

ABSTRACT

Changes in water, energy, and food (WEF) affect one another directly. The WEF Nexus concept captures these sectors' interconnections and trade-offs holistically. This study aims to evaluate WEF security across Indian States and Union Territories (UTs) and within a river basin, examine sectoral interlinkages, assess future climate change impacts, and develop a user-friendly, freely accessible Web-based WEF Nexus tool. The Pardee RAND Water–Energy–Food Nexus Index (PR-WEFNI) was applied to assess WEF security in Indian States and Union Territories (UTs) for 2015–16 and 2019–20, and a Policy Implementation Score (PIS) was developed to evaluate policy effectiveness. The PR-WEFNI framework was extended by incorporating water balance components and sectoral connectivity indicators, resulting in a distributed WEF Nexus model. This model was used to quantify coupling and coordination across States/UTs for 2011 and 2021. For basin-scale analysis, the framework was integrated with CMIP6 climate projections, the AquaCrop model, and a scenario-based energy model to assess impacts under SSP245 and SSP585 scenarios (2031–2091) in the Kangsabati River Basin. Results indicate that India's overall WEF security improved by 12% between 2015 and 2020, driven primarily by gains in water (92% of States/UTs) and energy security (97%), while food security stagnated or declined in over 83% of regions, revealing significant spatial disparities masked by national aggregates. The coupling degree (>0.90) reveals strong interdependence among sectors, but improvements in coordination between 2011 and 2021 remain uneven, with several regions exhibiting high coupling but low coordination. Climate projections indicate increased rainfall variability and evapotranspiration, leading to declines in energy production, rice yields, and overall WEF security in the Kangsabati Basin by 2091. A freely accessible Web-based WEF Nexus Model (WbWEFNM) was developed to support scenario analysis and policy evaluation. The framework provides a robust basis for identifying region-specific interventions and advancing integrated resource management. This research will assist policymakers and stakeholders in managing WEF resources holistically and fairly.

Keywords: Water-Energy-Food Nexus Model, Pardee RAND WEF Nexus, Policy Implementation Score, Policy Analysis, Sustainable Development Goals, Climate Change, Coupling and Coordination Degree.