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Quantifying the impact of climate change on Food-Energy-Water nexus interactions

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Increasing anthropogenic stresses have challenged the global population's ability to meet the growing demands of food, energy, and water (FEW). With the population set to hit 9 billion by 2050, it becomes indispensable to manage these three vital resources sustainably. Moreover, climate change is expected to have adverse consequences on agriculture, which is one of the primary occupations in developing countries like India. Extreme weather events caused by climate change could impact agricultural productivity severely, affecting economic-food-water-energy security. Hence, there is a dire need to study the impact of climate on agricultural production and its supporting resources – water and energy. Although studying the nexus between FEW is gaining attention lately, evaluating the future FEW interactions in the agricultural sector with an emphasis on climate change is missing. Therefore, this study employs a data-intensive approach to quantify the current and future FEW interactions under the impact of climate change.

First, FAO's CROPWAT 8.0 model was used to estimate crop water requirements for major crops like paddy, sugarcane, groundnut, cotton, and maize in the study area of Andhra Pradesh state, India. CROPWAT uses a soil water balance approach that requires information about several datasets like evapotranspiration, rainfall, soil, and crop information. Massive datasets such as farm-level agricultural data, station-wise rainfall data, and reference evapotranspiration data were incorporated into the model. Second, we calculate the future crop water requirements using future rainfall and temperature datasets, available till 2095, from Global Climate Models (GCMs) under the Representative Concentration Pathway (RCP) 4.5 emission scenario. To achieve this at the district-scale, we downscaled the information regarding temperature using the delta change method and applied the Thornthwaite method to estimate the reference evapotranspiration. Then, energy consumed by each crop in every district was quantified. Third, we estimated the current and future FEW interactions using the commonly employed two-at-one-time methodology.

Results indicated that water-intensive crops like paddy and sugarcane account for most groundwater and energy consumption. Southern districts of the state consume relatively more groundwater and energy than the northern regions. Further, high water-intensive crops like paddy were being cultivated in several dry regions, furthering the groundwater resources depletion and rising energy costs. For instance, in Kurnool district, the irrigation water requirements for paddy increased by almost 20% from the 2020s (644 mm) to the 2090s (772 mm). Clearly, such an increase can be attributed to a changing climate causing increased evapotranspiration. The

resulting increase in groundwater and energy consumption, has the potential to endanger food and water security in countries like India. The approach outlined in this study also allows us to identify vulnerable hotspots that would enable policymakers to design effective adaptation strategies in the agricultural sector. The synergistic benefits offered by FEW nexus approaches have the potential to ensure food security at local and global scales.