSR', Agricultural Statistics and reports of the Special Relief Commissioner (SRC), Odisha. By using the simple random sampling method, primary data was collected in 2023 from Cuttack District, Odisha. Cuttack district has been selected as the study area because farmers here primarily depend on rainfall for their agricultural needs. One hundred and thirty (130) samples were collected from five villages. The sample was collected from four blocks of Cuttack, which are Athagarh, Cuttack Sadar, Barang, and Banki. The study area covered five villages under these blocks: Regedapada comes under Athagarh block, Damodarpur and Fakirpada come under the Cuttack Sadar block, Tutasahi comes under the Barang block, and Gayalabanka comes under Banki block.

2.2 METHODS

This study has used the livelihood vulnerability indicator (LVI) method to calculate the vulnerability of farmers' households to climate change. One of the most important and commonly used methods is the econometric and indicator method to determine the level of vulnerability to climate change [30]. The indicator approach is used in this study to assess the vulnerability of farmers. The study used the livelihood vulnerability index (LVI) as developed by Hahn et al., (2009). For measuring the vulnerability of the farmers' households, 33 variables were selected using the Livelihood Vulnerability Index (LVI) as developed by [31]. The LVI is divided into nine major categories, such as socio-demographic profile, livelihood strategies, social networks, health, food, water, climate variability, natural disasters, knowledge and skill, wealth, and assets. These nine major components are made up of 33 indicators or sub-components, with each major component being composed of several of indicators or sub-components. Each indicator or sub-component is measured on a distinct scale and has a unique functional link to the vulnerability of farmers, which is reflected in Table 1. Each sub-component is standardized as an index using the following equation (Hahn), therefore, each sub-component, as shown above, is measured on a different scale in the equation (1),

$$IS = \frac{C - \min c}{Maxc - Minc} \qquad (1)$$

Equation (2) will be used, when the vulnerability has an inverse relationship with the sub-components.

$$IS = \frac{Maxc - C}{Maxc - MinC} \qquad (2)$$

Where,

IS - For every standardized index score of sub-component.

C- The sub-components observed value
MinC - The sub-components Minimum value
MaxC - The sub-components Maximum value

Once the standardize index score of each sub-component has been obtained then, value of each major component is determined using the following equation (3).

$$Vmc = \frac{\sum_{i=1}^{n} Isi}{n} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

Where,

VMC = shows the Value of all the nine major components
Isi - Index i, of the sub-component, which shows each major component.
n- Number of each major component and its sub-component.

When all the nine values of major components are calculated, and then averaged these values using the following equation (4) and to obtain the Livelihood vulnerability index (LVI).

$$LVI = \frac{\sum_{i=1}^{9} WmiV}{\sum_{i=1}^{9} Wmi} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

In equation (4) it was written as:

$$LVI = \frac{WSDPVSDP+WLSVLS+WSNVSN+WHVH+WFVF+WWVW+WCVNDVCVND+WKSVKS+WWAVWA}{WSDP+WLS+WSN+WH+WF+WW+WCVND+WKS+WWA} \quad (5)$$

Here, the above equations (4) and (5), *WMi* or Ws, respectively, represent the weight of each major component, which is determined by the number of subcomponents that make up all major components to ensure that all subcomponents contribute equally to the overall livelihood vulnerability index (LVI). It refers to the composite index of the livelihood vulnerability index (LVI), which is used as a balanced weighted average method that each sub-component makes equal to the overall index while having a different number of sub-components, but each component is comprised. The value of the livelihood vulnerability index (LVI) is scaled from 0 (least vulnerable) to 1 (most vulnerable).

To analyze the adaptation strategies used by farmers and the factors that determine those adaptation strategies, this study used descriptive statistics and a probit model. The study used this econometric model to identify an important factor in determining adaptation to climate change and variability. Generally, there are two types of variables, such as qualitative and quantitative variables, used here. Qualitative responses are the dependent variable, while mixed qualitative responses are the independent variables. Therefore, a binary probit model specification is adapted to model climate change adaptation behavior of farmers involving dummy dependent variables with binary choices. The binary variable indicates whether or not a farmer has modified their farming practices in response to the changing climate. The study has taken fourteen adaptation strategies for analysis. Every adaptation option was denoted by Y=1, if it adopted a farmer household and 0 not adapted. These adaptation strategies were selected and regressed on a set of independent variables as obtained from theory and literature. These independent variables are the age of the farmer, gender of the farmer, size of the family, nature of the house, farming experience of the farmers, land ownership, education of the household head, cooperative member of the society, non-farm income of the household, livestock ownership of the farmers, credit access by the farmer and availability of electricity at farmer house. The probit regression model was expressed as:

$$Wi = (\Psi\ Xi) + \varepsilon \ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

Where,

Wi = the ith adaptation strategy adapted by farmers to climate change
Xi = the vector of explanatory variables of probability of adapting i^{th} strategy by farmers,
Ψ = the vector of the parameter estimates of explanatory variables and
ε = the error terms

For this reason, the linear specification of the probit regression model is given as:

$W_i = \Psi_0 + \Psi_1 age + \Psi_2\ gender + \Psi_3 householdsize + \Psi_4\ house\ type + \Psi_5\ farm\ experience + \Psi_6\ farm\ size + \Psi_7\ farm\ ownership + \Psi_8\ education + \Psi_9\ cooperative\ member + \Psi_{10}\ non\ farm\ income + \Psi_{11}\ livestock\ ownership + \Psi_{12}\ access\ to\ credit + \Psi_{13}\ electricity\ at\ home + \varepsilon$

The model is calculated by using the STATA 13.0 program.

3. RESULTS AND DISCUSSION

3.1 Vulnerability of Farmer's Household to Climate Change

The overall composite LVI value is 0.41, as seen in Table 1. which shows that farmers in Cuttack district are moderately vulnerable to climate change. Social network and livelihood strategies are the detrimental components of vulnerability. Because, in social network the household members who are not associated with any cooperative societies and self-help groups face credit unavailability during the time of havoc. Livelihood strategies comprise household members working in different community or migrated, households depend only on agriculture, household with semi-pucca or kutcha house, farming household cultivating one single crop and the poor farmer household covered in the below poverty line (BPL) list. These farmer household generally, have no resource or asset during the period of climate change catastrophic situation. They have no other source of livelihood except agriculture practices and cultivates one single crop i.e. rice. During the period of harvest flood and cyclone affect the district and in sowing period, cyclone and erratic rainfall create huge loss to those farmer household. Rice is mostly a Kharif crop and solely depends on monsoon rainfall because the farmers are still using traditional irrigation practices for their crop cultivation. Moreover, not switching from one crop to another and ignorance about modern and advances farming practices makes the farmer household vulnerable to climate change. Fig. 1 shows that social networks, which have the highest value of the nine key components of vulnerability (0.9), have a significant impact on vulnerability. The sub-components hence have the biggest influence on the social network index in the Cuttack area. The second-most significant elements affecting vulnerability as key components are livelihood strategies (0.656923). The remaining seven other factors are there in order of their vulnerability as Food (0.594872), Climate variation and Natural Disaster (0.569967), Knowledge and Skill (0.486154), Water (0.403846), Wealth and Assets (0.330769), Socio-Demographic Profile (0.115159), and Health (0.102564).

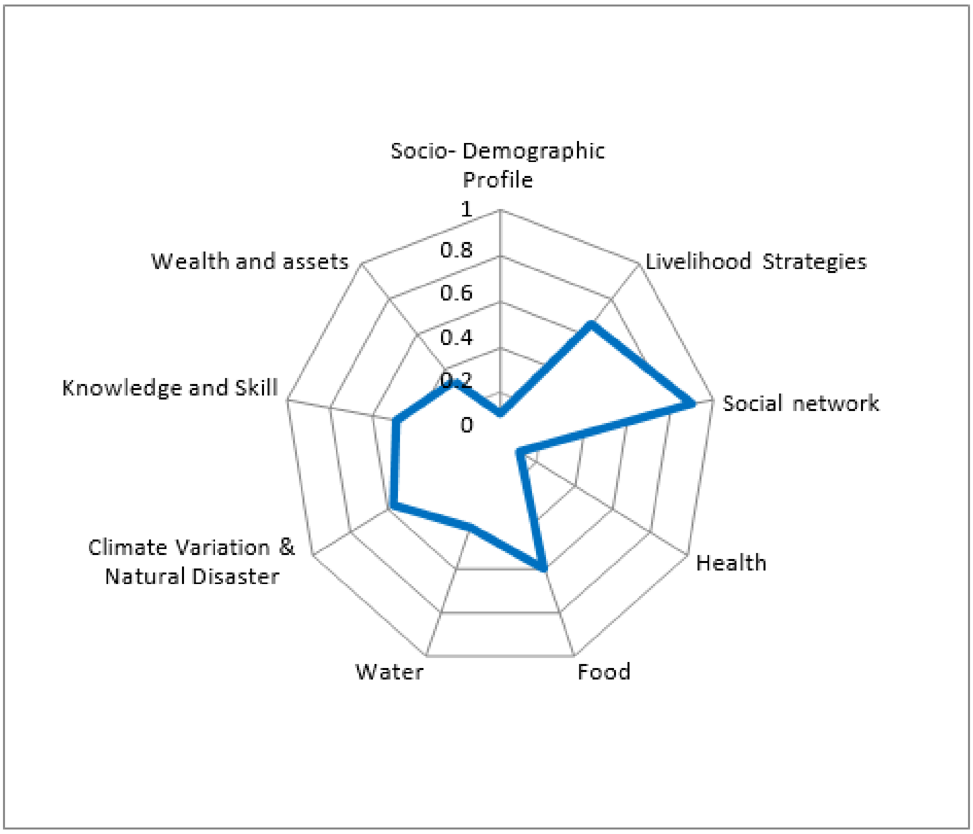

Fig. 1. Major Components Indices values

Table 1. Sub-Components of LVI and Major Component Indices Values

Sub- components/ vulnerability indicators	Unit	Max value	Min value	Relation with vulnerability	Observe d Value	Vulnerability Index value	Major Component s	LVI Value
% of female headed households	%	100	0	Direct	3.846	0.038		
% of HH heads who are illiterate	%	100	0	Direct	0.000	0	Socio- Demograp hic	
Dependency Ratio*	Ratio	3	0	Direct	0.314	0.126	Profile	0.115
Average family members in HH	Unit	8	2	Direct	4.238	0.373		
% HH who do not hold land title	%	100	0	Direct	3.846	0.038		
% of HH with family member working in a different community/ migration in some time	%	100	0	Direct	81.538	0.815	Livelihood Strategies	
% HH depends only on agriculture as a source of income	%	100	0	Direct	86.153	0.862		0.656
% of HH with Semi-Pucca or Kutcha houses	%	100	0	Direct	17.692	0.177		
% of HH cultivating single crop	%	100	0	Direct	62.307	0.623		
% of HH in BPL list	%	100	0	Direct	80.769	0.808		
% of HH are not members of cooperative society/ SHGs or any institution	%	100	0	Direct	10	0.900	Social Network	0.9
% of HH where family member has chronic illness	%	100	0	Direct	6.153 154	0.062	Health	0.102
% of HH do not have access to health services	%	100	0	Direct	4.615	0.046		
% of HH do not have toilet	%	100	0	Direct	20	0.200		
% of HH dependant on family farm for food	%	100	0	Direct	86.153	0.862	Food	
% of HH do not save crops	%	100	0	Direct	49.230	0.492		
% of HH do not save seeds	%	100	0	Direct	43.0769	0.431		0.594
% of HH do not have irrigation facilities	%	100	0	Direct	52.307	0.523	Water	
% of HH utilizing natural water sources	%	100	0	Direct	51.538	0.285		0.403
Average of SD of monthly average max temperature (2000- 2019)	C	36.16	31.98	Direct	1.256	0.716	Climate Variation &	
Average of SD of monthly average min temperature (2000- 2019)	C	23.25	18.73	Direct	1.457	0.509	Natural Disaster	
Average of SD of monthly average of rainfall (2000- 2019)	Mm	146.6	97.98	Direct	19.719	0.485		
								0.569
% of HH do not have crop insurance	%	100	0	Direct	93.846	0.938	Knowledge and skill	
Average of HH head farming experience	1/Yrs	1	0.02	Direct	0.341	0.123		
% of HH all family members with less than primary education	%	100	0	Direct	76.153	0.754		
% of HH with family member attend any training for farming	%	100	0	Inverse	0.000	0.000		0.486
% of HH using improved seeds	%	100	0	Inverse	38.461	0.615		
% of HH own livestock	%	100	0	Inverse	61.538	0.385	Wealth and assets	
% of HH own television	%	100	0	Inverse	76.923	0.231		
% of HH own mobile phone	%	100	0	Inverse	93.076	0.069		
% of HH own vehicle or motor cycle	%	100	0	Inverse	64.615	0.354		0.330
% of HH having life insurance or health insurance	%	100	0	Inverse	95.384	0.046		
% of HH access to credit	%	100	0	Inverse	10	0.900		

Overall LVI value: 0.417748

Sources: calculated by author from field survey data 2023

Table 2. Farmers' Adaptation Strategies in the Study area

Adaptation Strategies	Percentage
Crop Saving	50.7
Cultivating of early maturing crops/ HYV	48.5
Mixed farming	37.7
Cover cropping	37.6
Crop rotation	38.4
Migration to a different area for work	81.5
Changing soil and improving land under cultivation	36.9
Switching from farming to non-farming activities	5.3
Increased used of fertilizer and pesticides	39.2
Increase water conservation practice	6.1
water conservation practice	6.9
Using more irrigation	27.6
Using more fertilizer or pesticides	38.4
Have crop insurance	5.3

Source: calculated by author from field survey data 2023

3.2 Adaptation Strategies of Farmers to Climate Change

If no adaptation measures are taken, the effects of climate change on agriculture will become increasingly severe. Welfare losses are threatened by climate change, especially for marginal and small farmers, whose primary source of income comes from farming. The potential negative effects of climate change on agriculture are offset by adaptation methods. As a result, adaptation is widely recognized as a crucial element in reducing the effects of climate change. To determine whether agricultural households are adapting to climate change, farmers were asked to suggest measures they have taken to cope with the adverse effects of temperature and precipitation changes. Farmers have also been asked whether they are using or not the following adaptation strategies: (1) cultivating improved varieties of crops; (2) changing planting or sowing dates; (3) practicing crop diversification or mixing crops; (4) practicing crop rotation; (5) practicing cover cropping; (6) increasing use of soil and water conservation; (7) increasing use of irrigation; (8) increasing use of fertilizer and pesticides; (9) migrating to a different area; and (10) taking crop insurance.

Table 2 expresses different adaptation strategies that have been used by farmers in Cuttack districts. In brief, this study has calculated the fourteen adaptation strategies of the farmer's household to climate change in Cuttack district. The highest popular methods of adaptation in Cuttack district is migration to a different area for work (81.5), followed by crop saving (50.7), Cultivating of early maturing crops (48.5), increase use of fertilizer and pesticides (39.2), crop rotation (38.4), mixed farming (37.7), changing soil and land under cultivation (36.9), using more irrigation due to climate change (27.6), increase water conservation practice (6.1). Adaptation strategies like; switching from farming to non-farming activities and crop insurance (5.3) adopted by the farmers are very minimal in number due to non-availability of better facilities and proper skills and training.

3.3 Determinants of Adaptation Strategies to Climate Change

Numerous socioeconomic, demographic, institutional, technical, and biophysical elements all have an impact on how farmers adapt to the climate change. As a result, it is now crucial to determine the key factors that influence the different adaptation strategies. We estimated fourteen adaptation strategies for avoiding climate change in a probit model. The model was first estimated using all thirteen explanatory variables, and the variance inflation factor (VIF) was used to test for multicollinearity. A significant variance inflated factor (VIF) multicollinearity problem is being caused by age and land owned by the farmers, according to the VIF results. To estimate the model without age and land own by the farmers and to avoid heteroscedasticity, we run the probit model using robust. Table 3 shows the probit results of the factors that significantly influence the adaptation strategies by the farmers.

Table 3 shows the results of the adaptation strategy taken by farmers due to climate change. In this table, the first row denotes the number of dependent variables, and the first column shows the explanatory variables. From the result, the gender of the household head of the farmer plays an important role in the measurement of adaptation strategies. Gender of the household head is found to be significant and positively related to the irrigation mechanism, adoption of crop insurance and water conservation practices due to climate change. It implies that male headed households were more likely to adopt different irrigation mechanisms, crop insurance and water conservation practice than female respondents due to climate change. According to the findings of our investigation household size has been insignificant and negative effect on the both migration and save crops and significantly positively affect both migration and save crops. This implies that a larger family size enhances the likelihood that people will be engage in agricultural activity when they migrate. It implies that more size of the family more will be the adjustment in the irrigation mechanism due to climate change.

The nature of the house indicates the socio-economic condition of the farmer's household due to climate change. It indicates that a family staying in pucca house in the Cuttack district area is well adopting the adaptation strategies like mixed cropping, cover cropping, crop rotation, irrigation facilities, Switching from farming to non-farming activities, use of fertilizer and pesticides due to climate change.

The knowledgeable crop cultivators are using better crops, crop diversification, cover cropping and more use of fertilizer and pesticides due to climate change and compared to those who have

Table 3. Probit model result on determinants of adaptation strategies for Cuttack district

Variables	Crop Saving	Cultivating early maturing crops	Mixed cropping	Cover cropping	Crop rotation	Migration	Improving land under cultivation	Switching from farming to non-farming activities	Increase in use of fertiser and pesticides	Increase water conservation practice	water conservation	Irrigation	Use of fertilizer/ pesticides use	Crop Insurance
Gender of HH	.508	.174	.236	.158	.175	-1.130	.113	.142	.208	4.407	4.435	5.312	.175	4.386
	(0.531)	(0.783)	(0.769)	(0.844)	(0.825)	(0.126)	(0.870)	(0.837)	(0.800)	(0.000) ***	(0.000) ***	(0.000) ***	(0.829)	(0.000) ***
Family Size	-.034	.132	.456	.406	.404	-.285	.334	.086	.347	.436	.431	.234	.386	.290
	(0.746)	(0.189)	(0.001)***	(0.004)***	(0.004)***	(0.115)	(0.004) ***	(0.578) *	(0.010) ***	(0.038)**	(0.031)**	(0.093)*	(0.005)***	(0.136)
Nature of house	.194	-.034	.034	.0126	.033	-.034	-.050	.390	.041	-.024	.060	.098	.048	-.100
	(0.103)	(0.754)	(0.785)	(0.919)	(0.790)	(0.808)	(0.682)	(0.183)	(0.733)	(0.851)	(0.578)	(0.409)	(0.697)	(0.461)
Farming Experience	-.070	-.152	-.018	-.090	-.085	.0004	-.147	.426	-.096	.508	.110	-.125	-.076	.127
	(0.582)	(0.211)	(0.909)	(0.576)	(0.599)	(0.998)	(0.345)	(0.122)	(0.547)	(0.064)*	(0.521)	(0.405)	(0.635)	(0.545)
Land Ownership	1.316	.374	1.339	1.319	1.334	1.164	5.943	4.038	1.308	4.598	4.643	.863	1.303	-.682
	(0.047)**	(0.509)	(0.072) *	(0.079) *	(0.071) *	(0.061) *	(0.000)***	(0.000)***	(0.075)*	(0.000)***	(0.000)***	(0.222)	(0.080)*	(0.310)
Education	-.020	-.006	-062	-.067	-.053	.111	-.052	-.010	-.067	.097	.053	-.061	-.074	-.103
	(0.576)	(0.860)	(0.192)	(0.159)	(0.251)	(0.050)**	(0.250)	(0.863)	(0.148)	(0.097)*	(0.415)	(0.215)	(0.125)	(0.122)
Cooperative member	-4.873	5.454	5.532	5.475	5.482	2.631	5.029	-.6007	5.484	4.635	4.498	5.701	5.755	4.395
	(0.000) ***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.006)***	(0.000)***	(0.534)	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
Non -farm income	-.688	.385	-.522	-6.373	-6.389	-.909	-.747	2.249	-.294	-.064	-5.247	-5.633	-6.304	-4.954
	(0.067)*	(0.287)	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.002)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
Livestock	1.116	.536	1.013	1.014	1.037	.538	.859	.668	.940	.478	.096	.881	1.053	-.144
	(0.000)***	(0.025)**	(0.000)***	(0.000)***	(0.000)***	(0.080)*	(0.001)***	(0.346)	(0.001)***	(0.171)	(0.799)	(0.002)***	(0.000)***	(0.704)
Access to credit	4.444	-4.919	-5.901	-5.885	-5.904	4.096	-5.461	-3.950	-5.982	-4.189	-4.259	-5.662	-5.923	-4.177
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
Electricity	5.726	-.262	5.369	5.412	5.415	-4.458	5.061	3.647	5.567	3.535	3.911	5.346	5.468	4.194
	(0.000)***	(0.783)	(0.000) ***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***

less farming experience [30]. Here in our study area who are experienced farmers they are easy to access more information and knowledge related whether information due to climate change. Similarly, it experience on farming activities they are not able to take prayer knowledge and whether related information due to climate change. Furthermore, experienced farmers are good at water conservation practices.

A physical resource for farmers is the area of land they cultivate. The possibility of several adaptations being adopted increases with land holding size. The findings however indicate that the likelihood of the farmers changing the planting dates, and taking out crop failure insurance increases with the amount of land they own All the adaptation strategies, except of migration, are found to be favorably and significantly influenced by land ownership.

Higher education can lead to greater opportunities for adaptation [30]. Education is essential for successful migration and water conservation. Education helps farmers make good decisions. A cooperative member is found to be significant and positively related to irrigation mechanisms due to climate change. It implies that farmers who are members of cooperative societies can adopt almost all the adaptation strategies mentioned, except for not switching from farming to non-farming activities due to a lack of expertise and training.

Non-farm income is highly significant and negatively related to the irrigation mechanism due to climate change, and it positively indicates switching from farming to non-farming activities. Non-farm income acts like an asset to switch from one activity to another. Crop rotation, cover cropping, and changing from farming to non-farming activities are more common among farmers who keep livestock. According to the findings, those livestock owners are better equipped to handle climate shifts.

Access to credit increases the likelihood of adaptation. According to this study’s findings, the likelihood of migration is significantly positively impacted only by access to credit. Therefore, the credit policy should be set up so that a farmer can borrow money for agricultural expansion. Households having access to electricity are concerned that they are more likely to switch from farming to non-farming occupations and get crop insurance, and this physical infrastructure leads to the adoption of all other adaptation strategies. Amongst all the adaptation strategies mentioned, farmers choose based on their capacity for adaptation, given the response variables.

4. CONCLUSION

As a coastal state, Odisha is susceptible to the effects of climate change and extreme events such as floods, storm, droughts, coastal erosion, etc. Therefore, this study found out the effects of climate change in Odisha and studied Cuttack district to assess the vulnerability of farmers’ households to the climate change and to identify adaptation strategies for farmers to climate change. This study has incorporated both primary and secondary data & used LVI and Probit models for vulnerability assessment and identified the determinants of adaptation strategies respectively. From the primary survey, it was found that the majority of respondents were marginal farmers. After analyzing the data this study found that Cuttack district is moderately vulnerable to climate change, with a vulnerability ranking score of 0.41. Among all the major indicators, social networks and factors related to livelihood strategies determine high vulnerability, while socio-demographic factors and health components show the district as less vulnerable due to the existence of better physical infrastructure in the health aspect. Since poor households are less able to adapt to these catastrophic situations and the effects of climate change will be detrimental to them. As a result, it is crucial to take adaptation measures to help farmers adapt to and cope with climate change. On the one hand, diverse farming systems represented varying capacities for adaptation. On the other hand, it demonstrated the priorities that farmers set based on their chosen crops and means of subsistence. As an adaptation strategy, most farmers prefer to migrate from one region to another, and the adaptation strategies like; use of irrigation facilities, crop insurance, and shifting from farming to non-farming activities seem to be the lowest in practice by the farmers. The reason is that, in the study area, we generally found the marginal farmers, with the non-availability of better credit facilities. Therefore, they are not switching from one farming to another farming activity out of fear of risk. By keeping in view all the results, this study suggests policies like government intervention regarding the spread of awareness about crop insurance policies, the availability of credit facilities with lower interest rates, irrigation facilities and projects should be entertained. Training programs, flood- and drought-resistant seed libraries, and the promotion of cultivars should be effectively promoted by agriculture extension officers.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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