Tropentag 2022
September 14-16, 2022
Conference on International Research on Food Security, Natural Resource Management and Rural Development
organised by the Czech University of Life Sciences, Prague, Czech Republic

Rangeland desertification and land use changes on commercial land in Namibia's Waterberg region

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Key words: land cover changes, social-ecological system, freehold farmers, object-based image classification, cattle farming, savanna

Introduction

Looming desertification and ongoing climate change put semi-arid rangelands and thus fodder resources for livestock and farmers' livelihoods under increasing pressure (Mirzabaev et al. 2019). In Namibia, the driest country in Sub-Saharan Africa, cattle farmers are repeatedly forced to apply short-term risk coping and long-term risk mitigation strategies to maintain their farming business (Brinkmann et al. 2021). Due to a distinct interdependency between society and nature, Namibian rangelands are a prime example for tightly coupled social-ecological systems (SES). In order to sustain rangelands in the face of climate change, a deeper understanding of land use and land cover changes (LULCC) and their drivers and related effects is necessary. Therefore, the aim is to explore the historical context and recent trends of LULCC. The research is focused on commercial land comprising four case studies, which are located approximately 250 km north of Windhoek near the Waterberg Plateau Park. Addressing the complexity of rangelands as SES, a mixed method approach was chosen comprising remote sensing techniques, semi-structured interviews with commercial farmers, participatory on-farm mapping, and archival research of the historical development.

Material and Methods

Historical and recent literature build the basis for the empirical research of the study at hand. As the available imagery for the geospatial analysis is limited to the past 60 years, the literature research done for this work concentrates on the development of the area before 1961. Furthermore, laws and policies as well as events affecting livestock husbandry and game farming, such as drought, large veld fires, animal disease epidemics, and market changes, were taken into account.

An object-based classification of panchromatic aerial photographs from 1961 and 1996/97, panchromatic Corona images from 1972 (Corona KH-4B, Dashora et al. 2007), and Sentinel-2 images from 2020 was applied within QGIS 3.10.12 with GRASS 7.8.4 using simplified land cover classes (woodland, shrubland, grassland savanna, barren land, water area). To improve classification results, the Normalized Difference Vegetation Index (NDVI) was computed for the Sentinel-2 imagery and texture data was derived from the historical aerial imagery as supplementing classification inputs (Neteler & Mitasova 2008). Image segmentation and classification were performed with the sequential maximum a posteriori (SMAP) algorithm (Neteler & Mitasova 2008). To capture land use changes on commercial land, camps and areas used as cropland were manually digitalized based on visual interpretation.

To interpret LULCC received from image classification results and figure out the underlying drivers of changes from the farmers' perspective, semi-structured interviews with commercial farmers (n = 4) were conducted in 2021.

Results and Discussion

Literature research of LULCC before 1960 revealed that after the German-Herero war (1904-08) freehold land was allocated to white settlers who started with commercial dairy farming and Herero pastoralists were pushed to adjacent communal land (Werner 1993). In the 1950s, the South African Administration started to regulate dairy production more strictly and simultaneously promoted commercial cattle farming through subsidization. Consequently, new financial opportunities opened up for farmers, who started to divide their rangeland into camps and expanded water infrastructure. As a result, cattle numbers increased rapidly peaking in the late 1950s (Lau & Reiner 1993, Lange et al. 1998).

The examined commercial farms are run either in the third or fourth generation and were established subsequent to the German-Herero war, in the wake of the settlement efforts of the South African Administration, and World War II. The farm size ranges between 5,200 and 12,000 ha and cattle numbers between 220 and 1,000 in May 2021. All farmers apply rotational grazing with seasonal variations oriented towards rainfall and plant readiness. Although the sources of farm income can temporarily vary according recent events (e.g., droughts, epidemics), a considerable diversification and heterogeneity in the operational orientation of the interviewed farms has emerged over time.

In the early 1960s, the outbreak of the Foot and Mouth Disease and drought conditions resulted in decreasing cattle numbers. With the commercialization of game farming in the late 1960s farms started to engage in trophy hunting. The early 1970s and 1980s were characterized by intermittent drought conditions leading to a decrease in cattle numbers. Within the course of severe drought conditions in the 1990s, the National Drought Policy and Strategy was established including drought relief measures.

After 1960, the most important changes include the progressive bush encroachment, its containment by de-bushing, the subdivision of rangeland into progressively smaller management units, and the diversification of farm-income. Overall, the area of shrub-dominated savanna has increased by 18 % and the area of grass-dominated savanna has simultaneously decreased by the same amount within the last 60 years (Fig. 1). However, the extent of this varies greatly among farms in dependence of the underlying site conditions and applied management strategies.

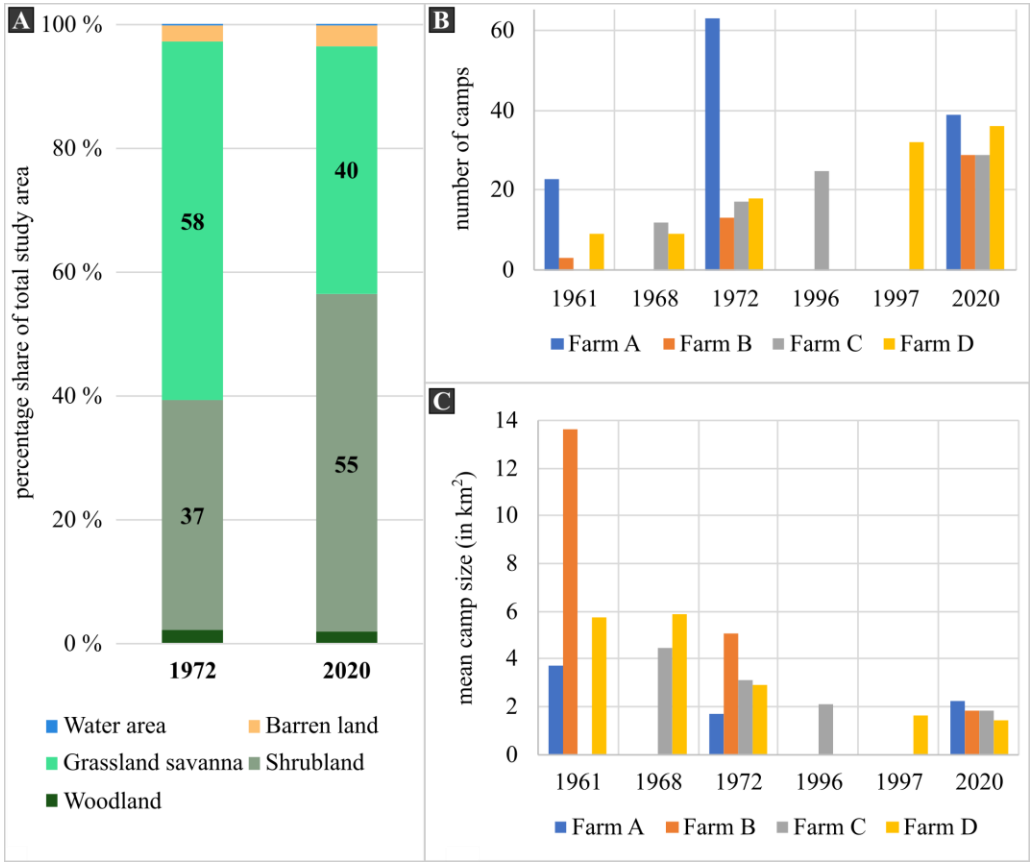

Figure 1. (A) Percentage share of land cover types of the total study area (Farm A, B, C, and D) for 1972 and 2020. (B) Number of camps for each farm and year (where available). (C) Mean camp size for each farm and year (where available).

In response to political and economic changes as well as looming desertification, farmers apply short-term risk coping strategies to maintain their farming operation and prevent overuse and rangeland degradation. These include the adaptation of camp rotation, the use of supplementary fodder, and a reduction of livestock and game. Furthermore, they apply long-term risk mitigation strategies to maintain or improve rangeland conditions and productivity and to secure their livelihoods and income. These risk mitigation strategies include rangeland management options such as fencing, hay making, and bush control as well as on-farm income diversification (e.g., tourism, trophy hunting, live sale of game, charcoal production, crop production) and off-farm income activities.

Conclusions and Outlook

Direct causes of land cover changes are driven and shaped by underlying, synergistically acting socio-economic (e.g., market/price changes, guidelines, policies) and biophysical drivers (e.g., resource scarcity, site conditions, rainfall variability). In particular, climatic trigger events (e.g., droughts) associated with short-term and long-term land use changes play a key role in our case studies.

To achieve sustainable land use in the long-term, small-scale selective bush control and aftercare measures, the full utilisation of removed shrubs, further diversification of farm-income generating activities, strategic decision-making, and proactive management are pivotal.

Acknowledgements

We acknowledge the financial support from the German Federal Ministry of Education and Research (http://www.bmbf.de/en/) via the "NamTip" project (grant 01LC1821E) within the BioTip Program.

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