Climate-smart land management methods for enhancing the adaptive capacity of food production systems in the tropical regions

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The island ecosystem is influenced by the maritime climate and endemic flora and fauna that predominate the food production system. The observed variations and projected changes in rainfall and temperature severely affect the small islands and island states (SIS) more than large countries. In this study, we analyse the long-term changes in total rainfall, its seasonal variations, the number of rainy days and extreme events based on standardized global datasets and ground observations for SIS, including island regions of India, to identify suitable adaptation options in order to ensure sustainable food production. We link these climatic parameters with the observed waterlogging, moisture stress and salinity, compounded by the sea-water intrusion, which severely affects agricultural diversification and food production. In these areas, climate-smart alternative land management (ALM) methods, viz. raised beds, paddy–fish, farm ponds with broader dykes, etc. have been demonstrated and evaluated against these climate change-linked challenges at smallholder farms in the Andaman Islands and Sundarbans region of India. The results showed that the ALM methods created favourable conditions for crop growth and agricultural diversification by excluding sea-water intrusion, harvesting rainwater, reducing salinity and facilitating drainage amidst extreme events experienced during the observation period (2010–2020). ALM enhanced on-farm food production (2.7–34.6 tonne ha^{-1} rice equivalent yield), sustainability (0.23–0.79, measured as sustainable yield index) and net mitigation benefit (2.2–5.7 Mg CO_2 eq. year^{-1}), providing greater scope for its upscaling in the island and coastal regions as adaptation measures.

Keywords: Adaptation, alternative land management, climate change, coastal regions and islands, waterlogging.

GLOBAL climate change and food insecurity are the two major challenges for humanity, with the former escalating faster than the latter[1]. Analysis of output from the general circulation models (GCMs) and regional observations revealed the negative impact of climate change on agricultural growth through increase in the frequency and intensity of drought, heavy rainfall, flooding and high maximum temperatures, which are projected to accelerate in many regions[2]. Small islands and island states (SIS) located in the tropical regions, including the Indian island territories, are highly vulnerable[3] to these changes, as many of the SIS have small land areas with a high population density and low economic resilience[4]. Intropical regions, agriculture is a key economic sector and major employment source for 40–60% of the population, but more than 20% of the people still remain food-insecure[5]. The current hydro-meteorological extreme events cause significant loss to GDP (17–59%) in this region[6]. Further, interannual variability in temperature, rainfall and sea level related to the ENSO (El Niño/southern oscillation) phenomenon make these regions increasingly vulnerable to climate change[7]. In future, this increased climatic variability may exacerbate production risks and challenge farmers' coping ability, particularly the landless and marginalized ethnic groups[8]. This concern has created a strong demand for understanding global climate change in the regional context with high confidence so that long-term adaptation strategies could be formulated for the sustainable development of the SIS regions.

Climate change and its associated events are normally witnessed in the form of low cropping intensity, lack of agricultural diversification and low production in the SIS regions[9,10]. Averting this challenge requires farmers to adapt by making changes in farming and land management decisions that reduce the negative consequences of land degradation and changing climate[11]. In recent years, permanent raised bed systems (land shaping) have been adopted in a wide range of irrigated and dryland farming systems to harvest rainwater and increase water-use efficiency[12,13], provide better opportunities for the leaching of salts[14,15] and growing rainfed crops[16] under changing climatic and waterlogged-saline areas. This is more pertinent to India's islands and coastal regions, which are geographically similar and a part of the SIS regions.

Thus, it is imperative to study climate change and its spatio-temporal variations to understand the imposed regional challenges to agricultural production. This study presents large-scale experimental evidences based on the demonstrations conducted at smallholder farmers' fields

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