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Water-energy-food nexus in Xinjiang Uygur Autonomous Region: Combined Impact of Climate change and Policies, and potential adaptation pathways

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Food, energy and water are essential resources for human survival and development, and they are three elements of the 17 UN Sustainable Development Goals (SDGs). Expansion of human activity and climate warming are exacerbating severe risks of water, energy, and food shortages. How to manage the limited resources in an efficient and synergistic manner is essential to achieving sustainable development. Since there are few studies on the Water-energy-food (WEF) nexus for semi-arid regions in northwest China, we took Xinjiang Uygur Autonomous Region (XUAR) as an example to assess the impacts of climate and policies on the water, energy and food sectors in the context of global warming and identify ways to adapt. Firstly, we developed a non-linear system dynamic model to illustrate the interactions between food, energy and water, then 5 scenarios were set up by mainly change food self-sufficiency rate, clean energy use rate and energy intensity, to figure out the impact of different decisions and strategies on WEF nexus from 2020 to 2060, and provide solutions that are conducive to achieve carbon neutrality goal. Finally, we conducted a multi-objective optimization algorithm to attempt to mitigate the conflict between limited resources, socio-economics and a low-carbon environment. The results showed that: (1) The supply and demand for food and energy resources in XUAR showed an increasing trend between 2000 and 2020, while water resources decrease with greater decline on demand side. (2) For every 10% increase in food self-sufficiency, irrigation water, energy demand and carbon emissions will increase by 3.22%, 0.04% and 0.08%, respectively. And every 10% increase in clean electricity usage will cut down water demand and carbon emissions by 8.21% and 8.84%, respectively. (4) Under future water resources conditions, the feasible scenarios can reduce carbon emissions by 79% and enable a 13% reduction in agricultural water consumption comparing to the baseline scenario. Besides, the water stress will switch from very high to very low, which is a qualitative leap in achieving the Sustainable Development Goals (SDGs), especially SDG6 (Clean water and sanitation). To conclude, by reducing the area of cereals, improving irrigation efficiency and increasing the use of clean energy, we can achieve the goal of carbon peak and carbon neutrality, as well as sustainable development.