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Groundwater-energy-food nexus for sustainability

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Water, energy, and food are fundamental resources for human beings and sustainable society, and three resources are linked each other. Therefore we need integrated social decisions for the water-energy-food (WEF) nexus by increasing synergies and reducing trade-offs among the three resources. Groundwater is mostly used for agriculture production, therefore the groundwater-energy-food nexus is essential for water and food securities. Municipal trans-boundary aquifer in Kumamoto, Japan, shows the synergy effects of WEF nexus in the local basin scale. In this area, the reduction of rice cultivation up-river, following the government agricultural policy, reduced the water table downstream where urban population have traditionally enjoyed the availability of both groundwater and food. In this case, the synergy that had existed in the traditional system was destroyed by the government policy that overlooked the effect on the availability of water resources downstream. From the national to global scale trans-spatial connections, various types of WEF nexus analyses have been made in the Asia-Pacific region with the policy goals of self-sufficiency and the diversity of resource use.
In order to connect the present and future, water-energy-food nexus model for integrated policy decision has been suggested and applied to the Japanese case. The model with various entry points and modules can evaluate water, energy, food, and carbon emission which will have changed synergies and trade-off relationships. There are many disconnections of WEF nexus governance such as issues disconnections of water-energy-food and social-economy-environment, and spatial and temporal disconnections. Beyond the current disconnection of WEF nexus governance, trans-scale solutions are needed with tans-spatial connections from local, national, regional and global, and trans-temporal connections from past, present, and future. WEF nexus governance with integrated nexus model using variable spatial and temporal boundaries can evaluate the synergies and trade-off of the nexus to the tipping points, and they could be usefully used for the study of sustainability.