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"Reconcile land system changes
with planetary health"

Exploring livelihood security and looming desertification in namibia's communal rangelands using an agent-based model

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Abstract

Namibia, the driest country in sub-Saharan Africa, sees a large portion of its population dependent on pastoralism. One particular example are eastern Namibia's semi-arid rangelands where pastoralism has been securing livelihoods for the local Herero communities for centuries. However, these areas face increasing pressure from factors like increasing drought frequency and woody plant encroachment, depleting productive grazing areas and placing livelihoods at risk. Despite studies on drought and degradation, there is limited understanding of how these intertwined factors, including climate and financial shocks, population increase, and changing management strategies, shape the resilience and livelihood security of these communities.

To address this research gap, we developed an agent-based model to explore the long-term social-ecological dynamics of a communal pastoralist semi-arid rangeland. The model simulates interactions between pastoralist households, their herds, and the rangeland environment, incorporating processes like rainfall, vegetation growth, grazing, and household decision-making. We analysed three scenarios: the impact of increasing population density, the system's response to climate and income shocks, and the effectiveness of income-related mitigation strategies.

Our findings indicate that increased population density negatively affects both ecological conditions (proportion of grass vs. shrub and bare soil patches) and socio-economic outcomes (herd size, household insolvency), with lower-income households being disproportionately affected. Climate shocks have significant, potentially tipping-point effects depending on their duration, leading to severe ecological degradation (e.g., perennial grass extinction) as well as drastic reductions in herd size and increased household insolvency. Income shocks, however, showed no lasting impact on the long-term system state in our model. Investigating mitigation strategies, we found that income support measures improve

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socio-economic outcomes, particularly reducing household insolvency. Especially providing a minimum income to all households showed the highest benefit for livelihood security. However, these income-focused strategies had little effect on safeguarding the ecological state of the system.

Our modelling results highlight that while income support is vital for livelihood security, particularly for vulnerable groups, it is insufficient to address ecological degradation. Therefore, addressing the looming desertification and enhancing the resilience of the entire social-ecological system requires integrated strategies that also target ecological processes, such as managing grazing pressure or shrub encroachment.

Keywords: Agent-based modelling, pastoralism, rangelands, shocks, social-ecological system, tipping point