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Impacts of climate-induced water scarcity on rice production in the northern region, Ghana

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Abstract

Climate-related and environmental stressors intensify water scarcity, directly threatening food production and posing a critical challenge for sustainable rice farming, particularly in Northern Ghana. These challenges, including unpredictable rainfall patterns, rising temperatures, and inadequate irrigation facilities, etc., have led to farmers' overreliance on rain-fed agriculture. This study was situated within the water-energy-food nexus framework, highlighting the interconnection between resource use and management. Employing an integrated approach, the study investigated the impacts of climate-induced water scarcity on rice production in the Northern Region (Ghana), using a multi-stage sampling technique, and assessed both primary and secondary data. Trends analysis showed an upward trend in rainfall, minimum and maximum temperatures, solar radiation, and minimum relative humidity. In contrast, decreasing trends were detected in wind speed, radiation, and maximum relative humidity over the period of 1990–2022. The spatio-temporal dynamics of land-use/land-cover changes based on satellite imagery between 2014 and 2024 show a significant expansion in settlement (63.62 %) and cropland (19.23 %), while a decline in vegetation (-25.06 %), water bodies (-33.56 %), and open land (-5.29 %) demonstrates rapid landscape changes over this period. The study confirmed that climatic factors, including rainfall, minimum and maximum temperatures, significantly influenced rice output between 1990 and 2022. Furthermore, the study revealed that adaptation practices such as improved seed varieties, irrigation practices, soil moisture conservation, crop diversification, water harvesting, agroforestry, and early warning systems significantly influenced rice yields in the region. The study identified four underlying factors, including institutional weakness (19.8 %), water scarcity stress (14.3 %), financial challenges (13.5 %), and climate vulnerability (12 %), which accounted for 60 % of the total variance of the multi-dimensional challenges faced by farmers. The study developed two vulnerability models: the Farmer Vulnerability Tree and the Integrated Farmer Vulnerability Model for future studies. In conclusion, rice farming is threatened by climate-related and environmental stressors, worsened by declining water availability, and requires the efforts of stakeholders to reduce its adverse impacts, vulnerability, and risk to food security. The study underscored that stakeholder-led interventions, including capacity building in the water-energy-food nexus, access to weather information, and institutional support to drive the adoption of climate-smart practices and ensure regional resilience.

Keywords: Land-use/land-cover changes, multidimensional challenges, Northern Region Ghana, rice production, vulnerability, water scarcity