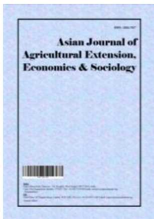

Asian Journal of Agricultural Extension, Economics & Sociology

39(9): 167-179, 2021; Article no.AJAEES.73629
ISSN: 2320-7027

Determinants of Adaptation Strategies of Agricultural Farmers to Climate Change Vulnerability in Odisha

Manoj Kumar Das[1*]

[1]Department of Economics, Ravenshaw University, Cuttack, Odisha-753003, India.

Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

Article Information

DOI: 10.9734/AJAEES/2021/v39i930654
Editor(s):
(1) Dr. Roxana Plesa, University of Petrosani, Romania.
Reviewers:
(1) Ir. Lamria Sidauruk, Methodist University of Indonesia, Indonesia.
(2) Elisha Akech Ochungo, University of Nairobi, Kenya.
Complete Peer review History: https://www.sdiarticle4.com/review-history/73629

Original Research Article

Received 20 June 2021
Accepted 28 August 2021
Published 28 August 2021

ABSTRACT

Climate change poses severe threat to agriculture sector in terms of welfare losses especially for marginal & smallholder farmers whose main source of livelihood derives from agriculture. It is required to neutralize the potential adverse effects of climate change if welfare losses to this vulnerable segment of the society are to be avoided. So this study aims to assess the agricultural farmers' vulnerability and determine quantitatively the factors that contribute in adaptation strategies. To accomplish the stated objective, primary surveys of agricultural farmers are designed and data are collected to analyse the results using probit regression model. The study is conducted in the Jagatsinghpur district of Odisha, India. For the study, a total of 197 farmers' households were surveyed and to assess the vulnerability of farmers' household to climate change, IPCC-LVI approach is used. Then to identify the determinants of adaptation strategies, a regression model is run using probit model. The results reveal that farmers are moderately vulnerable to climate change in the study area. Further, marginal & small farmers are relatively more vulnerable than medium and large farmers to climate change. It is observed that size of the farm, income level, access to credit facilities, extension training and access to climate & weather information are important determinants of adaptation strategies of farmers. Therefore, the study concludes that better credit facilities, extension training facilities and dissemination of climate information may be done through policy intervention for more adaptation strategies by farmers.

**Corresponding author: E-mail: manojdas4@yahoo.co.in;*

Keywords: Climate change; adaptation; vulnerability; agriculture; farmers; LVI.

1. INTRODUCTION

Notable climate changes in terms of rising temperature, changing rainfall pattern and increased climate shocks have been observed across the globe in recent decades [1]. It is also evident that climate changes are accelerating and affecting the agricultural productivity of different crops in different magnitude in Odisha [2]. Odisha is an agriculturally predominated state and highly prone to natural calamities and therefore, the implications of climate change and variability on agriculture activities and farmers livelihood cannot be understated. The vulnerability to climate change varies in time and space. According to IPCC report 2007, vulnerability depends on climate factors and the extent to which a system is exposed, its sensitivity, and adaptation capacity. Food and Agricultural Organisation defines that sensitivity is the extent to which a system is either negatively or positively, directly or indirectly affected by climate change; and adaptation capacity is the ability of a system to reduce, the potential effects of climate change and variability by either taking advantage of existing opportunities or undertaking measures to deal with its consequences. Thus, it is important to assess the degrees of vulnerability for the populace to cope well with climate change impacts and appropriate measures can be applied for future resilience to the climate change. In other words, for a society to prepare itself for gradual or sudden changes in livelihoods due to climate change, the society need to understand the projected changes and how vulnerable they are to those changes.

Agriculture being one of the most important sector, it is set to be hit the hardest by climate change. Indeed, studies established the fact that climate change negatively impact agriculture [3]. Further, climate change poses severe threat to welfare losses especially for marginal & smallholder farmers whose main source of livelihood derives from agriculture. Thus, there is a need to neutralize the potential adverse effects of climate change if welfare losses to this vulnerable segment of the society are to be avoided. Adaptation is widely accepted as a vital component of any policy response to climate change. Literature shows that without adaptation, climate change is generally detrimental to the agriculture, but with adaptation, vulnerability can largely be reduced [4,5]. Climate change will have greater negative impacts on poorer farm households as they have the lowest capacity to adapt and therefore, adaptation measures are important to help farmers to better face climate change and variations [6]. Adaptation is the most efficient and friendly way for farmers to reduce the negative impacts of climate change and this can be done by the farmers themselves taking adaptation actions in response to climate change or by governments implementing policies aimed at promoting appropriate and effective adaptation measures [7]. In the above background, it is necessary to determine quantitatively the factors that contribute to farmers' vulnerability to climate change before suggesting any adaptation strategies. In this study we assess the farmers' household vulnerability to climate change in Jagatsinghpur districts of Odisha followed by identifying the factors determining the adaptation strategies.

The word vulnerability is not only associated with natural hazards like flood and droughts but also extensively used in climate change literature to denote the extent of damage expected to a region, community and households [8]. Efforts have been made by researchers and policy makers for assessments of households' vulnerability to understand the differential impacts of climate change in particular places and the potential obstacles to effective responses by society [9]. In the context of climate change the definition of vulnerability vary in literature according to the perception of the researchers. There are two sides of vulnerability, on one hand, there are the external side of risks of shocks to which an individual or household is subject to climate change and on the other hand an internal side which is defenselessness- meaning a lack of means to cope without damaging loss [10]. Similarly, vulnerability is also defined as the characteristics of a person or group in terms of their capacity to anticipate, cope with, resist and recover from the impacts of natural hazards and states that vulnerability can be viewed along a continuum from resilience to susceptibility [11]. This definition stresses on two sides of vulnerability such as climate change impacts and the capacity to withstand these effects. Experts have identifies two components of vulnerability such as the effects that an event may have on humans (capacity or social vulnerability) and the risk that such an event may occur (exposure) [12]. It is stated that vulnerability is the extent to which a natural system or social system is susceptible to sustain damage from climate change [13]. Similarly, vulnerability is the likelihood of a shock causing a significant loss of welfare [14]. So, vulnerability can be understood as the propensity of a society or a household to experience substantial damage and disruption on results of natural hazards. It is also presented in a formal nomenclature for the vulnerability which includes the threat, the region, the sector, the population group, the consequence, and the time period [15]. This framework largely agrees with the dimensions of vulnerability which are fundamental to describe a vulnerable situation.

The most widely accepted definition of vulnerability to climate change is given by the Intergovernmental Panel on Climate Change (IPCC). The IPCC defines vulnerability to climate change as the degree to which geophysical, biological and socio-economic systems are susceptible to and unable to cope with adverse impacts of climate change. This definition states that vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity. Thus the vulnerability to climate change is the function of three factors:

I. The types and magnitude of exposure to climate change impacts
II. The sensitivity of the target system to a given amount of exposure &
III. The adaptive capacity of the target system

Exposure can be interpreted as the degree of climate stress , nature and extent of changes to particular system which may be represented as change in climate conditions and variability including the magnitude and frequency of extreme events. It reflects factors external to the particular system of interest. Sensitivity refers to the conditions that can worsen, ameliorate or trigger an impact to which a system will respond to climate change either positively or negatively. It is given by the degree to which a system is modified or affected by an internal or external disturbance or set of disturbances [16]. Adaptive capacity describes the ability of a system to adjust to actual or expected climate change stresses to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. These three factors are variable and dynamic in nature and differ with reference to different system that we consider to study their vulnerability. Thus, based on the IPCC definition of vulnerability, different socioeconomic and biophysical indicators are classified into adaptive capacity, sensitivity and exposure. Therefore, this study focuses on vulnerability assessments and identifies the factors that determine adaptive capacity.

2. MATERIAL AND METHODS

The study is conducted in the state of Odisha, India. Geographically Odisha is located between $17^{0}49'$ to $22^{0}36'$ North latitudes and $81^{0}36'$ to $87^{0}18'$ East longitudes. The economy of the state is primarily depends on agriculture where majority of population (82%) of the state live in rural areas. As per the administrative set up of the state of Odisha, it consists of 30 districts and entire state is divided into five physiographic regions and 10 agro-climatic zones. For the analysis of climate change vulnerability and adaptation strategy, the study selected Jagatsinghpur district of Odisha as sample district. Geographically, Jagatsinghpur district lies between 19º58'N to 20º23' N latitude and 82º3' E to 83º45E longitude. It is surrounded by the districts of Kendrapara in north, Cuttack in west, Puri in south and Bay of Bengal in East. The district has a geographical area of 1759 km^2. According to the census of India, 20011, the population of the district is 11,36,971, comprising 5,77,865 males and 5,59,109 females. The percentage of male population is 50.82 percent and that of females is 49.18 percent. The sex ratio of the population works out to be 968 females per 1000 males and of 0-6 years population is 929 in the district. The population density of the district is 682 per km^2 of area. The people in the district mostly depend on agriculture for their livelihood. Due to the strategic location of the district in the coastal area of the state, it is witnessing all types of climate change effects including sea level rise to climate shocks.

The study is based on both primary and secondary data. Secondary data on rainfall and natural disaster are collected from various issues of Agricultural Statistics of Odisha. The primary data are collected from a survey of 197 farm households in a total of four villages Jagatsinghpur districts of Odisha. To select the sample, first the Jagatsinghpur district of Odisha is deliberately selected due to its strategic location in the coastal area and dominance of agricultural activities. From the district, two blocks such as jagatsinghpur and Biridi blocks are selected out of eight blocks though simple random lotteries draw. After selecting the blocks, two villages from each blocks are selected again through random lotteries draw. The villages are Manitri, Hajipur, Arana and Patasara which are selected using simple random sampling methods. To select the sample households, we visited the villages and listed the households whose primary occupation is agriculture. Then from the listed households, 50 households are randomly selected and then we collected data in a structured schedule from them. The map of the study area is shown in the Fig. 1.

2.1 Assessing Vulnerability of Farmers

For assessing the vulnerability of farmers, the study has used IPCC-LVI approach that derives from the IPCC vulnerability definition which characterizes vulnerability with three components: Exposure, Sensitivity and Adaptive Capacity. For the calculation of IPCC-LVI, we combined nine different sub-components of the LVI and its values, into three major components of the IPCC vulnerability as per definition. Table 1 shows the distribution of nine sub-components into three major components of IPCC-LVI.

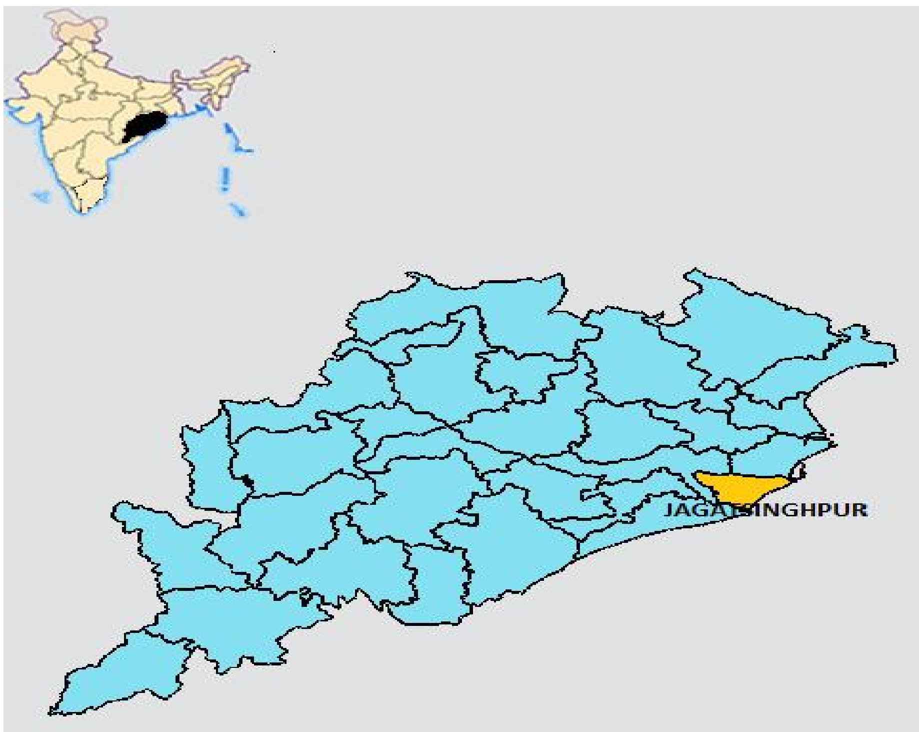

Fig. 1. Map of the study area
Sources: www.veethi.com

Table 1. IPCC-LVI Indicators

IPCC Components	Sub-components
Adaptive Capacity	Socio-Demographic Profile
	Livelihood Strategies
	Social Network
	Knowledge & Skills
	Wealth & Assets
Sensitivity	Health
	Food
	Water
Exposure	Climate Variation & Natural Disaster

Then the following equation 1 is used to compute the vulnerability index value of each IPCC indicator.

$$CF = \frac{\sum_{i=1}^{n} W_{Mi} V_{MC}}{\sum_{i=1}^{n} W_{Mi}} \quad (1)$$

Where,

CF = IPCC vulnerability contributing indicators (Exposure, Sensitivity, or Adaptive Capacity).

V_{MC}= values of major components

W_{Mi}= weight of each major component which is equal to the number of sub-components forming the major components and

n = number of major components in each IPCC vulnerability contributing indicators.

Here, the value of the adaptive capacity is calculated from the inverse of the subcomponents that make up this factor. This is because the adaptive capacity contributes to vulnerability in a different way than the Exposure and Sensitivity i.e. high values for Adaptive Capacity contribute negatively to vulnerability (reduces vulnerability) where as high values of Exposure and Sensitivity contribute positively to vulnerability. Once these three contributing factors are calculated, the following formula is used to get the result of the IPCC-LVI:

IPCC-LVI = $(e - a) \times s$ (2)

Where, the LVI-IPCC is the vulnerability index, e is the calculated exposure score, a is the calculated adaptive capacity score and s is the calculated sensitivity score. The IPCC-LVI value is scaled from -1 (least vulnerable) to 1 (most vulnerable).

2.2 Determinants of Adaptation Strategies

Then to find out the determinants of adaptation strategies, we used probit model. The regressand in the model are farmers' adaptation to climate change, which is a binary variable that indicates whether or not a farmer has adapted a particular strategy to climate change. Every adaptation option was represented by Y =1 if it is adopted by a household and 0 if not. Thirteen adaptation strategies are considered for the analysis. Each adaptation strategy choice is regressed on a set of relevant explanatory variables whose choices are based on theory and literature. These explanatory variables include the gender of the farmer, age of the farmer, household size of the farmer, type of house of the farmer, number of years in farming or farming experience, farming size, farm ownership, education level of the household head, members in cooperatives/farming clubs, formal farming training, farm income of the household, non-farm income of the household, livestock ownership of the farmer, credit access by the farmer, electricity at farmer house and access to climate information. The empirical probit regression model is specified as in equation 3.

Wi = **(ΨXi) +ε** **(3)**

Where,

Wi = the ithadaptation 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.

The linear specification of the probit regression model which is estimated is given as in equation 4.

$$W_i = \Psi_0 + \Psi_1 age + \Psi_2 gender + \Psi_3 householdsize + \Psi_4 housetype + \Psi_5 farmexperience + \Psi_6 farmsize + \Psi_7 farmownership + \Psi_8 education + \Psi_9 cooperativemember + \Psi_{10} farmingtraining + \Psi_{11} farmincome + \Psi_{12} nonfarmincome + \Psi_{13} livestockownership + \Psi_{14} accesstocredit + \Psi_{15} electricityathome + \Psi_{16} accesstoclimateinformation + \varepsilon \quad (4)$$

The model is estimated using the STATA 12.0 program

3. RESULTS AND DISCUSSION

3.1 Vulnerability of Farmers

For assessing vulnerability of farmers the IPCC-LVI is computed by grouping the nine sub-components into three factors contributing to vulnerability namely exposure, sensitivity and adaptation capacity. LVI-IPCC results can lie between -1 to +1, where -1 indicates low vulnerability, 1 indicates high vulnerability and 0 indicates medium vulnerability. Table 2 represents the results for LVI-IPCC focusing on the three indicators contributing to vulnerability: exposure, sensitivity and adaptation capacity.

The Fig. 2 shows the above contributing factors for vulnerability index based on the LVI-IPCC framework.

The IPCC-LVI result shows that the study area is moderately vulnerable to exposure (0.569) to climate change indicators. Further, the adaptive capacity index (0.567) shows that the study area is moderately equipped to cope up the climate change vulnerability. So far as, the sensitivity contributing factor is concerned, the study area has the vulnerability score of 0.301, indicating the area is sensitive to the climate change. The composite LVI-IPCC result is 0.001, which indicates that the study area is moderately vulnerable to climate change impacts. In terms of adaptation capacity of farmers' households, it is found that low indicator values in socio-demographic profile, livelihoods strategies, social networks, knowledge & skills and wealth & assets are major areas of concern of moderate level of adaptation capacity. Farmers are relatively vulnerable due their heavy dependence on rainfall and there is lack of irrigation facilities.

Table 2. IPCC-LVI Values

Contributing Factors	Major Components	No. of Sub-components	Sub-component Index Value
	Socio-Demographic Profile	5	0.794
	Livelihood Strategies	8	0.502
Adaptive Capacity	Social Network	5	0.477
	Knowledge & Skills	5	0.520
	Wealth & Assets	8	0.575
Adaptive Capacity Contributing Value			**0.567**
	Health	5	0.348
Sensitivity	Food	7	0.307
	Water	4	0.235
Sensitivity Contributing Value			**0.301**
Exposure	Climate Variation & Natural Disaster	8	0.569
Exposure Contributing Value			**0.569**
IPCC-LVI Composite Value:			**0.001**

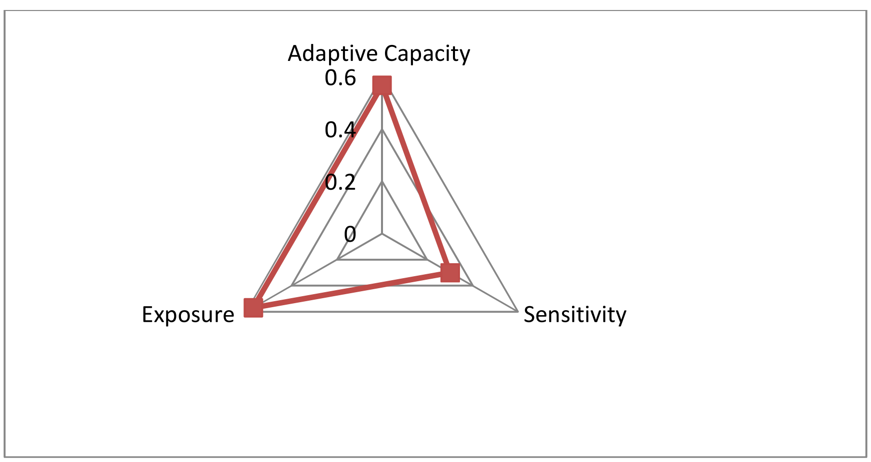

Fig. 2. IPCC-LVI Values of three indicators

3.1.1 Vulnerability of different categories of farmers

Table 3 presents the results for the IPCC-LVI, focusing on the three factors contributing to vulnerability: exposure, sensitivity and adaptation. Here results are reported for three categories of farmers such as marginal & small, medium and large farmer. The LVI-IPCC value -1 represents low vulnerability where as 1 represents high vulnerability and 0 represents moderate vulnerability.

Table 3 shows that LVI-IPCC value for marginal & small, medium and large farmers are 0.005, -0.015 and -0.044 respectively. LVI-IPCC vulnerability index, which takes into consideration exposure, sensitivity and adaptation capacity is also represented in the vulnerability triangle Fig. 3.

The vulnerability triangle diagram indicates that marginal & small farmers are more sensitive (0.316) to climate change & variation than medium (0.295) and large (0.166) farmers. It is interesting to note that the medium farmers are found to be most exposed (0.609) to climate change and variation than large (0.573) and marginal & small (0.566) farmers. But in terms of adaptive capacity, marginal & small farmers are found to be lagging (0.549) behind the medium (0.660) and large (0.836) farmers and this is making marginal & small farmers most vulnerable than other farmers.

3.2 Adaptation Strategies of Farmers

Adaptations are the adjustments or alterations which are introduced by farmers in their farming system in order to manage the losses or to take advantage of changes in climate (IPCC, 2001). More to say, adaptations are adjustments or interventions or effective measures which take place to reduce climate vulnerability or manage losses caused by climate change. The adaptive capacity of each regions or community is determined by factors like available technology, resources and their distribution, structure of the institutions, the stock of human capital, property rights, access to risk spreading processes, the ability of decision makers to manage information and public perception [17]. Therefore, this study seeks to investigate actual adaptations at the farm level as well as the factors driving them. The study used econometric model to identify the major factors determining adaptation options to climate change and variability. Normally, two types of variables are involved here such as qualitative and quantitative variables. The dependent variables used are qualitative responses where as independent variables are mixed qualitative responses. Therefore, a binary probit model specification is adopted to model climate change adaptation behavior of farmers involving dummy dependent variables with binary choices (Table 4). The Fig. 3 shows various adaptation strategies being used by farmers in the study area in response to climate variation and change.

It is revealed from the Fig. 3 that several adaptation strategies are undertaken by farmers. The most popular method of adaptations is the increasing use of fertilizers and pesticides (81.44%).The least popular adaptation methods employed by farmers is switching from crop cultivation to livestock rearing 11.34%. Further, it is observed that the percentage of farmers practicing different adaptation strategies are changing crop planting date (56.70%), cultivating improved crops (47.42%), crop rotation (45.36%), crop insurance (27.83%), migration to other place for work (25.77%), crop diversification/mixing (24.74%), shifting from farming to non-farming (22.68%), increasing use of irrigation (20.62), investments (20.62%), soil and water conservation (16.49%) and cover cropping (16.49%).

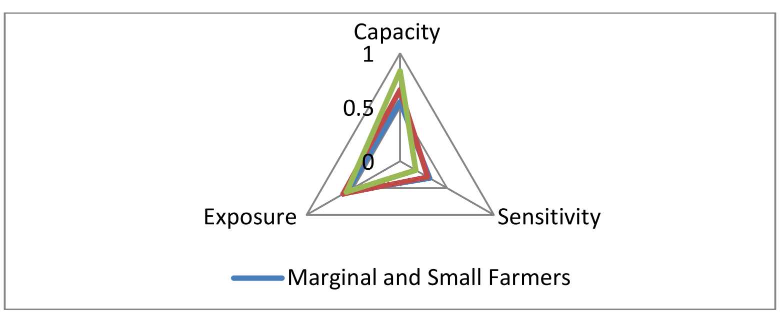

Fig. 3. IPCC-LVI Values for Different Categories of Farmers

Table 3. IPCC-LVI Values for Different Categories of Farmers

IPCC Indicators	Contributing Factors	Vulnerability of Different Categories farmers		
		Marginal & Small Farmer	Medium Farmer	Large Farmer
Adaptive Capacity	Socio Demographic Profile	0.821	0.770	0.887
	Livelihood Strategies	0.487	0.503	0.683
	Social networks	0.423	0.544	0.791
	Knowledge and skill	0.500	0.712	0.997
	Wealth and assets	0.549	0.786	0.883
Adaptive Capacity Contributing Value		**0.549**	**0.660**	**0.836**
Sensitivity	Health	0.354	0.381	0.208
	Food	0.334	0.279	0.146
	water	0.236	0.214	0.146
Sensitivity Contributing Value		**0.316**	**0.295**	**0.166**
Exposure Contributing Value		**0.566**	**0.609**	**0.573**
IPCC-LVI Composite Index Value		**0.005**	**-0.015**	**-0.044**

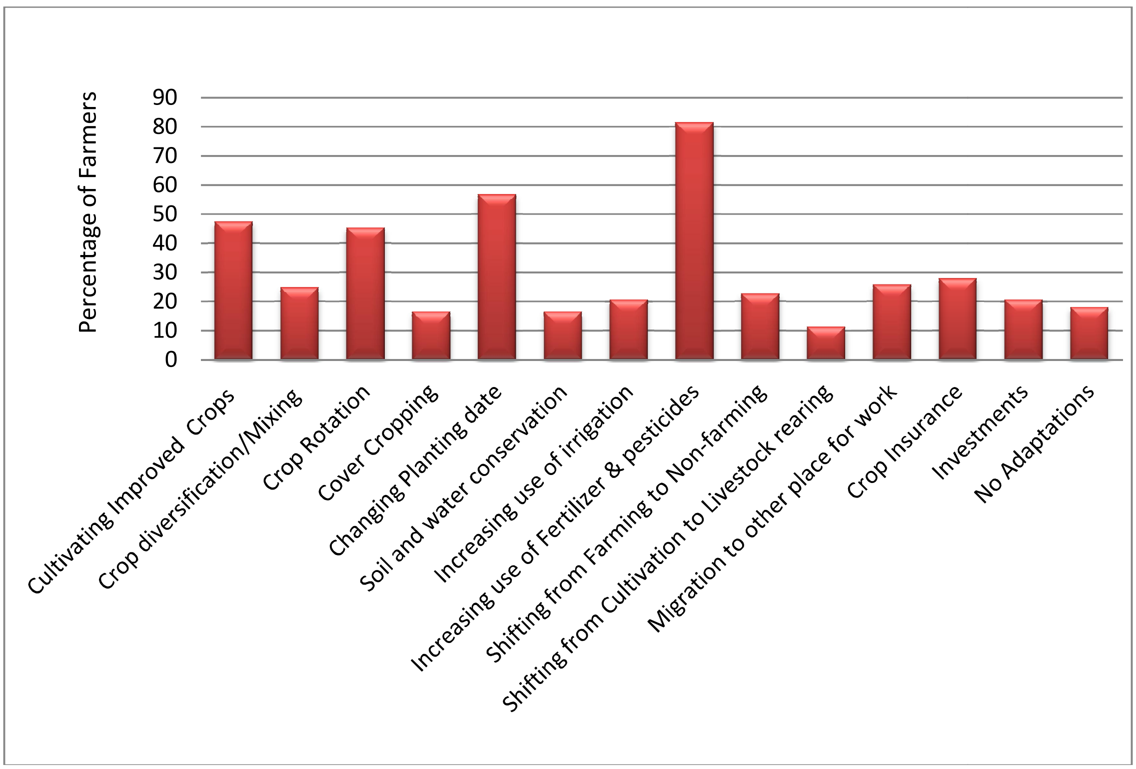

Fig. 4. Farmers' Adaptation Strategies (% of Respondents)

Overall, result shows that reactions of the farmers are different to climate change and they have adapted several strategies at the same time. The reason for adapting several measures at a time is to reduces the risk of crop loss, if one of the measures fails to have the desired effect, the other one may work. Literature suggest that adaptation measures are more effective if applied in combination with others, such as the application of irrigation and fertilizer [18].

3.2.1 Determinants of Adaptation strategies of Farmers

Farmers' adaptation behavior is influenced by a complex set of socio-economic, demographic, technical, institutional and biophysical factors

[19]. Hence, modeling farmers response to agricultural adaptations has become important in identifying major determinants of adaptation of the various adaptation measures. Thus, to find out the determinants of adaptation strategies to climate change we estimated probit model for each of the thirteen adaptation strategies separately. First we estimated the model considering all the sixteen explanatory variables and there after we checked multicolliniarity using Variance Inflation Factor (VIF). The result of the VIF reveals that age and gender are creating the multicollinearity problem with high Variance Inflated Factor (VIF). Therefore we dropped age and genders to estimate the model once again and to avoid heteroscedasticity the probit model run with robust. The Table 4 (Appendix 1) shows the probit results for the determinants of adaptation strategies. The coefficients of the binary probit model analysis represent the effect of each explanatory variable on the ratio of the probability of the household to adopt an adaptation option, relative to the probability of not adopting the option.

Table 4 (Appendix 1) shows the probit results for the determinants of adaptations strategies to climate change. The result reveals that farm income, credit access and farming ownership are some of the major important determinants of adaptation strategies. The importances of each of the determining factor of adaptation strategies as per the probit results are discussed below.

A large Household size is more likely to take up adaptive measures. But a significant negative relationship is observed between household size and investment option as an adaptive measure. The possible reason for this could be the lower per capita income of a large family for which investment as an adaptive strategy is not feasible for the households. Further the result reveals that a large family is less likely to adapt more irrigation facilities. The type of house shows the economic ability of a household to cope of the climate variability. Family staying in a pucca house is more likely to take up adaptive measure than the family staying in kuchha or semi-pucca houses. It is observed that a family staying in pucca house is more likely to use increased irrigation facilities in the wake of climate change. Farming Experience has an increased likelihood of using improved crops, crops diversification, cover cropping and increased use of fertilizers & pesticides. Experienced farmers are likely to have more information and knowledge on changes in climatic conditions and therefore, such farmers are able to adapt more than other farmers who do not have such experience and are not yet adapting to changing climatic conditions. Farm size is another important determinant and with the increase in farming size, there is increased likelihood of using improved crops, increased irrigation practices and increased use of fertilizers. A large size farmer is generally better posed with resources to use more inputs for better yield and production and therefore they adapt climate change with increased use of inputs like fertilizers and irrigations. Farming land Ownership or tenure is more likely to increase the use of improved crops, crop diversification, fertilizers & pesticides, irrigation, crop insurances and investments. It means farmers who own their farm have a higher propensity to invest in adaptation options compared to no ownership. Thus it is important to ensure that tenure arrangements are secure for facilitating investments in long-term adaptation measures by farmers. Ownership of land act as a positive incentive in facilitating farmer investments on their farms that include investments in adaptation and good crop and livestock management practices.

Similarly, level of education is positively significant in cover cropping, soil & water conservation, shifting from farming to non-farming activities and crop insurances. The farmers who are the members of cooperative societies or any farming associations are found to be more likely adapting crop diversification, changing planting dates, using more irrigation and investing more to cope with the changing climate. Farming training of the farmers increases the probability of farmers using crop diversification but decrease the use of fertilizers & pesticides and investments. Farming income is an indicator of wealth and found to have a positive influence on crop diversification & mixing, crop rotation, cover cropping, soil & water conservation, increasing use of fertilizers & pesticides, crop insurances and investments. On the other hand the non-farm income has little positive effects on the adaptation strategies. Farmers with livestock owning are more likely to use crop rotation, cover cropping and shifting from farming to non-farming activities. The results imply those livestock owners are better able to cope with changes to climatic conditions. As expected, access to credit increases the likelihood of adaptation. The results show that access to credit increases the likelihood that farmers will take up crop diversifications & mixing, crop rotation, cover cropping, use of more fertilizers & pesticides and crop insurances.

Thus there are number adaptation strategies available before the farmers but these strategies are influenced by a number of socioeconomic factors like household size, farming experience, farm size, land tenure or ownership, level of the education of the farmers, members farming groups or cooperatives, farming Training, farm Income, and access to credit.

4. CONCLUSION

Moderate level of vulnerability is observed in the study area. Marginal and small farmers found to be relatively more vulnerable due to climate change. In response to the vulnerability, farmers area using various adaptation strategies such as using more fertilizers and pesticides, switching from crop cultivation to livestock rearing, changing crop planting date, cultivating improved crops, crop rotation, cover cropping, crop diversification/mixing, crop insurance, shifting from farming to non-farming, soil and water conservation. Different strategies in farming systems reflected on one hand that systems had a different ability to adapt; on the other hand it reflected where farmers put their priorities, depending on crop type and livelihood strategy. The available adaptation strategies before the farmers are determined by a number of socioeconomic factors like household size, farming experience, farm size, land tenure or ownership, level of the education of the farmers, members farming groups or cooperatives, farming training, farm income, and access to credit. As access to credit, climate & weather information, and farming training positively influence adaptation strategies of farmers, better credit facilities, extension training facilities and dissemination of climate information may be done through policy intervention for more adaptation strategies by farmers.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Guiteras Raymond. The impact of climate change on Indian agriculture. Job Market Paper Draft, MIT Press. 2007;1-55.
2. Das MK. Impacts of climate change on agricultural yield in India: Evidence from Odisha The Indian Economic Journal, Special Issues. 2016;519-525.
3. Deressa TT, Rashid MH. Economic impact of climate change on crop production in Ethiopia: evidence from cross-section measures. Journal of African Economies. 2009;18(4):529-554.
4. Mendelsohn R. Efficient adaptation to climate change. Climatic Change. 2000;45:583-600.
5. Reilly J, Schimmelpfennig D. Agricultural impact assessment, vulnerability and the scope for adaptation. Climatic Change. 1999;43(4):745-788.
6. Adger WN, Vincent K. Uncertainty in adaptive capacity. Comptes Rendus Geoscience. 2005;337:399–410.
7. Fraser E, Simelton E, Termansen M, Gosling SN, South A. Vulnerability hotspots: Integrating socio-economic and hydrological models to identify where cereal production may decline due to climate change induced drought. Working paper no 83, Centre for Climate Change Economics and Policy. University of Leeds, UK; 2012.
8. Terence M. An assessment of climate change vulnerability of smallholder farmers in ward 18, Chikomba district (Master Dissertation). Geography Department, Faculty of Science Education, Bindura University of Science Education, Bindura, Zimbabwe; 2013.
9. Eakin H, Tapia LA. Insights into the composition of household vulnerability from multi-criteria decision analysis. Global Environmental Change. 2008;18:112–127.
10. Chambers R. Vulnerability, coping and policy. IDS Bulletin. 1989;20(2):1-7.
11. Blaikie P, Cannon T, Davis L, Wisner B. At Risk: Natural Hazards, People's Vulnerability, and Disasters. Routledge, London; 1994.
12. Adger WN. Social vulnerability to climate change and extremes in Coastal Vietnam. World Development. 1999;27(2):249-269.
13. Santiago O. Vulnerability and adaptation to climate changes concept, issues, and assessment methods. Climate Change Knowledge Network Foundation Paper. 2001;20. Available:http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.119.576&rep=rep1&type=pdf
14. Okunmadewa F. Risk vulnerability in agriculture; concept and context. Paper

Presented at the Development of Agricultural Economics, University of Ibadan, Nigeria; 2003.
15. Downing TE, Patwardhan A. Vulnerability assessment for climate adaptation. APF Technical Paper 3, UNDP, New York City, NY. Final draft; 2003.
16. Gallopin GC. A systemic synthesis of the relations between vulnerability, hazard, exposure and impact, aimed at policy identification. In Economic Commission for Latin American and the Caribbean (ECLAC). Handbook for estimating the socio-economic and environmental effects of disasters. Mexico, D.F. ECLAC; 2003.
17. Mendelsohn R, Dinar A, Sanghi A. The effect of development on the climate sensitivity of agriculture. Environment and Development Economics. 2001;6:85-101.
18. Tittonell P, Corbeels M, Wijk MT, Vanlauwe B, Giller KE. Combining organic and mineral fertilizers for integrated soil fertility management in smallholder farming systems of Kenya: Explorations using the crop-soil model FIELD, Agronomy Journal. 2008;100(5): 1511-1526.
19. Feder G, Just RE, Zilberman D. Adoption of agricultural innovations in developing countries: A survey. Economic Development and Cultural Change. 1985;33:255-297.

APPENDIX-1

Table 4. Regression results of determinants of adaptation strategies

Variables	Cultivating Improved Crops	Crop diversification	Crop Rotation	Cover Cropping	Changing Planting date	Soil and water conservation	Increasing use of irrigation	Increasing use of Fertilizer & pesticides	Shifting from Farming to Non-farming	Shifting to Livestock rearing	Migration to other place for work	Crop Insurance	Investments
HH Size	.03041 (.04278)	.05244 (.05215)	.08026 (.0489)	-.0963 (.06239)	-.0486 (.0447)	-.09364 (.0844)	-.1085* (.06775)	-.06473 (.05192)	.06382 (.05588)	.12648 (.08401)	.04192 (.05227)	.02676 (.04985)	-.06975 (.07064)
Type of House	.02331 (.32186)	-.11909 (.31505)	-.45347 (.31357)	-.8884 * (.47991)	.1182 (.3163)	-.3870 (.4062)	.75729 * (.39037)	.25171 (.3486)	-.08411 (.32258)	.08799 (.46400)	-.54645 (.33865)	.01995 (.36731)	.05786 (.40833)
Farming Experience	.03209** (.01354)	-.00995 (.01492)	.02009 (.01444)	.03172* (.0180)	-.0378 # (.0134)	.00579 (.0174)	-.00161 (.01458)	.04939 # (.01802)	-.01008 (.01471)	.00782 (.01693)	-.00610 (.01389)	-.01480 (.01465)	-.01661 (.02153)
Farm Size	.22476* (.12887)	-.110119 (.16996)	-.11205 (.12664)	.06364 (.15262)	.05050 (.1493)	.02636 (.1299)	.16497 (.1491)	.28655 ** (.13294)	-.15440 (.19220)	-.20886 (.2652)	.02569 (.18295)	.15835 (.16542)	.12664 (.15903)
Farm Ownership	.06629 (.36172)	.91360** (.36019)	-.158644 (.35677)	-.1533 (.5483)	.03781 (.3557)	.5632 (.4049)	.74018 * (.44337)	.29975 (.43786)	-.06618 (.36635)	.30445 (.5062)	-.01038 (.34357)	1.1670# (.4344)	1.208 ** (.50097)
Education Level	.331215 (.34776)	-.37351 (.38185)	.25276 (.37864)	1.748# (.5710)	-.04915 (.35153)	.01408 (.4629)	.57880 (.46332)	.10767 (.42309)	1.1201# (.40804)	.54274 (.50944)	-.21279 (.33186)	.26723 (.48362)	-.31325 (.58005)
Members of Cooperatives	-.02668 (.33127)	.75200 * (.45598)	.36751 (.32909)	.5120 (.5982)	.16827 (.35154)	-.1853 (.4251)	.4567 (.3624)	-.22191 (.36552)	-.52558 (.3546)	.29057 (.4576)	.26715 (.35701)	.47704 (.35143)	-1.308** (.46949)
Farming Training	-.12825 (.45771)	-1.4553# (.55288)	.35546 (.5185)	.1499 (.5750)	-.0049 (.4627)	-.3792 (.5226)	-.0835 (.5491)	-.03250** (.5976)	-.83106 (.57404)	.35761 (.64715)	.17321 (.56535)	-.10045 (.45781)	.11898 (.60569)
Farm Income	-4.48 (5.86)	.00004 # (.00001)	.00002** (.00001)	2.46 (7.08)	7.32 (5.58)	.00004* (5.55)	5.81 (5.94)	-.0001* (6.04)	-2.03 (7.20)	-7.63 (.0001)	-9.54 (8.96)	5.00 (5.08)	5.59 (5.46)
Non-farm Income	4.02 (2.30)	-8.58 (2.84)	1.56 (2.22)	3.22 (2.89)	3.43 (2.22)	-8.98* (5.70)	-4.65 (2.13)	-5.82 (2.88)	8.12 (1.99)	-.00017** (6.99)	3.49 * (2.11)	1.41 (2.08)	-4.29* (2.60)
Livestock	.18766 (.33456)	-.51884 (.4053)	.61682** (.36144)	1.267** (.5559)	.4948 (.3190)	.0828 (.3771)	.51019 (.3688)	.31532 (.34902)	.14304 (.33998)	0 (omitted)	.3491 (.35688)	.3926 (.4155)	-.08836 (.4081)
Credit Access	.362920 (.3110)	-.06205 (.40234)	.00717 (.3237)	2.147# (.7461)	.3836 (.3342)	-.3284 (.3917)	-.51109 (.37276)	.58291* (.35572)	.20055 (.38311)	-.2992 (.45763)	.22934 (.3348)	.7020 ** (.34414)	0 (omitted)
Electricity at Home	.22292 (.47192)	-1.0379 (.52059)	.26657 (.52317)	-.8748 (.8232)	-.5172 (.5125)	0 (omitted)	-.58787 (.53423)	-.6755 (.56378)	.90971 (.62250)	-.04862 (.83755)	-.4704 (.53656)	.17923 (.50739)	.5109 (.8350)

Variables	Cultivating Improved Crops	Crop diversification	Crop Rotation	Cover Cropping	Changing Planting date	Soil and water conservation	Increasing use of irrigation	Increasing use of Fertilizer & pesticides	Shifting from Farming to Non-farming	Shifting to Livestock rearing	Migration to other place for work	Crop Insurance	Investments
Access to Climate Information	.387359 (.34167)	-.30589 (.38944)	-.02253 (.36122)	-1.195** (.5337)	-.9286 # (.3487)	.0864 (.3969)	-.03719 (.42465)	.40138 (.34484)	.40069 (.38165)	1.0183** (.41486)	-.8769 # (.33779)	.4222 (.4455)	-.0930 (.5855)
Const	-2.467# (.7033)	-.94114 (.66679)	-2.5427# (.81054)	-4.131# (1.2315)	1.55** (.7029)	-.8239 (.67682)	-1.7801** (.69809)	-.12009 (.83051)	-2.3395# (.81524)	-2.6556# (.98066)	.07641 (.7680)	-3.5254 # (1.0619)	.24314 (1.107)

*Figures in the bracket are the Robust Standard Error. *, **, # Significant at 10%, 5% and 1% respectively*

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle4.com/review-history/73629