North East India: soil and water management imperatives for food security in a changing climate

The signs of climate change in the north-eastern region (NER) of India are becoming increasingly evident. The annual maximum and mean temperature from 1901 to 2003 has increased by 1.02°C and 0.60°C respectively[1]. The temperature is projected to rise by another 3–5°C during the latter third of this century[2]. The most striking evidence of changes in rainfall comes from the drastically reducing amount of rainfall in Cherrapunji, one of the wettest places in the world. Cherrapunji received less rain in the entire year of 2001 (363 inches) than it got in just one month in 1861 (366 inches in July)[3]. The annual rainfall there has now fallen sharply to less than a third of the quantity in the 1860s. The frequent deficits in rainfall and the recurrent droughts in the region further substantiate the climate change-induced alteration in the rainfall pattern. Particularly noteworthy is the projected decline (~10%) in *rabi* season rainfall and increase (~20%) during the rest of the year in the latter half of this century[2], indicating the possibility of increasing events of high-intensity rainfall in future. Being intricately linked to agricultural productivity, these climatic changes will have definite impacts on food production in NER.

Despite sharing ~8% of geographical area and ~13% of rainfall, NER contributes only 1.5% to the total foodgrain production of the country, leading to a perpetual food deficit in the region. This is mostly due to soil fertility and water availability-related constraints. According to a recent report by the Ministry of Environment and Forests, Government of India, the yields of rice, wheat and maize in NER may decline up to 35%, 20% and 40% respectively, in the climatic scenario of 2030. Considering the current acceleration in atmospheric warming, the associated climatic changes and their effects on agriculture related to water availability and soil fertility (which have not been considered in the present impact estimations), the actual impacts on food production in NER may be more severe than anticipated.

The expected increase in water requirement for agriculture (from 20 km^3 in 2001 to 28 km^3 in 2025) coupled with higher evapotranspiration losses under the warming atmosphere will further aggravate the water crisis in NER. With the river-feeding Himalayan glaciers receding, water stress will increase in the Brahmaputra basin, where a large population depends on agriculture.

Soil acidity, the biggest impediment to crop productivity in NER, may further intensify under the rising atmospheric CO_2 concentrations. This possibility stems from the frequent experimental observation of increased CO_2 production in the soil due to enhanced soil respiration under elevated CO_2 conditions[4]. It leads to more carbonic acid (H_2CO_3) formation in soil water, which upon leaching, removes base cations from the soil, thereby causing soil acidification. Models suggest that a doubling of atmospheric CO_2 may increase acid inputs from H_2CO_3 leaching by up to 50%. In fact, it is believed that increases in atmospheric CO_2 since the interglacial era have gradually acidified soils throughout the world[5], and will continue to do so in the high-CO_2 atmosphere of the future.

Soil organic matter (SOM), a key determinant of soil health, may also suffer a quantitative as well as qualitative decline under the warming atmosphere[6]. At higher temperatures, there is enhanced decomposition of SOM, particularly the labile fractions that are more important for nutrient supply, with an increasing proportion of relatively inert carbon fractions. Such reductions in SOM can reduce the water and nutrient holding capacities, decrease the buffering capacity, degrade the soil aggregate stability rendering it more susceptible to erosion, decrease the biological activity, and cause many other associated changes that will ultimately lead to progressive decline in soil health and crop productivity.

Over 600 million tonnes (mt) of soil accompanied by 1.5 mt of nutrients (NPK) gets eroded every year due to the steep slopes in NER and rainwater mismanagement. A greater frequency of high-intensity rainfall can further increase these losses. The possibility of high temperature-induced increases in transient salinity, denitrification and nutrient loss due to volatilization cannot be overlooked: so also the loss of nutrients through enhanced leaching under high-intensity rainfall[6]. The yield benefits of elevated CO_2 are realized only when there is no limitation to the availability of water and nutrients in the soil[7]. However, the continued impoverishment of the soil due to heavy nutrient mining (annual depletion of 258,000, 73,000 and 179,000 tonnes of N, P_2O_5 and K_2O respectively), inadequate fertilization and declining water availability strikes out any possibility of elevated CO_2-induced yield benefits in the NER agriculture.

Clearly, the climate change-induced aggravations in water scarcity and progressive deterioration of soil fertility are likely to be the most important factors threatening future prospects of food production in NER. Thus, there is an urgent need to prioritize the development and implementation of various soil and water conservation and management practices, such as rainwater harvesting, improvement of irrigation potential, soil erosion control, balanced and adequate fertilization, SOM improvement, soil acidity amelioration and conservation agriculture, to improve the climate resilience of NER agriculture.

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