Ind. Jn. of Agri. Econ.
Vol.72, No.3, July-Sept. 2017

Adaptation to Climate Change and Factors Affecting It in 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 what are the adaptations practices that farmers use to minimise the effect of climate change and to identify the main factors affecting their choice to adapt. Interviewing 230 farmers from three agro-climatic zones of Assam, the results depict that the adaptation choices mostly practiced are found to be more fertiliser usage, varietal adjustments, new crop and adjustment of planting dates. Probit regression model shows that among the main determinants affecting adaptation choices the most important are income, extension activity and credit availability.

Keywords: Adaptation choices, Agro-climatic zones, Migration, Northeast India, Assam

JEL: D81, O15, Q25

I

INTRODUCTION

The Northeast India 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; and Mandal, 2014; Purkayastha, 2015;) and farmers' vulnerability to flood (Chaliha *et al*., 2012). Das *et al*., (2010) document various coping and adaptation strategies used by the flood-affected households in Brahmaputra plains but this study lacks methodological rigour. 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. To the best of our knowledge, this seems to be the first study in Northeast India that tries to find the factors affecting the farmer's adaptation choices in a systematic manner.

Adapting to the changes has consequently emerged as a solution to address the impacts of climate change that are already evident in some regions (Schipper 2007; Vignola *et al*., 2015). Adaptation that occurs at the farm-level, focuses on micro-

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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 varies from region to region. 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 deemed 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) in general and risk preferences (Jianjun *et al*., 2015) social capital, agro ecological set up (Deressa *et al*., 2009), access to employment guarantee scheme, crop loss compensation and access to informal credit (Bahinipati and Venkatachalam 2015) in particular are recognised as most important.

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.[1] Almost 70 per cent of the total population relies directly or indirectly on agriculture for their livelihood. Low productivity is a major attribute to Assam's agriculture which is mainly due to traditional farming techniques, soil degradation, poor credit facilities, lack of irrigation facilities, poor marketing and infrastructures etc. (Sarmah, 2015). In addition, changes in climatic factors like temperature and rainfall as well as increase incidence of extreme events like flood and drought in recent years are creating havoc (Das *et al.,* 2010; De and Bodosa, 2015; Nath and Deka, 2010).[2]

II

MATERIALS AND METHODS

The study covers three non-contagious districts (Darrang, Dhubri and Lakhimpur) that fall in three different agro climatic zones in lower, middle and upper part of Assam.[3] A total of 230 farmers are interviewed on the basis of random selection of farmers. Primary data covering farmer's socio-economic characteristics, various adaptation practices to climate change are collected through a semi-structured questionnaire.

To identify the factors influencing farmer's climate change induced adaptation measures, socio-economic variables are used as explanatory variables. Although some studies stated that adaptation choices are interdependent but this study assumes them to be independent. This is mainly because we assume farmers' choice to either adopt or do not adopt a particular adaptation strategy although these strategies depends on same factors and these factors affects different adaptation strategies in a different way. Therefore owing to the nature of dependent variable, *Probit* regression model has been used. The empirical model is defined as

$$Y_i = \alpha + \beta_i \sum_{i=1}^{n} X_i + \varepsilon_i$$

where Y_i is a dichotomous dependent variable taking value 1 if farmer uses any climate change adaptation measure and 0 otherwise; α is the intercept, β_i is a set of coefficients to be estimated; X denotes the set of explanatory variables selected on the basis of related literature as well as experiences from pilot study which influences farmers' climate change induced adaptation strategies. The definitions of the variables used for estimation are presented in Table 1.

TABLE 1. LIST OF VARIABLES AND THEIR DEFINITIONS

Variables (1)	Definitions (2)
Dependent	
Crop variety	1=Planting new variety; 0=otherwise
New crop/Mix cropping	1=New Crop/mix cropping; 0=otherwise
Irrigation investment	1=increase irrigation investment; 0=otherwise
Adjusting planting dates	1=advance/delayed planting dates; 0= otherwise
Increase use of fertilisers	1= increased fertiliser usage; 0= otherwise
Pest and disease management	1=increased pest and disease management; 0=otherwise
Farm to non farm	1= changed to non-farm; 0=otherwise
Crop to livestock	1= changed to livestock; 0=otherwise
Independent	
Age	Age of respondents (in years)
Household size	Number of members in household(continuous)
Land owned	Total land owned by the farmer
Experience in farming	Years involved in farming activities
Log income	Monthly income of farmer household
Education	Number of years in schooling (continuous)
Awareness about climate change	1= Aware about climate change; 0= otherwise
Credit availability	1=credit received;0=otherwise
Extension contact	1=have extension contact; 0=otherwise
Mass media Exposure	1=have exposure to mass media; 0=otherwise

III

RESULTS AND DISCUSSION

3.1 *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 tasks. Climate change is one of the driving forces among different driving forces of adaptation (Kristjanson *et al*., 2012). However the paper tries to identify certain important adaptation practices that farmers are using in Assam. Table 2 gives percentage of farmers using all the adaptation practices and Table 3 gives a brief summary of a few important adaptation practices.

TABLE 2. FARMERS' ADAPTATION CHOICES

Adaptation options (1)	Frequencies (2)	Percentage (3)
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
Over all	878	100.00

Source: Calculated by authors from field data.

One of the important adaptation 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 2). 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. 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 3). It can be observed from Table 2 that among different adaptation strategies, the most widespread adaptation practice is fertiliser usage (17.65 per cent). Farmers are also uses various chemicals as well as traditional methods to control pest and disease (Table 3). The use of chemicals increases productivity but degrades the

TABLE 3. IMPORTANT ADAPTATION STRATEGIES AT FARM LEVEL

Adaptation options (1)	Farmers adapted measures (2)
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. Boccoli requires upto 50 kg urea per bigha.
	(2) P_2O_5-phosphorous used for cabbage, cauliflower, turnip, brinjal, tomato, capsicum, and broccoli is 50- 70 kg/ bigha.
	(3) K_2O-Potash requirement is 15-20 kg for cabbage, cauliflower, tomato, turnip and capsicum.
	(4) In addition to this well rotten FYM or compost application in nursery beds are used to improve soil physical condition.
	(5) Borax up to 25 kg is used for some vegetables like cauliflower.
	(6) 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: Field study.

quality of land (Purkayastha, 2015). Moreover 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 2). On the other hand, 8.54 per cent farmers have increased investment in irrigation. Irrigation helps in dry land areas to carry agricultural practices during off monsoon period. Due to deficiency of rainfall in peak agricultural seasons as well as erratic rainfall, farmers are increasing their investment in irrigation which is helping them to meet water requirements. Hence it is an important adaptation practice adopted by farmers. 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. Among the different adaptation options the least adopted measure is migration to other 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.

3.2 *Factors Affecting Adaptation of Farmers*

The results of estimated co-efficient related to determinants of adaptations are presented in Table 4.

Model-1: In *crop variety model*, the regression results show that the co-efficient related to farmers' experience is positive and significant, indicating that highly experienced farmers are likely to have more knowledge on climate changes and hence make varietal adjustments to adapt to such changes. In order to mitigate flood induced crop loss, farmers can adopt high-yielding improved varieties considering early maturing crop varieties. Farmers could opt 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 can help to promote adaptation management among those who do not have such experiences. The income co-efficient is also positive indicating that wealthier households are more likely to use new crop varieties as an adaptation measure. 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 respect, State Government could encourage farmers to cultivate *Boro* rice by supplying free seeds to compensate the loss of *Sali* rice.

TABLE 4. RESULTS OF PARAMETER ESTIMATES OF PROBIT REGRESSION

Variables (1)	Crop variety (Model-1) (2)	Crop switching (Model-2) (3)	Adjusting planting dates (Model-3) (4)	Fertiliser usage (Model-4) (5)	Pest and disease management (Model-5) (6)	Irrigation investment (Model-6) (7)	Crops to livestock (Model-7) (8)	Farming to non-farm (Model-8) (9)
AGE	.010	-.013	-.028 **	-.017	-.011	-.002	.032***	-.001
	(.012)	(.013)	(.016)	(.014)	(.012)	(.013)	(.013)	(.014)
	[0.79]	[-0.94]	[-1.82]	[-1.21]	[-0.90]	[-0.13]	[2.42]	[-0.00]
EDU	-.019	-.006	.035	.011	.019	.021	-.072***	.045**
	(.030)	(.029)	(.030)	(.030)	(.027)	(.030)	(.030)	(.027)
	[-0.62]	[-0.20]	[1.18]	[0.36]	[0.69]	[0.73]	[-2.45]	[1.63]
HH SIZE	.013	-.055	-.020	.007	.043	.021	-.033	-.031
	(.039)	(.040)	(.040)	(.041)	(.039)	(.043)	(.048)	(.043)
	[0.34]	[-1.37]	[-0.49]	[0.17]	[1.10]	[0.48]	[-0.68]	[-0.72]
LAND	.142	-.187	-.031	-.219	-.027	.226 **	-.228	-.301 ***
	(.177)	(.134)	(.111)	(.146)	(.118)	(.106)	(.155)	(.132)
	[0.80]	-1.40	-0.28	[-1.50]	[-0.23]	[2.13]	[-1.47]	[-2.28]
FARM EX	.044 ***	.064***	.067***	.054**	.027**	.045**	-.033***	.018
	(.017)	(.017)	(.018)	(.0185299)	(.015)	(.016)	(.014)	(.016)
	[2.63]	[3.89]	[3.64]	2.91]	[1.88]	[2.82]	[-2.27]	[1.12]
LOG	.539**	1.408***	.619**	1.66 ***	1.210***	1.547***	.156	-.130
INCOME	(.264)	(.338)	(.316)	(.314)	(.289)	(.375)	(.305)	(.265)
	[2.04]	[4.17]	[1.96]	[5.29]	[4.18]	[4.13]	[0.51]	[-0.49]
AWARE	.262	. 365 (.309	.506*	.543	.235	.818**	1.26***	-.367
	(.328)	)	(.290)	(.327)	(.285)	(.285)	(.350)	(.299)
	[0.80]	[1.18]	[1.75]	[1.66]	[0.82]	[2.87]	[3.60]	[-1.23]
MM EXP	.047	.084	.115	.018	.299***	.216	-.110	-.134
	(.163)	(.158)	(.139)	(.175)	(.141)	(.138)	(.170)	(.146)
	[0.29]	[0.53]	[0.83]	[0.10]	[2.13]	[1.57]	[-0.65]	-0.92]
EX CONT	.957***	.308	.263	.877 ***	.085	.093	.200	-.152
	(.253)	(.243)	(.303)	(.248)	(.182)	(.191)	(.238)	(.190)
	[3.79]	[1.27]	[0.87]	[3.55]	[0.47]	[0.49]	[0.84]	[-0.80]
CREDIT	.126	1.584***	1.158***	.480 .	-.182	.327	-.875 **	-.217
	(.085)	(.565)	(.3163)	(.586)	(.327)	(.311)	(.479)	(.359)
	[1.47]	[2.80]	[3.66]	[0.82]	[-0.55]	[1.05]	[-1.83]	[-0.60]
Constant	-3.767***	-6.052 ***	-3.469***	-6.891***	-5.317***	-8.457 ***	-2.265**	-.0718
	(1.067)	(1.386)	(1.257)	(1.206)	(1.193)	(1.581)	(1.195)	(1.096)
	[-3.53]	[-4.36]	[-2.76]	[-5.71]	[-4.46]	[-5.35]	[-1.90]	[-0.07]
Pseudo R^2	0.298	0.364	0.362	0.428	0.230	0.369	0.135	0.080
Wald $Chi^2(9)$	67.79***	114.37***	80.14***	80.78***	52.29***	72.11***	28.48***	19.00**

Source: Calculated by authors.

(), [] indicates robust standard errors and t values respectively. ***, **,* indicates significant at 1, 5 and 10 per cent respectively.

Model-2: In *crop switching model*, along with farming experience, income and credit availability has shown positive and significant impact. Credit availability helps farmers to strengthen their financial position and thus they can take any risks associated with new adaptation. Access to credit increases the monetary resources of farmers and helps to meet transaction costs associated with the adaptation option (Okezie *et al*. 2011). New crops are generally costlier and hence with credit availability as well as more income they can choose it easily.

Model-3: In *adjusting planting date's model*, the positive co-efficient of farming experience and significant negative age coefficient implies the importance of farming experiences to adapt. Hassan and Nhemeachema (2008) also had a similar opinion that experience and not age that matters in adaptation to climate change. Moreover awareness of young farmers tends to be more now days as they are more educated as well as have more access to mass media or e-media. As expected awareness to climate change has also played a significant and positive role in adjusting planting dates. The other variables which are significant and positive are income and credit availability.

Model-4: Regarding the *increase fertiliser usage model*, income, farming experience and extension contact are found to be positive and significant. Although the Government agricultural department provides fertilisers at subsidised rate but most farmers do not get the benefit. They have to buy from private companies or market. So the wealthier households have easy access to it. Now a days, different meeting and training are provided by agricultural department as well as private companies and NGO's regarding proper usage of both chemical and organic fertilisers. Moreover private companies' officials also visit villages during peak agricultural season to sell their fertilisers. Thus the farmers having extension contact are adapting this adaptation option as expected.

Model-5: In *pest and disease management model*, income and farming experience shows a positive and significant influence on pest and disease management. Among other factors mass media exposure is positively related to pest and disease management. Different advertisements telecasted through TV and radio regarding pest and disease management have created more awareness among farmers who have greater access to TV and radio.

Model-6: For increase in irrigation investment, land owned has positive and significant influence on irrigation investment. This indicates that large farm owners have more access to irrigation than small land owners. Irrigation needs certain investment which is possible with more income. Hence income is also positively and significantly related with irrigation investment. The other variables which have positive and significant influence on increased irrigation investment are farming experience and awareness to climate change.

Model-7: In *changing crops to livestock model***,** age is playing a significant and positive role. The income from livestock is more fixed and also helps during drought period when crop production may fail. Hence aged farmers use both combination of mix crop and livestock as adaptation measures. Farming experience shows negative impact on changing crops to livestock. This is an interesting finding as in all other adaptation choices except this it has a positive impact. The negative impact can be interpreted as with experience, the farmers can take alternative adaptation choices which can increase their crop production like new variety or new crops but they do not shift from crops to livestock. We can also infer this as they might have include livestock as adaptation but do not leave crop production completely.

Model-8: For the model of change from farming to non-farming sector, education played a significant and positive role indicating that higher educated person gets better exposure in non-farm sector hence as adaptation options they choose non farm sector. The educated farmers are also risks averters. With more education, they became more aware about better income opportunities and thus change from farming to nonfarm sector. Interestingly land owned has showed a negative and significant impact on this adaptation choice. This indicate that larger the farm size, lesser is the tendency to change from farm to non-farm.

IV

CONCLUSION

This study makes an elaborate presentation of farmers' adaptation practices and determinants of such adaptation choices. Among the most widely practiced are varietal adjustments, switching to different crops, increase irrigation investment, fertiliser usage as well as pest and disease management. The determinants of climate change adaptation are analysed using Probit model. The determinants found to be mostly significant are income, extension contact and credit availability. Effective credit management as well as proper dissemination of knowledge about climate change can enable farmers to adapt to climate change in future.

NOTES

1. Forest Survey of India, 2011.
2. Mentioned may be the year of severe drought of 2005, 2006, 2012, and 2014 which affected more than 50 per cent districts of Assam. These drought incidents are considered as indicators of climate change in Assam (IPCC 2007). Again flash flood took place in Goalpara (2004, 2011, 2014), Sonitpur (2004), Dhemaji (2007, 2009, 2011, 2013), Lakhimpur (2008) and North Kamrup (2008).
3. Assam is divided into six agro-climatic zones based on patterns of rainfall, soil type, terrain and climatic conditions. They are North Bank Plain Zone, Upper Brahmaputra Valley Zone, Central Brahmaputra Valley Zone, Lower Brahmaputra Valley Zone and Barak Valley Zone Hills Zone.

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