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Separating the effects of timber plantations and climate variability on streamflow in a sub-catchment of the Umvoti River Basin, Kwazulu-Natal

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In the middle and lower Umvoti River Basin (Kwazulu-Natal, South-Africa), rural dwellers are suffering from severe water scarcity. For their subsistence farming and domestic water use, they are largely dependent on informal water sources such as rivers, streams and springs. Municipal provision of groundwater through standpipes is not comprehensive and only temporal. However, the flow in streams and rivers has decreased and streams have turned from perennial to periodic. Water users themselves attribute this to a perceived decrease in annual rainfall.

Timber plantations likely also play an important role in reducing surface flow. A large part of the upper Umvoti is covered by commercial forest plantations with three main tree species: Black wattle, gum tree and pine tree. Black wattle and gum tree are both invasive, fast-growing tree species that are native to Australia with high evapotranspiration rates.

For policy and decision makers to be able to address pressing water scarcity in the Umvoti River Basin, an understanding of the separate effects of plantation forestry and climate change on streamflow dynamics on a catchment level is needed. This understanding can be crucial when framing adaptation strategies and planning future water use patterns.

In this study, we estimate and separate the effects of climate change and afforestation in a sub-catchment of the upper Umvoti River Basin with an area of approximately 700km^2. Its outlet is marked by a streamflow gauging station with daily data, located on Mistley Estate, downstream of the Umvoti Wetland. From a climate station close to the river gauge there are daily rainfall and temperature records available.

Following the methodology of Liu et al. (Liu, Liu, & Xia, 2013), the change in streamflow between two periods ΔQ can be apportioned to climatic variation (ΔQ_C) and human activities (ΔQ_H). To estimate ΔQ_C, we employ the climate elasticity method; with elasticity defined as the ratio of proportional change in streamflow and proportional change in a climatic variable such as precipitation or potential evapotranspiration.

In our case, ΔQ_H is primarily due to the conversion of grassland or cropland to timber. In order to specify this contribution of timber plantations, we estimate the sensitivity of streamflow change to change in the total area of timber plantations as derived from a series of Landsat satellite images. Data uncertainty is considered in all analytical steps. In particular, the independent estimation of ΔQ_C and ΔQ_H serves to benchmark the two respective methods and eventually reduce uncertainty.

Our results are expected to contribute to a deeper understanding of the sensitivity of streamflow to both forest plantations and climate variability on a catchment scale, as a basis for sustainable water and plantation management under likely significant future climate change.

Reference:

Liu, X. M., Liu, W. H., & Xia, J. (2013). Comparison of the streamflow sensitivity to aridity index between the Danjiangkou Reservoir basin and Miyun Reservoir basin, China. Theoretical and Applied Climatology, 111(3-4), 683-691. doi: 10.1007/s00704-012-0701-3