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Impact of climate change on agriculture and adaptation: Farmers' experience in North-East India

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Abstract

Climate has already changed. All sections of the society are going to be adversely affected by the changing climate but farmers and marginal section of the society is going to be the worst sufferer. The scientist community has already identified the impact of the change in climate but farmers and lay man may not be aware of it. Unless there is awareness, proper adaptation measures are not likely to take place. This will not only increase vulnerability but also aggravate the whole scenario. Therefore, it is necessary to understand to what extent farmers are aware of the impact of the changing climate and how they are coping with it.

To carry out the study we conducted a field survey in the state of Assam, India. The sample was randomly selected and interviewed with the help of a pre-structured questionnaire. We find that the farmers are able to identify those impacts which are visible

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like reduced output, increased pests' infestation, reduced fodder and reduced income from livestock etc. However, farmers are yet to identify the subtle impact of changing climate. In the name of coping strategies, they have not done much. By applying Chi square, we find that farmers' perception and adaptation are often associated with their land size, education and frequency of crop loss. We recommend climate education and institutional support to strengthen adaptation because marginal farmers are more vulnerable but often fail to adapt to changing climate.

Subject Classification: *62P12, 62P20.*

Keywords: *Climate change, Farmer, Adaptation, Agriculture, Perception.*

1. Introduction

One of the biggest challenges the globe is facing recently is the change in climate which is ultimately threatening the survival of life on the earth. Climate change has already proven to be threatening the food security by limiting the food production as a result of the effects on agriculture in many regions of the world [1, 2, 3, 4] and this without urgent action, will put millions of people at risk of hunger and poverty.

The changing climate around the globe will have an impact on all sectors of the world economy in the coming decades. But it is the agricultural sector that would be affected the most creating food insecurity and water scarcity particularly in the developing world [5, 6]. The burden will mostly fall on the smallholder farmers, who also lack financial and technological efficiency to master effective adaptation measures [7, 8]. Small holder rural farmers are mostly nature dependent and changing climate is affecting their terrain and the environment on which they depend, harming the backbone of rural economy [9].

In this connection, several attempts have been made till date to understanding how climate vulnerability affects farmers by the scientific community. However, the issue is less explored in the context of the north eastern region encompassing the socio-economic dimensions. To develop proper adaptation measures or strategies decades of planning is required and it is also necessary to consider how the rural farmers perceive the changing climate and their local coping strategies [10]. Perceptions of the changing climate are the process of receiving information from the environment and transforming it into psychological awareness [11]. Any misinterpretation of the problems may result in more intense risks [12]. Therefore, the policy makers must consciously apply the perception and response choices of changing climate in order to guide how and where to enhance coping behavior of the farmers [13].

Therefore, the main objectives of the paper is to understand how farmers perceive the impact of changing climate and how they cope with it. This study is grounded on perception of farmers which was recorded during interview. The main argument of the paper is that climate has changed and it is a reality. Ordinary farmers do not understand much about climate and there is lack of evidences in terms of reliable data to prove it. However, farmers can feel the changes in agriculture from their observation. They are capable of observing that climate has changed but fail to relate these changes to climate change.

2. Review of literature

Studies in different parts of the world have already revealed that with every passing year the pressure of climate change is increasing continuously from households to regional levels worldwide [14]. There may be more crop failure and death of livestock, causing financial stress and high food prices may cause hunger [9]. Over the years farmers have been trying to adjust to the changing climate to ensure agricultural sustainability. But the increasing unpredictability of weather has created a challenge to farmers [16, 17]. The effects of the changing climate on agriculture are multi-dimensional, reflected through changes in average temperatures, rainfall and other climate extremes like heat waves etc.; changes in phenology of the pests and diseases; changes in the nutritional standard of some foods; and changes in sea levels etc. [18]. These conditions have direct impact on the overall food production across the globe.

It has been observed that farmers who practice rainfed agriculture are more vulnerable [21, 22]. Effective management of such adversities requires awareness among farmers [23, 24, 25-27]. So, farmer's perception and experience in this case is the determining factor not only for their planting decisions, but also for the adoption of adaptation measures [28]. Hence, considering farmers' perceptions about climate change can be seen as a condition for the design and successful implementation of adaptation policies in agriculture [25, 28].

3. Conceptual framework

In general climate change is understood to be only related to global warming and melting of glaciers. The deep-rooted influence of climate change is ignored at times, which depends on the indivisibility of the backgrounds and the unclear observation of the effects. People need to change their livelihoods or lifestyles to cope with the impacts of

the changing climate from time to time. The success of climate related adaptation and mitigation actions depends on the existing knowledge, attitudes, past behaviour, and social pressure. So, to understand the prolonged impacts of the changing climate, effective communication aimed at changing behaviour is one way to control these determinants [37]. Theory of planned behaviour/reasoned action is one of the psychological theories of behavioural change that works in the direction of achieving this target [38-40].

In this study, we have attempted to explore the behaviour of farmers of North-East India using the theory of planned behaviour (TPB). Theory of planned behaviour is an advancement of the theory of reasoned action (TRA) [41]. Behavioural intent is the key component of this model, which is influenced by the attitude about the likelihood that the behaviour will have the expected outcome and the subjective evaluation of the risks and benefits of that outcome. Therefore, according to this theory, farmers' perception of the changing climate and the coping strategies, is determined by the attitudes of the farmers, the intention or motivation behind the application of the measures, acceptance by their peers and society in combination with their personal abilities and other external forces that may facilitate their actions.

4. Methodology

The study is mainly based on primary data collected at household level. However, secondary data has also been used as and when required and are extracted from different sources like websites, Statistical Handbook of Assam and Statistical Year Book of India which are easily available in the internet. We have used multistage sampling to collect the primary data. First, we have purposively selected 12 districts which are spread across the state. From each district we have selected a block randomly and surveyed 40-45 samples from each block randomly. Before the data collection, data enumerators were trained and explained all aspects of the survey. They were all graduates and could speak local language. We completed the survey during the period 2020 December to May 2021.

To conduct the survey, we prepared a bilingual questionnaire including English and Assamese. While preparing the questionnaire we have consulted NSSO Schedule used for situational assessment of farmers [42-44]. In addition, we have also constructed questions to cover important points which emanated from literature review. The data collected were analyzed by applying simple descriptive tools and diagrams.

To understand the association between farmers' perception and their characteristics, we applied Chi square tests of independence. This is a nonparametric test used to determine if there is any association between two or more categorical variables. Our observations are independent and sample size is relatively large. Here we hypothesize that impact of climate change as perceived by respondents and adaptation measures are independent of characteristics like farmers' education, land holding size and frequency of crop loss.

5. Result and discussion

We have surveyed a total of 638 household heads of which nearly 95 percent of the respondents were male. On an average they were 52 years old. They had a family of size 5.35 having children of size 1.06 on an average per household. We observed inequality in the data set and their median income has been found to be INR 10,000 which is quite low compared to many states of India. Their median expenditure is as low as INR 7500. Thus, it refers to a subsistence level of economic activities.

Although income level is not so high, farmers in Assam still enjoy the minimum facilities required for a good living condition. Nearly 97 percent households have electricity. Almost all the households have water supply availability in their premises. Most of them have toilets. However, their energy use pattern is not that satisfactory as only 38 percent of the families use cooking gas and rest use either firewood or combination of fuels as they do not have enough money to refill the cylinders. Thus, it indicates that they collect firewood from different sources in the villages.

The people of Assam predominantly practice agriculture for livelihood. They predominantly produce rice along with wheat, maize, jute, oil and vegetables to some extent. Majority of them apply tractors (mostly hired) to plough their fields instead of bullock. Focus group discussion revealed that there is decline in fodder and grassland in their localities and it has increasingly become difficult to rear livestock. Nearly 70.5 percent farmers use their own produce as seeds. There is instance where seeds supplied by government fail to germinate and for this reason, they prefer to use their own output as seeds. In addition, farmers often lack capital to buy good quality seeds from the market. More than half of the farmers use pesticides and fertilizers.

It is apparent from Figure 1 that farmers' level of education is not satisfactory, whereas the role of education in farming is immensely important in the present time. An illiterate farmer does not have the required skill to augment production. They can not take advantage of the

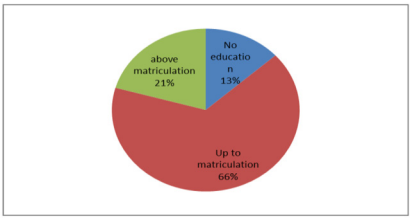

Figure 1

Educational attainment of farmers

Source: Authors' calculation from field survey

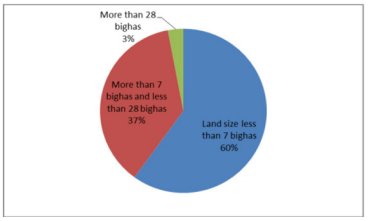

Figure 2

Size of land holding

Source: Authors' calculation from field survey

existing facilities available in the market or provided by the governmnent. Education enhances farmers' productivity and capacity to adopt [45].

Most of the farmers are marginal in terms of land holding (Figure 2). It has been found that the percentage share in number of operational holdings for marginal category of land holdings is 60 percent. The size of ownerships/operational holdings possessed by marginal farmers as stated by NSS report is 0.02 to 1 hectare which is equivalent to 0.15 hectare or approx. 5 kathas to 7.46 bigha in Assam [42].

Crop loss is a major problem among the farmers and they suffer from financial loss owing to crop loss (Figure 3). Nearly 90 percent farmers face the problem recurrently. When farmers were asked about the cause of crop loss; variety of reasons emerged, flood being the most common one.

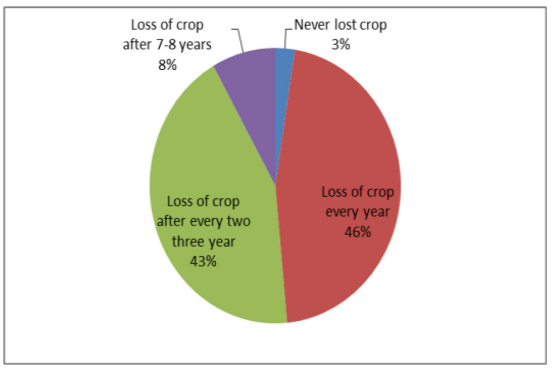

Figure 3

Experience of crop loss

Source: Field survey

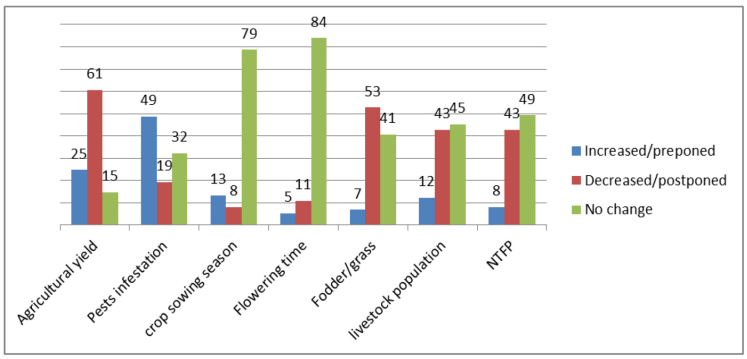

Figure 4

Impact of climate change as perceived by farmers

Flood is a perennial problem in the state. After flood there is infestation of pests in the paddy field and farmers lose crops. The intensity of pest attack has increased owing to increase in temperature, change in moisture and concentration of carbon dioxide [46]. Pests' infestation has some indirect costs as well. Although not very common, variability in rainfall is another cause of crop loss [47].

There are a lot of evidences from all over the world that prove climate change to be affecting agriculture in different ways. We find that majority of the farmers believe that agricultural yield has declined due to climate change (Figure 4). They perceive that there is an increase in the intensity of pests attack and different types of pests have emerged in the recent years. But most of the farmers do not think that there is change in crop sowing season and flowering time. It is natural because climate change is a slow process and farmers without proper knowledge of climate change phenomenon may fail to understand such slow changes. Lay men may fail to understand climate change easily and precisely [48].

Most of the farmers believe that there is decline in fodder. It was revealed by respondents that rearing livestock has become increasingly difficult with passing time. As a result they use fewer bullock to plough. Rather they hire tractors even for a small plot of land. They also believe that livestock population and non timber forests products have declined over the years. Farmers are senstive to the availability of these things [49].

We find from Table 1 that farmers' perception about flowering time, availability of grass/fodder, livestock and NTFP are not accidental but depends on their level of education. At the same time, we also find that perception about changing yield, changes in sowing and flowering time and availability of fodder/grass and livestock population also not

Table 1

Perceived impact of climate change on agriculture in relation farmers' characteristics

Changes	Education	Land size	Crop loss severity
Agricultural yield	X^2 (4, N=634) =2.988, p=0.560	X^2(4, N=634) =8.430, p=0.077	X^2(6, N=634) =14.089, p=0.029
Crop pests	X^2(4, N=634) =1.219, p=0.875	X^2(4, N=634) =5.515, p=0.238	X^2 (6, N=634) =13.308, p=0.038
Crop sowing season	X^2(4, N=634) =7.015, p=0.135	X^2 (4, N=634) =10.689, p=0.030	X^2 (6, N=634) =5.168, p=0.522
Flowering time of crops	X^2 (4, N=634) =15.536, p=0.004	X^2 (4, N=634) =15.439, p=0.004	X^2(6, N=634) =3.046, p= 0.803
Availability of fodder/ grassland for animal rearing	X^2 (4, N=634) =23.546, p=0.000	X^2 (4, N=634) =9.046, p=0.060	X^2(6, N=634) =9.588, p=0.143
Changes in livestock population and income	X^2 (4, N=634) =21.923, p=0.000	X^2 (4, N=634) =15.618, p=0.004	X^2 (6, N=634) =29.324, p=0.000
Non-Timber forests product (NTFP)	X^2 (4, N=634) =12.360, p 0.015	X^2 (4, N=634) =3.758, p=0.440	X^2 (6, N=634) =10.426, p=0.108

Source: Authors' calculation from field survey

independent of size of land. For example, a farmer with smaller land holding needs more grasses from common pool resources and he may also depend on livestock for additional income [50].

Perception about change in yield, pests and changing livestock population is not independent of frequency of crop loss. A farmer suffering from crop loss needs more income from livestock which may work as

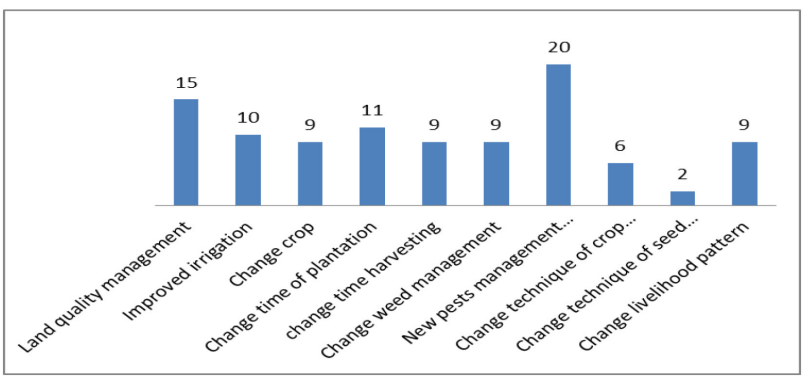

Figure 5

Measures taken to adapt to change in climate

Source: Authors' calculation from field survey

an asset to manage flow of cash especially during emergency. Similarly, pests attack is one of the main causes of crop loss and therefore, farmers' perception about this is not an accidental one [51].

To cope with changing climate farmers implement different measures to reduce the vulnerability. There are many different local and global strategies that farmers are using from their perception toward resilience to environmental change [52, 53]. Adaptation strategies such as use of new crop variety, improved facilities of irrigation, change in the time of plantation, pest management are some important measures implemented by the respondent farmers (Figure 5).

Our result shows that farmers' effort to manage land and soil quality, change in irrigation, harvesting, plantation time, practices and storage harvested crop is not independent of education level (Table 2). To improve the quality of the soil a farmer has to implement different techniques. The farmer has to ensure that there is proper supply of water without which fertilizer and pest management strategies may fail. In addition to all these

Table 2
Adopting to the impact of by farmers' and its association with farmers' characteristics

Measures	Education	Land size	Crop loss severity
Land and soil quality management	X^2 (2, N=634) =5.672, p=0.059	X^2 (2, N=634) =6.484, p=0.039	X^2(3, N=634) =2.643, p=0.450
Irrigation management	X^2 (2, N=634) =8.658, p=0.013	X^2(2, N=634) =7.756, p=0.021	X^2(3, N=634) =2.541, p=0.468
Change in main crop	X^2 (2, N=634) =2.906, p=0.234	X^2 (2, N=634) =2.423, p=0.298	X^2 (3, N=634) =13.107, p=0.004
Plantation time	X^2 (2, N=634) =7.389, p=0.025	X^2 (2, N=634) =1.705, p=0.426	X^2 (3, N=634) =13.994, p=0.003
Harvesting practice	X^2 (2, N=634) =2.294, p=0.682	X^2 (2, N=634) =9.399, p=0.052	X^2 (3, N=634) =1.589, p=0.953
Weed management	X^2 (2, N=634) =1.465, p=0.481	X^2 (2, N=634) =4.523, p=0.104	X^2 (3, N=634) =4.026, p=0.259
Pest management	X^2 (2, N=634) =2.955, p=0.228	X^2 (2, N=634) =0.945, p=0.623	X^2 (3, N=634) =5.046, p=0.168
Storage of harvested crop	X^2 (2, N=634) =4.105, p=0.128	X^2 (2, N=634) =11.077, p=0.004	X^2 (3, N=634) =1.574, p=0.665
Methods of Storage of seeds for next year cultivation	X^2 (2, N=634) =5.936, p=0.051	X^2 (2, N=634) =0.365, p=0.833	X^2 (3, N=634) =.665, p=0.274
Other livelihood opportunities	X^2 (2, N=634) =14.01, p=0.001	X^2 (2, N=634) =1.776, p=0.412	X^2 (3, N=634) =0.348, p=0.440

Source: Authors' calculation from field survey

farmers should know how to store the harvested crop. An ignorant farmer will be having difficulty in adapting such measures.

We find that farmers' adoption of efforts for land and soil quality management is not independent of land size. Land size represents farmers' wealth. Besides education wealth is also important for taking adaptation measures. In addition, irrigation, change in plantation time and methods of storage of seeds are also not independent of land size. Probably marginal farmers are not in a position to adopt such measure. Those farmers with smaller land holdings often need to diversify livelihood to ensures flow of income in the off season and during crises. A poor farmer with less output does not worry about storing his/her harvests much and therefore, this practice is not independent of size of land.

Farmers' change in the main crop and time of plantation are not independent of the frequency of crop loss. Our finding is similar to that of in study [54], in which it has been found that experience of crop failure in the past affects the perception of farmers about climate change. The success of adaptions depends on their perceived ideas about the change in climate and the past adaptation measures. Agronomic practices such as adjusting the time of plantation and changing the crop varieties or main crop have been successfully used as the main adaptive response to change in climate in different studies previously [56].

6. Conclusion

This paper tries to understand farmer perception about the impact of climate change on agriculture and what kind of adaptation strategies they adapt to it. It is important to understand the issue for policy making process and we find that farmers have mixed experience of climate change. The impacts which are directly related to farmers' need are clear for them. For example, farmers believe climate change has affected yield, pests, availability of fodder, income from livestock and availability of NTFP. These farmers are not so highly educated and their perception is completely based on their experience. The subtle impact like change in flowering time has been noticed by a few farmers.

Farmer's perception often has significant relation with level of education and land size and incidence of crop loss. However, when asked about their adaptations strategies, efforts seem to be lacking among the farmers and in most cases, they are independent of farmers' education level, land size and incidence of crop loss.

We recommend proliferation of climate change education. Farmers should be trained to cope and adapt to the impact of changing climate or they will practice maladaptation in absence of knowledge. Climate

change has already taken place and we cannot prevent it from showing its impact. Therefore, farmers should be provided with opportunities to insure against the risk of climate change to minimize the damage to the environment and mankind in the long run.

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