# Towards improved decision-making in degraded drylands of southern Africa: an indicator based assessment for integrated evaluation of restoration and management actions in the Kalahari rangelands

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ABSTRACT: The loss of ecosystem resilience and land productivity is a major problem in drylands of southern Africa. This needs to be addressed in an integrated way linking science to society. Identifying best practices for land restoration and sustainable land management in a process combining local and scientific knowledge is therefore very important as regional perspectives are created and knowledge shared among affected land-users. A corresponding bottom-up framework was suggested by the multinational EU-project PRACTICE, which has been tested in arid Kalahari rangelands of South Africa. Following the identification of a multi-stakeholder platform (MSP) related to the farming community of the study area, the participants' baseline assessment and site-specific indicators for the evaluation of locally applied restoration and management actions to combat desertification were obtained in a participatory process. The MSP ranked the relative importance of the indicators on an individual basis using the pack-of-cards method, and re-ranked these indicators following group discussions. The individual ranking results were combined and integrated with biophysical and socio-economic measurements for the indicators through a multi-criteria decision analysis (MCDA), which ranked the alternative actions according to their relevancy and performance. The MCDA outcome was shared back with the MSP to stimulate group discussion and re-evaluation of the restoration and management actions aiming at improving management decision-making in Kalahari rangelands. The steps of this participatory approach are documented and results and the overall potential for implementation in local and national policy frameworks critically discussed.

*Keywords:* Best practice, Local knowledge, Multi-stakeholder platform, Participatory process, Social learning

## 1. INTRODUCTION

Subsistence in the rural dryland areas worldwide depends on the effective and sustainable utilization of the natural resources, which are increasingly threatened by land degradation, mainly due to extensive droughts and mismanagement, such as overgrazing. The African continent is spatially the most impacted with more than 70% of its agricultural drylands being already desertified (Hoffman and Ashwell 2001). In particular the socio-ecological systems of sub-Saharan countries underwent dramatic changes in recent decades due to the combined effects of land use change (away from traditional practices like pastoralism towards sedentism) and climate change (Archer and Tadross 2009; Oba et al. 2000). This development is also symptomatic for South Africa, with serious environmental, social and economic implications for the country (Hoffman and Ashwell 2001; Milton and Dean 1995).

Land degradation is a complex and dynamic process driven by a multitude of factors including biophysical and socio-economic factors. Recognizing their interrelated impacts, any monitoring and assessment framework of land degradation should be based on an integrated and multidisciplinary approach (Vogt et al. 2011; Von Maltitz 2009). Although South Africa has a relatively long history of combating land degradation emerging in the second half of the 20th century, it took a while until the needs of environment and development (e.g. community participation) started to be considered together (Hoffman and Ashwell 2001). However, many land-use practices in rural areas are still driven by inappropriate policy frameworks, which emphasizes the urgent need for local-level institutions assisting land users in sustainable land management (Von Maltitz 2009). Attempts in South Africa's drylands to mitigate degradation at local scale should make use of land-user knowledge and actively involve them at all levels of project planning, decision-making and execution (Reed et al. 2006; van Rooyen 1998). This principle of linking science to society by combining traditional knowledge with ecological expertise for improved decision-making and sustainable environmental management is nowadays perceived a necessity in order to combat the loss of ecosystem resilience and land productivity, for creating local to regional perspectives and to share knowledge for the benefit of the socio-ecological environment (Fraser et al. 2006; Reed 2008). A corresponding bottom-up framework is therefore suggested by the international, European Commission-funded project PRACTICE (Prevention and Restoration Actions to Combat Desertification. An Integrated Assessment) aiming at filling the gap of systematic evaluation of practices for land restoration and sustainable land management in a participatory and integrated manner (www.ceam.es/practice). In the course of the project, an evaluation protocol was developed and tested for its general applicability in different socio-economic and biophysical contexts and syndromes of land degradation in selected dryland sites worldwide (Rojo et al. 2012). The present study reports its application in degradation-prone Kalahari rangelands of South Africa.

## 2. THE SOCIAL-ECOLOGICAL ENVIRONMENT

The PRACTICE approach is presently applied in two different cultural and biophysical settings of the Kalahari farming area in South Africa comprising different land tenure systems in the Mier municipality of the Northern Cape Province (test completed) and the wider Molopo area of the North West Province (evaluation running). The focus of the present study lies on the Mier rural area just south of the Kgalagadi Transfrontier Park, between the Namibian and Botswana borders. It forms part of the arid Kalahari receiving between 150-200 mm of rainfall per year, and encompasses two broad *veld* types: (1) the duneveld characterized by nutrient-poor aeolian sand forming linear dunes intersected by dune streets and covered by open, savanna type vegetation, and (2) the rather level hardveld on loamy, stony soils with a karroid shrubland vegetation. Livestock farming and game ranching are the two main land use activities in especially the duneveld (Van Rooyen 2000). However, most properties (leased or owned) are relatively small (< 2500 ha) and allow for smallholding to semi-commercial farming only. They have little infrastructure, such as fencing to make paddocks and watering points for better distribution of livestock and rotational grazing options. Many of the local farmers are not able to expand or develop their farms because of financial constraints. This causes inflexibility in employing ecologically sustainable management practices and forces farmers to utilize continuous grazing systems with inadequate water availability. In combination with a highly variable climate, rangelands in the study area easily deteriorate, which may result in profound changes in veld condition (Van Rooyen 1998; Van Rooyen 2000). Signs of land degradation are apparent in the form of decreased vegetation cover, biomass production, and soil quality, as well as an increase in shrub density (bush encroachment).

## 3. THE INTEGRATED ASSESSMENT

The PRACTICE integrated assessment protocol (IAPro) (Bautista and Orr 2011) was applied to identify best practices for desertification mitigation in Kalahari rangelands of the Mier area. The protocol integrates both the human and biophysical dimensions of desertification in seven steps, four of them being fully participatory. The participatory part is based on key common indicators representing overall ecosystem and human-environmental system functioning, site-specific indicators identified by local stakeholders (SHs), indicator quantification by biophysical measurements, SH perspectives and collective integrated evaluation of actions (Rojo et al. 2012).

### *3.1 Identification and evaluation of actions and indicators*

In Mier, IAPro step 1 and 2 were conducted simultaneously in a semi-structured interview due to logistic constraints. A divers set of SHs was identified through a local consultation process and chain referrals, which resulted in a selection of 28 SHs forming the multi-stakeholder platform (MSP) to be involved throughout the study (Fig. 1A). Information was obtained on the participants' baseline evaluation of locally applied land management and restoration actions, and site-specific indicators identified from the participants to be selected for action evaluation from the individual semi-structured interviews.

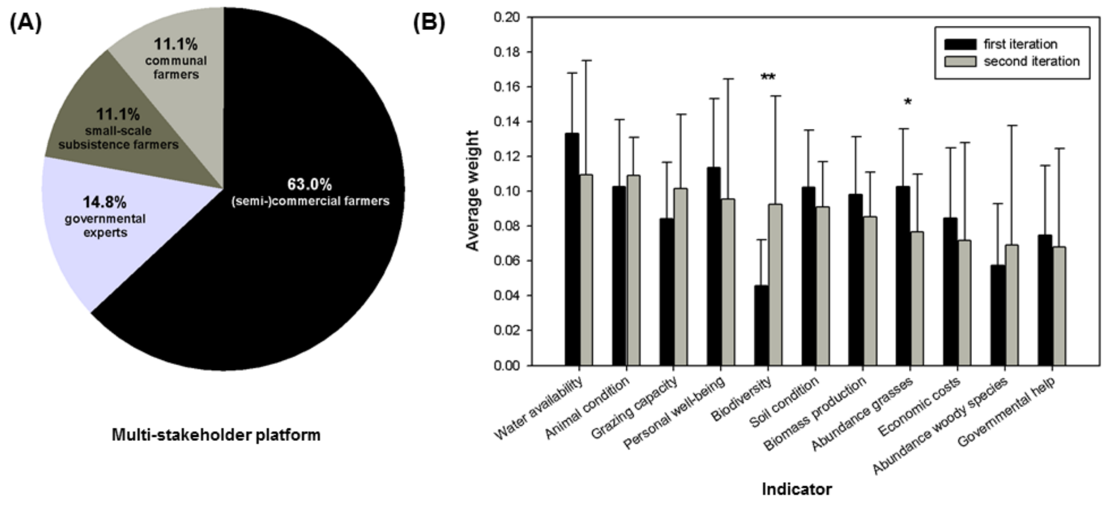


Fig. 1: (A) Composition of the multi-stakeholder platform and (B) relative importance of indicators averaged over individual stakeholder perceptions (group composite weights) before (first iteration) and after (second iteration) group discussions. Bars represent means ± SD; asterisks indicate significant differences at *p < 0.05 and **p < 0.01 (Mann-Whitney-Wilcoxon test).

The interviews revealed that the most commonly applied actions to mitigate desertification in the Mier area include: (1) chemical shrub control (duneveld only), (2) good management (i.e. rotational grazing, resting periods, herding), (3) dune stabilization by brush packing (duneveld only), and (4) revegetation by transplanting grasses (hardveld only). A total of 30 ecological and socio-economic indicators were mentioned and/or proposed by the interviewees, documenting the wealth of information available among land users as also found elsewhere in the Kalahari region (Reed et al. 2008). This can be seen as a significant benefit, as the complex variety of land user perspectives is addressed (Reed et al. 2006) and the set of indicators is less likely too simple and incomplete (Fraser et al. 2006). A final set of meaningful indicators was short-listed by taking into account aspects of redundancy, popularity, data availability and collectability. Combined with expert-selected common indicators based on the ecosystem services approach, this resulted in a condensed list of 11 refined indicators for evaluating the identified actions (Fig. 1B and Table 1).

Table 1: Final set of indicators and their quantification (±SD) exemplified by two actions applied in the duneveld.

| Categories | Criteria | Indicator/proxy | Unit | Good management | Shrub control |
|---|---|---|---|---|---|
| Supporting services | Soil fertility | Soil condition | % organic carbon | 0.1±0.02 | 0.2±0.08 |
| Regulating services | Resource regeneration | Grass abundance | plants $m^{-2}$ | 14.0±3.9 | 25.7±11.9 |
| | Ecosystem integrity | Woody abundance | rank* | 1±0.4 | 2±0.7 |
| Provisioning services | Grass phytomass | Biomass production | kg $ha^{-1}$ | 2755.7±374.1 | 2238.4±343.5 |
| | Forage production | Grazing capacity** | ha $LSU^{-1}$ | 4.7±1.4 | 4.4±1.2 |
| | Meat production | Animal condition | rank* | 1.2±0.4 | 2.4±1.0 |
| Economy | Water availability | Water availability | rank* | 1.1±0.25 | 2.1±0.8 |
| | Labor & material costs | Economic costs | rank* | 1.1±0.3 | 2.3±0.9 |
| | Sustainability | Personal well-being | rank* | 1.1±0.3 | 2.5±1.0 |
| | Subsidies | Governmental help | rank* | 1.9±1.0 | 1.9±1.4 |
| Biodiversity | Species diversity | Grass diversity | H' | 1.04±0.2 | 0.9±0.6 |

*effect of action on the indicator as assessed by stakeholders (1 = affecting the most to 6 = no effect)
**overestimated for Kalahari ecosystems; applied method needs to be adapted (relations remain the same)

In IAPro step 3, the MSP established the relative weight of the final set of indicators. Following Figueira and Roy (2002), indicator prioritization was processed via the revised Simos' procedure or pack-of-cards method. Participants were asked independently to rank cards symbolizing the indicators according to their perceived importance and to insert blank cards to reinforce ranking differences. After computation of both the individual and integrated SH perspectives (*sensu* Figueira and Roy 2002), the resulting normalized weighting (Fig. 1B, first iteration) was presented to the MSP during a workshop. Participants were encouraged to discuss each other's results in small sub-groups, followed by an open group discussion and a second round of weighting for potential re-ordering the indicators should their perspectives have changed. The integrated collective weighting of indicators was indeed different from the first iteration (Fig. 1B). This might indicate a social learning effect through the exchange of views and experiences between land users, as well as individual and group reflections on the issues discussed. However, ideally both iterations including group discussions should be implemented in a single meeting (Bautista and Orr 2011). Unfortunately, due to logistic constraints (compare also 4.1) the gap between first and second round of the ranking exercise was longer than one year. Thus, although each single SH was informed about his/her first ranking results, in the meantime other factors may have caused the change in mind. Nevertheless, the SHs clearly rated the indicators 'grazing capacity' and 'biodiversity' (referring to fauna and flora) higher and 'abundance of grasses' lower in the second run, with the latter two being assigned a significantly different mean weight after the group discussions (Fig. 1B). In both iterations, the availability and supply of water was ranked highest as this indicator promotes the application of better management strategies, such as rotational grazing. Second highest was 'animal condition', which is a function of the 'grazing capacity' of the rangeland (third rank). Aspects related to personal factors such as finances and future well-being of the family play obviously an important role for Kalahari farmers when evaluating the actions (Fig. 1B).

### *3.2 Combining stakeholder perspectives with quantitative data*

Ecological indicators were also quantitatively evaluated in the field (IAPro step 4) based on the FIXMOVE methodology for standardized rangeland assessments (Morgenthal and Kellner 2008). Field measurements followed a preferential sampling approach by asking the SH to determine the sampling sites according to their perception of what their most degraded area, rangeland in best condition or successful restoration site is. This type of approach gives the SH some kind of control and increases their acceptance in site selection (van Rooyen 1998). No quantitative data could be gathered for social or economic indicators for reasons of being not directly measureable (e.g. personal well-being) or confidentiality (e.g. economic costs). For these, SHs were asked to rank each action in order of decreasing impact on the indicator (compare Table 1).

In IAPro step 5, the results from the indicator ranking in step 3 were combined and integrated with respective biophysical measurements for the indicators through a multi-criteria decision analysis (MCDA) using ELECTRE IS (Aït Younes et al.

2000). This is an outranking procedure based on pairwise comparisons of all the alternative restoration and management actions according to their relevancy (indicator relative importance representing SH perspectives) and performance (indicator quantification). The method identifies the indicators that are either indifferent (meaning have a similar performance in both actions being compared) or supportive for a certain action over another. Based on this, outranking relationships are constructed, where one action outranks another when it is at least as good as the other, as underlined by enough supportive arguments (integrated data).

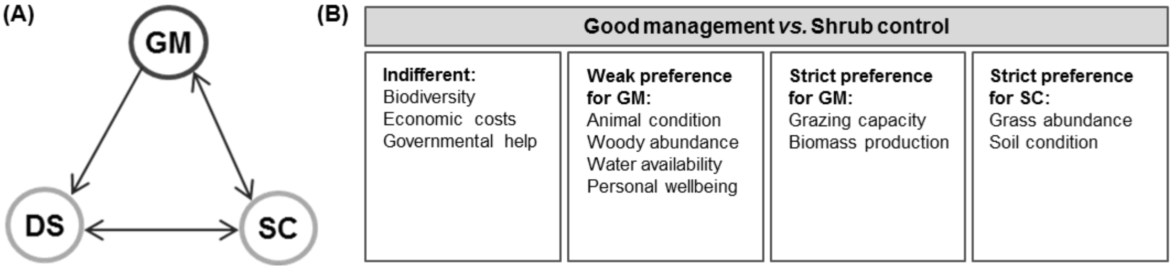


Fig. 2: Outranking relationships of the MCDA performed for the duneveld. (A) Graphical expression (GM = good management; SC = shrub control; DS = dune stabilization; direction of arrows indicate an outranking relation, two way arrows mean an equal performance), (B) example of a comparison of pairs of alternatives.

As shown for the duneveld, a good management action (GM) in the Kalahari rangelands outranks dune stabilization but is equally good as shrub control (SC) (Fig. 2A), although there are a couple of indicators where the preference is weak in favor of GM over SC (Fig. 2B). Accordingly, GM provide best results in terms of biomass production and grazing capacity, whereas SC effectively decreases the competition for moisture and soil nutrients between shrubs and grasses, thus favoring the latter. SC also contributes to an increase in soil organic carbon due to litter accumulation. It should be noted that the MCDA does not identify the best option possible on an absolute scale but rather provides a relative ranking and information on which action outranks each other as a function of the indicators considered (Bautista and Orr 2011).

### *3.3 Integrated evaluation of actions*

A final step of IAPro (step 6) is the collective integrated assessment of the locally implemented actions based on the results of the weighting exercise of indicators, the subsequent MCDA, and related group discussions during the workshop. This step integrates scientific and local knowledge, biophysical data and SH perspectives for the purpose of a more informed re-evaluation. An adapted language, easily accessible figures and other visualizations were used to summarize all participatory outputs. As was also done in IAPro step 2, SHs were asked to rate each action on a scale from 1 to 5 (very bad to excellent choice). The rating was performed in an open, interactive setting allowing for ongoing discussions and exchange of opinions.

Table 2: Stakeholder rating of actions using a Likert scale (pre- / post- integrative assessment (% of responses)).

| | **Excellent choice** | **Very good choice** | **Moderate choice** | **Bad choice** | **Very bad choice** |
|---|---|---|---|---|---|
| **Good management** | 62.1 / 100 | 24.1 / 0 | 13.8 / 0 | 0 / 0 | 0 / 0 |
| **Shrub control** | 55.2 / 75 | 20.7 / 25 | 10.3 / 0 | 3.4 / 0 | 13.8 / 0 |
| **Dune stabilization** | 44 / 10 | 40 / 70 | 12 / 10 | 0 / 10 | 4 / 0 |

All respondents perceived the application of ‘good management’ as an excellent choice. The majority of the SH (75%) also rated ‘shrub control’ as excellent, whereas the rating of ‘dune stabilization’ was less consistent and overall lowest (Table 2). Compared to the first assessment done in IAPro step 2 (pre-integrative assessment, Table 2), the final action rating remained basically the same, but the underlying pattern was more distinct showing clearer preferences (Table 2). However, even if certain actions are preferred above the others, high associated costs (e.g. expensive chemicals for shrub control) are a core constraint often hampering their application. Thus, the dependency on funding and resources supplied by national and provincial government is a critical factor for sustainable land management in the area, in particular with respect to the implementation of dune stabilization and shrub control actions.

## 4. CONCLUSIONS

### *4.1 Lessons learned*

As concluded by Rojo et al. (2012), the general strength of PRACTICE is its bottom-up approach for assessing both environmental sustainability and social acceptance and integration. Indeed, the overall response of the Mier MSP was positive, appreciating in particular their direct involvement, learning-effect and immediate transformation of input into outcome of practical value. This feedback shows that locally important factors are captured by identifying indicators relevant to the SHs. The iterative nature of weighting options, group discussions, and collective integrated assessments is central to establish a more diversified understanding and hybrid knowledge based on traditional and scientific expertise (Fraser et al.

2006). Thus, being more informed, allows to adapt more effectively to changing environmental conditions and observed signs of rangeland deterioration, respectively. Overall, preliminary indications suggest that the PRACTICE approach is promising for evaluating restoration and management actions in Kalahari rangelands. However, replication and comparisons are essential for proper evaluation of participatory approaches (Reed 2008). Thus, it remains to be seen how well it performs under the different socio-economic and biophysical setting of the Molopo area, which will then allow for a more detailed and critical evaluation of the framework. Accordingly, and as requested in step 7 of IAPro, dissemination of results will take place after completing this second Kalahari case study in order to support knowledge sharing between land users, farming communities, extensions officers in comparable social, economic and environmental contexts, including researchers and the wider desertification community (Reed et al. 2006; Rojo et al. 2012).

So far, the present study revealed some critical shortcomings and challenges of overall importance for its successful application. (1) A problem was that the Mier community was already “over-workshoped” by many projects in recent years taking place in the area. This can result in a consultation fatigue, especially if their involvement in participatory processes gains them little reward (Reed 2008). In addition, the huge distances between localities in the Kalahari farmers have to take into consideration when invited to workshops may result in low participation rates at critical participatory steps of IAPro like the collective integrative assessment (step 6). This is especially true if no financial expenses at least for travel costs can be rewarded. (2) Another critical point is that the biophysical assessment based on a preferential sampling approach has some disadvantages related to the subjective course of action. Thus, data is only ecologically representative for the certain habitat chosen. In addition, it might be very difficult to identify enough suitable sites for replications in order to reduce the variability in data caused by the heterogeneity of both the biophysical environment and with respect to differences in management strategies and restoration design. In the course of the running case study in the Molopo area, the number of replicates was significantly increased. However, this kind of effort is very time consuming and requires a good knowledge of a place, i.e. all the habitat conditions. Implementing such a project in remote areas as the Kalahari sites therefore involves high costs not only in terms of time but also financial outlay, and thus may decide over proper application. (3) It should be noted that land-user perceptions of what is meant by certain aspects, such as “land degradation” or “biodiversity”, can differ substantially (Reed et al. 2008). As in the Mier case, this can be particularly evident when comparing different land tenure systems (e.g. commercial *vs.* communal), and even in similar biophysical and socio-economic contexts, pointing out that implications are only of relevance at a certain local scale to particular SHs and must be adapted from case to case (Reed et al. 2006; Von Maltitz 2009). In addition, environmental awareness is also a question of ownership related responsibilities, often with shared ownerships in a communal land management setup, reducing individual liability and motivation to conserve natural resources (van Rooyen 1998). How flexible the PRACTICE approach is in dealing with this heterogeneity will be seen when comparing results from all sites on national, regional and global scale.

### *4.2 The way forward*

Combating desertification needs to take place particularly at the local level, but concerted action must be enabled by appropriate institutional mechanisms and structures adapted to the particular land tenure forms in South Africa (Von Maltitz 2009). Thus, the challenge is now to find ways to promote the use of PRACTICE results and the approach itself at local scales and to couple it with local-level institutions. Facing the need for the formulation of environmentally sound and socio-economically accepted prevention and restoration projects to combat desertification in South Africa, an adjusted PRACTICE approach might also represent a promising tool for the exploration of potential alternatives for management and/or restoration options, i.e. other than identified by the local MSP. There is quite a high degree of overlap between the framework of the PRACTICE approach and the participatory approach for land degradation adaptation in other parts of the Kalahari rangelands developed by Reed et al. (2007, 2008), showing many conceptual and methodological parallels. The PRACTICE approach differs mainly in representing in first instance an evaluation tool for best practices (i.e. action assessment), whereas the work of Reed et al. (2007, 2008) ultimately adds up to providing a monitoring tool (i.e. degradation assessment). Combining best practices from both frameworks might be promising to create a more holistic framework for improved decision-making and sustainable land management embedded in a long-term monitoring program.

## 5. POLICY ORIENTED RECOMMENDATIONS

Any national and international project that assesses land degradation and restoration actions which will help land users making better decisions regarding improved land management must comply to the National Action Programs (NAPs) of the three International Conventions (i.e. UNCCD, CBD and UNFCCC). The NAP of especially the UNCCD emphasizes popular participation and the creation of an enabling environment designed to enable local people to reverse land degradation. The NAP also acknowledges the medium-term strategic framework of Government, which is an outcome based approach, similar to that followed by the PRACTICE project. There is already a wealth of information related to combating desertification, land degradation and mitigating the effects of drought (DLDD), which has been collected by Universities, Government, non-governmental and research organizations through national and international research projects (e.g. PRACTICE, LandCare, Desert Margins Program, Kalahari-Namib Project or LADA (Land Degradation Assessment in Drylands)). The challenge now is that South Africa’s government, in collaboration with all these organizations, creates a supportive policy environment including a comprehensive information system, which makes the information available and more accessible in a format understandable by any SH. This should be facilitated by the established multi-stakeholder-based National Coordinating Body (NCB), whose function is to advise government on the appropriate policies, strategies and action plans for the implementation of South Africa’s NAP for the UNCCD. The Committee on Science and Technology (CST) is a subsidiary body of the NCB, and as such has the function, among others, to help with the improvement of coordination, integration and prioritization of DLDD issues and collating related scientific information that is of use and needed by all SH. The NCB as a whole should therefore play a leading role in the design, formulation and establishment of a South African information system on DLDD, sustainable land management and dryland restoration.

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