



Linkage between climate change and rural development in North-East India: An econometric analysis.

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Abstract

Human led economic and social activities effect the environment as well as the climate. On the other hand, impact of climate change on human life; especially on human development is one of the rising concerns of present days' discussions. Since climate change is a global phenomenon, its negative impacts may affect all countries, irrespective of their contribution to the climate change. Developing countries are in general dominated by rural economy and agricultural activities mostly. So it is of immense importance to study the linkage between climate change and rural development, if any, in developing countries like India. Several studies have been raising this issue. However, less attention has been paid to study this linkage in North-East India. North-East India is a biodiversity hotspot of India. At the same time this region is developing very fast although it is one of the least industrialized parts of the country. So taking North-East Indian states as a case study, this paper endeavours to examine if there is a linkage between climate change and the rural development of North-East India for the study period from 1970s to 2014-15 within the framework of indicators suggested by the Intergovernmental Panel of Climate Change (IPCC). The various econometric tests and analyses provide evidences regarding the relationship between climate change and rural development in this region. The rising temperature and unseasonal rainfall even with little industrialization is a matter of concern for this region and for the whole of India, because it is the development of agriculture in particular and rural area in general which makes all round development of the Indian economy.

Keywords: *Carbon dioxide, global warming, sustainable development.*

1. Introduction

The Intergovernmental Panel of Climate Change (IPCC) has documented that the global average surface temperature will become 4^o Celsius till 2100 (IPCC, Climate Change Impacts, Adaptation, and Vulnerability 2007). Weather inconsistency due to both natural as well as human induced factors, has been increasing significantly which in turn expanding damage records of both living and non-living things. Change in climate is a significant, wide-ranging and severe global environmental problem which impacts sustainable development, food production, water supply, biodiversity, ecosystem services as well as the human society (Ravindranath *et al.*, 2011; Kamble, 2016). Economic development activities in the country are

also affected by change in climate. This poses an urgent need for studying economic impact of the climate change. Climate change disturbs all the countries irrespective of their involvement in the climate change (Kamble 2016). Developing countries are more vulnerable to change of weather mostly because of lack of awareness, insufficient facilities, weak infrastructure, degraded resources and lack of advanced technology. Change of weather affects the rural agricultural economy which is a dominating factor for developing economies. India is an emerging country still heavily relied on rural economy and agriculture. India has a population of over one billion out of which nearly two thirds live in climate sensitive rural areas (DoNER, 2011).

Hence it is of very much importance to study the impact of the change of climate on rural development of India along with its agriculture. The North-East India is a very important region of India as being a hotspot of natural resources. Along with perennially humid climate, this region is characterized by heavy rainfall, six distinct seasons and diverse climate regimes which are highly dependent on the southwest monsoon (Ravindranath *et al.*, 2011). Having over 60% of the crop area under rain-fed agriculture and 82% rural population, this region is highly vulnerable to climate change. Temperature and rainfall patterns of north-east India have been changing. For example, the highest increase in annual mean minimum temperature among India was observed for the 8th North-Eastern Indian state- Sikkim followed by the other North-Eastern states- Arunachal Pradesh, Manipur and Tripura (Rathore, L.S., Attri, S.D., Jaswal, A.K. 2013).

With this background, the present paper intends to examine the impact of the climate change on the rural development of North-East India, which is of crucial significance for sustainable development for the whole country.

The North-East region of India consists of eight states- Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura covering a geographic area of 26.2 mha and a population of 40 million. The region has a large rural population (82%), low population density (159 per square km), large percentage of indigenous tribal communities (34–91%) and large area under forests (60%) (Ravindranath *et al.*, 2011). The Brahmaputra and the Barak are the two main river basins of this region. A large population still depends on natural resources. The North-East India is full of tributaries of Brahmaputra, mountains, hills, plains and lakes.

2. Literature review

Our lives and livelihood depend on climate. Human society and culture is seen to be changed with the changing climate. Climate is a critical factor for sustainable development as a whole (Rathore, Attri and Jaswal, 2013). So, impact of climate change on economy as well as on development process is a very important matter to be studied. Many studies are found in this regard. According to Morton (2007), impacts of global climate change are felt mostly in developing countries like India having subsistence farmers. In this regard, studies are conducted at the national level in India. Kamble (2016) has examined the impact

of climate change on the rural development of India for the latest study period from 2006 to 2013. The study finds that even though India is not a dominant contributor to the global warming and climate change, it is a major sufferer of the climate change especially in case of rural development and consequently the overall development of the economy, because it is the development of agriculture in particular and rural area in general which drives the overall development of the Indian economy.

However few case studies are available for North-East India. Ravindranath *et al.*, (2011) conducted a very important study on this part of India. Adopting the IPCC definition of vulnerability², the study finds that majority of the districts in North-East India are subject to climate induced vulnerability currently and in the near future. Many districts face severe water scarcity during the summer months. The study also argues that the natural resources of the North-East are degraded due to deforestation, unsustainable shifting cultivation practices, fragmentation which ultimately impacts the biodiversity as well as forest biomass production. The authors (Ravindranath *et al.*, 2011) claim the study as the first of its kind which exhibits ranking of districts of North-East India on the basis of the vulnerability index values. The study assists in identifying and prioritizing the most vulnerable sectors and districts; identifying adaptation interventions, and mainstreaming adaptation in development programmes. Again Das (2016) explores climate change induced hydro hazards and its impact on tribal communities in Majuli (largest river island of Brahmaputra River Basin) which has distressed the socio-economic foundation and livelihood of the *Mishing* community of North-East India. The findings reveal that in the selected villages, the dependency ratio is high, average income of the household is low and is declining as compared to last few years because of frequent floods, erosion and siltation that has decreased farm productivity which is the main source of income. The impact of changing climate and heightened flood and erosion risk to farmlands has been resulted in out migration of the rural people in search of stable livelihood options.

It can be visualized from above studies and available literature that in North-East India, dependence of rural people on agriculture is very high. This is also evident from the following data (Table 1) published by the Ministry of Statistics and Programme Implementation (GOI 2014).

Table 1: Estimated number of agricultural households and rural households in the North-Eastern states of India during the agricultural year 2012-13.

State	Estimated no. of agricultural households (00)	Estimated no. of rural households (00)*	Agricultural households as percentage of rural households (%)
Arunachal Pradesh	1080	1659	65.10
Assam	34230	52494	65.21
Manipur	1762	2584	68.19
Meghalaya	3544	4721	75.07
Mizoram	758	936	80.98
Nagaland	2621	4128	63.49
Sikkim	674	1150	58.61
Tripura	2445	6635	36.85

* The estimate of rural households as per the results of the Land and Livestock Holding Survey of NSS 70th round

Understanding this fact that the people of North-East India are highly dependent on agriculture (Irengbam, 2012), it is very important to study its sustainability³. In doing so, study of the economic impact of climate change on rural development is almost unavoidable. The foregoing review of the research studies concerning the present topic of the paper reveals that no doubt, there are some studies relating to the economic impact of climate change in general, and impact on agriculture in particular for India as a whole. No more such studies are found with reference to North-East India. Hence it is of crucial importance to take up a study on the impact of climate change on the rural development of North-East India of India.

3. Methodology and data

3.1. Data and data sources

Data are collected from secondary trustworthy sources like the Metrological Department of India, Ministry of Statistics and Programme Implementation, Ministry of Agriculture through their databank, various reports and other published materials.

3.2 The model

The objective of this paper is to analyse the interrelationship between climate change and rural development in North-East India using annual data over

the period 1971-2014. Economic output is considered a key indicator of national success. A country's productivity is often determined by its Gross Domestic Product (GDP) and is used as substitutions to quantity economic affluence (Tribunella and Friedman 2010). Studies like Cox, Friedman and Tribunella (2011), Tribunella and Friedman (2010) etc. have successfully used this dependent variable weighted by the nation's ability to maintain environmental sustainability (weighted GDPC). These studies have established that Gross Domestic Product can be positively related to a country's ability to correlate economic concerns with upkeep of its environment.

So as a dependent variable this study has used the annual Gross State Domestic Product (GSDP). To represent climate change, three indicators are selected as independent variables, viz-average minimum temperature (*avgmintemp*), average maximum temperature (*avgmaxtemp*), and average rainfall (*avgrain*). To represent human induced factor, another indicator- urbanization (*urbp*) is used as the 4th independent variable. The temporal unit of defining all these variables is annual. We have considered these variables simultaneously in a multivariate time series modelling framework.

$$gsdp = f(\text{avgmintemp}, \text{avgmaxtemp}, \text{avgrain}, \text{urbp}) \dots \dots \dots (1)$$

So the multiple linear regression model is

$$egsdp_t = \alpha + \beta_1(avgmintemp) + \beta_2(avgmaxtemp) + \beta_3(avgrain) + \beta_4(urbp) + \varepsilon_t \dots\dots\dots (2)$$

Where $egsdp_t$ is the estimated gross state domestic product at the t^{th} year ($t=1971, \dots, 2014$); ε_t is the error term which is assumed to be normally distributed with mean 0 and constant variance. $egsdp_t$ is the estimated values of the GSDP as all values before 2006 are not available. The values of $egsdp_t$ are estimated through fitting the trend line. To avoid violent

fluctuation in the data, data for all the 5 variables are transformed into their respective natural logarithms. The equation represents the North-East India for 44 years' time period.

3.3 Descriptive statistics

The descriptive statistics for the data set is provided at Table 2.

Table-2 : Descriptive statistics

Variable	Mean	Std. Dev.	Min	Max
<i>avgmintemp</i>	18.49714	1.235386	17.05	21.912
<i>avgmaxtemp</i>	30.99666	5.185314	28.10833	46.279
<i>avgrain</i>	189.8889	29.9989	143.7583	254.196
<i>urbp</i>	20.44084	5.290299	10.29286	29.212
<i>egsdr</i>	7.6013	2.096342	4.0925	11.1101

4. Results and discussion

4.1 Trend analysis

The paper has considered three indicators to represent climate change due to anthropogenic factors in the North-East India: average minimum temperature,

average maximum temperature and average rainfall. Though there is a clear increasing trend in the case of average minimum and maximum temperature, the change in average rainfalls is very fluctuating in this region. The trend lines of the logarithmic values of these three natural indicators are shown in figure 1, 2 and 3 respectively.

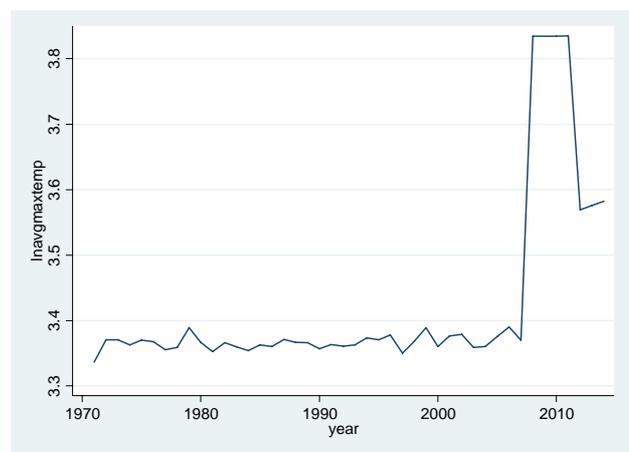
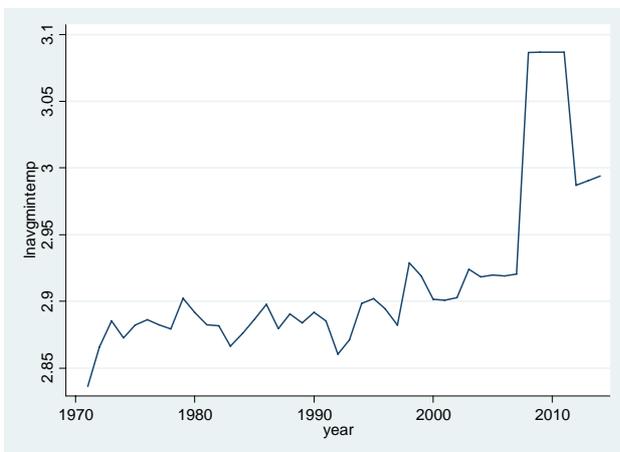


Fig. 1 : Logarithmic trend of maximum temperature

Fig. 2: Logarithmic trend of minimum temperature

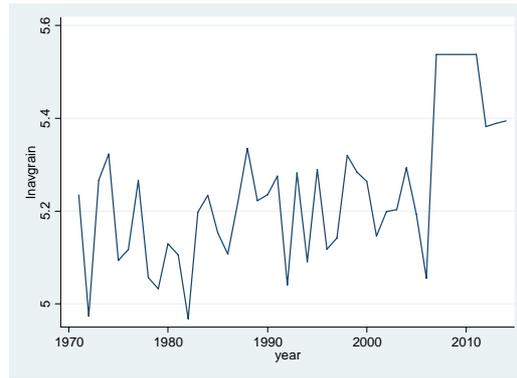


Fig. 3: Logarithmic trend of average rainfall

In case of plotting the logarithmic trend lines of all the three natural indicators of climate change, one can observe that there is a considerable increase in the trend in the later years of the decade 2001-10, which indicates that the rate of climate change has increased significantly in recent years.

The study has considered urbanization as an indicator to explore if human induced factor has an

impact on rural development. The logarithmic trend line of urbanization (Figure 4) suggests an increasing trend of out migration in the North-East Indian states. Although urbanization is not very significant in this region, various environmental factors like flood, erosion; social factors like lack of college and hospitals; economic factors like unemployment etc. are forcing rural people to migrate to urban areas in search of better living facilities.

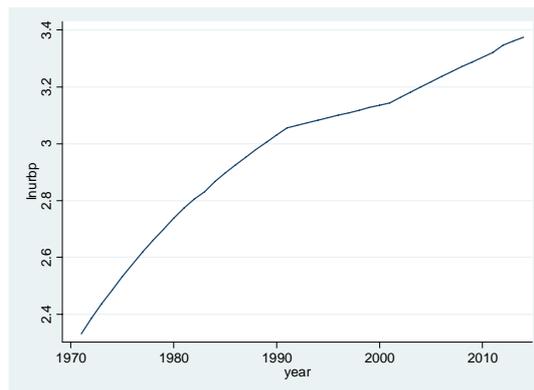


Fig. 4: Logarithmic trend of urbanization

Figure 5 depicts the growth rates of Gross State Domestic Product (GSDP) of the eight North-East Indian states from 2005-06 to 2013-14. The figure

shows that from 2007-08 to 2011-12, these states performed well in terms of their GSDP compared to the national level (black line).

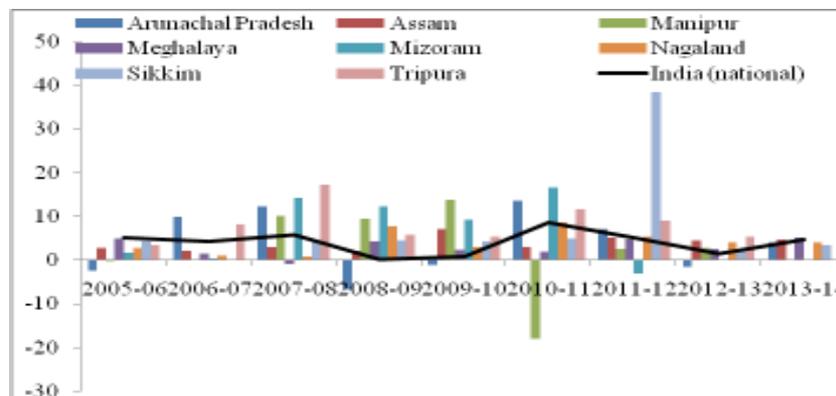


Fig. 5 : Growth Rate of Gross State Domestic Product in Agriculture & Allied Sector at constant 2004-05 Prices (2005-06 to 2013-14)

But after 2011-12, growth rates of GSDP of all the eight states are declining. Arunachal Pradesh has experienced a negative growth rate in 2012-13. Similarly, there is a large decrease in the growth rate of Sikkim also (-36%) which had a very high growth of GSDP in 2011-12. Sikkim has recorded remarkable decrease in average annual rainfall along with significant increase in the average annual maximum temperature during the last six decades (Rathore, L.S., Attri, S.D., Jaswal, A.K. 2013). Out of all the eight NE states, Manipur is the worst performer of the growth rate of state domestic products. State averaged monsoon season average maximum temperatures have

shown remarkable increasing trends over Assam, Manipur, Mizoram, Sikkim, and Tripura.

4.2 Multivariate regression analysis

To estimate the causal relationship between the rural development, urbanisation and the three elements of climate change a multiple regression has been performed on the log values of each of the variables. The indicator of rural development is the dependent variable and climate change and urbanisation serves as the independent variables in this regression analysis. In all the three cases the urbanisation shows a significant effect as depicted in Table 3.

Table 3 : Results of multiple linear regression analysis

Variable	Coefficient	t	P> t
<i>Average minimum temp.</i>	1.3253*** (0.466)	2.85	0.007
<i>Average maximum temp.</i>	-0.4154**(0.181)	-2.30	0.027
<i>Average rainfall</i>	0.0291 (0.054)	0.54	0.595
<i>Urbanization</i>	0.9241*** (0.031)	30.28	0.000
Constant	-3.3603***(0.687)	-4.89	0.000
Observations	44		
R square	0.9862		
Adjusted R-Square	0.9847		
F (4,39)	694.25***(0.000)		

Standard errors in parentheses
 *** p<0.01, ** p<0.05, * p<0.1

The multiple linear regression test results show that average minimum temperature, average maximum temperature and urbanization have a significant impact on growth rate of GSDP of the North-East India. While *avgmaxtemp* has statistically significant negative impact, *avgmintemp* and *urbp* has statistically significant positive impact on GSDR. Again average rainfall also has positive relationship with GSDP, but not statistically significant.

The results unfold valuable estimations about the relationship between weather and rural development. Rising temperature, especially in the seasonally dry tropical regions, like India, decreases agricultural production (Lakshmikumar et al. 2012). But at the same time rising minimum temperature helps in agriculture and allied sectors. It is already noticed by the IPCC (2001) that climate change has positive effects also. Because rising minimum temperature helps to increase

the concentration of carbon dioxide in the atmosphere, to a certain level, which speeds up photosynthesis. This phenomenon has a positive fertilization effect on many crops. Though its magnitude is under doubt.

Again urbanization has a positive impact on agriculture and allied sectors in the study region. Urbanization impact on development is not homogenous in all regions. Urbanization does not only lead to environmental changes, but also leads to structural change of the society. It is about modernization of life styles, both economically and socially (Poumanyong, P., Kaneko, P. 2010). Although many studies are conducted and many reports are composed to study the relationship among climate change, urbanization and development, including energy use and carbon emissions, still a general conclusion is yet to be received. Contradictory results

are seen to be obtained. Some studies have shown that urbanization increases energy demand, generating more emissions (e.g. Zhao and Wang, 2015; Rafiq et al., 2015). Conversely, other scholars argue that urbanization and urban density improve the efficient use of public infrastructure, lowering energy use and emissions (Sadorsky 2014). For example, (Liddle 2013) found a U-shaped relationship between urban population's impact and the level of development. Sadorsky (2014) argues that more the urbanization more is the economic activity which is in turn related to higher affluence. "Increased urbanization also helps to facilitate economies of scale for public infrastructure and these economies of scale lead to lower environmental damages" (Sadorsky 2014). This helps in growth of agricultural and allied sectors' product.

5. Conclusion and way forward

The results of this empirical study suggest that there is a significant relationship between climate change and rural development in the North-East India. Urbanization is taken as additional information. The effects have relationship with the growth rate of gross domestic products of agricultural and allied sectors. The conclusions of this study are robust. The regression results shed light on the fact that there is linkage between climate change and sustainability of the rural development process of the selected states.

The thorough analysis of the present state of climate change in North-East India and its impact on rural development reveals that no doubt, this region has been facing a significant weather as well as climate

change. Hence the impact of climate change on these states is in variety and multiple. Rural sector of North-Eastern states is a very essential sector of the Indian economy, because India's economy depends on its rural economy to a large extent (Kamble 2016). The present study sufficiently indicates that the effects of climate change on rural development are visible and this effect may be intensified in the future. The adverse impacts of climate change, especially of the maximum temperature rising on rural development are observed in production and productivity of agriculture and allied sectors such as forestry, fishing and livestock. There is an urgent need to endeavour for mitigating climate change on the rural development of the selected North-Eastern Indian states.

Rainfall impact on GSDP is non-significant should not be a matter of pride for these states as presently these states are already rainfall abundant. However, any further change may lead to an adverse effect on the rural development in the future.

Nonetheless, the piece of work provides only preliminary results derived from a very macro-level analysis. Sustainability depends on many other factors. Climate change is a real transformation of weather that has been going on in almost every country. It depends not only on carbon dioxide emission or energy consumption; but also on various other factors like policy, economic activities, urban expansion, consumption, etc. which are beyond the scope of the current paper. Future research may be performed considering all these factors so that impact of climate change on rural economy can be studied in a better way.

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Foot notes

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² Vulnerability: The Intergovernmental Panel on Climate Change defines it as 'the degree to which a system is susceptible to or unable to cope with adverse effects of climate change, including climate variability and extremes' (IPCC, <http://www.ipcc.ch/ipccreports/tar/wg2/index.php?idp=22>)

³ Sustainability means meeting our own needs without compromising the ability of future generations to meet their own needs (WCED, 1987)

