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Selecting and scheduling water-energy-food nexus infrastructure investments in the Zambezi River basin

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Planning water infrastructure investments requires consideration of the interdependencies within the water-energy-food nexus. Ecosystem preservation, hydropower production and irrigation development will contribute to multiple Sustainable Development Goals. Typically, planners have to evaluate a long list of potential projects that interact with each other, resulting in trade-offs or synergies. Evolving socio-economic context and uncertain future climate further complicate investment planning. Therefore, there is a need for decision support tools to objectively determine the value of investments and help decision makers select and schedule projects.
Based on an existing open-source hydroeconomic optimization model, we develop an investment selection and scheduling module, using mixed integer programing. The hydroeconomic model links representations of the water, agriculture, and power systems in a holistic framework. All potential projects are described, and the investment module selects and schedules projects considering economic impacts, budget constraints, and developing socio-economic context. We apply the methodology to select projects in the Zambezi river basin, where multiple investment opportunities exist, including new or resized reservoirs, development of irrigation agriculture, new hydropower and thermal power plants, and investments into the power grid.
We show that optimal selection and scheduling of projects depends on the climate change scenario, carbon-pricing and environmental-flow policies, and socio-economic uncertainties such as capital costs of solar technologies and crop world market prices. Preliminary results indicate that with growing energy demand some hydropower projects are priority investments (e.g. refurbishment of Upper Kafue plant), however further development of hydropower (e.g. Lower Kafue plant) requires investments in the transmission network (e.g. transmission lines from Zambia to Tanzania).