



Farmers' Climate Change Adaptation Intention in North Eastern Hill Region of India

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Authors' contributions

This work was carried out in collaboration among all authors. Authors MVD and RJS designed the study, performed the statistical analysis and wrote the first draft of the manuscript. Authors LD and LH managed the literature searches of the study. Authors RS and BS checked the first draft. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2020/v39i430525

Editor(s):

(1) Dr. Orlando Manuel da Costa Gomes, Lisbon Accounting and Business School and Polytechnic Institute of Lisbon, Portugal.

Reviewers:

(1) M. V. Chandramathi, Delhi Public School, India.

(2) Kanis Fatama Ferdushi, Shahjalal University of Science and Technology, Bangladesh.
Complete Peer review History: <http://www.sdiarticle4.com/review-history/55366>

Original Research Article

Received 05 January 2020

Accepted 13 March 2020

Published 24 March 2020

ABSTRACT

Climate change is real. Production and productivity are affected by the variability in climate. Adaptation measures to climate change are needed to tackle by the farmers. To know the adaptation intention measures practices by the vulnerable farmers of North Eastern Hill Region (NEHR) of India, the study was conducted in three states of NEHR viz., Arunachal Pradesh, Manipur and Meghalaya. The most vulnerable district to climate change from each selected states were purposively selected. With α at 0.05% level of significant and effect size of 0.40, a total of 257 farmers were selected by proportionate random sampling without replacement. The respondent

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farmers have medium 'Mass media exposure', low 'Extension contact, medium 'Exposure to long term stress or shocks and low 'Access to climate change mitigation & adaptation services. The majority farmers practiced Crop and variety diversification and 'Adjusting planting calendar' as 'Climate change adaptation intention'. 'Mass media exposure' and 'Extension contact' were found significant with the 'Climate change adaptation intention' of farmers. From the Multinomial Logistic Regression model, there exist a relationship between the independent variables of the study and the dependent variable, 'Climate Change adaptation intention' of farmers in Agriculture and allied ventures. The study suggested improvement of accessibility and usefulness of local services like agricultural extension deemed a necessity for successful adaptation strategies in the North Eastern Hill Region of India.

Keywords: Climate change; adaptation; mitigation; vulnerable; North Eastern Hill Region; India.

1. INTRODUCTION

With the consternation of the potential impacts of climate change, adaptation strategies have attracted much interest from the multidisciplinary research community [1,2]. According to IPCC adaptation refers to adjustments in ecological, social or economic systems in response to actual or expected stimuli. This term refers to changes in processes, practices, and structures to moderate potential damages or to benefit from opportunities associated with climatic change [3]. Adaptation strategies are particularly crucial for communities reliant on agricultural production as this sector depends substantially on climate sensitive resources. To understand the protection and adaptive behaviour of farmers, it is required to examine not only how farmers perceive climate change but also how they appraise their adaptive measures [4]. Under current climatic change scenario, adaptation strategies are crucial for vulnerable farmers because failure to adapt could lead to deprivation, social disruption and population displacement, and even morbidity and mortality [5]. Adaptation strategies are not only actions that reduce or avoid the effects of specific environmental changes but also take advantage of opportunities for well-being and survival [6]. Different countries have applied different approaches and techniques to adapt with climatic vulnerabilities. Farmers do not have a clear perception of the climatic changes and vulnerabilities. Farmers' adaptation practices to the climatic vulnerability are mostly based on their common sense responses [7]. Adaptation is required to return to, maintain, or achieve the desired state based on awareness that conditions have changed or will change [8]. Currently, investigation of the appraisal of coping and adaptive measures in climate change research is limited in India. A number of factors have been hypothesised to affect farmers' appraisals of adaptive measures to climate change. Cognitive

bias, social discourse on climate change risks, time, money, knowledge, power, entitlements, social and institutional support were raised [9]. The usefulness of information on climate change and adaptive measures based on farmers' assessments significantly influenced their adaptation assessments. Farm households who thought the information of climate change that they received was useful perceived the adaptation more effective, and they had more ability to conduct the adaptive measures [4]. The North Eastern Region comprises eight states Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura. The region shares an international border of 5,182 Kilometres (Km) with several neighbouring countries – 1,395 Km with Tibet Autonomous Region, China in the north, 1,640 Km with Myanmar in the east, 1,596 Km with Bangladesh in the south-west, 97 Km with Nepal in the west, and 455 Km with Bhutan in the north-west. It comprises an area of 262,230 square Km, almost 8% of that of India, and is one of the largest salients in the world. The North Eastern Hill States consist of seven hill states viz., Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura except Assam (as it has areas of plains). In the context of India and North Eastern region, adaptation to climate change through Climate Smart Agriculture (CSA) approach is needed for improving and transforming existing agricultural system to promote national food security while adopting sustainable adaptation measures, respecting local concerns and contributing to global climate change mitigation targets. Agriculture is the main source of livelihood for the people in this region. Due to climate change the region face frequent flood, severe drought like situation, landslide, frost, etc. and affect the yield of many crops. Out of hundred most vulnerable districts in the country, seventeen districts are from the North Eastern

Region [10]. In This study, effort is given to understand the farmers' adaptive measures to the steady changes in climate especially in Agriculture and the factors influencing their adaptation intention to climate change. In order to reduce the vulnerability of the region to climate change robust study on Climate related study are very much essential for the region. The present study tries to understand the farmers' adaptation intention to climate change in the region and factors influencing it.

2. MATERIALS AND METHODS

2.1 Location of Study

East Siang district of the state Arunachal Pradesh cover an area of 4,005 square Km and lies in between 27°30' to 29°42' N latitudes and 94° 42' to 95°35' E longitudes. Being in tropical zone with large water body and sudden rise of hills that obstructs South West Monsoon, the area is one of the wettest parts of the country.

Bishnupur District is situated between 93°43' and 93°53' E Longitudes and 24°18' and 24°44' N Latitudes bounded by Senapati and Imphal West district on the North, Churachandpur district on the south, Chandel district on the south-east and Thoubal district on the east. The famous world's largest floating lake 'Loktak Lake' is located in the district, the world's only floating national park 'Keibul Lamjao National Park' is in this lake. The district has a moderate sub-tropical climate.

East Khasi Hills is one of the seven districts of the State of Meghalaya. The district occupies an area of 2748 Sq Km and it lies between 25°07" & 25°41" N Latitude and 91°21" & 92°09" E Longitude. Bounded by Ri-Bhoi District on the north, Karbi Anglong District on the north east, Jaintia Hills district on the east, Bangladesh on the south and West Khasi Hills district on the west. The climate of East Khasi Hills varies according to elevation and exposure. The Central Highlands with elevation of 1500 m and above have a temperate climate; Places at lower elevations are warm and humid.

2.2 Sampling

The study was conducted in three states viz., Arunachal Pradesh, Manipur and Meghalaya of North Eastern Hill Region of India representing *Tropical, Sub-Tropical and Temperate Agro-Climatic Zone* respectively. The East Siang district of Arunachal Pradesh, Bishnupur district of Manipur and East Khasi hills district of

Meghalaya were selected purposively based on the most climate change vulnerability. Through cluster sampling, five villages from East Siang district, eight villages from Bishnupur district and four villages from East Khasi Hills district were selected purposively. Considering $\alpha = 0.05$, $\beta = 0.95$ and Effect Size = 0.40, the size of sample 'N' of the study was 257 farmers selected based on proportionate random sampling without replacement.

2.3 Variables

The research considers the following ten variables viz., 'Age', 'Gender', 'Education', 'Farming Experience', 'Mass media exposure', 'Extension contact', 'Exposure to long term stress or shocks', 'Access to Climate change mitigation & adaptation services', 'Risk Perception' and 'Scientific Orientation' as independent variables and 'Climate Change adaptation intention' as Dependent variable. For studying the dependent variable 'Climate Change adaptation intention' *Dang et al.* scale of adaptation measures was adapted with slight modification [4].

2.4 Analytical Tools

2.4.1 Multinomial Logistic Regression (MLR)

Multinomial logistic Regression (MLR), an extension of the binomial logistic regression model. It is used when dependent variable has more than two nominal or unordered categories. Like binary logistic regression, MLR uses maximum likelihood estimation to evaluate the probability of categorical membership. According to Alauddin and Sarker [11], the MLR model specifies that:

$$\ln \delta_{m/b}(x) = \ln \frac{\Pr(y=\frac{m}{x})}{\Pr(y=\frac{b}{x})} = x\beta_{m/b};$$

$$m=1\dots j$$

Where, b is the baseline category logit

$$\Pr\left(y = \frac{m}{x}\right) = \frac{\exp(x\beta_{m/b})}{\sum_{j=1}^j \exp(x\beta_{m/b})}$$

Where, x is a vector case specific regression.

The reason of MLR instead of other techniques is that most multivariate analysis required the basic assumptions of normality and continuous data, involving independent and /or dependent variables as aforementioned. Tabanick et al., argued that multinomial logistic regression

technique has a number of advantages as: it is more robust to violations of assumptions of multivariate normality and equal variance and covariance matrices across groups, easily interpretable diagnostic statistics, most importantly, MLR does not assume a linear relationship between the dependent and independent variables, independent variables need not be interval, MLR does not require that the independents be unbounded and lastly normally distributed error terms are not assumed [12].

With the above advantages, MLR is widely used as problem solving tool, particularly in the field of psychology, mathematical finance, engineering, medicine and also in Agriculture especially for risk analysis and identifying risk factors for a given condition/ event/disease. In attempt to identify model on 'Climate change adaptation intention', MLR has been employed. The MLR model was employed with the following H_0 and H_1 hypothesis.

H_0 : There was no significant difference between model without independent variables and model with independent variables.

H_1 : There was significant difference between model without independent variables and model with independent variables.

3. RESULTS AND DISCUSSION

3.1 Profile of Respondents

The socio-personal variables of the respondent farmers are shown in Table 1. The majority of the farmers (38.13% each) were of young (i.e. 42 yrs

& below) and middle (i.e. 43 yrs to 56 yrs) age group. Majority of the farmers (59.92%) were male and female were of only 40.08 percent. Majority of the farmers (39.30%) have education level of Up to class X, followed by illiterate (17.12%), Up to class XII (14.78%), etc. Majority farmers (80.94%) belong to low experience of about 10 to 25 years of farming, followed by Medium experience (14.78%) of about 26 to 40 years of farming. Only 4.28 per cent of the farmers were of high experience for about 41 to 60 years of farming.

The respondent farmers were of medium level of Mass Media Exposure (45.52%) followed by low (43.58%) mass media exposure. Majority farmers were having low Extension contact (70.04%) followed by medium (20.23%) extension contact. For exposure to long term stress or shocks, majority farmers were of medium level (58.75%) of exposure followed by low level of (26.85%) exposure. The farmers were found of low (63.03%) access to climate change mitigation and adaptation services followed by medium (31.52%) access to climate change mitigation and adaptation services. The farmers were also found having medium (56.81%) level of risk perception on climate change followed by low level (37.35%) of risk perception. Also the farmers have medium level (48.25%) followed by high level (28.02%) of scientific orientation. The Fig. 1 represents the distribution of Farmers on Mass Media exposure, Extension contact, Exposure to long term stress or shocks, Access to climate change mitigation & adaptation services, Risk Perception on Climate change and Scientific Orientation.

Table 1. Socio-personal profile of respondents

Sl. no.	Variables	Category	Frequency	Percentage
1.	Age	Young age (42yrs and below)	98	38.13
		Middle age (43yrs to 56yrs)	98	38.13
		Old age (57yrs and above)	61	23.74
2.	Gender	Male	154	59.92
		Female	103	40.08
3.	Education	Illiterate	44	17.12
		Literate & Up to IV standard	12	4.67
		Up to VII standard	27	10.51
		Up to X standard	101	39.30
		Up to XII standard	38	14.78
		Up to B.A	31	12.06
		Master & above	4	1.56
4.	Farming experience	Low experience (10 to 25 years)	208	80.94
		Medium experience (26-40 years)	38	14.78
		High experience (41 to 60 years)	11	4.28

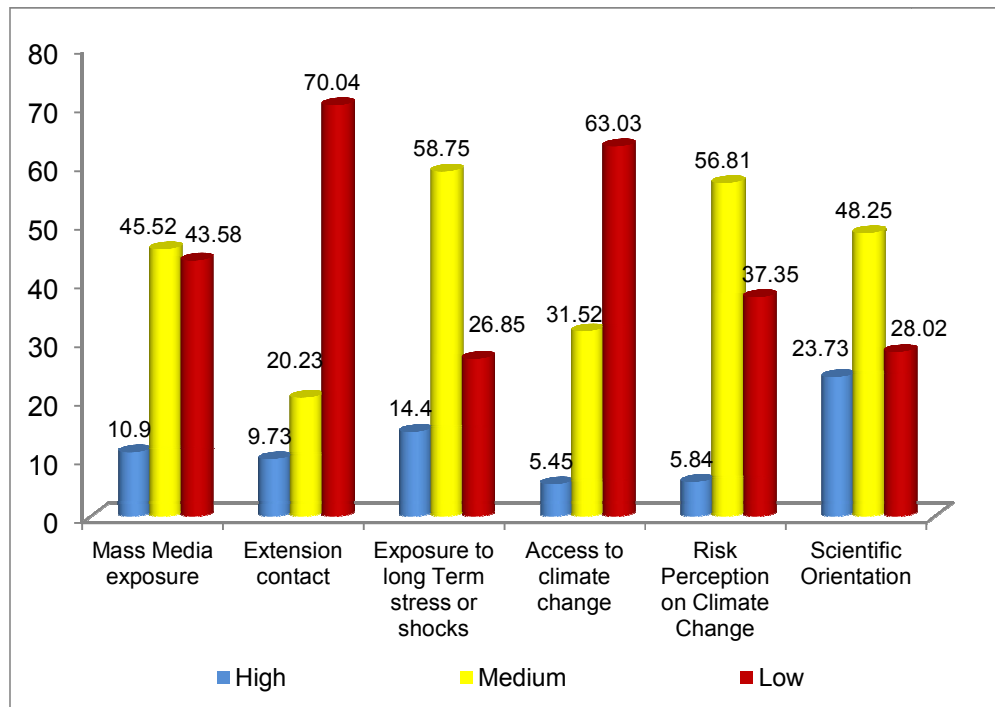


Fig. 1. Distribution of farmers (in %) on mass media exposure, extension contact, exposure to long term stress or shocks, access to climate change mitigation and adaptation services, risk perception on climate change and scientific orientation

3.2 Climate Change Adaptation Intention

The Table 2 represents the Climate change adaptation intention in Agriculture by the vulnerable farmers. The variable is categories into six components viz., *Adjusting planting calendar*; *Adjusting planting techniques*; *Crop and variety diversification*; *Water management*; *Diversifying income source* and *Reinforcing safety for human and assets*. Around half of the respondents (52.29%) found practiced of *Adjusting planting calendar* which comprises of Early planting or harvesting, shortening crop season and growing short/long duration crop as adaptation intention to climate change. Under *Adjusting planting techniques* almost half of respondent (49.90%) found practices of changing irrigation schedule, fertilization timing, Change in used of chemicals and use of labour. For *Crop and variety diversification*, majority farmers (68.51%) were found practice of Growing number of different crops, Use of different varieties, Applying crop rotation and Use of different cropping pattern. *Water management* comprises Invest on water storage/reservoir, Changing water use practices to save water, Recycling use of water and Filtering water where 44.81 per cent

farmers practices as adaptation to climate change. *Diversifying income source* includes Changing from farming to non farming activities, moving from crop to livestock, moving from livestock to crop and integrating crop and livestock where only 40.01 per cent farmers found practiced as adaptation to climate change. Only 33.88 per cent farmers found practiced of *Reinforcing safety for human and assets* which consist of Relocation or reinforcing house, Planting of trees, Buying safety tool kits and Paying attention to disaster warning information and management practices as adaptation measures to climate change. It was observed that the level of adaptation measures and intentions performed by the farmers in the study are less showing that the farmers have low capacity of adaptation. This may be due to the farmers low access to services related to adaptation and mitigations, their low exposure and less contact with extension agents. During the author's visit to village it was observed that the farmers have very low aware of adaptive measures to climate change and also the farmers were interested to follow what they learned from their forefathers, many of them do not want to change to scientific way of practices. Alam et al., mentioned that

Adaptation approaches of farmers vary based on the perceptions, knowledge, locations, availability of resources, cropping patterns, nature and degree of vulnerability; some farmers try to seek solution to the problem through natural process such as by changing the crop planning schedules [7]. Dang et al., also report of high proportion of farmers used the adaptive measures such as adjusting planting calendar, adjusting planting techniques and water use management options in Mekong Delta [4].

3.2.1 Model on climate change adaptation intention of vulnerable farmers of NEHR

The study incorporated the following H₀ and H₁ which had been examined for its best fit in the study.

H₀: There was no significant difference between model without independent variables and model with independent variables.

H₁: There was significant difference between model without independent variables and model with independent variables.

3.2.2 Overall test relationship

A perusal of Table 3 divulged that the probability of the model chi-square (148.552) was 0.000 which was highly significant (i.e. p<0.01). Hence, the H₀ is rejected and H₁ is accepted. By this, it could be suggested that there exist a relationship between the independent variables viz., 'Age', 'Gender', 'Education', 'Farming Experience', 'Mass media exposure', 'Extension contact', 'Exposure to long term stress or shocks', 'Access to Climate change mitigation & adaptation services', 'Risk Perception' and 'Scientific Orientation' and Dependent variable namely 'Climate Change adaptation intention' of farmers in Agriculture and allied ventures.

Table 2. Climate change adaptation intention of farmers

Sl. no.	Climate change adaptation intention	Consolidats core	Percentage
1.	Adjusting planting calendar	2417	52.29
	i. Early planting or harvesting		
	ii. Shortening crop season		
	iii. Growing short/long duration crop		
2.	Adjusting planting techniques	3078	49.90
	i. Changing irrigation schedule		
	ii. Changing fertilization timing		
	iii. Chang in used of chemicals		
	iv. Change in use of labour		
3.	Crop and variety diversification	4226	68.51
	i. Growing number of different crops		
	ii. Use of different varieties		
	iii. Applying crop rotation		
	iv. Use of different cropping pattern		
4.	Water management	2764	44.81
	i. Invest on water storage/reservoir		
	ii. Changing water use practices to save water		
	iii. Recycling use of water		
	iv. Filtering water		
5.	Diversifying income source	2468	40.01
	i. Changing from farming to non farming activities		
	ii. Moving from crop to livestock		
	iii. Moving from livestock to crop		
	iv. Integrating crop and livestock		
6.	Reinforcing safety for human and assets	2090	33.88
	i. Relocation or reinforcing house		
	ii. Planting of trees		
	iii. Buying safety tool kits		
	iv. Paying attention to disaster warning information and management		

Table 3. Model fitting information

Model	Model fitting criteria		Likelihood ratio tests	
	-2 Log likelihood	Chi-Square	df	Sig.
Intercept Only	502.379			
Final	353.827	148.552	20	.000

3.2.3 Strength of MLR relationship

The pseudo-R² viz., Cox and Snell R² and the Nagel kerke R² values of 0.439 and 0.511 respectively shows in Table 4. It implies that between 43.90 percent and 51.10 percent of variability in dependent variable 'Climate Change adaptation intention' was explained by the set of independent variables viz., 'Age', 'Gender', 'Education', 'Farming Experience', 'Mass media exposure', 'Extension contact', 'Exposure to long term stress or shocks', 'Access to Climate change mitigation & adaptation services', 'Risk Perception on climate change' and 'Scientific Orientation' used in the model.

Table 4. Pseudo R-square

Cox and snell	Nagel kerke
0.439	0.511

3.2.4 Relationship of independent and dependent variables

Ascertaining the relationship between independent and dependent variables, the study employed the 'likelihood ratio test'. The 'Likelihood ratio test' evaluates the overall relationship between an independent variables

and dependent variable. The likelihood ratio test in Table 5 shows independent variables viz., 'mass media exposure', 'extension contact', 'Risk perception on climate change' and 'Scientific orientation' of the farmers were highly significant at 1% level of significance apropos of 'Low' and 'Medium' categories of 'Climate change adaptation intention' of farmers. Similarly, the variable 'Exposure to long term stress or shocks' was significant at 5% level of significance with 'Low' and 'Medium' categories of 'Climate change adaptation intention' of farmers. Similar result of 'Risk perception on climate change' found significant with 'low' and 'medium' level of mitigative and adaptive competency in the study of Dympep [13] and Singh [14] were reported. It can be seen from the study that some of the communication and psychological characteristics of the farmers found significant with the intention of adaptation to climate change. This means that the more the farmers have exposure to the external environments and sources, the chance of having more ideas on adapting to climate change increased. It can be conclude that external influences such as intervention of extension agents, Media platform and accessibility to adaptation strategies may be helpful in increasing the adaptation intention of farmers to this changing climate.

Table 5. Likelihood ratio tests

Effect	Model fitting riteria	Likelihood ratio tests	
	-2 log likelihood of reduced model	Chi-square	Sig.
Intercept	377.282	23.455	.000
Age	356.365	2.538	.281
Education	357.701	3.874	.144
Experience	356.710	2.882	.237
Gender	354.793	.966	.617
Mass media exposure	382.465***	28.638	.000
Extension contact	366.898***	13.071	.001
Access to Climate Change mitigation & adaptation services	354.351	.524	.769
Exposure to long term stress or shocks	363.815**	9.987	.007
Risk perception on climate change	384.227***	30.399	.000
Scientific orientation	381.463***	27.636	.000

N.B. - The reference category is 'High level of Climate Change Adaptation Intention'

4. CONCLUSION

The study suggests some directions for adaptation policies. Sources and quality of information can be of important consideration due to the potential influences by extension contact, exposure to long term stress, risk perception and scientific orientation to the farmers' adaptation assessments. Additionally, improvement of accessibility and usefulness of local services like agricultural extension deemed a necessity for successful adaptation strategies in the North Eastern Hill Region of India.

ACKNOWLEDGEMENT

The authors are thankful to Indian Council of Social Science Research for funding the study.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:

The peer review history for this paper can be accessed here:
<http://www.sdiarticle4.com/review-history/55366>