



Multi-criteria assessment of climate smartness in rice-based cropping systems



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ABSTRACT

Rice is one of the major staple food grains in the world and because of its higher water requirement, rice production is heavily threatened by climate change and extremes. As global warming and climate variabilities increasingly affect most of the rice growing regions including India, it is vital to introduce alternative options to rice-rice monocropping. To address this issue, we developed a climate smart index (CSI) to evaluate the climate smartness of different cropping systems such as, rice-sunflower (R-S), rice-maize (R-M), rice-black gram (R-BG) and rice-green gram (R-GG) compared to a conventional rice-rice (R-R) system grown in the eastern coastal belt of India. Diversifying rice-based cropping systems with legumes and sunflower significantly enhanced system productivity and the partial factor productivity of nitrogen by 33–41% and 40–45%, respectively over the rice-rice cropping system. Further, these systems reduced the global warming potential (GWP) by 46.3–51% compared to the rice-rice system. The soil organic carbon content increased by about 5–7 % due to the adoption of pulse crops. The climate-smart index for rice-sunflower (R-S), rice-black gram (R-BG), rice-green gram (R-GG), and rice-maize (R-M) systems were found to be higher than the rice-rice (R-R) system by 26.5%, 18.7%, 18.7%, and 14.9% respectively, on average across seasons. Hence, incorporating legumes and oilseed crops during the dry/minor seasons of the year in rice-based cropping systems can be proposed as a climate-smart alternative. Further, we propose conducting large-scale assessments of these cropping systems using spatial data to deliver decision tools for regional planning and policy formulation in agriculture.

1. Introduction

Agriculture continues to be a vital pillar of India's economic landscape. It accounts for over 40% of India's food grain production, employs 58% of the population, and contributes around 20% to the GDP (Balkrishna et al., 2022). Sustainable agriculture is a key component of achieving sustainable development goals (SDGs), particularly in terms of poverty and hunger alleviation and other deprivations, as well as ensuring cleaner and safer environment to the humanity (Khalid et al., 2021). National food security mission (NFSM) of the Government of India has set a target food grain output of 30.1 Tg by 2021, including 12

Tg of rice, 2.9 Tg of maize, and 2.6 Tg of pulses (Varma, 2022). Despite the fact, Indian agriculture is facing the triple challenges namely, feeding nutritious food over 1.4 billion people, greenhouse gas (GHGs) emissions, and climate change impacts (Lal et al., 2020). Moreover, developing nations such as India are still vulnerable to food insecurity and expected to be most significantly affected by climatic extremes, leading to a future food crisis in the changing climate (Jat et al., 2016).

Rice is the staple in the diet of more than 70% of the Indian population and around 67 million families practice rice cultivation (USDA, 2019). The rice-rice cropping system is the second most prevalent in India, next to rice-wheat. This system is widely adopted in the southern

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