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RESEARCH ARTICLE

Adaptation Strategies of Climate Change Effect and Factors Affecting the Adaptation Choices of Large Cardamom in Sikkim

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ABSTRACT

Adaptation to climate change has become a major concern to farmers as many researchers reported the contribution of climate change to the decline of large cardamom production. The paper aims to study the adaptation strategies of climate change and factors affecting the adaptation choices in large cardamom in East Sikkim district. Data for the study were collected from 114 farmers through personal interview, focus group discussions and participatory rural appraisal methods. Simple random sampling technique was used for selection of the households. The study identified 10 adaptation strategies followed by the sample farmers (73.68%) to cope up the changing climate and its impacts. Among the identified strategies, gap filling, change in cultivar and cultivate smaller area than usual were the major strategies adopted by the farmers. Binary logistic regression model reveals that four variables viz., age, annual income, influence and extension agent contact were positively influencing the adaptation decision. Therefore, the study suggests more farmers will take up adaptation strategies if information about the climate change and adaptation strategies are made available and the gap between the farmers and extension agent were reduced through better trainings and follow up programmes.

Key words**:** *Climate change; Large cardamom; Problem tree; PRA; Sikkim.*

Adaptation is not a new practice; people have been adapting for survival since immemorial to the changing environment by adjusting and coping with more or less effective results. Main responses to the climate change are of two types: mitigation and adaptation. Mitigation addresses the main causes while adaptation addresses the impacts of climate change. The Inter-governmental Panel for Climate Change (*IPCC, 2007*) defines adaptations as adjustments in natural and human systems in response to actual or expected climatic stimuli or effects which moderates harms or exploits beneficial opportunities. In short, adaptation is a practice followed to decrease the negative effects of climate change.

Recently, climate change has become a major concern for the large cardamom growers as many researchers reported its contribution to the decline of large cardamom production. The State produces about 4,970 tonnes annually from an area of 23,312 hectares (*Spice board, 2021*). Among the four districts of Sikkim, North and East Sikkim district contributes largest in terms of area and production (*GoS, 2016*). Though farmers perceive the long-term effect of the climate change, many fail to take the remedies due to less immediate effect. A major challenge is that climate change adaptation is not a one-size fits all phenomenon; adaptation strategies and farmer responses will vary across regions (*Berry et al., 2006*) based on agro-ecological contexts, socio-economic factors (*Adger et al., 2009, Muthulakshmi and Singh (2019*).

Common adaptation practices are crop diversification, use of different crop varieties, intercropping, changing cropping pattern, tree planting, soil and water conservation, change in planting and harvesting time, using irrigation and supplementing livestock feed (*Tripathi and Mishra, 2016; Gbetibouo et al., 2010; Zizinga et al., 2017*). Drought tolerant crop varieties and technological inputs are used to adapt against increasing climatic stresses in Nepal (*Shreshtha and Sada, 2013*). Socio-profile of the farmers like age, gender, education, occupation, experience, etc.

are reported to have roles in their perception and knowledge of climate change by many researchers. As global climate change has become more apparent, it is important to take measures to the uncontrollable impacts caused by the climate change.

METHODOLOGY

The study carried out in East Sikkim District of Sikkim during 2020-21. Multi-stage sampling method was adopted in which selection of State, District, sub-divisions and villages were done purposively while selection of farmers was done through simple random sampling method. Out of the four sub-divisions in East Sikkim, Gangtok and Rongli sub-divisions were selected purposively. From each sub-division, two cluster villages were selected purposively A sample size of 114 farmers was selected from the cluster villages through simple random sampling method.

Primary data of individual farmers were collected through personal interview using structured interview schedule. Focus group discussions (FGDs) and participatory rural appraisal (PRA) were conducted with the farmers in order to have a general idea of the common adaptation practices and seasonal activities of the farmers. Descriptive statistical tools such as frequency, mean, percentage, Chi square test and standard deviation were used for analysis the data. Adaptation decision of farmers is a binary variable with a choice whether to adapt or not to adapt. Thus, binary logistic regression model was employed in order to find out the factors influencing the adaptation decision of the farmers.

RESULTS AND DISCUSSION

Agricultural profile of the sample cardamom farmer: Majority of the farmers in the study area put most of their lands in cardamom farming. The average land holding under cardamom was 0.68 ha. Based on the area under cardamom, farmers were grouped into 3 categories as marginal, small, and semi medium as per Agricultural Census, 2015-16. Majority of the farmers (81.58%) were marginal farmers followed by small farmers (15.79%) and semi-medium farmers (2.63%).

Table 1. Land use pattern of farmers based on season

Season	Crop	Variety
Pre-kharif	Maize, broomstick, ginger	Local
Kharif	Paddy, millet, beans, pumpkin etc.	Local
Rabi	Cabbage, cauliflower, beans, etc.	Local

Farmers used varieties such as *Golsay*, *Ramsai, Sawney, Bharlangey, etc., Bharlangey* and *Seramna* being the most promising varieties.

Based on the season, the land use pattern of the farmers was categorized into three major groups as pre- *kharif*, *kharif* and *rabi*. The sampled farmers cultivated maize, broomstick, ginger in pre-*kharif* season; paddy, millet, beans pumpkin, *etc.,* in *kharif* season and cabbage, cauliflower, beans, mustard, spinach, *etc*. in *rabi* season. They primarily followed used traditional farming practices and cultivated local varieties of different crops.

Adaptation strategies adopted by the farmers : From the descriptive analysis, it was found that 84 farmers (73.68 %) had taken up various adaptation strategies (Table 2) against the impact of climate change while the remaining 26.32 per cent of the farmers had not taken any adaptation measures. Similar findings were reported by *Destaw and Fenta (2021*) who indicated 93.9 per cent of the households employed various adaptation measures to the adverse effects of the climate change. Further, the study identified 10 adaptation strategies in the study area and they were assigned rank based on the frequency of adoption by the farmers. The list of which is given below in Table 2.

Among the identified adaptation strategies, gap filling was the most popular strategy adopted by majority of the farmers (57.14%) in the study area. This strategy was not adopted earlier as it involves labour and planting materials which are associated with higher cost. However, the State Horticultural Department and village *Panchayat* office have used the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) scheme labour in the cardamom field in order to increase its production. Also, the Department had supplied planting materials to the farmers free of cost. Change in crop cultivar is the second most adopted adaptation strategy which was practiced by 51.19 per cent of the farmers in the study area. Similar finding was also reported by other researchers (*Gbetibuou et. al., 2010; Shrestha et. al., 2010*) against the different impacts of climate change. *Seramna* and *Bharlangey* were the two popular varieties which were adopted by the farmers for its large capsule, disease resistance and higher productivity. *Seramna* is popular for its diseases and pests resistance and *Bharlangey* is popular for its high productivity owing to its large capsule (*Sharma et al., 2016*).

Majority of the farmers participated in FGDs

Table 2. Types of adaptation strategies adopted by the farmers (N=84)

Adaptation Strategies	No.	%	Rank
Gap filling	48	57.14	I
Change in crop cultivar	43	51.19	II
Cultivate smaller area than usual	42	50.00	III
Water management/saving techniques	26	30.95	IV
Change in cropping sequence	17	20.24	V
Change in intercultural operation	16	19.05	VI
Leave complete fallow	14	16.67	VII
New nutrient management techniques	12	14.29	VIII
New diseases/pest management technique.	9	10.71	IX
Establishment of nursery	4	4.76	X

reported that the area under cardamom has decreased considerably. From the table above, it is evident that about 50.00 per cent of the farmers cultivated smaller area than usual cardamom area. The main reason of cultivating smaller area than usual was decrease in the cardamom productivity. The productivity of the crop has decreased due to diseases and pests caused by intermittent heavy rainfall and high temperature. At the same time the market price of the cardamom decreased in comparison to the earlier years reducing overall profit of the farmers. About 30.95 per cent of the farmers had also taken up water management/water saving techniques. The farmers faced water scarcity during the month of December to April due to drying up of the streams which consequently result in the drying of the flowers and plants. In order to reduce the problem, the Sikkim State Government has supplied water storage tank for irrigation through Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) scheme to some selected farmers which encouraged the other farmers to take up the strategy.

About 20.24 per cent of the farmers had also changed the cropping sequence. The main reason for changing cropping sequence was due to diseases and pests. As the farmers couldn't apply chemical control method, the farmer changed cropping sequence in order to eradicate the diseases and pests. Similarly, about 19.05 per cent of the farmers who have taken up climate change adaptation strategies had also changed in intercultural operation. The farmers who adopted the practice reported that tillering of the crop has increased due to viral disease called *foorkey*. The frequency of intercultural operations such as weeding and removal of old and dry shoots were also increased than the earlier years. Also, about 16.67 per cent of the farmers leave the land complete fallow in order to increase the soil fertility and to eradicate the diseases and pests completely. New nutrient management techniques were also adopted by 14.29 % of the farmers. The farmers used cow dung, cow urine and organic manure to increase the soil fertility. New diseases and pests' management techniques were also adopted by 10.71 per cent of the farmers in the study area. Some of the farmers used bio-fertilizers and bio-pesticides to control the diseases and pests. Many of them managed diseases and pests by uprooting, cleaning and burning the disease and pest infected plants. The findings coincide with *Sharma et al. (2016)* and *Kumari et al (2020)*. who reported that use of disease and tolerant varieties, use of manure, irrigation during dry seasons and managing diseases and pests were the adaptation measures developed by the farmers using traditional knowledge. Also, about 4.76 per cent of the farmers had established nurseries to multiply the suckers of the cardamom.

Association of adaptation decision of farmers with explanatory variables : In order to find the association between the adaptation decisions of farmers with the explanatory variables, Chi-square test of independence was employed.

Table 3 depicts the association of different selected explanatory variables with the adaptation decision of the farmers. The significance of the association is determined based on the corresponding calculated p-value. Out of the 11 explanatory variables, three variables *viz.,* influence (source of information), social participation, and extension contact were found to be significant while the rest eight *viz*., age, gender, education, occupation, experience, area under cardamom, annual income and mass media exposure were non-significant.

Among the three significant variables, influence (source of information) turned out to be significant at 1 per cent level of significance. This indicates that there is association between the influence (source of information) and the adaptation decision of the farmers. Also, social participation and extension agent contact were significant at 5 per cent level of significance. This indicates that adaptation decision of the farmer is associated with social participation and extension agent contact. The similar findings were also reported by *Mudiwa (2011)* and *Haque et al. (2020)*. Thus, the null hypothesis that there is no significant association between adaptation decision with influence (source of information), social participation and extension agent contact was rejected.

Table 3. Association of independent variables with adaptation decision

Variable	χ^2	p-value
Age	3.547^{NS}	0.190
Gender	2.076^{NS}	0.206
Education	9.423^{NS}	0.318
Occupation	1.183^{NS}	0.427
Experience	4.509^{NS}	0.119
Area under cardamom	3.907^{NS}	0.167
Annual Income	3.542^{NS}	0.207
Mass media exposure	0.511^{NS}	0.823
Influence (source of Information)	14.126***	0.000
Social participation	10.894**	0.005
Extension agent contact	7.098**	0.035

***Indicates association at 0.01 level of significance
**Indicates association at 0.05 level of significance
*Indicates association at 0.10 level of significance and NS- non-significant

Table 4. Regression analysis of adaptation decision with the explanatory variables

Independent Variables	Beta	S.E	p-value
Age	0.118**	0.047	0.012
Gender	1.229	0.790	0.120
Education	-0.022	0.155	0.886
Occupation	-0.712	0.766	0.353
Experience	-0.090	0.050	0.070
Area under cardamom	0.758	0.960	0.430
Annual Income	0.007**	0.003	0.035
Mass media exposure	0.223	0.149	0.135
Influence (Source of information)	1.638**	0.696	0.019
Social participation	0.205	0.412	0.620
Extension agent contact	0.460**	0.225	0.041
Constant	-6.057	2.700	0.025

log likelihood= 87.835; **Correlation is significant at the 0.05 level (2_tailed)

Binary logistic regression analysis of adaptation decision with the explanatory variables : Adaptation decision of farmers could be influenced by personal, socio-economic and communication characteristics of the farmers. *Jha and Gupta (2021)* reported the influence of the socio-economic characteristics in their adaptation decision at farm level. The dependent variable was binary with a choice whether to adapt (scored as 1) or not to adapt (scored as 0). In order to find the factors influencing the adaptation decision of the farmer, binary logistic regression analysis was employed.

It can be observed from the Table 4 that out of the eleven independent variables fitted in the analysis, four variables *viz*., age, annual income, influence (source of information), and extension agent contact were turned out to be significant with the adaptation at 5 % level of significance. This indicates that the adaptation decision of the farmer is likely to influence by these variables. The positive sign of the variable 'age' implies that with the increase in age, the farmers are likely to adapt the adaptation strategies. Similar findings were also reported by other researchers too (*Asrat and Simane, 2018; Marie et al., 2020*).

Annual Income was found to have positive influence to the adaptation decision. This indicates that farmers with stronger economic background, the possibility of the adaptation increases. The findings coincide with the findings of *Destaw and Fenta (2021*). Influence (source of information) also turned out to have positive influence to the adaptation decision which means the more the farmer are cosmopolite in nature the possibility of taking up adaptation strategies is more. Similarly, extension agent contact was positively associated with the adaptation decision of the farmers. This indicates that the more the farmers are in contact with the extension agent, the more the farmers are likely to adapt. The reason could be due to increase in the awareness and information of the adaptation strategies. The findings coincide with the findings of *Haque et al. (2020), Mihiretu et al. (2020)* and *Golay, and Singh (2021).* These four variables may be termed as the good predictors which are significantly contributing to the prediction of the adaptation decision of the farmer (*Shelar et al (2022).*

CONCLUSION

Farmers in the study area were conscious of climate change and some of them were adjusting and coping up the impacts with their available resources. The study identified 10 adaptation strategies against the climate change followed by the farmers (73.68%). Gap filling, change in crop cultivar, cultivating smaller area than usual were the most popular adaptation strategies taken up by the farmers. Other identified strategies were adoption of new water management techniques, change in cropping sequence change in intercultural operations, leave land complete fallow, adoption of new nutrient management techniques and new disease management techniques. Very few of them had established nursery in their own farm. Furthermore, binary logistic regression showed found four variables *viz*., age, annual income, influence (source of information), and extension agent contact

significant with the adaptation decision at 5% level of significance which indicates that adaptation decision of the farmers were influenced by these four variables in the study area.

CONFLICTS OF INTEREST

The authors have no conflicts of interest.

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