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Factors influencing adaptation to climate change: Evidence from potato growers of Meghalaya state in North East India

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Abstract
Adaptation is an efficient way to fight against the adverse impacts of climate change. The adaptation of farmers to climate change is influenced by many socio-economic factors. However, there is a dearth of studies regarding factors influencing the adaptation of farmers against climate change in Meghalaya. Thus, this study attempted to identify the factors responsible for adaptation by interviewing 120 randomly selected potato growers of East Khasi Hills district of Meghalaya. The findings revealed that majority of the respondents had/were medium adaptation to climate change (42.50%), medium perception level (42.50%), illiterate (19.17%), large family size (35.83%), marginal farmers (44.17%), medium farm income (35.83%), very low non-farm income (29.17%), medium farming experience (47.5%), medium farmer-to-farmer information exchange (43.33%), medium knowledge about local agro-climate (49.17%), low level of credit and subsidy orientation (47.50%), medium information seeking behavior (43.33%), medium preparedness (45.00%) and low resistance to change (40.83%). In the case of the relationship between independent variables and adaptation, there was a positive and significant relationship between independent variables, namely, perception level, farming experience, knowledge about local agro-climate and preparedness and the adaptation of farmers to climate change at 1 percent level of significance. Whereas, there was a positive and significant relationship between independent variables i.e., size of household, farm income, farmer to farmer information exchange, credit and subsidy orientation and information seeking behavior and adaptation at 5 percent level of significance. But it was found that there was no significant relationship between farm size and adaptation of farmers and there was a negative and significant relationship between change resistance and adaptation at 1 percent level of significance. The study suggested that the future climate and agricultural policies and researches in the state should focus on improving the socio-economic factors which potentially influenced the adaptation of farmers to climate change.

Keywords: Adaptation, climate change, Meghalaya, potato, socio-economic factors

Introduction
Climate change is one of the most widespread anthropogenic challenges threatening the livelihood and development of millions of people around the globe. Even though it is a global phenomenon, it has a differential impact on different parts of the world [17], depending on the vulnerabilities of a region and the adaptation capabilities of the people [15]. Adverse impacts of climate change lead to crop losses, fluctuations in food supply and market prices and food insecurity around the world [11, 12]. Researchers and administrators all over the world have given their best efforts to reduce the adverse impacts of climate change; even farmers, using their knowledge and wisdom, tried very hard to cope with the adverse climatic factors [15].
The agriculture sector is highly vulnerable to the impacts of climate change, since it is mostly depending on climatic parameters. Climate change will have a significant impact in India, as agriculture and allied activities contribute about 17 percent to the country's Gross Value Added and provide more than 50 percent of the employment. India is particularly vulnerable to climate change and is likely to suffer from damages to agriculture productivity, food and water security, human health and cattle populations [1]. In North East India, the negative impact of climatic change is far more evident than in other parts of the country [18]. Potato is an important crop in North East India, where the crop is grown under rainfed conditions [25]. However, the potato productivity in the region is very less, hovering around 8-10 tons per hectare during the last 10 years as compared to the national average productivity of about 24 t/ha [21].

Potato is the second most important crop after rice in Meghalaya, and it is well integrated into the dietary habits of people and in their cropping system [8]. During 2018-19, the production in the state was about 1.87 lakh metric tons from an area of about 19 thousand hectares, with the productivity of about 9.98 t/ha. The low productivity could be due to the adverse impacts of climatic factors in the state, among other things. The Compound Annual Growth Rate (CAGR) of area, production and productivity in the state was only 0.3, 1.2 and 0.9 percent respectively, during the last 15 years (2004-05 to 2018-19), which is lower than the national average (Figure 1).

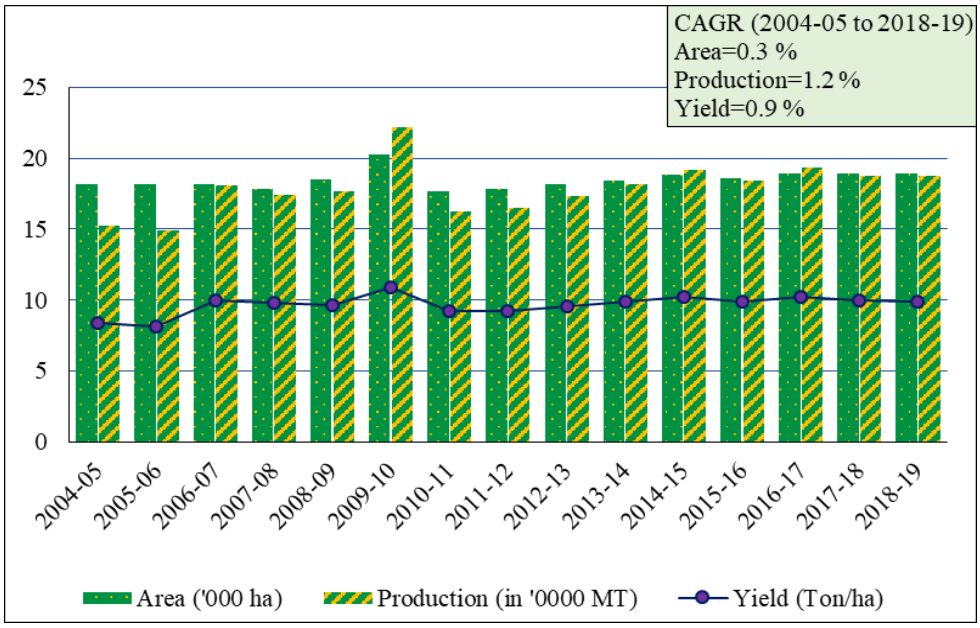

Fig 1: Trends and growth rate of potato area, production and productivity in Meghalaya [(Source: Department of Economics and Statistics of the Ministry of Agriculture and Farmers' Welfare, GOI, CAGR was calculated using the following expression: $\ln(Y) = \ln(b_0) + b_1 t$; where, Y = Variables (Production, Area or Yield); ln = natural log; CAGR is obtained as CAGR (%) = (Antilog b_1-1) X100)]

Adaptation has been considered by many researchers as the efficient way to restrict the negative impacts of climate change. Adaptation enables farmers to maintain food, income and livelihood security while facing changes in climate [14]. The perception of farmers about climate change and its associated risks is a prerequisite for adaptation [28]. Many researchers across the globe attempted to analyze factors influencing the adaptation to climate change, reported that adaptation of farmers is influenced by many socio-economic factors. However, there is a dearth of information regarding adaptation of farmers against climate change in North East India, even though it is a region that is highly vulnerable to the adverse impacts of climate. Based on this scenario, the aim of this study was to identify the socio-economic factors which influence farmers' adaptation to climate change in Meghalaya.

Materials and Methods

Research design and sampling procedure

The ex-post facto research design was selected for the study. The study was conducted in Meghalaya state of North East India. Multi-stage sampling was followed for the study. Out of eleven districts of Meghalaya, East Khasi Hills district was selected purposively for the study as it has the largest area under potato cultivation and also the highest potato producing district. Two blocks, namely, Mawkynrew block and Mylliem block were selected using a simple random sampling technique. Then, from each block, two Gram Sevak circles were selected randomly making a total of four circles. Subsequently from each selected circle, three villages were selected randomly making a total of 12 villages. Finally, ten respondents from each village were selected randomly making a total of 120 respondents.

Variables and their quantification

The study was based on data collected from primary sources (potato growers) using a pre-tested and pre-structured interview schedule. Relevant variables were identified in consultation with experts, and also based on an extensive review of related literatures. The dependent variable, i.e., the adaptation level to climate change was analyzed based on the total score of adaptation of each respondent farmer. The total score of adaptation was obtained by summation of (i) total number of adaptation practices followed by each farmer and (ii) weighted total score of adoption of the adaptation practices which was calculated based on three-point continuum Likert scale, viz., full adoption (score=3), partial adoption (score=2) and non-adoption (score=1) respectively. The independent variables consisted of perception level towards climate change, education, household size, farm size, farm income, non-farm income, farming experience, farmer to farmer information exchange, knowledge about local agro-climate, credit and subsidy orientation, information seeking behavior, preparedness for adaptation and change resistance. The scoring for independent variables like size of household, farm size, farm income, non-farm income and farming experience in potato cultivation were obtained directly based on their respective units and for variables like knowledge about local agro-climate, credit and subsidy orientation, information seeking behavior, etc., their total scores were obtained by asking the respondents to respond to statements which consisted of yes-no questions and Likert scale type questions.

The data generated were subjected to simple descriptive statistics like frequency and percentage. The Product-moment correlation coefficient was used to find out the relationship between the scores of dependent and independent variables

using the following formula.

$$r = \frac{\Sigma xy - \frac{\Sigma(x)\Sigma(y)}{n}}{\sqrt{\left[\Sigma x^2 - \frac{(\Sigma x)^2}{n}\right]\left[\Sigma y^2 - \frac{(\Sigma y)^2}{n}\right]}}$$

Where, r = Co-efficient of correlation between x and y, Σx = Sum of scores of variable x, Σy = Sum of scores of variable y, Σx^2 = Sum of squares of scores of variable x, Σy^2 = Sum of squares of scores of variable y, $(\Sigma x)^2$ = Square of sum of variable x, $(\Sigma y)^2$ = Square of sum of variable y, Σxy = Sum of product of variable x and y and n = Size of sample

Results and Discussion

Socio-Economic Characteristics of Potato Growers

The summary of the independent variables is presented in Table 1. It could be indicated from the Table 1 that majority of the respondents had medium perception towards climate change (42.50%), followed by high perception (30.83%) and low perception (26.67%). The reasons for medium perception level could probably be due to low education level, low to medium information seeking behavior, medium farmer to farmer information exchange, low knowledge about local agro climate and low to medium preparedness for adaptation. Illiterate farmers (19.17%) was the major group, which was followed by primary school (18.33%), functionally literate (15.83%), high schooling (15.00%), middle schooling (14.17%), intermediate (13.33%) and under graduation (4.17%) category respectively. The low level of literacy could probably be due to poor financial conditions, large size of the household (7-8 members), lack of good educational facilities in the rural areas and also of unavoidable necessity in the family to help their parents in farming instead of continuing school due to financial problems. Large family size constituted about 35.83 percent, followed by very large (25.83%), medium (24.17%), and small (14.17%) family size. The prevalence of large family may be due to lack of family planning in rural areas and might also be due to lack of awareness programs about health and family planning.

Table 1: Definitions and summary statistics of independent variables used for the study (N=120)

Variables	Category with score/level	Frequency	(%)
Perception level	Low perception (81 - 101)	32	26.67
	Medium perception (101- 121)	51	42.50
	High perception (121-141)	37	30.83
Education	Illiterate (1)	23	19.17
	Functionally literate (2)	19	15.83
	Primary school (3)	22	18.33
	Middle school (4)	17	14.17
	High school (5)	18	15.00
	Intermediate (6)	16	13.33
	Under graduation (7)	5	4.17
Size of household	Small (1-3 members)	17	14.17
	Medium (4- 6 members)	29	24.17
	Large (7 - 8 members)	43	35.83
	Very large (Above 8 members)	31	25.83
Land holding (ha)	Marginal (0.1-1.0 ha)	53	44.17
	Small (1.1-2.0 ha)	31	25.83
	Semi-medium (2.1-4.0 ha)	26	21.66
	Medium (4.1-10.0 ha)	8	6.67
	Large (above 10 ha)	2	1.67
Farm income (Rupees)	Very low farm income (< 20,000)	9	07.50
	Low farm income (20,000 – 40,000)	29	24.17
	Medium farm income (40,000 – 60,000)	43	35.83
	High farm income (60,000 – 80,000)	27	22.50
	Very high farm income (> 80,000)	12	10.00
Non-farm Income (Rupees)	Very low (<5,000)	31	25.83
	Low (5,000 – 10,000)	21	17.50
	Medium (10,000 – 15,000)	29	24.17
	High (15,000 – 20,000)	22	18.33
	Very high (> 20,000)	17	14.17
Farming Experience (years)	Low experience (3 to 16 years)	33	24.17
	Medium experience (16 to 29 years)	51	47.50
	High experience (29 to 42 years)	36	28.33
Farmer to farmer (F2F) information exchange	Low F2F information exchange (24 to 30)	38	31.67
	Medium F3F information exchange (30 to 36)	52	43.33
	High F2F information exchange (36 to 42)	30	25.00
Knowledge about local agro-climate	Low knowledge (6 to 10)	29	24.17
	Medium knowledge (10 to 14)	59	49.17
	High knowledge (14 to 18)	32	26.67
Credit and subsidy orientation	Low (6 to 9)	57	47.50
	Medium (9 to 13)	39	32.50
	High (13 to 15)	24	20.00
Information seeking behavior	Low information seeking (22 to 30)	38	31.67
	Medium information seeking (30 to 38)	52	43.33

	High information seeking (38 to 46)	30	25.00
Preparedness for adaptation	Low preparedness (18 to 24)	43	35.83
	Medium preparedness (24 to 30)	54	45.00
	High preparedness (30 to 36)	23	19.17
Change resistance	Low resistance (14 to 18)	49	40.83
	Medium resistance (18 to 22)	42	35.00
	High resistance (22 to 26)	29	24.17

Majority of the respondents were marginal farmers (44.17%), followed by small farmers (25.83%), semi-medium farmers (21.66%), medium farmers (6.67%) and large farmers (1.67%). It was also found that majority of respondents (35.83%) had medium farm income, followed by low (24.17%), high (22.50) and very high farm income (10%). With regards to non-farm income, majority of respondents (25.83%) had very low non- farm income, followed by medium (24.17%), high (18.33%), low (17.50%) and very high (10.83%) non-farm income, respectively. About 47.5 percent of the respondents have medium farming experience, followed by high (28.33%) and low farming experience (24.17%). Respondents with medium F2F information exchange constituted about 43.33 percent, followed by low (31.67%) and high (25.00%) F2F information exchange respectively. About 49 percent of the respondents had medium knowledge about local agro-climate followed by high (26.67%) and low (24.17) knowledge. Majority had low level of credit and subsidy orientation (47.50%), followed by medium (32.50%) and high (20.00%) level of credit and subsidy orientation.

With respect to information seeking behavior, majority of the respondents had medium (43.33%), followed by low (31.67%) and high information seeking behavior (25.00%), respectively. Majority of the respondents had medium preparedness for adaptation (45.00%), followed by low (35.83%) and high (19.17%) preparedness for adaptation respectively. This was probably due to the fact that majority of the respondents were illiterate, have medium knowledge about local agro-climate and have low to medium information seeking behavior. Large number of respondents had low change resistance (40.83%), followed by medium (35.00%) and high (24.17%) change resistance, respectively. Many farmers were willing to use the newly improved technologies. Some farmers had high resistance to change due to uncertainty about the new technologies, distrust, lack of knowledge and lack of consultation about the new technologies and their unwillingness to gather more information.

Relationship between independent variables and adaptation to climate change

It could be indicated from the Table 2 that majority of the respondents had medium adaptation to climate change (42.50%), followed by high (30.00%) and low (27.50%) adaptation to climate change respectively. To find out the relationship between the independent variables and the adaptation of potato growers, the Pearson's correlation coefficients were worked out and the results are presented in Table 3.

Table 2: Distribution of the respondents according to their level of adaptation to climate change (N=120)

Category	Class interval	Frequency	(%)
Low adaptation to climate change	20 to 26	33	27.50
Medium adaptation to climate change	26 to 32	51	42.50
High adaptation to climate change	32 to 38	36	30.00

It is evident from Table 3 that there was a positive and significant relationship between independent variables namely, perception level, farming experience, knowledge about local agro-climate and preparedness with the adaptation of farmers to climate change at 1 per cent level of significance. Adaptation to climate change involves a two-stage process, first perceiving change and then deciding whether or not to adopt a particular measure. Thus, there is a significant relationship between perception and adaptation to climate change. Bryant *et al.* (2000) and Maddison (2006) [5, 19] reported similar findings. Highly experienced farmers are likely to have more knowledge on changes and skills regarding climatic conditions and crop and livestock management practices. This finding is in conformity with the results of Nhemachena and Hassan (2007) [20], who inferred that farming experience increases the probability of uptake of all adaptation options. Farmers who are aware of their local agro-climatic conditions have higher chances of perceiving accurate climatic situations, thus take up adaptive measures in response to observed changes perceived. This could be the reason of the positive relationship between knowledge about local agro climate and adaptation to climate change. Nhemachena and Hassan (2007), Deressa (2009) and Niggli *et al.* (2009) [20, 7, 22] found similar findings. Preparedness for adaptation helps the farmers to face the adverse impacts of climate change as they have already prepared for them, thus, there was a positive relationship between preparedness and adaptation of farmers.

Table 3: Correlation coefficient (r-value) between independent variables and adaptation (N=120)

Sl. No.	Independent variables	r
1.	Perception	0.373**
2.	Education	0.232*
3.	Size of household (family size)	0.217*
4.	Farm size	0.172^{NS}
5.	Farm income	0.222*
6.	Non-farm income	0.185*
7.	Farming experience	0.294**
8.	Farmer to farmer information exchange	0.192*
9.	Knowledge about local agro-climate	0.361**
10.	Credit and subsidy orientation	0.183*
11.	Information seeking behavior	0.210*
12.	Preparedness for adaptation	0.335**
13.	Change resistance	-0.285**

**=Significant at 1% level of significance, *=Significant at 5% level of significance, NS=Non significant

Independent variables viz., education, family size, farm and non-farm income, farmer to farmer information exchange, credit and subsidy orientation and information seeking behavior, positively and significantly influenced the adaptation of farmers to climate change at 5 per cent level of significance. A higher level of education is believed to be associated with access to information on improved technologies and climate information. Therefore, farmers with higher levels of education are more likely to better adapt to climate change. The finding is in conformity with the results of Maddison (2006), Apatha (2011) and Tiwari *et al*. (2014) [19, 2, 27]. A large family size is normally associated with a higher labor endowment, which would enable a household to accomplish various agricultural tasks, especially during peak seasons. In a large family, some members would diversify themselves to non-farm activity and as a result add extra income to the family, which in turn helps in purchasing adaptation technologies. The result of the study agreed with the finding of Oyekale and Oladele (2012) and Belay *et al.* (2017) [23, 3]. Lack of money hinders farmers from getting the necessary resources and technologies which assist to adapt to climate change. But higher-income farmers are less risk averse, have more access to information, have a lower discount rate and longer term planning horizon [6]. Hence, there is a positive correlation between farm and non-farm income and the adaptation of farmers. This finding agrees with the results of Nhechema and Hassan (2007), Semenza *et al*. (2008) and Gbetibuou (2009) [20, 26, 10]. Information on climate change through farmer-to-farmer extension increases the likelihood of adaptation to climate change. Isham (2002) and Deressa *et al.* (2009) [13, 7] also found that farmer-to-farmer extension increases the likelihood of using different adaptation measures. Availability of credit eases the cash constraints and allows farmers to purchase the adaptation inputs and technologies. These could be the reason of positive relationship between credit and subsidy orientation and adaptation to climate change. This finding is in conformity with the results of Nhemachena and Hassan (2007), Deressa *et al*. (2009), Gbetibouo (2009) and Fosu-Mensah *et al*. (2012) [20, 7, 10, 9]. Farmers who have high level of information seeking behavior have better chances to be aware of changing climatic conditions and also of the various adaptation practices that they can use to adapt to changes in climatic conditions. Maddison (2006) and Prokopy *et al.* (2008) [19, 24] reported similar results.

As expected, there was a negative and significant relationship between change resistance and adaptation of farmers to climate change at 1 percent level of significance. Farmers who are resistant to change are difficult to adopt new adaptation practices easily. This could be the reason for the negatively significant relationship between resistance to change and adaptation to climate change. There was no significant relationship between farm size and adaptation of farmers, which was against the report of Kide (2014) [16], who found that the total land size of the household had a positive effect on farmer's choices of adaptation strategies. Bradshaw *et al.* (2004) [4] indicated that farm size has both negative and positive effects on the adoption of adaptation practices showing that the effect of farm size on technology adoption is inconclusive.

Conclusion

This study revealed that majority of farmers had medium level of adaptation to climate change. The farmers' adaptation to climate change was influenced by several socio-economic factors. The study suggested that future climate institutional, policy and technology supports should be given more emphasis for strengthen the adaptation capabilities of the farmers in the state. Supports like provision of regular weather and climate-related information to all level of farmers, extension services by conducting various training programs, demonstrations, workshops, etc., financial means through affordable credit and subsidy schemes, development of climate-smart agriculture technologies, validation and merging of traditional adaptation practices with the scientific systems, informal farmer to farmer information exchange and availability of production and adaptation technologies at the right times, would be very helpful for farmers to adapt against the adverse impacts of climate change in the state.

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