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# Review on Climate Change and its Impact on Agriculture of Arunachal Pradesh in the Northeastern Himalayan Region of India

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## ABSTRACT

Current paper aims to review the climate change scenario of Arunachal Pradesh and its impact on the agricultural productivity and the farming system of the state. Arunachal Pradesh is witnessing climate change with rise in average temperature, particularly the minimum temperature. Though the amount of rainfall remains more or less constant, but the intensity increases with lowering of number of rainy days by 11 per cent in the recent decades. Also, there are profound variations in the spatial and temporal distribution in rainfall patterns with persistent mid season dry spell during July and August. Climate change is threatening food production system and therefore the livelihood and food security of people across the State, particularly that of the hill regions. Fragile and poorly accessible landscapes with sparsely scattered settlements, primitive agricultural practices and poor infrastructure make agriculture of Arunachal Pradesh extremely vulnerable to climate change. The observed and likely future effects are diverse and geographically differentiated, creating uncertainty, which makes the task of preparing for climate change impacts very difficult. To increase the resilience of sector in the state needs pro-environment and pro-development research and policies tailored to the local needs and conditions.

## INTRODUCTION

Climate change is a fact (IPCC 2007) and its impacts are not only apparent in the environment and ecosystem, but also in the socio-economic and cultural life of the people across the globe, though with spatially varied intensity. The impact of climate change is believed to be more prominent and extensive on mountain as they are among the most fragile environments on earth (Sharma et al. 2009). The mountains, besides having a rich repository of biodiversity and water, they provide ecosystem services to the communities downstream (Hamilton 2000, Korner 2004, Viviroli & Weingartner 2004). They harbour some of the world's most endangered and endemic flora and fauna species as well as the home to traditional communities who are highly dependent on the ecosystem services for their subsistence and livelihood (Kollmair et al. 2005). Eastern Himalaya is a priority eco-region and biologically rich 'hotspot' (WWF 2005). Mountain ecosystems are likely to experience wide ranging effects on the environment, biodiversity, agriculture and socio-economic conditions under the influence of climate change (Beniston 2003). Climate change, especially change in the hydrological cycle due to changes in precipitation patterns leading to changes in river runoff and consequently affecting whole ecosystems downstream, including agricultural productivity and human livelihood.

Arunachal Pradesh is the largest hill state in North Eastern Himalayan Region of India with a total geographical area of about 8.37 million hectares of land. It has rich biological as well as cultural diversity. The state is custodian of 23.52% of total flowering plants of India (Hegde 2002), including around 4,500 species of angiosperm and 550 species of orchids; and is also regarded as nature's repository of medicinal plants (Haridasan 1989), where around 500 medicinal plants were identified during the preliminary survey. Arunachal Pradesh possesses India's second highest level of genetic resources (SAPCC 2011). The fauna diversity includes 85 species of mammals and 760 species of birds (SAPCC 2011). The region has been identified by Indian Council of Agricultural Research (ICAR) as the centre of rice germplasm while the National Bureau of Plant Genetic Resource (NBPGR) has highlighted the region being rich in wild relatives of crop plants. It is the centre of origin of citrus crops. The State is home of 26 major tribes and 110 sub-tribes (Srivastava 2009). Agriculture is the mainstay of the people of the State with around 85 per cent of population directly or indirectly depending on it for their livelihood and the sector accounts for 25% of the gross state domestic product (SAPCC 2011). The difficult agro-climatic condition with undulating topography, poor soil quality, subsistence nature of agriculture, traditional nature of culti-

vation, inadequate investment capabilities and improper enterprise mix account for poor development of the sector in the State and hinders in achieving its full potential. These factors are compounded by changes in precipitation patterns and temperature in the recent decades due to climate change. Agriculture is most vulnerable to climate change due to its high dependence on climate and weather.

There are very few documents available on the climate change of Arunachal Pradesh in spite of its strategic location influencing the activities of almost all the Northeastern States of India. The current review gives a brief overview of climate change scenario of Arunachal Pradesh and its impact on the agricultural productivity and the farming system of the State.

**Climate change scenario of Arunachal Pradesh**: Arunachal Pradesh is the land of climatic diversity with five agro-climatic zones within the State viz. alpine zone, temperate zone, sub-tropical hill zone, mid-tropical hill zone and mid-tropical plain zone. Topographically, Arunachal Pradesh is generally a hilly region, with the elevation of the hills ranging from 60 meters to over 7300 meters (GORICHEN peak in West Kameng district). Arunachal Pradesh is one of the highest rainfall recipient States of the country with more than 3500 mm in a year with over a period of 8 to 9 months, excepting in winter, however, most of the rainfall is between May and September. Higher regions experience snow fall during winter. The average annual rainfall is 1000 mm in the higher elevations and 5750 mm in the foothill areas. This diversity in the climate and also in topography accounts for a wide diversity in vegetation and agriculture. The normal temperature during winter months varies between 15°C to 21°C, while it varies from 22°C to 33°C during monsoon months. In the summer months, the temperature sometimes reaches to around 40°C in foothills of the State.

The long term analysis of trends in observed seasonal precipitation and temperature over Arunachal Pradesh using IMD gridded and temperature at daily time scale shows that the rise in temperature is appreciable with more significant in case of mean minimum temperature trends compared to maximum temperature (Table 1). Overall analysis indicates that Eastern Himalaya in general and Arunachal Pradesh in particular are experiencing widespread warming generally 0.01 to 0.04°C per year (Sharma et al. 2009).

Though the change in rainfall is not found to be significant but found to be decreased in number of rainy days by about 11 percent. The distribution of rainfall also observed very erratic in the recent decade.

According to the PRECIS regional climate model, annual rainfall is projected to decrease by 5 to 15 per cent in the 2030s as compared to baseline and increase by 25 to 35 per cent towards 2080s. Decrease in rainfall is projected for all seasons except pre-monsoon for 2030s. Maximum temperature is projected to increase by 2.2°C to 2.8°C during 2030s as compared to baseline and towards 2080s the increase is projected by 3.4°C to 5°C. Minimum temperature is projected to increase by 1°C to 2.6°C during 2030s and by 2.8°C to 5°C during 2080s (SAPCC 2011).

**Impact of climate change on agriculture**: Agriculture in the State of Arunachal Pradesh with nearly 81 per cent crop land under rainfed cultivation and high dependence on the southwest monsoon has been a highly risky venture with vagaries of monsoon, besides the interplay of other abiotic and biotic factors. Climate change is set to compound the daunting complex challenges already being faced by agriculture. Agricultural productivity is sensitive to two broad classes of climate-induced effects (1) direct effects of changes in temperature, precipitation or carbon dioxide concentrations, and (2) indirect effects through changes in soil moisture and the distribution and frequency of infestation by pests and diseases.

Rainfall plays an important role in determining the fate of agriculture in Arunachal Pradesh as only 19 per cent of gross cropped area is under irrigation (SAPCC 2011). Getting crops the right amount of water at the right time has always been a challenge for farmers and for the success of agriculture of the State. Too much or too little water/precipitation can jeopardize whole agro-system, so the seasonality, amount, distribution and the timing of the rainfall is of particular importance. But due to climate change, the reliability of agriculture on rain has reduced in the recent years as the seasonal rainfall has been marked by delayed onsets, declining number of rainy days and increased intensities altering farming calendars with negative effects on the yields. Climatic manifestations in terms of variable rainfall over the last decade have made it difficult to maintain this fragile balance between the onset, duration and the amount of rain, and the timing of agricultural activities. During the last decade, climate-related crop failures in the eastern part of Arunachal Pradesh attracted much attention (Arunachal Times 2009, 2012). Increase in frequency and magnitude of floods in the recent years devastated large areas of near-ready grain fields. While low rainfall resulted in several episodes of late rains during planting seasons, and persistent droughts in large portions of the region. The frequency of extreme weather events like floods, landslides and drought increased in the recent decade (Shrestha 2004, WWF 2005). About 80 percent of the soil of the State is acidic in nature with ferrous toxicity in valleys and aluminium toxicity in the hills/uplands (Ngachan 2013), which is further aggravated by increasing intensity of rainfall leading to more leaching.

Table 1: Climatic conditions (long term averages)[1].

| Temperature Trends | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Mean Maximum Temperature Trends in °C per year** | | | | | | | | | | | | |
| Annual | | | Winter | | | Summer | | | Monsoon | | | Post Monsoon |
| +0.02* | | | +0.02* | | | No trend | | | No trend | | | +0.02* |
| **Mean Minimum Temperature Trends in °C per year** | | | | | | | | | | | | |
| Annual | | | Winter | | | Summer | | | Monsoon | | | Post Monsoon |
| +0.02* | | | +0.02* | | | +0.02* | | | +0.01* | | | +0.02* |
| **Monthly mean temperature trends in °C per year** | | | | | | | | | | | | |
| Months | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| | +0.02 | +0.03* | -0.02 | -0.03* | +0.03* | NT | -0.01 | NT | NT | +0.01 | +0.02* | +0.02* |
| Rainfall Trends | | | | | | | | | | | | |
| Annual | | | Winter | | | Summer | | | Monsoon | | | Post Monsoon |
| -3.63 | | | -0.10 | | | No trend | | | -2.30 | | | -0.83 |
| **Monthly rainfall trends in mm per year** | | | | | | | | | | | | |
| Months | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| | -0.29 | -0.05 | +0.49 | +0.86 | -2.19 | -0.82 | +0.06 | -3.29 | +0.26 | -0.88 | -0.09 | -0.13 |

Increasing (+) and decreasing (-) trends significant at 95% level of significance are shown in bold and marked with '*' sign. [1]Agro-climatic classifications (Trends: 1950-2014, IMD)

Studies show that in the northern hemisphere, the species are shifting towards northern latitude or higher elevation (Hickling et al. 2006, Wilson et al. 2007). The species already in the higher altitude or in alpine or subalpine zone are particularly vulnerable as they have limited scope to move further. Rise in minimum temperature has significant impact on temperate fruits of Arunachal Pradesh. During growing season, the rise in minimum temperature leads to shift in apple and kiwi cultivation to higher elevation due to non-fulfilment of chilling temperature requirement (Gautam et al. 2014). The low temperature during winter and precipitation in the form of snow are important and critical climatic factors for introduction of dormancy, bud break and also to ensure proper flowering in apples. The fruit requires 1200-1500 hours of chilling depending on the type of cultivar. Chilling hours<1000 lead to poor fruit formation.

In terms of food crop production the State still has minus 6 per cent deficit, producing around 2,50,400 tones of grains against the requirement of 2,68,100 tones (Ngachan 2013). Climate change and uncertainty further increases the pressure on the sector. The net cereal production in the region is projected to decline by at least 4 to 10 per cent by the end of this century, under most conservative climate change scenario (Lal 2005).

Weeds, insects and diseases are benefitted by warming environment. The climate change is a concern to researchers and farmers because it would lead to changes in insect and disease dynamics, i.e. the distribution, abundance and management of insects and pathogens. Climate change will probably alter the geographical and temporal distribution of pests and insects. New diseases may arise in certain regions, and other diseases may cease to be economically important, especially if the host plant migrates into new areas (Coakley et al. 1999). More aggressive strains of pathogen with broad host range, such as *Rhizoctonia, Sclerotinia, Sclerotium* and other necrotrophic pathogens can migrate from agro-ecosystems to natural vegetation, and less aggressive pathogens from natural plant communities can start causing damage in monocultures of nearby regions (Chakraborty 2000). Regarding unspecialized necrotrophs, the range of hosts can be extended due to crop migration. The rice blast disease (*Pyricularia oryzae)* which is much prevalent in the region and main cause behind hindrance of achieving the full potential of rice cultivars is favoured by rise in temperature in the State. The simulation model shows that the risk of blast epidemic is likely to increase under current trend of temperature rise in Arunachal Pradesh (Luo et al. 1995).

Livestock sector plays multiple roles in the livelihood of people in agriculturally underdeveloped States like Arunachal Pradesh, especially the poor. The sector is negatively affected by a decline in forage quality, heat stress and disease like food and mouth in cattle. Grassland productivity in the region is also expected to reduce as much as 40 to 90 per cent with an increase in temperature of 2 to 3°C combined with reduced precipitation (Smith et al. 1996). In case of poultry, the mortality due to chronic heat stress is found to be significant in foothills (Jini et al. 2015). The rise in temperature associated with high humidity make

environment congenial for diseases like Ranikhet, Fowl Pox and Coccidiosis. Temperature also found to have a detrimental effect on the laying capacity of the hens and also lowers the quality of egg in Arunachal Pradesh (Jini et al. 2015).

Thus, climate change has the potential to act as a 'risk multiplier' in Arunachal Pradesh, where agriculture and other natural resource-based system are already failing to keep pace with the demand on them.

## CONCLUSION

While agriculture's contribution to gross domestic product is declining throughout the North Eastern region, large populations are still based in rural areas, depending on agriculture directly or indirectly for employment and income. The Eastern Himalayan region is likely to face the highest reductions in agricultural potential due to climate change. As a result, climate change will place an additional burden on efforts to meet long-term development goals in Arunachal Pradesh in particular. To cope up with the current crisis, the ongoing development initiatives need to be strengthened to reduce vulnerability to climate change by adopting suitable policies and technologies. The adaptation will require improvements that take existing development policies above and beyond their current capacity that encompasses innovative policies like changing investment allocation within and across sectors, increasing the focus on risk-sharing and risk-reducing, disaster preparedness, capacity building, focused research for agricultural GHG mitigation, proper study of indigenous traditional knowledge on farming to compliment the scientific recommendation for wide acceptability, jhum improvement etc. Thus the agriculture and the farming system of the State must make necessary adjustment and readjustment with the changing climate to enhance the resilience of the sector. Connectivity and accessibility has major role to play in the economic development of the agri-allied sector and it needs an immediate attention in the State.

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