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Evaluate the Future Scenarios of Water Demand in the Middle Nzoia River Catchment

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Abstract Effective water allocation in river catchments experiencing rapid population growth, land-use change, and climatic variability remains a pressing global concern. This study evaluated the future scenarios of water demand within the Middle Nzoia Catchment in western Kenya using WEAP model. The study utilized a comprehensive dataset covering hydrological, water Quantity, and socio-economic variables from 1982 to 2022. Model calibration (2001-2010) and validation (2011-2020) were undertaken using observed streamflow data. Future demand scenarios to 2052, projected a potential increase to 45% from the base year under the High Growth scenario, reaching 260 million m³ annually. The agricultural and domestic sectors experienced the most significant increases, driven by population growth and intensified irrigation practices. Water allocation simulations demonstrated that during low-flow months, supply could meet only 69% - 72% of total demand, signaling potential water scarcity and inequitable distribution. Allocable water volumes were estimated at 240 million m³ annual but without integrated management strategies, unmet demand could increase to 31% to 2052. The study highlights the critical need for adaptive management approaches, including enhanced demand- side efficiency, investment in storage infrastructure, and strengthened institutional coordination. These results provide actionable guidance for policymakers, and water managers in similar hydrological contexts facing complex socio-environmental pressures.

Keywords Catchment; Water demand; Scenarios; WEAP model

1 Introduction

Water allocation and management are critical issues worldwide, particularly in regions experiencing rapid population growth, climate change, and competing demands for water resources (Amitaba et al., 2024). Water resources management refers to the planning, development, distribution, and management of water resources, to ensure their efficient and equitable use for various purposes such as domestic consumption, agriculture, industrial use, and environmental protection. Water allocation specifically focuses on determining the fair distribution of available water resources among different sectors, ensuring that all users, including ecosystems, have their needs met (Phung et al., 2023). Traditionally, water resources management has been approached through sector-specific plans, often developed at the national or regional level, but in many cases, this fragmented approach has led to inefficiencies and unsustainable practices. In response to these challenges, integrated water resources management (IWRM) has emerged as a more holistic approach, seeking to balance competing demands and promote sustainability through coordinated, science-based decision-making (Elshorbagy, 2006).

International organizations like the International Water Association (IWA) and the Global Water Partnership (GWP) play essential roles in advancing global water management practices. The IWA is focused on promoting the science and practice of water management through innovation, research, and technological development. It provides a platform for professionals to exchange knowledge, develop innovative solutions, and collaborate on various water-related challenges (Smith et al., 2023). The IWA's initiatives primarily target improvements in water treatment technologies, the optimization of water distribution systems, and the promotion of sustainable practices across different sectors (Group, 2016).