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Climate change effects on hydrological services: simulations on a monthly time scale

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Climate change affects hydrological services in many ways, but particularly so by limiting our water resources. Previous researches have confirmed that the shortage index of Taiwan's Chih-Nan water supply system will increase between 5.7 and 9.0, denoting a general water shortage in the coming years under climate change conditions. Additionally, climate change's indirect effect on ecosystem services further affects our daily lives. By simulating climate change effects on a monthly time scale, differ to most of previous studies in annual scale, we can gain additional insight from the more detailed and varied data, when compared with analysis based only on roughly integrated annual data.
To simulate climate change in Taiwan, we used the five most suitable General Circulation Models (GCM) for Taiwan's climactic conditions, under "most optimistic" (RCP2.6) and "most pessimistic" (RCP8.5) scenarios to investigate the monthly variations from 2016 to 2035 of four ecosystem services (water yield, sediment export, nitrogen nutrient export, and phosphorus nutrient export) within the Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) software suite with a developed spatial dynamic model in the eastern part of Taiwan. We found that water yield will decrease between 6% and 57% in dry seasons, but increase between 3% and 21% in rainy seasons; sediment export will increase between 2% and 27% in the most optimistic scenario, but will acutely increase between 9% and 37% in the most pessimistic scenario; nitrogen nutrient export will increase between 0.02% to 4% in the most optimistic scenario, and 0.2% to 12% in the most pessimistic scenario, especially in dry seasons; though phosphorus nutrient export does not appear to change on a monthly time scale, values vary up to $\pm$15%.
By combining current research and system dynamics principles, this study investigates the spatial and temporal interactions (e.g. antecedent moisture conditions, accumulated water retention) between climate change and ecosystem services. Our results call attention to Taiwan's limited water storage capacity required for increased water yield in rainy seasons, and the lack of resource availability during dry seasons when there is decreased water yield. The loss of sediment, i.e. nitrogen and phosphorus nutrient export, may also lead to soil degradation which is observed to a greater extent in the most pessimistic scenario. Hence, we recommend developing adaptation strategies such as delimiting protection areas for immediate resource deterioration mitigation.

Keywords: Climate change, hydrological services, spatial system dynamic modeling