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Exploring the potential of desalination and aquaponics in the integrated management of arid river basins: the case of the Nile River basin

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Water scarcity is one of the major challenges of the century. Climate change and population growth are exacerbating this problem, especially in river basins with arid climates such as the Middle East or North Africa, calling for the design of integrated water management strategies to meet competing water demands in interconnected Water-Energy-Food systems. In this work, we explore the potential for integrating innovative technological solutions, namely desalination and aquaponics, into conventional water management measures to mitigate existing tradeoffs. Our approach is demonstrated on the Nile River basin, a paradigmatic example of transboundary river basins where the overexploited traditional water sources cannot fully satisfy the increasing water demands, thus requiring innovative solutions to address this challenge. Here, we first investigate the optimal operation of the major water infrastructures in the basin to explore the tradeoffs between hydropower generation and irrigation supply across Ethiopia, Sudan, and Egypt. Then, we analyse the role of desalination and aquaponics in reducing the Egyptian water demand in the Nile delta and mitigating the existing tradeoffs. Desalination is widely used in many of the Middle East's countries and offers the possibility to unlock the potential contribution of sea water in meeting the water demand of the coastal region. Aquaponics is a soilless agricultural technique characterized by lower levels of water consumption than traditional techniques. For both desalination and aquaponics, we run an exploratory analysis to understand the key technological parameters influencing the successful uptake of these solutions. Our results aim to demonstrate the effectiveness of integrated management solutions in arid river basins and explore the potential uptake of new technologies for reducing agricultural water demands. These measures contribute in increasing the flexibility of water management strategies in arid areas when coping with water scarcity while improving water quality conditions.