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Aniruddha Roy

Scientist, Division of Social Sciences, ICAR Research Complex for NEH Region, Umiam, Meghalaya, India

Deepthi Kolady

Assistant Professor, Ness School of Management & Economics, South Dakota State University, Brookings, USA

NU Singh

Senior Scientist, Division of Social Sciences, ICAR Research Complex for NEH Region, Umiam, Meghalaya, India

D Chakraborty

Scientist, Division of Agricultural Engineering, ICAR Research Complex for NEH Region, Umiam, Meghalaya, India

SM Feroze

Associate Professor, Central Agricultural University, Iroisemba, Imphal, Manipur, India

Anjoo Yumnam

Scientist, Division of Social Sciences, ICAR Research Complex for NEH Region, Umiam, Meghalaya, India

Corresponding Author

Aniruddha Roy

Scientist, Division of Social Sciences, ICAR Research Complex for NEH Region, Umiam, Meghalaya, India

Impact of climate change on agriculture in north-east India: A case study in Meghalaya

Aniruddha Roy, Deepthi Kolady, NU Singh, D Chakraborty, SM Feroze and Anjoo Yumnam

Abstract

The climate of North-East is highly variable, and the area contains temperate, sub-temperate, tropics and semi tropics environments. The proximity to the Himalayan range is the predominant force determining the climatic regions of the region. A large portion of NE's ecosystem includes hill and mountain regions, foothills, valleys and plain land with a subtropical climate influenced by heavy rainfall as compared to other parts of the country. During last 3 decades, North East as well as Meghalaya experienced climate change. Hence, the present study was conducted to analyze the meteorological drought, to estimate the impact of climate change on rice yield and to assess the socio-economic impact of climate variability on livelihood of farmers. The study was conducted in Ri-Bhoi district of Meghalaya. A sample of 125 farmers was drawn randomly from a cluster five villages of the selected block. The average age of the respondents was 42 years and a family comprised of 5 members. More than 94 per cent of the farmers perceived that the summer temperature has increased over the years, whereas, the views were mixed in case of winter temperature. More than 99 per cent of the farmers felt that the arrival of monsoon has been delayed. The farmers could use the own farm produce for 10.5 months in normal years but during the years of climatic variability it lasted for 8 months only. The average decline in productivity of rice was estimated to be 28.65 per cent in the case of droughts/low rainfall situations. Majority (65%) of the responding farmers perceived that the pests and disease infestations on rice crop have increased in recent times and resulted into productivity loss (12.5%). Around 15% farmers have changed time of sowing or transplanting in late rainfall situation. An inclusive and effective strategy for adaptation to changing climate (mostly warming) from the perspective of farming may be developed and extended to the farmers of the region.

Keywords: Climate change, variability, livelihood, impact, Meghalaya

Introduction

Climate is the long-term regime of the atmospheric variables, or the composite of the day to day values of the weather elements over a long period of a given place or area whereas weather refers to physical state of atmosphere at a given time in terms of temperature, rainfall, relative humidity, etc. (Rao, 2008). The word climate change refers to a shift in the climatological parameters from the long-term average of the recorded data, normally 30 years of the recorded data (Sharda and Tripathi, 2010). The Intergovernmental Panel on Climate Change (IPCC) defined climate change as 'a long-term change in average weather patterns over a specific region, over a period of time, whether due to natural variability or as a result of human activity' (IPCC, 2007b) [9]. Among the natural disasters caused due to climate change, drought is complex, difficult to assess and its impact is at varying degree on nature, quality of life and the economy (Hisdal and Tallaksen, 2003). The Northeastern Region of India is expected to be highly prone to the consequences to climate change because of its geo-ecological fragility, strategic location vis-à-vis the eastern Himalayan landscape and international borders, its trans-boundary river basins and its inherent socio-economic instabilities. The climate induced natural disasters like drought, flood and cyclone are the major outcome of the intensification of climate change and the incidence of these natural disasters is increasing in the recent years in India (Goswami *et al.*, 2006). Climate change results into change in temperature and rainfall pattern (EPA, 2010). Nearly 75 per cent of rainfall occurs during June to September but extreme conditions of rainfall like drought and flood are also observed in certain years (Ray *et al.*, 2011). Environmental security and sustainability of the region are and will be greatly challenged by these impacts.

The region falls under high rainfall zone with subtropical type of climate. Still, under influence of global climate change even high rainfall areas are facing drought like situations in the current years. Droughts and floods are the adverse climatic conditions arising out of deficit and excess rainfall, respectively. Drought assumes significance mainly in rainfed conditions like in North East India.

The North Eastern Region (NER) comprises of the states of Arunachal Pradesh, Assam, Manipur, Nagaland, Mizoram, Sikkim and Tripura. The region stretches between 21°50' and 29°34' N latitude and 85°34' and 97°50' E longitude. The region has a population of 45 million (2011 census) and geographical area of 26.2 million hectare, which is about 4% and 8% of the population and area of the country, respectively. The annual rainfalls in the region is received mainly from south-west monsoon from middle of May and continue till October. On an average, the NE region receives about 2450 mm of rainfall. In Meghalaya, the Cherrapunji-Mawsynram range receives rainfall as high as 11,500 mm, annually. The region shows great variation in temperature regime too. The temperature varies from 15 °C to 32 °C in summer and 0 °C to 26 °C in winter. The NE region is very rich in biodiversity and harbors the largest number of endemics and species then anywhere in the country. The agricultural practices of the region are broadly of two types, viz., (i) settled cultivation practiced in plains, valleys, foot hills and terraced slopes and (ii) shifting cultivation in hilly areas of all the states with the exception of Sikkim, where settled cultivation is practiced on terraces. Meghalaya is mainly agrarian state and rice-based agriculture is the largest source of livelihood for majority of the people. Agriculture sector contributes a major share (19.53%) to the total State Domestic Product in the year 2012-13 (GoI, 2014) and provides employment to about 52.19 per cent of the total workers in Meghalaya. Rice occupied 95.21 per cent of the total net sown area (0.23 mha) in Meghalaya in 2013 (GoM, 2013a). Rice is grown mainly in Kharif season in both valley as well as the hills in Meghalaya. Hence, a slight change in the amount of precipitation, primarily in monsoon season will have direct impact on rice productivity and indirectly on the livelihood of the people of the state. The above discussion makes it clear that the Indian agriculture as well as North-Eastern hill agriculture is facing challenges due to increase in climatic variability. Thus, it was essential to analyze the Socio-economic impact of Climate Change in livelihood of farmers and to identify the adaptive measures adopted by the locals in the changing climate.

Materials and Methods

Primary and secondary data pertaining to climate and agriculture and the socio-economic aspect of the sample farmers were used. Central Research Institute for Dryland Agriculture (CRIDA) identified one vulnerable district from each State of NE Region. As Ri-Bhoi district of Meghalaya was identified as vulnerable district, Primary data was collected from 5 villages of Ri-Bhoi district i.e. Mawkyrdep, Klew, Mawblang, Nongpyrdet and Nongthymmai. The time

series seasonal data on agriculture were collected from Department of Agriculture, Government of Meghalaya. Time series monthly data on rainfall and temperature for the period 2006-07 to 2015-16 was collected from IMD website. The Umsning block has been selected purposively from where five villages were selected randomly. 25 farmers have been selected randomly from each village making up the total sample size to 125. The primary data on socio-economic condition of the farmers and other relevant data to understand the perception of farmers towards climate change, the impact of draught on rice productivity, sowing time, etc and the level of sustainable agricultural practices in their farming practices were collected. Primary data on food, fuel, water (drinking and irrigation), income etc. were also collected from the farm households, using well-structured schedule, to understand the impact of climatic variability on farm livelihood. The study used tools of social sciences such as focus group discussion (FGD) and survey method.

Results and Discussions

Climate of Meghalaya: The average annual rainfall in Meghalaya is about (2300±1090) mm and has decreased during the last 10 years but it was not found to be statistically significant. The average temperature during a year was about (23 ± 4.4) °C and has increased significantly at the rate of 0.17°C per year. Ri-Bhoi District had maximum variability in average monthly temperature (2009-2013) among the districts, followed by Jaintia Hills and East Khasi Hills.

Table 1: Average Coefficient of Variation (CV) of monthly temperature of the districts of Meghalaya over the years 2009 -2013

Sl. No.	District	Mean (°C)	Standard Deviation	CV
1	East Khasi Hills	18.51	1.8	0.10
2	West khasi Hills	18.59	1.64	0.09
3	Jaintia Hills	19.50	2.16	0.11
4	Ri-Bhoi	23.12	3.94	0.17
5	East Garo Hills	-	-	-
6	West Garo Hills	24.00	2.17	0.09

Socio-economic status of sample farmers in Ri-Bhoi District of Meghalaya

Ri-Bhoi district was selected for the study based on the maximum CV (Coefficient of variation) for average monthly temperature during the years (2009-13) and also being the most vulnerable district to climate change in Meghalaya.

The socio - economic information of the sample farmers are presented in Table 2. In all the districts, the maximum population were in the range 30 – 50 years except in village Klew where the maximum of the population were less than 30 years of age. The average family size was 4.6. The average years of farming experience was 15 years. The literacy in all the villages was quite low, highest number of sample population having completed secondary followed by primary, higher secondary and graduate. There were no farmers with post graduate degree in any of the sample villages. All the sample farmers belonged to ST category.

Table 2: Socio-economic information of sample farmers in Ri-Bhoi District, Meghalaya

Particulars	Unit	Mawkyrdep	Klew	Mawblang	Nongpyrdet	Nongthymmai
Age						
<30 yrs	%	38.00	65.00	20.00	24.00	28.00
30-50 yrs	%	40.00	25.00	63.00	64.00	64.00
>50 yrs	%	22.00	10.00	17.00	12.00	8.00

Family Size	Nos.	4.40	5.00	4.80	3.80	5.80
Average years of farming	years	17.20	7.40	16.50	17.80	14.00
Education						
Primary	%	32.00	20.00	32.00	16.00	32.00
Secondary	%	40.00	56.00	36.00	60.00	44.00
HS	%	24.00	16.00	28.00	24.00	24.00
Graduate	%	4.00	8.00	4.00	0.00	0.00
Post Graduate	%	0.00	0.00	0.00	0.00	0.00

Perception of farmers on climate change and its impact on Agriculture

More than 94 percent of the farmers in the sample districts perceived that the summer temperature has increased over the years, whereas, the views were mixed in case of winter

temperature. More than 99 per cent of the farmers in the sample districts perceived that monsoon rainfall has declined and majority of them felt that the arrival of monsoon has been delayed.

Table 3: Farmers’ perception (%) about change in temperature and rainfall

Temperature			Timing of rainfall			Amount of rainfall		
Change	Summer	winter	Change	Monsoon	winter	Change	Monsoon	Winter
Decrease	0.83	7.50	Late	95.83	5.83	low	99.16	6.67
Increase	94.17	80.83	Early	0.00	0.00	high	0.00	0.00
No Change	3.33	9.17	No Change	3.33	82.50	No Change	0.00	80.83
Not sure	1.67	2.50	Not sure	0.83	11.67	Not sure	0.84	12.50

Table 4: Perception (%) about effect of Climatic variability on area under rice

Response	Rice area			Fallow		
	Early	Late	Drought/ Low Rainfall	Early Rainfall	Late	Drought/ Low rainfall
Decrease	-	7.02	20.00	-	0.00	0.00
Increase	-	0.00	0.00	-	100.00	100.00
No change	-	92.98	80.00	-	0.00	0.00
Not sure	-	0.00	0.00	-	0.00	0.00

Rice is the major staple crop of Meghalaya. About 7.02 per cent in Ri-Bhoi have reduced the area under rice cultivation in case of late rainfall and 20 percent farmers decreased their rice area under drought or low rainfall situation.

Table 5: Effect of rainfall variability on yield of Rice

Response	Direction (in %)			Quantum (Kg/ha)	
	Low	High	Early/ late	Drought/ low rainfall	Normal
Decrease	89.07	-	100.00	1744.44	2445.23
Increase	0.00	-	0.00	(28.65%)	
No Change	10.93	-	0.00		
Not sure	0.00	-	0.00		

The average decline in productivity of rice was estimated to be 28.7 percent in Ri-Bhoi in case of droughts/low rainfall situations.

Table 6: Perception (%) about effect of change in Climate on rice pest and disease

Response	Disease	Pest	Crop damaged
Decrease	0.00	0.00	12.54
Increase	98.94	100.00	
No Change	1.06	0.00	
Not sure	0.00	0.00	
New disease	0.00	0.00	

Majority of the responding farmers perceived that the pests and disease infestations on rice crop have increased in recent times and resulted into productivity loss. The productivity loss is estimated to be 12.54 per cent in Ri-Bhoi.

Table 7: Effect of Climate change on availability of food

Particulars	Normal	Drought/ low rainfall
Supply of food from own land (months)	10.5	8.25
Perception (%)		
Insufficient/ decline	15.83	97.50
Sufficient/ improve	80.00	0.83
No change	3.33	1.67
Not sure	0.83	0.00

The period of consumption of produce from own farm reduced during the periods of droughts than the normal periods and many of them reported about insufficiency of money but no gender discrimination was observed in case of food distribution among the family members.

Table 8: The effect of Climate change on water availability

Type of change	Irrigation	Drinking
Decrease	88.57	75.68
Increase	2.86	2.70
No Change	8.57	21.62
Not sure	0.00	0.00

Majority of the farmers has reported about shortage in water for irrigation during low rainfall period. More than 75.00 per cent of the respondents reported that water for drinking facility has dwindled during drought season in Ri-Bhoi district.

Table 9: Sources of fuel, members engaged in firewood collection and perception on wood availability

Source of cooking fuel		Who collects wood?		Fire wood availability during drought	
Source	Frequency (%)	Member	Frequency (%)	Responses	Frequency (%)
Wood	93.26	Husband	60.50	Decrease	6.72
Charcoal	0.00	Wife	5.88	Increase	39.50
Cow dung	0.00	both	11.76		
LPG	6.74	Grown up Children	10.08		
		Elders	14.29		
		Market	10.92		

Measures taken by farmers to adapt to climate change

Some of the measures which are established sustainable agricultural practices were listed down and the percentage of farmers who adopted them have been recorded and presented in Table 10. These practices are known to increase the adaptability of farmers towards uncertainties of weather vagaries due to climate change. Among these practices, irrigation, livestock rearing, crop rotation, manuring and

agroforestry are popular among the sample farmers as more than 50 percent of them have adopted each of these practices in their farming activities. The result shows low level of awareness in regard to mulching, cover crop, wind breaks, bamboo irrigation and integrated farming. Low level of adoption in case of mechanization and afforestation was due to technical unfeasibility rather than non-awareness.

Table 10: Measures of adaptation to climate change in agricultural practices in the study area (%)

Measures	Mawkyrdep	Klew	Mawblang	Nongpyrdet	Nongthymmai
Irrigation	48.00	72.00	76.00	60.00	52.00
Mechanization	20.00	48.00	28.00	32.00	28.00
Livestock rearing	100.00	100.00	100.00	100.00	100.00
Intercropping	20.00	32.00	16.00	28.00	12.00
Crop rotation	60.00	76.00	80.00	68.00	48.00
Mulching	12.00	24.00	36.00	16.00	8.00
Manuring	72.00	76.00	84.00	60.00	80.00
Cover crop	0.00	0.00	0.00	0.00	0.00
Wind breaks	4.00	12.00	4.00	8.00	0.00
Water harvesting	44.00	32.00	64.00	40.00	24.00
Bamboo irrigation	8.00	4.00	8.00	20.00	0.00
Agroforestry	60.00	20.00	40.00	80.00	56.00
Afforestation	4.00	4.00	0.00	0.00	0.00
Integrated farming	8.00	4.00	8.00	12.00	0.00

Conclusion and recommendation

The climatic trends showed the average annual rainfall in Meghalaya is about (2300±1090) mm and has decreased during the last 10 years but it was not found to be statistically significant. The average temperature during a year was about (23 ± 4.4) °C and has increased significantly at the rate of 0.17 °C per year. All the sample farmers in all the villages perceived that the climate is changing. The perception was based mainly on warming of the temperature during the last decade. The sample farmers had however differences in their response as regard to the trend in rainfall but farmers observed delayed monsoon. On an average, 99 per cent of the farmers perceived the rainfall during the last decade delayed which impacted sowing season of rice. Development of adaptation strategies may be focused mainly on temperature adaptation. Larger percentage of the sample farmers perceived that pest and disease infestation in their crop has increased. An inclusive and effective strategy for adaptation to changing climate (mostly warming) from the perspective of farming may be developed and extended to the farmers of the state. Since the state is experiencing increasing temperature in the last ten years, it is recommended that the state climate change action plan be adequately and inclusively framed and implemented.

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