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Impact of climate change on indigenous people of Assam

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ABSTRACT

Adapting to the climate changes has emerged as a solution to address the impacts of climate change that are already evident in some regions. The present paper aims to investigate the adaptations practices that the farmers of Assam used to minimise the effect of climate change and to identify the main factors affecting their choice to adapt. The results intervened that the adaptation choices mostly practiced are found to be more fertiliser usage, varietal adjustments, new crop and adjustment of planting dates. While adopting the different practices, the farmers mostly focus on income generation rather than sustainable agricultural practice.

1. Introduction

The North-east India is full of natural resources. Since globalization it has been under the influence of climate change. Assam, situated in North Eastern Region (NER) of India has a geographical area of 78,438 square km (30 per cent of total area in NER) with 35.3 per cent forest cover. Almost 70 per cent of the total population relies directly or indirectly on agriculture for their livelihood. It has been experiencing an increase in temperature and rainy days over the years (Deka *et al.*, 2009). Climate variability and change is one of the major sources of risk for farmers who depend on crop production (De and Bodosa. 2015; Nath and Deka 2010). Farmers prone to such climatic changes are adapting to minimise the impact on agriculture. There are studies in Assam that examine farmers' diversification strategy to minimise flood risk (Goyari 2005; Purkayastha, 2015;) and farmers' vulnerability to flood (Chaliha *et al*., 2012). Das et al., (2010) documented various coping and adaptation strategies used by the flood affected households in Brahmaputra plains. The paper aims to investigate the various adaptation practices that farmers use to minimise the climate change induced risk and to identify the main factors affecting their choice to adapt such practices in Assam. Not acclimatization but adapting to the changes has consequently emerged as a solution to address the impacts of climate change. Adaptation that occurs at the farm-level, focuses on micro-analysis of farmers decision making while adaptation at the national level or macro level is concerned about agricultural production at the national and regional scales and its relationship with domestic as well as international policy (Kurukulasuriya and Mendelsohn, 2006; Seo and Mendelsohn, 2007). Moreover, adaptation varied from region to region depending on cultural and religious values. Therefore, regional analysis is necessary to get a clear picture of actual damage. For sustainable livelihood farmers have implemented various strategies like crop diversification, increase irrigation investment, increase fertiliser usage, pest as well as disease management and soil conservation techniques (Jianjun *et al*., 2015; Quaing-yi *et al*., 2014; Ghazanfar, 2015; Nhemachena and Hassan, 2007). Although these options are widely available there are a range of determinants recognised to be important that varies from one adaption to the other. Among the factors that influence a farmer ability to adapt, perceptions about climate change (Nhemachena and Hassan, 2007), farming experience, land owned, farm income, age, household size, agricultural extension (Jianjun *et al*., 2015; Calzadilla *et al*., 2008) and risk preferences (Jianjun *et al*., 2015). In general, social, capital, agro- ecological set up (Deressa *et al.*, 2009), access to employment guarantee scheme, crop loss compensation

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and access to informal credit (Bahinipati and Venkatachalam 2015) in particular are recognised as most important.

a. Changes in agro-climatic condition of Assam

Assam is well known for its diverse sub-himalayan agro-climatic conditions which is suitable for the growth of number of crops across the districts. The climatic conditions in the state also changed significantly over the years and that to some extent led to the variation in crop cultivation but not observed to be in line with the growth process as expected from a progressive agricultural economy. A study by De (2017) stated that thirty one year's average of monthly minimum and maximum temperature showed a rise in minimum temperature from1.1 to 1.3 ^{0}C while a rise of maximum temperature from 0.7 ^{0}C to 1.8 ^{0}C. Also, variation in average minimum temperature across the months declined significantly the rate along with the rising yearly average minimum temperature over the years. Thus, an inverse relation is revealed between the yearly average temperature and the seasonal variation in minimum temperature. This is an indication of gradual convergence of seasonal temperature with global warming in the state. However, there is insignificant change in month-wise variation in maximum temperature with rising trend, which is subject to significant volatility in the prime monsoon months that starts little early than the normal monsoon season of Indian plains. Zone-wise variation in minimum temperature has also been rising at a faster rate than the maximum temperature. This growing regional variation is also associated with increasing volatility. Yearly rainfall also declined during the last six decades. Not only that, its seasonal pattern has been changed and the monthly rainfall reaches its peak alternately in June, July, or August. Three decades' average rainfall in the peak months declined from 486.2 mm during 1950–1980 to 444.7 mm during 1980–2010 (De, 2017). Despite the fall in total annual rainfall, occurrence of flood became erratic for heavy concentration of rainfall in a few days when maximum portion of rainfall of the season occurs. The share of the annual rainfall that occurred during the peak monsoon months declined over time. Not only having inter-zonal skewed distribution of rainfall, the month-wise variation in rainfall also increased significantly in the high rainfall areas, while that of low rainfall area declined. In Lakhimpur and Dhemaji district, monsoon rainfall has increased continuously over the years during Kharif season, and thus incidence of flood and its severity also increased which has more damaging impact on the late summer and autumn crops. On the other hand, Nagaon district recorded the lowest annual rainfall among all the zones and that too declined over time. Annual average rainfall in Cachar was about 3777.4 mm during 1951-56 and increased to 2833.6 mm during 2005-10, while in Nagaon it decreased drastically from around 1980.3 mm in 1951-56 to 1335.3 mm during 2005-10. In Karbi Anglong district and N.C. Hills, rainfall over the years shows more erratic pattern, and thus farmers avoided settled paddy cultivation even in low lying areas in order to avoid uncertainty, and the diversity pattern shows people's preference for more tea, horticulture, and olericulture on the basis of wildly grown host plant, castor. Gradually, farmers in other areas also tried to switch to the short period, more resistant crop varieties to reduce the risk of cultivation due to changing frequency, intensity, and timing of occurrence of rain and flood emanated from the long-term changes in climatic condition, which has been closely associated with the changing relative humidity and temperature variation across the months and regions over the years. (De, 2017).

Table 1. Farmers' adaptation choices

Adaptation options	Frequencies	Percentage
No adaptation	49	5.58
Crop variety change	145	16.51
Crop switching/Mix cropping	125	14.24
Adjusting planting dates	82	9.34
Increasing irrigation	75	8.54
Increase use of fertilisers	155	17.65
Pest and disease management	133	15.15
Farm to non-farm	50	5.69
Crops to livestock	28	3.19
Migrate to other place	9	1.03
Lease out land	14	1.59
Using shades or shelter	13	1.48
Source: Begum and Mahanta (2017)		

b. Adaptations practices among the farmers

Adaptation to climate change at farm level includes many options which the farmers have adopted from time to time. To capture all such adaptations and to categorise it whether it is climate induced or not is a challenging task. Climate change is one of the driving forces among different driving forces of adaptation (Kristjanson *et al*., 2012). Table 1 gives percentage of farmers using all the adaptation practices and Table 2 gives a brief summary of a few important adaptation practices.

c. Crop diversification

One of the important adaptations that farmers choose is crop diversification. Crop diversification helps not only to reduce vulnerability due to climatic variability such as floods or drought but also increases the profitability that helps to reduce farmers' agricultural risks (De and Bodosa, 2015). Diversification is adopted in the form of variety change, mixed cropping, switching to new crops etc. By switching to new variety of crop (16.51 per cent) that suits the climate, farmers are adopting to changing climate. Similarly, farmers are shifting their cultivation mostly from low value crops to high value crops, from rice to vegetables and in some cases from low value crops to other low value crops (Table 1). These diversifications are to a great extent determined by changing climate uncertainty. The findings are at par with De and Bodosa (2015). Some parts with irrigation facilities diverted to commercial crops where as some parts like hilly zones have shown diversification towards some inferior crops. Some farmers (18%) of Kokrajhar district have changed traditional varieties to newer crops due to availability of HYV seeds; 83% of the respondents of the same district changed cropping pattern to earn more profit.

Table 2. Important adaptation strategies at farm level

Adaptation options	Adaptation options
Crop variety change	HYV as well as hybrid variety of rice, vegetables, jute, maize, wheat, rapeseeds and mustards
Crop switching/ Mix cropping	(1) Mix cropping among winter rice summer rice, rabi vegetables, rape and mustard, jute, wheat, kharif vegetables (2) Crop switching from sugarcane, jute, buckwheat, banana, lemon to mainly horticultural crops (high value crops), food crops to non-food crops
Adjusting planting dates	(1) 10-15 days delay in sowing of winter (sali) rice to get the benefits of early monsoon (2) 15-20 days earlier plantation of summer (boro) rice variety to avoid crop loss due to rain during harvesting time. (3) Delayed planting of Sali varieties like Hatisali, Bordhan during heavy rainfall. (4) Late plantation of rice like Hira (sali) in September to avoid heavy monsoon rainfall. (5) Adjusting planting dates of hybrid vegetables like turnip by late planting due to heavy rainfall
Increase use of fertilisers	Rice (1) N-Urea has increased to 20 kg/bigha from 10-15 kg/ bigha earlier. (2) P_2O_5-Phosphorous has increased to 25 kg/bigha from earlier 15-18 kg/ bigha. (3) K_2O-Potash increased to 10-12 kg/bigha from earlier 4-5 kg per hectare. Vegetables (1) For kharif vegetables like tomato, brinjal, chilli urea used is 20-22 kg per bigha, for capsicum, cauliflower cabbage, turnip, carrot it is 25-30. kg/bigha. (2) Boccoli requires upto 50 kg urea per bigha. (3) P_2O_5-phosphorous used for cabbage, cauliflower, turnip, brinjal, tomato, capsicum, and broccoli is 50- 70 kg/ bigha. (4) K_2O-Potash requirement is 15-20 kg for cabbage, cauliflower, tomato, turnip and capsicum. (5) In addition to this well rotten FYM or compost application in nursery beds are used to improve soil physical condition. (6) Borax up to 25 kg is used for some vegetables like cauliflower. (7) Organic manures are used up to 2 quintals per bigha by some farmers
Pest and Disease management	(1) Farmers uses various chemicals like, Boric acid powder, bordeaux , ustad, profax , DAP, captan, mancozeb, dithane Z-78, Karathane, bavistin,calixin, bentate etc to control pest and diseases (2) After sowing, some local practice like covering the seeds with a thin layer of sand mixed with well dried cow dung, wood fine ash, dried trees leaves are mashed and spread in to protect from insects like thrips.

	(3) Dried grass and banana leaf or thin layers straw are used in nursery bed of vegetables to prevent displacement of seeds as well as protect from water borne disease. (4) Burning rice strips and rice plant roots after harvesting to control insects. (5) Seedling tips of rice are trimmed to before sowing. (6) Vegetable like French beans seeds are protected by applying black pepper powder to the seeds that prevents from storage pest. (7) Applying lime before planting of vegetables like cauliflower, pea, carrot etc.
Using shades or shelter	(1) Shading is done by banana stem to protect the crops from harsh sun rays. (2) Use local plants like Khoria and Gancha that not only shelters the plants but also helps to increase soil fertility
	Source: Begum and Mahanta (2017)

In order to mitigate flood induced crop loss, farmers had opted for submergence-tolerant rice varieties like Ranjit sub.1, Bahadur sub.1, Jalashree, Jalkuwari etc. (The Assam Tribune, 2017). Though the varietal adjustments are done to some extent by adopting high yielding variety (HYV) seeds which are more climate resistant but only a few farmers could go for it due to different reasons. Moreover, a farmer who has more extension contact became more aware of any new variety available in the market. Thus, the experienced and progressive farmers in rural communities helped to promote adaptation management among those who do not have such experiences. It has been seen that during post flood, it becomes difficult for farmers to buy seeds due to crop loss in Sali season. In this aspect, State Government had encouraged farmers to cultivate Boro rice by supplying free seeds to compensate the loss of Sali rice (Begum and Mahanta, 2017).

d. Fertilizers and Manures

Crop switching and mixed cropping (14.24 per cent) represents that the extent of crop diversification in the study area is not very satisfactory. Fertilisers are required for improving soil nutrients. Modern agriculture has turned out to be fertiliser and pesticide enthusiast. Farmers use fertiliser throughout the plant growth period. Farmers have increased farm yard manure (FYM) application because soil fertility is deteriorating and it is a clear indication of climate variability (Table 2). It can be observed from Table 1 that among different adaptation strategies, the most widespread adaptation practice is fertiliser usage (17.65 per cent). Farmers are also used various chemicals as well as traditional methods to control pest and disease (Table 2). The use of chemicals increased productivity initially but degrades the quality of land (Purkayastha, 2015).

e. Sowing Time

Since the climate is unpredictable, the farmers of Assam adopted a strategy to cope with the changing climate. The farmers modified the sowing time of few crops in order to acclimate the crops. Dhemaji district of Assam, reported several adaptation measures to save their crops particularly from floods that occur frequently every year and at different times. Most of the respondents adopt early cultivation method and cultivate short-period crops to save from floods and harvest early. They argued that early land preparation and plantation is associated with increased chances of survival of the crops (mainly winter paddy) from floods. Over three-fourths of the respondents preserve seedlings for sowing again if the crop is damaged due to flood during the peak monsoon time.

f. Irrigation

Even though Assam is rain fed zone, farmers adopted for irrigation facilities, since erratic rainfall followed by dry spell in peak agricultural seasons. Moreover, the farmers planned their planting dates according to the onset of rainfall, amount of rainfall etc. These adjustments together accounts for 9.34 per cent farmers who either by late sowing or early sowing of crops adjusted their crops to current climate uncertainty (Table 1). On the other hand, 8.54 per cent farmers have increased investment in irrigation. Hence it is an important adaptation practice which is adopted by farmers (Begum and Mahanta, 2017).

g. Livestock and Animal Husbandry

Again, as livestock help farmers to earn income during dry seasons as well as drought period, they are mixing both to trim down risks. Some marginal farmers are also shifting from crops to livestock. Large farmers especially those who have income from non-farm sector are also leasing out their land due to uncertainty in weather.

h. Hands-on training

In respect of adaptation, looking at the features of the farmers, it is observed that the level of education of the heads of households improves level of adaptation. Education generally increases knowledge and helps farmer to gain adaptive capacity to the changing climatic conditions and use of appropriate agro-technologies. The size of operational holding of the farmer (total cropped area) and years of

cultivation experience also has significantly positive impacts on adaptation. The implication is that adaptive capacity of farmers increases with the increasing size of the landholdings and cultivation experience. However, training of the farmers by Krishi Vigyan Kendras and NGO's and other agricultural agencies is found to have a huge impact on adaptation as the training conducted by the concerned departments are basically held to train farmers on raising crop productivity through the use of modern technology rather than on adaptation and awareness strategy toward climate.

Among the different adaptation options, the least adopted measure is migration to another place. Farmers migrate due to better earning opportunities. When income from farm sector is not sufficient there is normally a tendency to move to other place in search of work. This percentage of farmers may vary as the one who have already migrated is not a part of the sample.

2. Conclusion

The present study makes an elaborate conclusion that the farmers are practicing adaptation and determinants of such adaptation choices. Among the most widely practiced varietal adjustments, switching to different crops, increase irrigation investment, fertiliser usage as well as pest and disease management is mostly intensified. The results obtained from analysis revealed that though there has been increase in the area of cultivation of crops and provision of farm inputs to farmer, however climate has taken its toll on the selected crops. This analysis of climate change and its impact on crop yield can help to deal with the repercussions and the crop production changes can be specified in different conducive regions, thus strengthening the sustainability of agricultural production. As a result, this study recommends the following measures towards improving crop production and agriculture in the study area: Rainwater harvesting in top and foothills of hilly areas along with integrated water resources management (IWRM) and proper crop planning.

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