Linking farmer knowledge and biophysical data to evaluate actions for land degradation mitigation in savanna rangelands of the Molopo, South Africa

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Abstract. The over-utilization of semi-arid savanna rangelands in the North-West Province of South Africa has resulted in profound habitat transformations. A common regional indicator of rangeland deterioration is the imbalance in the grass:woody ratio characterized by a loss of grass cover with increased shrub or tree density. This can result in profound reductions of rangeland productivity forcing farmers to apply active or passive actions to improve rangeland condition to mitigate economic losses. This study forms part of the multinational EU-project PRACTICE (Prevention and Restoration Actions to Combat Desertification: An Integrated Assessment) and aims to evaluate locally applied restoration and management actions using a participatory approach. Actions included rotational grazing, chemical control of woody species and re-vegetation with grasses, and were evaluated by common and site-specific indicators suggested by the farming community. Members of an identified multi-stakeholder platform ranked these indicators according to their relative importance, and results were combined with biophysical measurements for each indicator in a multi-criteria decision analysis. Preliminary results showed rotational grazing management and re-vegetation actions perform equally well in maintaining and restoring an open savanna with a high forage production, followed by selective shrub control. This type of participatory assessment helps to identify best practices, but there is still an urgent need to create legal policy frameworks and institution-building to support local-level implementation in all socio-ecological and economic settings, particularly in communal areas.

Keywords: Best practice, stakeholder participation, indicator identification, shrub encroachment, Kalahari.

Introduction

Approximately 65% of South Africa's rangelands are situated within arid and semi-arid regions and are subjected to infrequent rainfall events, resulting in unpredictable fluctuations in plant production (Snyman 1998). The over-utilization of these rangelands for extended periods can decrease ecosystem resilience and may result in profound habitat transformations (Ibáñez *et al*. 2007). Savanna ecosystems are particularly threatened by a temporary or permanent imbalance in the grass:woody ratio in response to mismanagement (*e.g.* Kgosikoma *et al.* 2012). The underlying process of shrub encroachment and an associated replacement of palatable with unpalatable grasses results in a decrease of biodiversity, rangeland productivity and carrying capacity (Richter *et al.* 2001; Smet and Ward 2005). This has significant socio-ecological implications for land users and forces them to apply active or passive actions to improve rangeland condition and compensate for loss of economic value.

There is a need in South Africa for an information base assisting land users in sustainable land management (Von Maltitz 2009). This can be best achieved through an integrated approach that combines local knowledge with scientific expertise and actively involves land users in evaluation, decision-making and execution processes (Fraser *et al.* 2006; Reed *et al*. 2006). The multinational EU-funded project PRACTICE (Prevention and Restoration Actions to Combat Desertification: An Integrated Approach; www.ceam.es/practice) responded to this general gap and suggested a bottom-up approach based on a participatory and integrated evaluation of local-level land management strategies and restoration actions to combat rangeland degradation (Rojo *et al*. 2012). A multi-step participatory protocol was developed and tested in selected dryland sites worldwide to promote social learning through knowledge exchange by integrating local and expert knowledge and assessments that capture biophysical and socio-economic criteria (Bautista and Orr 2011). Here, we report its application in the savanna rangelands of the semi-arid Molopo region in the North-West Province of South Africa, forming part of the southern Kalahari. Presented results are preliminary and highlight selected aspects of the integrative assessment approach.

Methods

The evaluation of management and restoration actions applied by local farmers in the study area followed the PRACTICE Integrated Assessment Protocol (for details please refer to Bautista and Orr 2011). Semi-structured interviews were used to identify: (1) a multi-stakeholder platform (MSP); (2) management and restoration actions; and (3) site-specific indicators for action evaluation. Indicators were ranked by members of the MSP according to their perceived importance using a pack-of-cards method and weightings computed *sensu* Figueira and Roy (2002). Indicators related to rangeland productivity and biodiversity were quantified based on biophysical data assessments using the Fixed Point Monitoring of Vegetation (FIXMOVE) methodology (Morgenthal and Kellner 2008). Site selection followed a preferential sampling design guided by the local stakeholders (SHs). A multi-criteria decision analysis (MCDA) conducted with ELECTRE IS (Aït Younes *et al.* 2000) was applied to integrate ranking results and biophysical data for pairwise comparisons of action performances. Reported statistics were carried out using PAST (Hammer *et al.* 2001).

Results and Discussion

The identified MSP consisted of 45 local SHs with different professional backgrounds (Table 1). The conducted interviews with members of the MSP revealed that the most often applied actions to mitigate land degradation in the study area include: (1) rotational grazing management (RGM); (2) chemical shrub control (CSC); and (3) re-vegetation with indigenous grass species (RV).

A short-listing of environmental and socio-economic indicators proposed by the interviewees and a selection of expert-based indicators resulted in a condensed list of 11 indicators for action evaluation (Fig. 1a). The computation of the indicator prioritization process showed that the indicators forage production, grazing capacity and income and profit were ranked highest. Interestingly, local land users perceived the abundance of woody species a less important indicator for evaluating management and restoration impacts (rank 9, Fig. 1a), although there was a clear negative relationship between woody density and grass phytomass as the main contributor to overall forage production (Fig. 1b). This is surprising as degradation indicators related to the density of certain shrub or tree species are commonly used in other parts of the Kalahari (Reed *et al.* 2008). Risks, such as fire or re-vegetation failure, were ranked as least important.

The quantitative assessments revealed that highest tree densities (converted into tree equivalents (TE) *sensu* Teague *et al.* 1981) were found under poor rangeland management (PM; here used as a benchmark), which largely refers to overstocking and no resting periods for vegetation. Accordingly, forage production in poor managed systems was significantly reduced (Table 2). CSC was shown to be important in the transformation of rangelands back into a condition similar to that under RGM with respect to woody density and forage

Table 1. Composition of the multi-stakeholder platform identified in a local consultation process.

Type of expertise	Farmer	Governmental expert	Service provider	Academic	Conservation
Stakeholder category	commercial-private (9) semi-comm.-lease (4) small scale-communal (12) small scale-LRAD* (6)	extension officer (5) researcher (5)	consultant (2)	researcher (1)	manager (1)

*LRAD = Land Redistribution for Agriculture Development

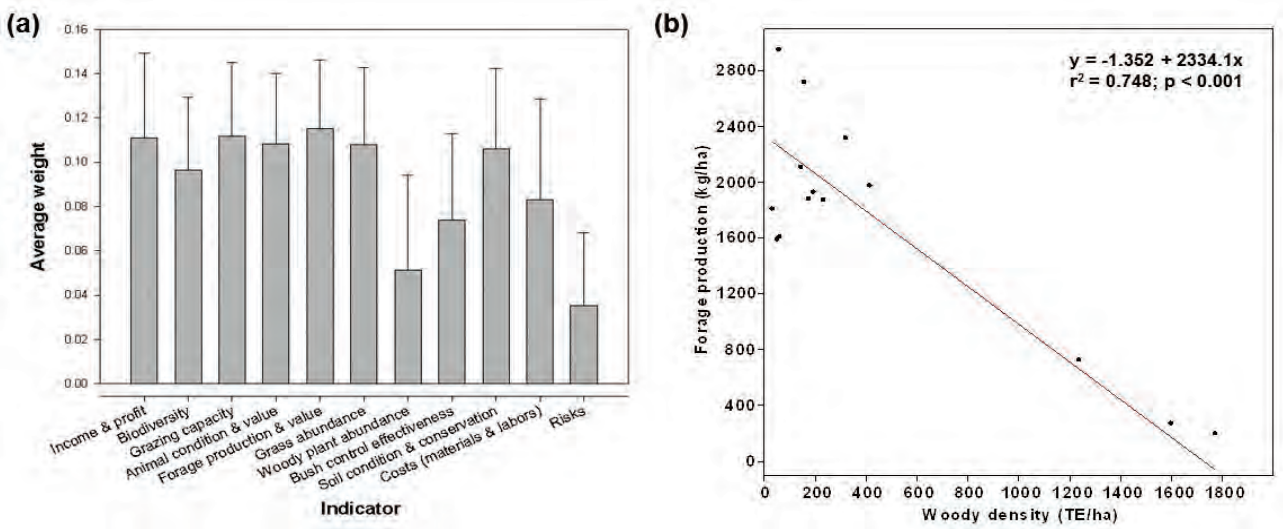

Figure 1. (a) Relative importance of identified indicators averaged over individual stakeholder perceptions, and (b) relationship between the two indicators woody density and forage production (linear model 2: reduced major axis regression).

Table 2. Effect of management and restoration actions as compared to poor management on selected parameters related to identified indicators used for action evaluation. Means (±SD) with different letters in a row indicate a significant difference at *P*<0.05 (ANOVA with post-hoc Tukey's HSD test).

	Rotational grazing (RGM)	Chemical control (CSC)	Re-vegetation (RV)	Poor management (PM)
Woody density (TE/ha)	260.6 ± 87.1 a	252.2 ± 116.3 a	44.4 ± 13.8 b	1531.8 ± 322.6 c
Woody species richness	5.8 ± 1.7 a	6.2 ± 1.7 a	3.3 ± 1.5 ab	8 ± 0 ac
Forage production (kg/ha)	2203.9 ± 328.5 a	1866.6 ± 249.8 a	2120.1 ± 730.1 a	370.7 ± 241.6 c
Grass species richness	6 ± 1.8 a	6.3 ± 4.2 a	5.7 ± 2.9 a	4.3 ± 2.1 a

production. Lowest woody densities were found where the rangeland was re-vegetated, which can be explained by the associated complete clearance of all woody plants. Grass species richness was not significantly affected by management and restoration actions but PM resulted in the lowest grass species richness (Table 2).

The MCDA based on the relevancy (local perception) and performance (biophysical assessment) of actions revealed that in pairwise comparisons RV outranks both CSC and PM, but is as equally good as RGM. The determining criteria were obvious as both these actions (RGM and RV) had the highest measured forage production, which in addition was the first ranked indicator averaged over the MSP. Forage production is also directly related to other indicators perceived as very important, such as income and profit, grazing capacity and animal condition. However, it is clear that to apply a sustainable land management strategy such as RGM, the rangeland has to be open, *i.e.* shrub encroached vegetation states first have to be thinned out. Apart from financial constraints, the choice of the control technology then also depends on the specific land-use objective. RV with its complete clearance of trees and shrubs is an extreme management intervention eliminating any competitive effects in favor of an increased phytomass production of grasses, and thus may be profitable particularly for commercial cattle ranchers. This management may also create open spaces needed on hunting farms, which in addition to having aesthetic value, play an important role in the tourism sector. On the other hand, the selective chemical control of certain increaser shrubs and trees may provide a more balanced approach, and retain important key resources for browsing herbivores such as goats or game.

Conclusions

Although the PRACTICE approach still has to be tested with a complete data set for the Molopo study area, these preliminary results indicate this type of participatory assessment may help to identify best practices. The stakeholder's perspective and circumstances may have a direct influence on the outcomes and contributes to the overall acceptance of results among land users. However, this aspect is likely to be impacted by a social learning effect, which will be verified during an upcoming workshop with members of the MSP aiming at the re-evaluation of actions following group discussions of the preliminary results. The technical implementation of actions will depend on the land-tenure types and management objectives under consideration. While the tested approach is certainly of direct benefit for farm owners, in communal farming systems both a sustainable rangeland management and shrub control are hard to implement. This is due to inappropriate governance structures, strong competition over resources and the high associated costs for materials such as fences and chemicals, respectively. This highlights the urgent need to create legal policy frameworks and institution-building supporting the local-level implementation in all socio-ecological and economic settings.

Acknowledgements

We are grateful toAnahi Ocampo-Melgar for help with the MCDA, the extension officers from the North West Department of Agriculture and Rural Development, and the farming community of the Molopo area for support during data collection. The European Commission funded the PRACTICE project (GA226818).

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