Climate-smart landscape management in North-East India: determining the influence of climatic variables on tea production

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Introduction:

The agricultural sector is likely to be significantly affected by future climate changes. Water demand for agricultural purposes (particularly rain-fed crops) is projected to vary under climate change, with the timing and magnitude of floods and droughts also indicating major shift[15]. Several studies on climate-induced water variability have been undertaken indicating that water scarcity will be an issue for agricultural productivity and water management practices for rain-fed agriculture need urgent attention[11,12,4,1]. Tea is an important global agricultural commodity both commercially and culturally. Here we investigate the extent to which climate influences tea yield in a major high-quality tea-producing region of the world.

Assam, a prime tea growing region of north-east India, produces 24% of the world's total tea [16], and contributes over 12% of the annual global yield (ASSOCHAM). Assam has four tea-growing regions: Upper Assam and South Bank have the highest yield, followed by Cachar and North Bank. The latter are the rain shadowed areas and therefore are more affected by fluctuations in water availability. Tea is a rain-fed perennial crop in Assam. Uneven spatial and temporal distribution of precipitation, coupled with rising temperatures has resulted in drought-like conditions during certain periods of the production season. In some localities, water scarcity has delayed the first flush tea crop (the highest quality tea crop of the season), reduced the resilience of the crop to rising temperatures, and degraded yield quality. No major irrigation facilities are present in the region due to traditional precipitation abundance. In an agrarian state like Assam, the majority of the population are dependent on income from tea plantations for sustaining their livelihoods and production contributes significantly towards economic development.

Tea crop growth (both quantity and quality) depends on several climatic variables such as temperature, precipitation, relative humidity and sunshine hours. This research aims to identify which climate variables (primarily focussing on temperature and precipitation characteristics) have the greatest impact upon tea yield in Assam. Quantifying regional climate-tea characteristics will enable more effective decision-making regarding climate change mitigation and adaptation to sustain (and enhance) future tea crop production.

Methods and materials:

Panel-based regression analysis was undertaken to determine which climate variables have the greatest influence on monthly tea yield data using time-series climate records (1977-

2007) in the four tea-growing regions of Assam. Climate variables used in the analysis were monthly, seasonal and annual rainfall, number of days with the optimum amount of rainfall, daily temperatures (min, max and mean), number of days with temperature greater than 35°C and number of consecutive days with temperature greater than 35°C. Variables were selected according to optimal climatic conditions for tea growth as stated in the literature[2,7]. Time-invariant variables such as soil properties (which are often omitted in cross-section models) were accounted for in panel-based regression through grouping such variables as site-specific intercepts[8]. These variables are likely to be constant (fixed effects) within sites and any variations were assumed to be statistically independent of climate. Temperature and precipitation variables were regressed with the yield data to investigate the impact of climate factors on yield. To complement the statistical analysis, qualitative information regarding plantation practices were obtained from tea estates which enhanced the viability of adaptive plantation practices to cope with changing climatic conditions.

Results and Discussion:

The panel-based statistical analysis indicates spatial heterogeneity in climatic variable influence on tea yields throughout the tea growing regions of Assam. In the Cachar region temperature has a greater influence on tea yield than in Upper Assam and South bank, where rainfall is the dominant factor. Panel-based model results show similar outcomes to other crop-based analyses which have investigated climate influence on yield e.g. corn and soya bean yields in USA were found to be affected significantly by a degree of temperature rise in a day, whereby crop yields increased within an optimal temperature range and decreased beyond this range[13]. Similarly, in tea production it has been found (in Assam, Malawi and China) that monthly tea yield reduces when days with temperature >35°C exceeded the average in a single month[5,3,6] and temporal inconsistencies in rainfall (in Sri Lanka and Assam) also influenced monthly yield[9,10,14].

To complement the results of the statistical analysis, field observation data is presented. During field visits various land and water resources management practices were observed as being adopted by tea estates e.g. water harvesting structures, such as check dams, in the tea estates of Upper Assam, Cachar and North Bank. These regions have undulating topography with garden micro-climates, so management practices to cope with changing climatic conditions is critical for sustaining high quality and quantity yields. Such land management practices are thought to be integrally linked to climate change adaptation in Assam. In this research we are interested in determining which climate variables raise a significant threat to tea yields, and how land management practices can benefit from such knowledge to enhance mitigation and produce more socio-resilient landscapes.

Conclusion

It is hypothesised that our study will conclude that under changing climatic trends, rain-fed crops, such as tea, are likely to face increased climate-induced stresses. This poses a serious threat to the stability of the tea planting community. There is a pressing need for building-up strategies for sustainable increases in yield and to minimise dry-spell induced crop failures.

Learning from best management practices where water resources are central to landscape resilience e.g. the use of irrigation for tea crop production elsewhere in India (Darjeeling) or further afield (Malawi) may be beneficial for the tea communities. The present research will assist in building resilience for coping with future climate challenges through climate-smart agricultural approaches to managing the tea landscapes of Assam.

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