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

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Introduction

Namibia's rangelands are complex **social-ecological systems (SES)**[1,2] that provide **livelihoods for 60-70% of its population**[3,4], mainly through pastoralism.

- But: increasing **land degradation & loss of grazing conditions**[5] due to climate change, land use intensification
- Risk of **tipping points**[6] (perennial grass cover loss, shrub encroachment) & **loss of SES functioning**[6,7]
- **Long-term effectiveness of mitigation strategies** (e.g., income diversification, livestock management, rangeland restoration measures) is not well known[7]

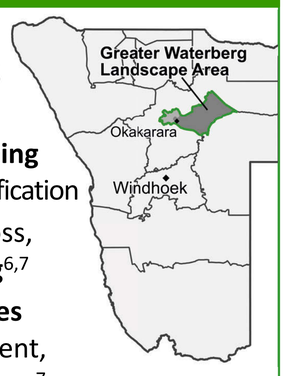

Fig. 1: Study area location

Research gap:

- Better understanding of **combined effects of social-ecological drivers and shocks** on rangeland SES and farmer's livelihoods

Methods

Agent-based simulation model[8] to explore long-term social-ecological dynamics of communal rangelands

- **Setting:** stylized communal village
- **Key processes:** stochastic rainfall, vegetation growth (grasses & shrubs), cattle grazing, and household decision-making

Household dynamics

- Households generate income by **selling livestock** & via **additional rainfall-dependent** (e.g., horticulture) & **rainfall-independent** (e.g., pensions) **income**
- **Baseline: three income groups** – no (30%), medium (60%) and high (10%) additional income

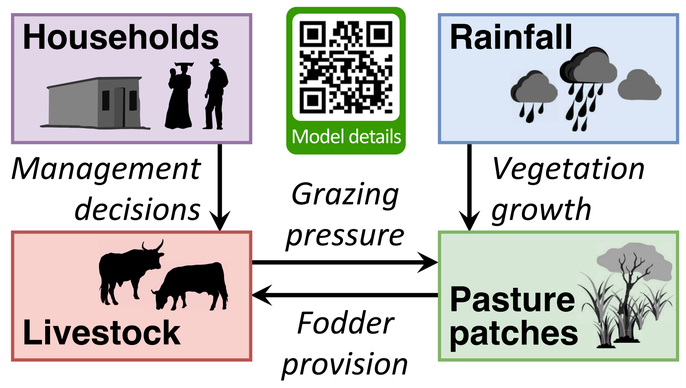

Fig. 2: Simplified conceptual diagram of the model showing the main model entities and relationships.

Results: Impact of population increase & shocks

A: Increase in population density

- **Ecological impacts:** significant decrease of grass-dominated patches, increase of shrub-dominated patches
- **Socio-economic impacts:** Lower herd sizes, higher household insolvency
- BUT: *no tipping point dynamics*
- Conclusion: SES relatively robust to population increase?

B: Impact of shocks

- **Climate shocks** (prolonged drought periods) may lead to *abrupt, tipping-point like changes*
- Longer shocks (> 5 years) lead to severe ecological degradation & household insolvency
- **Income shocks** (loss of additional income) have no lasting impact on long-term system state → *unexpected effect*

- Overall, **climatic drivers have stronger impact than socio-economic drivers**
- BUT: Linking of model results to empirical observations still ongoing

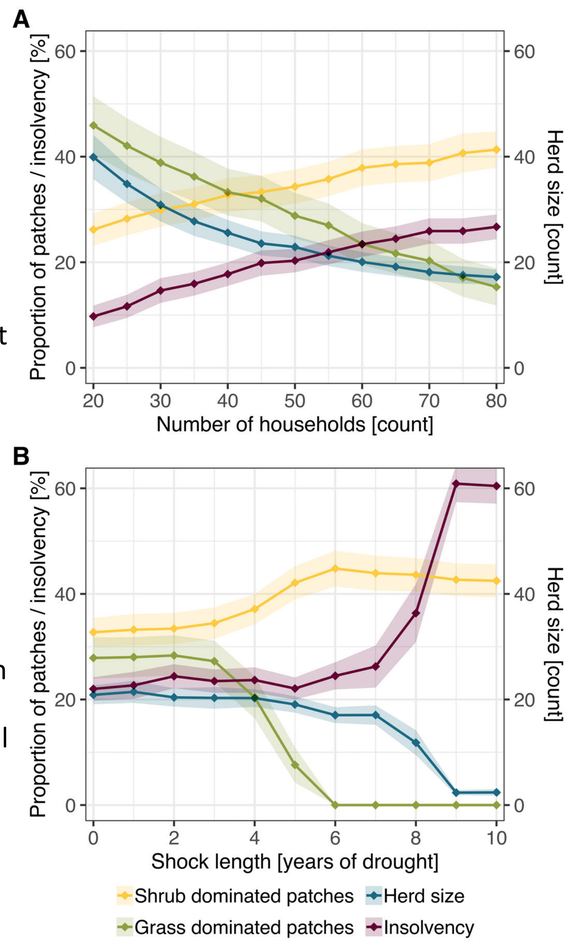

Fig. 3: Impact of population density (A) and length of climate shocks (B) on SES state. Shocks begin in year 50 of the simulation. Lines depict state of each variable at the end of the simulation after 200 years, averaged over 100 simulation runs. Shaded area represents the 95% confidence interval.

Results: Mitigation strategies

A: Income-related strategies

- **Increasing mean income:** positive effect on household insolvency & herd size
- Provision of **minimum income** (no households with zero income): largest positive effect on all socio-economic outcomes – larger reduction in insolvency compared to income increase
- BUT: **no effect on ecological system state**

B: Pasture resting

- **Resting** of pastures in bad rainfall years **slightly improves ecological system state**, no effect on socio-economic outcomes
- BUT: not effective to restore rangeland conditions from degraded state
- **Active restoration measures needed** that focus on improving rangeland conditions (e.g., bush control) → under further investigation

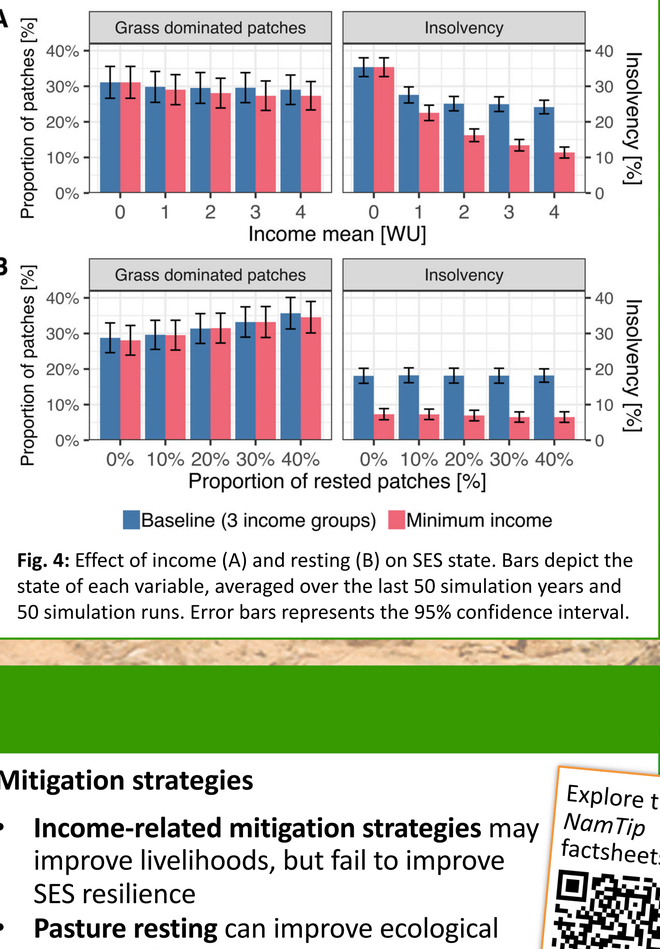

Fig. 4: Effect of income (A) and resting (B) on SES state. Bars depict the state of each variable, averaged over the last 50 simulation years and 50 simulation runs. Error bars represents the 95% confidence interval.

Conclusion

Likelihood of tipping points

- Approach: using modelling to **explore long-term social-ecological dynamics**
- **System is prone to shocks** – especially climate shocks may cause **tipping point**
- Increased **population density** may also cause significant deterioration of SES state
- **Unexpected low effect of income shocks** needs to be further investigated

Mitigation strategies

- **Income-related mitigation strategies** may improve livelihoods, but fail to improve SES resilience
- **Pasture resting** can improve ecological state but further **restoration measures** (e.g., bush control) are needed
- Further systematic analysis of rainfall-dependent/-independent income planned

Explore the *NamTip* factsheets

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More information: https://www.uni-potsdam.de/en/namtip/

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