Tropentag, September 16-18, 2026, hybrid conference

"Towards multi-functional agro-ecosystems
promoting climate resilient futures"

Diagnosing agricultural water risk and climate vulnerability in the tropics: A transcontinental comparative assessment of Amazonian and Mozambican watersheds

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Abstract

Climate-induced water scarcity is rapidly becoming the most binding constraint on rainfed tropical agriculture. The World Resources Institute estimates that twenty-five countries—home to one quarter of the global population – already face extremely high baseline water stress, a figure projected to escalate under CMIP6 trajectories. In agricultural hubs of the Global South, the convergence of declining freshwater availability, intensifying climate variability and Virtual Water Scarcity Risk (VWSR) along agri-food supply chains threatens food sovereignty, rural livelihoods and downstream economic resilience. Yet comparative diagnostics that translate sub-basin hydro-climatic indicators into actionable vulnerability assessments remain scarce, particularly across tropical geographies that are simultaneously climate-sensitive and structurally underserved. This study deploys the WRI Aqueduct Water Risk Atlas 4.0 a peer-reviewed, open-source framework underpinned by the PCR-GLOBWB 2 hydrological model and CMIP6 climate forcings – to diagnose current and projected hydro-climatic risks across two structurally analogous yet geographically distant agricultural frontiers: the municipalities of Belterra, Mojuí dos Campos and Santarém in the Brazilian Amazon (Tapajós sub-basin) and the districts of Boane, Moamba and Namaacha in southern Mozambique (Umbelúzi catchment). A comparative methodology was applied at monthly and annual scales, integrating sector-specific weighting schemes to evaluate quantitative indicators (baseline water stress, interannual and seasonal variability, drought risk), qualitative indicators (untreated wastewater, coastal eutrophication) and ecological vulnerability under business-as-usual, optimistic and pessimistic scenarios for 2030 and 2050. Results converge transcontinentally: quantitative water-stress indicators dominate the composite risk profile, accounting for approximately 70 % of the overall weighting relative to qualitative and ecological dimensions. Consequently, water scarcity already imposes severe, binding constraints on rainfed agricultural systems in both watersheds. Climate projections further indicate thermal increases of 1.0–2.6 °C by mid-century, expected to compress wet-season duration, amplify interannual variability and significantly compromise long-term water availability for staple and commodity production. These convergent findings across the Amazon and southern Africa underscore a shared tropical vulnerability profile and highlight the urgency of embedding Aqueduct-based diagnostics into the design of multi-functional, climate-resilient agro-ecosystems a strategic priority for safeguarding agri-food systems and rural livelihoods across the Global South.

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Keywords: Climate-resilient agro-ecosystems, rainfed tropical agriculture, virtual water scarcity risk, WRI Aqueduct 4.0