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Sustainable management of savannas – Integrating practitioners' knowledge

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Abstract
Namibian savannas are characterised by a variable climate in which societal processes are inextricably coupled with natural processes through land management and the benefits that people derive from the ecosystem. Savannas are home to a large proportion of the world's human population, and any disruption to the balance between these feedback mechanisms risks the livelihood of millions of households that depend on a sustainable provision of a variety of ecosystem services such as water supply, forage production and tourism. This provision is under extreme threat due to both climate change and the increasing pressure on land use. Starting from the challenge to better understand how the management of water and land use can mitigate degradation in Namibian savannas and enable their sustainable use, we present how our concept of social-ecological systems (SES) can be used to structure research and integrate practice-based knowledge along with scientific knowledge. Based on the results of an initial literature review and interviews with Namibian livestock farmers, we illustrate how the integration of ecosystem services (ESS) into the SES concept (according to Hummel et al. 2011) enables a systematic formalisation of feedback in SES. It is outlined how this approach improves the integration of non-scientific knowledge into our Namibian case study, thereby helping to reconcile non-scientific knowledge with simple analytical models. We argue that applying the SES concept in this way ultimately allows for a more detailed exploration of mechanisms within the social-ecological model, while improving iterative communication of research results to practitioners.

Introduction
Savannas cover about 20 per cent of the global land surface and 64 per cent of Namibia. They are considered to be among the ecosystems most sensitive to changes in land use and climate change (Reynolds et al. 2007). Maladapted land use can be a crucial driving force for the degradation of savannas and related ecosystem services (ESS), e.g. via increased erosion and bush encroachment. Degradation of ESS has become a serious challenge, exerting negative impacts on the ecosystem, livestock production and livelihoods (Kassahun et al. 2008). About 50 per cent of Namibian savannas are already negatively affected (de Klerk 2004; Joubert et al. 2013), prompting the Namibian Government to call for urgent action to halt degradation and restore productive and resilient savannas (MAWF 2012). Key ecosystem services at risk include net primary production (NPP) and corresponding livestock production, carbon sequestration, wildlife and biodiversity with related (eco-)tourism, as well as water yield and quality

(Blaum et al. 2009a, 2009b; Lindsey et al. 2013; NAU 2010). Rangelands form a major part of Namibian savannas under threat, but their sustainable management also leads to benefits beyond farm borders. For example, thinning of encroacher bushes on rangelands to an optimal degree may improve groundwater recharge, with benefits for urban and industrial water demand too (MAWF 2012; NAU 2010).

One important prerequisite for developing sustainable rangeland management schemes is an improved understanding of the feedback mechanisms that link the geo- and biosphere, such as vegetation cover dynamics and soil moisture/groundwater recharge under the impact of different land use (Dimple et al. 2011). Since savannas are home to a large proportion of the world's human population, any disruption to these feedbacks risks the livelihood of millions of households that depend on a sustainable provision of a variety of ecosystem services. This provision is under extreme threat due to both climate change and the increasing pressure on land use. To successfully tackle the challenge of finding sustainable solutions for savanna management, it is thus crucial to appreciate that this is a problem characterized by closely linked human-environment interactions, feedbacks and complexity. Management is partly driven by societal factors, including the knowledge of practitioners. The recommendation in approaching such problem constellations is to apply systemic approaches that jointly consider natural and social processes. 'Social-ecological' systems (SES) are proposed as the appropriate research unit (Gallopín et al. 2001; Hummel et al. 2011), and the integration of local and scientific knowledge can play a key role in implementing management changes to enable diverse inputs (Huntington 2000). When it comes to local knowledge, the past years have seen a growing recognition that its integration into scientific research is highly important, particularly in the fields of sustainable natural resource use (Pierotti/Wildcat 2002). Local users can offer alternative knowledge, values and insights concerning ecosystem processes, which go beyond those of researchers. Local land users often have an implicit knowledge of interrelated stochastic and deterministic processes. The greatest progress towards understanding complex social-ecological systems can therefore be achieved via a combination of local and scientific knowledge (Kaschula et al. 2005). Furthermore, an understanding of the reasons and motivations for using and managing ecosystems in a certain way enables research to focus on sustainable management options that seem feasible and relevant in a given context. However, there is still a lack of formalised, rigorous scientific methods and concepts (Da Cunha/de Albuquerque 2006). We present a scientifically sound framework with which to integrate local knowledge into research.

The main aim of this paper is to demonstrate how we structure and analyse the research problem by applying an SES concept that includes the concept of ecosystem services (ESS) and specify it for our Namibian case studies. We draw on science-based statements and the knowledge of local actors (focusing on Namibian commercial livestock farmers). For this purpose we assess the benefits that farmers seek from savanna systems, the management options they consider and their related knowledge of ecosystem functioning. These constitute the first steps towards the overarching aim of our study, which is to understand how water and land use management can mitigate degradation in savannas and enable their sustainable use. We do this by providing both systemic knowledge on the functioning of the social-ecological system and participatory models for communication with stakeholders.

Study area and local actors

We concentrate our field work on two case studies situated in an African savanna in the eastern part of Namibia. Three farms are situated around the Waterberg National Park, with a medium annual precipitation of 450 millimetres, and deep, sandy, dystrophic Kalahari soils. Six more farms are situated near a wildlife reserve with a medium annual precipitation of 250 millimetres and sandy soils. Rainfall variability exceeds 40 per cent. The biome is an Acacia tree and shrub savanna, and the vegetation structure is a mosaic of shrubland and woodland.

Research was conducted on private commercial cattle and game farms. Private land can be bought and sold, with the owners holding full title of their land. On private land, grazing is controlled entirely by the landowner as the sole manager. Private commercial livestock farming is dominated by cattle, but many game farms also exist. On game farms, wild animals (mostly large browsers and grazers) are kept for wildlife viewing, hunting or for sale (Mendelsohn et al. 2003).

In the case of private livestock farming, stocking rates may be lower than in communal areas, and animals are kept under a system of extensive rotational grazing in fenced camps (Mendelsohn et al. 2003).

Approach and methods

We draw on the concept of SES to i) structure the complex research problem and ii) identify its relevant parameters and the key issues of livestock and game farming in Namibia's savanna. The SES approach structures the research problem according to fields of action, support, risks and benefits (further developed from Liehr et al. in prep). In our study, we focus on local farmers and their strategies for deriving specific ecosystem-based benefits.

To conceptualise the link between the spheres of nature and society in complex real-world problems, various groups have introduced the notion of complex social-ecological systems as a broad heuristic model. According to Hummel et al. (2011), the sophisticated SES concept also takes into account non-scientific knowledge, and can serve as a heuristic model to describe and structure problem situations involving strong links between the social and natural realms. For specific contexts, it can further be applied as an analytical model that assists in identifying relevant parameters and relationships. By incorporating the concept of ecosystem services into SES (cp. Hummel et al. 2011; Liehr et al. in prep.), feedbacks between users (local farmers) and savanna ecosystems can be conceptualised and operationalised for scientific analysis.

With the SES approach, knowledge, practices, institutions and technology determine the analytical core of social-ecological structures and processes. Institutions form the external background, e.g. societal and political goals, and knowledge is the basis for decision making. Technology can support practices, e.g. traditions and proven everyday means of land use and management. Management by local actors feeds back into ecosystem functions that in turn provide ESS and thus influence these actors (Liehr et al. in prep).

A stakeholder analysis was conducted to identify relevant actors. To assess the local knowledge and practices of farmers, we reviewed literature including policy papers, reports and recommendations of Namibian Ministries. A workshop, semi-structured interviews and farm drives were conducted, in which we asked specifically about management options, relevant ESS and benefits.

Insights into local management – first results and discussion

We identified specific SES components in the case studies and via a review of literature and policy documents, including the national rangeland management strategy (MAWF 2012). To begin with, we identified main actors: employees from relevant ministries and extension services, and the local farmers. Knowledge, practices, institutions and technology determine the analytical core of the SES approach (Figure. 1). Applied to Namibian savannas, this means that knowledge is the basis for decision making, which in farming is the basis for adapting land use to changing situations with new management strategies. In this case, local knowledge comprises past experiences with land use. Practices can be traditions of land and water management and new developments in this respect. For Namibian savannas, this can include the diversification of land use to include tourism and game farming or some other kind of land use such as herd rotation. Further practices found in the case studies were the selling of livestock in years with low rainfall, or the establishment of drought reserves. Institutions form the external background, which for the farmers may be market opportunities and regulations, societal and political goals and land policy. Technology can support practices, e.g. farmers construct wind- and photovoltaic-driven water pumps, and perform aerial or manual pesticide application for de-bushing.

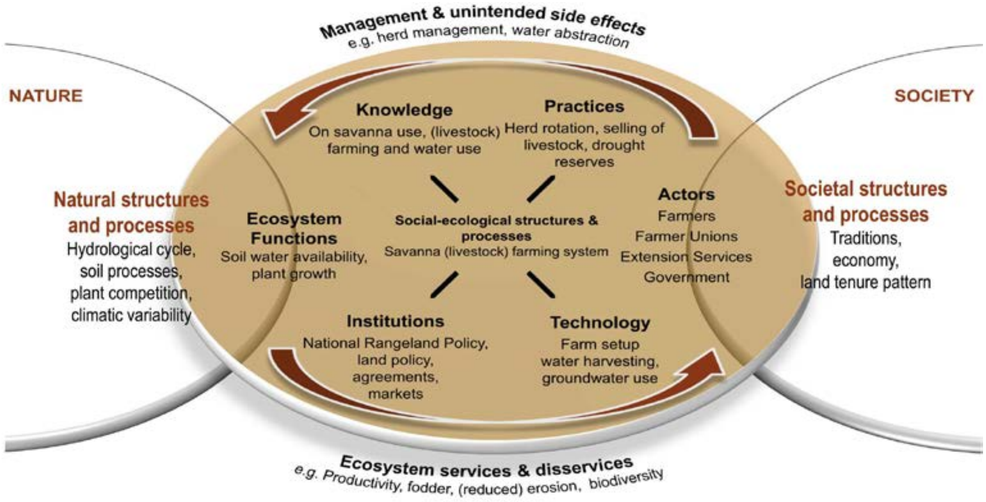

Figure 1: The concept of social-ecological systems (SES) applied to Namibian commercial livestock farming (further developed from Liehr et al., in prep). The main components are actors such as local farmers, and the ecosystem functions on their farm land. Arrows indicate major connections. Knowledge, practices, institutions and technology determine the analytical core to comprehend social-ecological structures and processes.

In the interviews we found that ESS are perceived differently depending on the farmer. Farmer types range from intensive hay producers who trade in calves to extensive cattle and game farmers. However, when asked about the benefit they get from their farm, most farmers stated that they value their way of life on the farm, e.g. healthy air, no direct neighbours, bringing up their children close to nature, not having to live in the city. Thus their direct benefit is human well-being.

Looking at knowledge and practices, we asked farmers about indicators for management decisions. One direct indicator is the condition of their animals, which is an indirect assessment of the quality and quantity of forage. Vegetation cover is mainly driven by precipitation, but virtually no farmers in our study areas are aware of groundwater reserves and balance. In their perception drinking water is not the limiting resource, which might be in contrast to larger scale hydrological analysis. This shows the importance of integrating scientific research such as groundwater analyses with the knowledge of farmers, e.g. on feedbacks between precipitation, vegetation cover and stocking numbers, to get an insight into the coupled ecosystem.

When asked for management options, farmers discussed different forms of herd rotation. Herd rotation can be adapted and practiced with smaller camps and shorter grazing periods. This can enhance plant production, e.g. fostering perennial grasses (MAWF 2012). Technological management options stated by farmers were, amongst others, dams and de-bushing. From a scientific point of view, this can enhance water security through the enrichment of soil water and groundwater. The outcome can be a water buffer. The underlying mechanism is the storage of water in the soil and in plants (Linstädter et al. 2010).

By linking practices and ESS, we know that livestock is highly dependent on ESS such as forage and drinking water. However resource dynamics are driven both by variable rainfall and the impact of livestock itself (Todd 2006). It is thus crucial to identify mechanisms that are capable of buffering rainfall variability (Stafford et al. 2009). Herds need ESS which support them through times of scarcity and act as a buffer against negative rainfall anomalies. Soil water enrichment can effectively buffer rainfall variability (Reynolds et al. 2004). Besides this abiotic buffer mechanism, rainfall variability can also be buffered via vegetation. Water buffering is thus key to tackling the challenges of climate change (MAWF 2012).

Outlook

We structured the research problem by applying our SES model (including the concept of ESS), and specified it for our Namibian case studies. The next steps are to analyse further management options and to assess their impacts on ESS. We shall look at the different categories of farmers and the ESS they consider, along with the management options they apply. Farmer categories will be defined as a basis for the participatory belief model. At a later stage, results will be integrated with a process-based eco-hydrological model.

The feedback from Namibian commercial livestock farmers was very positive; the need to exchange knowledge was clearly stated. For this purpose, we assessed what famers perceive to be the benefits derived from savanna systems, and the initial management options they apply. Integrated water and land use management and the combination of local and scientific knowledge might mitigate degradation in savannas and enable their sustainable use by providing both systemic knowledge on the functioning of the social-ecological system and participatory models for communication with stakeholders. Recommendations based on the latter type of model would promote better acceptance among the local actors.

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