Optimum Irrigation System Management for Climate Resilient and Improved Productivity of Flood-based Livelihood Systems

Authors : Mara Getachew Zenebe, Luuk Fleskens, Abdu Obieda Ahmed

Abstract : This paper seeks to advance our scientific understanding of optimizing flood utilization in regions impacted by climate change, with a focus on enhancing agricultural productivity through effective irrigation management. The study was conducted as part of a three-year (2021 to 2023) USAID-supported initiative aimed at promoting Economic Growth and Peace in the Gash Agricultural Scheme (GAS), situated in Sudan's water-stressed Eastern region. GAS is the country's largest flood-irrigated scheme, covering 100,800 hectares of cultivable land, with a potential to provide the food security needs of over a quarter of a million agro-pastoral community members. GAS relies on the Gash River, which sources its water from high-intensity rainfall events in the highlands of Ethiopia and Eritrea. However, climate change and variations in these highlands have led to increased variability in the Gash River's flow. The study conducted water balance analyses based on a ten-year dataset of the annual Gash River flow, irrigated area; as well as the evapotranspiration demand of the major sorghum crop. Data collection methods included field measurements, surveys, remote sensing, and CropWat modelling. The water balance assessment revealed that the existing three-year rotation-based irrigation system management, capping cultivated land at 33,000 hectares annually, is excessively risk-averse. While this system reduced conflicts among the agro-pastoral communities by consistently delivering on the land promised to be annually cultivated, it also increased GAS's vulnerability to flood damage due to several reasons. The irrigation efficiency over the past decade was approximately 30%, leaving significant unharnessed floodwater that caused damage to infrastructure and agricultural land. The three-year rotation resulted in inadequate infrastructural maintenance, given the destructive nature of floods. Additionally, it led to infrequent land tillage, allowing the encroachment of mesquite trees hindering major sorghum crop growth. Remote sensing data confirmed that mesquite trees have overtaken 70,000 hectares in the past two decades, rendering them unavailable for agriculture. The water balance analyses suggest shifting to a two-year rotation, covering approximately 50,000 hectares annually while maintaining risk aversion. This shift could boost GAS's annual sorghum production by two-thirds, exceeding 850,000 tons. The scheme's efficiency can be further enhanced through low-cost on-farm interventions. Currently, large irrigation plots that range from 420 to 756 hectares are irrigated with limited water distribution guidance, leading to uneven irrigation. As demonstrated through field trials, implementing internal longitudinal bunds and horizontal deflector bunds can increase adequately irrigated parts of the irrigation plots from 50% to 80% and thus nearly double the sorghum yield to 2 tons per hectare while reducing the irrigation duration from 30 days to a maximum of 17 days. Flow measurements in 2021 and 2022 confirmed that these changes sufficiently meet the sorghum crop's water requirements, even with a conservative 60% field application efficiency assumption. These insights and lessons from the GAS on enhancing agricultural resilience and sustainability in the face of climate change are relevant to flood-based livelihood systems globally.

Keywords : climate change, irrigation management and productivity, variable flood flows, water balance analysis
Conference Title : ICMEEWR 2024 : International Conference on Management of Ecosystems, Environment and Water Resources
Conference Location : Brussels, Belgium
Conference Dates : March 25-26, 2024