



THE **E**CONOMICS OF
LAND **D**EGRADATION

A Case Study of Botswana's Kalahari



**Assessing the socio-economic
and environmental dimensions
of land degradation**



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Executive summary

This report identifies key rangeland ecosystem service benefits (food, fuel, construction material, ground water, genetic diversity, climate regulation, recreation and spiritual inspiration) in southern Botswana's Kgalagadi District. It assesses the costs and trade-offs associated with ecosystem service delivery under: i) communal grazing, ii) private cattle ranching, iii) game ranching and in iv) Wildlife Management Areas. Multi-Criteria Decision Analysis (MCDA) is used to rank the four alternative land use options according to their abilities to deliver different categories of ecosystem services (i.e. provisioning, regulating and cultural categories), encompassing use- and non-use values and based on policy preferences. Overall ranking of each land use is ascertained through a combination of scoring (derived from ecosystem service delivery, identified through the use of a variety of indicators) and weighting (derived from policy analysis) of a range of quantitative and qualitative criteria. Data used to inform the MCDA include semi-structured interviews with land users and policy makers, market price data analyses, ecological assessments and literature reviews.

Findings suggest that communal livestock grazing delivers the widest range of ecosystem services. High scores for this land use are mainly linked to the provision of commercial food production, wild food production, fuel, construction material, climate regulation and spiritual values. Wildlife Management Areas delivered the next widest range of ecosystem services, followed by private cattle ranches and private game ranches. Total annual economic values estimated for quantitative criteria highlight that climate regulation, ground water, and commercial food production offer the highest economic values compared to recreation. However, the sustainability implications of exploiting these services remain questionable.

While the policy analysis shows that a range of approaches and land uses are promoted by national policies and strategies through incentives and subsidies to enhance delivery of particular ecosystem services, the MCDA reveals that focus upon inten-

sive commercial food production and ground water extraction compromises delivery of other provisioning ecosystem services (wild food, fuel, construction material and genetic diversity) and cultural services (recreation). As indicated by the literature review and interviews, these are important to people's livelihoods, particularly in communal grazing areas and Wildlife Management Areas. While cattle production in southern Botswana's rangelands tends to provide the largest financial returns to private cattle ranchers, its negative environmental externalities affect all users of communal rangelands. Costs and benefits are not distributed fairly. Veld products, construction material and fuel wood remain undervalued due to a lack of markets, while access to these ecosystem services is negatively affected by policy support for fencing and borehole drilling. Wildlife conservation across Wildlife Management Areas is also hampered by fencing. Obstructed herd mobility results in declining wildlife numbers, limiting the capacity for livelihoods to adapt to climatic variations, decreasing the economic viability of community based natural resource management and ecotourism activities, and causing the poor to rely on short-term government support that fails to address the longer-term environmental problems.

Livelihood diversification is needed to enable multiple ecosystem services to be harnessed from Botswana's rangelands and to support sustainable land management. Current policy approaches and incentives in the land and livestock sectors should be revised to better support communal livestock grazing, so that it delivers a broader range of ecosystem services. Creation of a market with commercial potential is needed so that the provisioning values of veld products are translated into wider economic benefits. However, whether such diversification could feasibly draw on climate regulation potential to include revenues from the trading of carbon credits remains unclear. This aspect requires further methodological refinement, as well as the development of safeguards, so that land degradation through the encroachment of woody species is not financially rewarding.

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Introduction

This report has been produced as one of the case study outputs supported by the Economics of Land Degradation (ELD) Initiative¹. It identifies key rangeland ecosystem service benefits in southern Botswana's Kgalagadi District, and using Multi-Criteria Decision Analysis (MCDA), ranks different land uses based on policy preferences for their delivery. The findings presented are based on semi-structured interviews carried out with land users and policy makers in 2013, which are analysed in conjunction with policy and market price data², and ecological assessments undertaken in 2014³. Our results suggest that communal grazing land uses are able to deliver the widest range of ecosystem services but that policy incentives supporting the livestock sector, in particular linked to fencing and borehole drilling, cause an over-emphasis on commercial food production, at the expense of other services. We identify a need for policy reform that can support livelihood diversification, and highlight the need for investment in further research to explore new and potential market opportunities for veld products and carbon trading.

Assessing the socio-economic and environmental dimensions of land degradation: A case study of Botswana's Kalahari

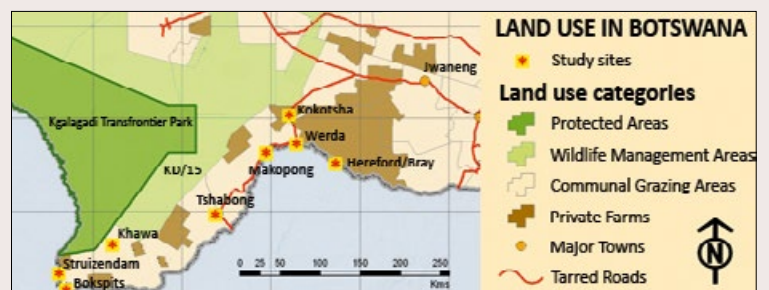
The sustainability of drylands (including arid, semi-arid and dry sub-humid sub-types) is challenged by a range of socio-economic, political and environmental factors⁴. Preserving the health of dryland ecosystems and the services they provide to humans, is vital for human and economic development^{5,6}. According to the Millennium Ecosystem Assessment (MEA)⁷, land degradation is a major threat to roughly 15% of world's drylands. Combined biophysical and socio-economic assessments of the different extents and forms of land degradation are needed for policy development^{8,9,10}. Such integrated assessments allow the degradation of different kinds of land-based ecosystem services to be recognised in the context of specific livelihoods and economic situations, enabling the prioritisation of actions to tackle degradation of land and land-based ecosystem services. Integrated studies can also inform the development of policy measures^{11,12} that can help reverse land degradation by enhancing ecosystem service delivery (and/or avoiding ecosystem services losses) and by promoting Sustainable Land Management (SLM) practices¹³.

This report presents an analytical framework that integrates the socio-economic, environmental and policy dimensions of land management in Botswana's southern Kgalagadi District, where dryland rangelands deliver a variety of ecosystem services^{14,15} that underpin livelihoods. New empirical data were collected through semi-structured interviews and ecological assessments during 2013–2014 along an east-west transect of the District (Figure 1), which incorporates a total area of around 66,000 km² and a human population of 50,400¹⁶. The study area includes key settlements of Werda, Tshabong, Khawa, Bokspits and Struizendam. Land uses analysed include communal livestock grazing areas (unfenced cattle posts) (around 14,800 km²), private cattle ranches (around 8,900 km²), private game ranches (around 800 km²) and Wildlife Management Areas (around 14,800 km²). The remaining major land use, not included in this study because communities do not live in the area, is the Kgalagadi

Transfrontier National Park (around 26,700 km²). The research initially planned to draw upon the ELD methodology and incorporate a full Total Economic Valuation (TEV) of costs and benefits⁸. However, bureaucratic and institutional delays linked to the award of a mandatory research permit restricted the scope of the empirical information that could be obtained within the timeframe of the project. This resulted in a scaling back of the TEV component and a change of methodological approach in order that the data that was able to be gathered could be drawn on to the fullest possible extent.

FIGURE 1

Land use of Botswana and study sites



Retreat of grass cover and perennial grasses, together with bush encroachment, are the major forms of land degradation experienced across all of the main land uses. In some areas in the south west of the study area, degradation is recognised in the form of reactivation of sand dunes. Different extents and types of degradation are not only attributed to the varied land uses and management practices that are adopted, but are also linked to rainfall. In the period 1975–2013, mean annual rainfall in the study area ranged from between 186 mm in Khawa and 360 mm in Werda (Table 1). High inter-annual variability (between 35% in Werda and 56% in Bokspits over the time frames considered) further

T A B L E 1

Mean annual rainfall (mm) and inter-annual variability (%) across study sites for periods between 1975–2013

Source: Elaborated from the Department of Meteorological Services. Time frames covered relate to data availability at each location, hence they are not uniform. Inter-annual variability is expressed by the relative standard deviation (RSD) of the annual rainfall mean

Area	Period	Mean annual rainfall (mm)	Inter-annual variability (%)
Bokspits	1975–2013	207	56
Khawa	1990–2006	186	47
Tshabong	1975–2013	304	44
Werda	2002–2013	360	35

exacerbates degradation levels during prolonged dry periods, when water and forage are lacking. This results in livestock mortality peaks¹⁷. This report identifies and scores the ecosystem service benefits provided by each land use, and discusses the costs and trade-offs associated with their delivery under different land uses and manage-

ment strategies. It provides decision makers with a valuable analytical framework that can be used to better understand ecosystem services provision, inform the development of measures that could reduce the degradation of particular services, and advance SLM.

Methods

A variety of analytical frameworks have been developed for quantifying and valuing ecosystem services with the aim to promote SLM and fight land degradation¹⁸. Significant efforts towards the establishment of a comprehensive and scalable valuation approach have been led by the United Nations Convention to Combat Desertification (UNCCD)¹⁹, and by an international consortium of donors who established the Economics of Land Degradation (ELD) Initiative⁸. Core valuation methods mainly focus on economic perspectives to allow stakeholders to assess alternative land management and policy options. These are grounded in the TEV framework, which aims to estimate the true economic value of land by deconstructing the ecosystem services it provides into independent categories. These categories and their contribution to human wellbeing can be valued separately following the MEA's classification of ecosystem services (i.e. provisioning, supporting, regulating and cultural services)⁷, which has been refined to better integrate ecological and economic dimensions²⁰. The concept of TEV encompasses the sum of use values (derived from the consumption of ecosystem services) and non-use values (not associated with consumption). Use values are deconstructed into: direct use values (e.g. food, timber, carbon storage and hunting), indirect use values (e.g. pollination and nutrient cycling) and option values (e.g. premiums for maintaining the ecosystem service for future direct and indirect uses such as recreation and tourism). Non-use values encompass existence values (e.g. symbolic species as cultural services), bequest values (e.g. values of ecosystem services transferred to future generations) and stewardship values (e.g. land kept in good functional health)^{8,18}.

The range of methods that can be used to value the different components include²¹: (i) non demand based methods e.g. market price analysis, replacement costs, damage costs avoided, mitigation costs and opportunity costs, (ii) revealed preference methods (demand-based) e.g. hedonic pricing and travel cost methods, (iii) stated preference methods (demand-based) e.g. contingent valuation, choice experiments and MCDA, and (iv) benefit transfer methods, in which valuation estimates are adapted

to those obtained by other studies for the same ecosystem services in similar environments.

The use of these methods may pose some challenges in the integration of qualitative aspects linked to major political, cultural and environmental dimensions of land management. As stressed by the ELD Initiative⁸, successful valuations require complementary perspectives. Consistent economic data may be lacking due to limited local capacity and reporting systems. Despite the efforts to build an environmental accounting system in Botswana led by the World Bank, through the Wealth Accounting and the Valuation of Ecosystem Services (WAVES) programme²² to bridge key information gaps in economic decision making, consistent economic data is still insufficient.

Taking into account the data limitations and practical constraints on data collection in the Botswana context linked to the delayed award of the research permit, this study integrates non-demand-based methods of economic valuation (i.e. market price analysis) with MCDA and benefit transfer methods. While MCDA is not a full "economic" valuation approach like TEV, it provides an interdisciplinary framework that allows monetary-based techniques to be integrated with non-monetary ecological and cultural values^{20,23}. MCDA ranks alternative options by quantifying, scoring and weighting a range of quantitative and qualitative criteria. It has been successfully applied in landscape planning research to assess varied land-use alternatives in relation to the ecosystem services they provide²⁵ and can be carried out by individuals or by multiple stakeholders. In this research, because of timing constraints for data collection, scoring and weighting was undertaken by the project team. An alternative way to derive weights is to use a multi-stakeholder approach (e.g. through workshops and stakeholder consultations, with e.g. government and parastatal organisations, land users, and the private sector). This can help to identify policy options that allow the promotion of an adequate mix of ecosystem services according to the overall preferences of society as a whole. Indeed, an important strength of MCDA is its capacity to consider multiple criteria and per-

spectives, through an approach that allows data from a range of sources to be incorporated, where conflicting objectives to be supported. By generating an overall ranking of the alternatives available, MCDA provides a valuable support tool to solve management problems²⁰.

As with all economic tools, MCDA faces a range of limitations. In instances where more participatory approaches are used than in the current study, it assumes that all stakeholders involved in the MCDA agree on the need to tackle land degradation and move towards SLM. The scoring and weighting of the criteria relies on judgements, which may be difficult to make in cases where reliable data are lacking. Judgements made may also not always correspond with the preferences of society as a whole, with the risk of generating biases increasing when judgements are made based on policy analyses (as was the case in this research) or with input from only small numbers of stakeholders. There is also potential for double-counting when using multiple criteria and indicators, while the capacity to generate economically sound decisions is challenged by the integration of monetary and non-monetary based techniques.

In terms of the limitations in applying the MCDA method to our study area, a lack of reliable data made it difficult for the project team to make informed judgements for scoring and weighting of the different criteria. Use of the farm scale as the unit of analysis hampered assessment of the aggregate interaction of land management options across the landscape as a whole. It also separated ecosystem services into their various categories, underplaying the values associated with the interactions between them. This is an important limitation for both the District and wider Kalahari context, where mobility, links and flows, of both wildlife and water, shape the delivery of ecosystem services such as wild food, fuel, construction material, recreation and spiritual inspiration. MCDA also did not allow us to take into account the entry point of different social and economic groups with regard to the prerequisite capabilities and stocks of capital assets required to access land under particular types of tenure, and therefore to deliver particular ecosystem service outcomes. The importance of the equity dimension is therefore underplayed in applying the MCDA approach to the case study setting. Despite this range of limitations, MCDA can identify preferred land use and associated land-based eco-

system services for which a more detailed economic valuation can be carried out in further studies.

The steps followed and data used in the MCDA development²⁶ are presented below.

(i). Problem definition and identification of options

Concerns over the dual threats of poverty and land degradation in southern Botswana are growing for dryland communities, particularly in the context of increasing vulnerability to environmental (including climate) change. In some areas, rangeland degradation has led to extensive bush encroachment; reducing access, good quality grazing, and economic returns; and threatening the delivery of a range of provisioning and cultural services. The land uses and management practices identified in the study area are widespread across the southern Africa region and semi-arid rangeland environments globally, and include areas that are degraded in different ways and to different extents. Within this context, the research problem to be tackled was therefore defined as: “Which land uses and land management strategies are best placed to deliver specific ecosystem services in Kalahari rangelands in Botswana’s southern Kgalagadi district?”

(ii). Criteria definition and assessment

Four land uses were defined as MCDA options: communal livestock grazing, private cattle ranches, private game ranches and Wildlife Management Areas. While it is helpful for analytical purposes to distinguish between communal areas and private cattle ranches (perimeter fenced, internally paddocked with water reticulation), in reality, there is a blending of the categories. For example, *de facto* private cattleposts (unfenced) occur within communal areas and many private cattle ranches are operated as unfenced cattleposts. It is a situation that is complicated further by the existence of dual grazing rights whereby larger herd owners graze their animals on the ‘commons’ before retreating to their own ‘private’ pastures on their ranch.

The performance of the four options was measured by their capacity to deliver ecosystem services identified for the year 2013 through the methods below. A total of 9 criteria were identified, supported by 14 indicators following ecosystem service categorisation based on the literature²⁰ (Table 2).

TABLE 2

Criteria (shaded) and indicators used to assess capacity to deliver ecosystem services

Food (commercial)	<ul style="list-style-type: none"> • Net profit of meat production (US\$/ha/yr) • Stocking level (Ha/Livestock Unit)
Food (wild)	<ul style="list-style-type: none"> • Gathering of veld products • Subsistence hunting
Fuel	<ul style="list-style-type: none"> • Firewood collection
Construction material	<ul style="list-style-type: none"> • Collection of thatching grass and poles for fencing
Ground water	<ul style="list-style-type: none"> • Value of water extracted (US\$/ha/yr)
Genetic diversity	<ul style="list-style-type: none"> • Genetic diversity between forage species • Genetic diversity between livestock breeds
Climate regulation	<ul style="list-style-type: none"> • Value of carbon sequestration (US\$/ha/yr)
Recreation	<ul style="list-style-type: none"> • Revenues from Community Based Natural Resource Management, trophy hunting & photographic safari (US\$/ha/yr) • Ecotourism potential • Wild animal diversity
Spiritual inspiration	<ul style="list-style-type: none"> • Presence of landscape features or species with spiritual value

Primary and secondary data were gathered through the following methods:

- A total of 37 semi-structured interviews were carried out across 8 villages to ensure diversity in responses from across the study areas. Respondents included: communal livestock farmers (n=20), private cattle ranchers (n=10), private game ranchers (n=3, including 1 safari operator), government officers (n=3) and village development committees (n=1). In addition, qualitative information was gathered on the different land management strategies adopted and their main implications for land degradation. Quantitative data were collected to investigate the monetary costs and gains from these land use activities, including examination of detailed financial statements where available. These data informed the MCDA criteria assessment.
- A total of 12 ecological assessments used in the MCDA were carried out across the study region (Figure 1). These involved assessment of 3 communal areas, 7 private cattle ranches and 2 game

ranches. A piosphere based sampling approach was adopted to assess changes with increasing distance from a waterpoint and thus declining grazing intensity. The following indicators were assessed for 5 km transects each with 7 sampling points: tree/shrub frequency, species composition, density and cover, grass and forb species composition and density, total canopy cover and bare ground cover (see Dougill et al., 2014 for full details).

- A comprehensive literature review and use of secondary data (including rainfall data, land tenure, national economic statistics and population data) informed the assessment of the socio-economic and ecological characteristics of the study area, as well as providing useful information to allow application of the benefit transfer method, where data from the study area were lacking. Policy analyses informed the criteria weighting by the project team (see step (iii) of MCDA development below) and the identification of the main drivers of the different land uses within the country.

The following points detail the methods and data used for the assessment of each criterion.

- *Criterion 1: Food (commercial).* The mean net profit of the meat production indicator was derived by subtracting the annual operating expenses under each option from the total operating revenues. Values provided by private cattle and game farms through financial statements²⁷ measured for different fiscal years within the period 2010–2013 were compared after being deflated to real 2013 prices using the Botswana Consumer Price Index (CPI). Private operating expenses included feeds and medicines, motor vehicles and transport, fuel and oil, electricity, repairs and maintenance, salaries and wages, bush removal. In the case of communal grazing areas, revenues and expenses were calculated based on interview data integrated with literature because no financial statements were available. Revenues included the average livestock herd size owned (cattle and smallstock; assessed through interview data) multiplied by the mean off-take rate (identified in the literature²⁸) and valued according to the 2013 market price². Expenditure identified from interview data included the mean cost of borehole drilling (with a 10-year depreciation period), borehole equipment and maintenance, kraals, feed and medicines, fuel and labour. Minimum and maximum expected profit values were estimated by calculating a 95% confidence interval of the standard deviation of the profit mean. The stocking level non-monetary indicator provides the mean stocking values, assessed through interviews and analysis of a national government report²⁸.
- *Criterion 2: Food (wild).* The two indicators (gathering of veld products and subsistence hunting) were qualitatively assessed using a 5-point scale (1 lowest, 5 highest) according to information gained through interviews and from the literature^{29 30 31}.
- *Criterion 3: Fuel.* Methods for the assessment of the indicator ‘firewood collection’ were the same as those used under criterion 2.
- *Criterion 4: Construction material.* Methods for the assessment of the indicator ‘collection of thatching grass and poles for fencing’ were these same as those used under criteria 2 and 3.
- *Criterion 5: Ground water.* This indicator does not include surface water resources which are

extremely rare in the Kalahari given the sandy soil cover. The economic value of the ground water indicator was estimated based on interview data. The average number of boreholes used per ha under each land use was calculated and multiplied by the borehole’s extraction capacity (L/hr). Total L/ha/yr of water extracted were derived by multiplying the latter value by 365 days and assuming a daily pumping time of 16 hours (interview data suggest that pumping time ranges from 9 hr/day in winter to 24 hr/day in summer). The result was valued according to the 2006 market price of non-potable (raw) water³² deflated to the real 2013 price by using the Botswana CPI. A 95% confidence interval was calculated to provide minimum and maximum expected values. Costs of extraction and desalination vary widely across the District and were not included due to a lack of reliable figures. This means that total costs are likely to be higher than those incorporated in this study.

- *Criterion 6: Genetic diversity.* This criterion classifies biodiversity (the variability among living organisms) as a final ecosystem service (i.e. it directly gives rise to a good)³³. In line with this view, the two indicators of genetic diversity (forage species and livestock breeds) indicate the capacity to ensure resilient food production against future climate change and or diseases. These indicators were qualitatively assessed using a 5-point scale (1 lowest, 5 highest) according to the findings of the ecological assessments and interviews (which considered livestock breeds).
- *Criterion 7: Climate regulation.* The monetary value of net carbon sequestration was assessed through the benefits transfer method³⁴ with values identified as part of the literature review. Above ground biomass (vegetation) carbon storage estimates were based on the projects field ecological studies³ rather than solely bush encroachment³⁵ scenarios used in other economic assessments nationally^{36 37}. Previous scenarios assume that soil carbon gains (through photosynthesis) in the lightly grazed Wildlife Management Area scenario are close to being balanced by carbon losses (through respiration and in fire events) with only low levels of soil carbon accumulation, typical of Kalahari sand soils³⁸. Net amounts of total soil carbon sequestered per annum were transferred from recent studies in southern³⁹ and north-east^{40 41} Botswana. Three scenarios were used: intense grazing (communal livestock grazing and private cattle

ranches) where net gains were identified as 0.25 t C/ha/yr, light grazing (game ranches) where net gains are 0.20 t C/ha/yr and very light grazing (Wildlife Management Areas) where gains are 0.05 t C/ha/yr. These figures were multiplied by the total land surface under each use and converted to t CO₂ by multiplying the results by 3.67 (i.e. the ratio of molecular weights between C and CO₂). The estimated carbon quantities were valued according to the 2013 CO₂ price set in the European Union Emissions Trading Scheme (EU ETS) (US\$ 6.7/t).

- **Criterion 8: Recreation.** The revenues from Community-Based Natural Resource Management (CBNRM) gained through trophy hunting and/or photographic safaris for the controlled hunting area KD15 (Figure 1) were assessed by examining the 2006 hunting agreement provided by the Khawa Kopanelo Development Trust during interviews. This was the most recently available data. Using the benefits transfer method, this data was integrated with CBNRM estimates from another study based in southern Botswana⁴², identified through the literature review. Real 2013 prices were deflated using the Botswana CPI. The ecotourism potential indicator was assessed using a 5-point scale linked to information provided in interviews, as well as the KD15 land use management plan and a local development plan designed by a private operator. The third indicator, wild animal diversity, considers biodiversity as a good in itself³³. This differs to the classification used in criterion 6, where biodiversity is considered a final ecosystem service. Wild animal diversity is here understood as the object from the ecosystem that people value through experience or use (ibid). This value is highly interlinked with the development of recreational activities such as ecotourism and trophy hunting. It was assessed using a 5-point scale developed by integrating the 2012 Aerial Census of Animals in Botswana⁴³ with interview data. Double-counting with the genetic diversity criterion was avoided as the latter includes different components of biodiversity (i.e. forage species and cattle breeds).

- **Criterion 9. Spiritual inspiration.** The same qualitative methods for the assessment of the indicator 'presence of landscape features or species with spiritual value' were used as for criteria 2, 3 and 4.

(iii). Criteria weighting

Each of the criteria was weighted to reflect their relative importance to society for the final ranking. Common weighting approaches in MCDA include multi-stakeholder processes aimed at promoting interactive decision making (e.g. value measurement models and outranking models)⁴⁴. In this study a multi-stakeholder approach was not possible. Instead, weights were assigned based on a policy analysis undertaken by the research team, where the main goals and priorities of national land, agriculture, development, tourism and wildlife policies were identified⁴⁵ using thematic analysis. This still allowed multiple views and options to be taken into account as the policies covered different sectors. The weights for the criteria were then normalised so that their total is equal to 1.

(iv). Derivation of each option's overall preference score

The quantitative and qualitative criteria assessed were scored on a homogeneous 100-point scale. A score of 0 represented the worst level of performance encountered in our assessments, and 100 represented the best level²⁶. After the end points were established for all criteria, a linear value function was used to translate the measure of achievement of each criterion into a MCDA value score (0–100). For each land use option, each criterion score was multiplied by the criterion's weight. The options' overall scores (or preference scores) were derived by summing these products for all the criteria under each option. Sensitivity analysis was carried out to check the robustness of the analysis. Different weights were applied to the criteria in different scenarios (e.g. in scenario 1 commercial food weight was doubled with the weights of the other criteria remaining unchanged; while in scenario 2 wild food weight was doubled with the weights of the other criteria unchanged). Results from these analyses indicated insensitivity of the results and the overall ranking of the options did not change substantially when different weights were tested. The communal grazing option was always ranked first, while minor shifts were observed between the rankings of private cattle ranches and Wildlife Management Areas. This suggests that if a multi-stakeholder approach is undertaken and the weighting changes based on the wider range of perspectives taken into account, it is likely that the results of this MCDA will not change significantly.

04 Results

This section presents the MCDA results, which are then discussed in Section 5. The performance of each criterion under the different land use alternatives is detailed in Table 3, alongside the type of valuation and data collection method(s) used to inform the MCDA.

The total annual economic values estimated for the quantitative criteria of the MCDA are reflected in Table 4. Market price valuation was used as detailed in step (ii) of MCDA development (criteria definition and assessment, see Section 3). The highest economic value of ecosystem services across southern

T A B L E 3

Criteria performance among the four land use alternatives and type of assessment

Criterion	Indicator / ecosystem service category	Communal livestock grazing	Private cattle ranches	Private game ranches	Wildlife Management Areas	Valuation/collection methods used to inform the MCDA
Provisioning						
Food (commercial)	Net profit of meat production (US\$/ha/yr)	(-0.56 ; 1.95) Mean: 0.64	(0.66 ; 1.75) Mean: 1.21	(-7.89 ; 3.75) Mean: -2.07	0	Interviews & market prices
	Stocking level (Ha/LSU)	9-13 Mean: 11	8-20 Mean: 14	7-12 Mean: 9.5	120-200 Mean: 16	Interviews & literature
Food (wild)	Gathering of veld products	High	Low	Low	Medium	Interviews & literature
	Subsistence hunting	High	Very low	Very low	Very high	Interviews & literature
Fuel	Firewood collection	Very high	Medium	Medium	High	Interviews & literature
Construction material	Collection of thatching grass and poles for fencing	Very high	Medium	Low	High	Interviews & literature
Ground water	Value of water extracted (US\$/ha/yr)	(0.63 ; 1.05) Mean: 0.84	(0.22 ; 1.71) Mean: 0.97	0.15	0	Interviews & market prices
Genetic diversity	Genetic diversity between forage species	Low	Medium	High	Very high	Ecological assessments
	Genetic diversity between livestock breeds	Low	High	Very low	Low	Interviews
Regulating						
Climate regulation	Value of carbon sequestration (US\$/ha/yr)	6.1	6.1	4.9	1.2	Benefit transfer & market prices
Cultural						
Recreation	Revenues from CBNRM trophy hunting and photographic safari (US\$/ha/yr)	0	0	0	0.04	Interviews & benefit transfer
		Low	Very low	High	Very high	Interviews
	Wild animals diversity	Medium	Very low	Very high	Very high	Literature
Spiritual inspiration	Presence of landscape features or species with spiritual value	Very high	Very low	Medium	Very high	Interviews

Botswana's Kgalagadi District is given by climate regulation (US\$ 16.8 million per year). This is followed by ground water (US\$ 2.1 million per year) and commercial food production (US\$ 1.8 million per year). Recreation, assessed through the revenues from CBNRM trophy hunting and photo-

graphic safari, ranks the lowest (US\$ 31,000 per year), but offers tangible livelihood benefits to the Wildlife Management Area community. While ground water achieves a high value because of the intensive extraction observed in the study areas, this is a finite resource which is being over-extracted

TABLE 4

Total economic values (US\$/yr) estimated for the quantitative criteria of the MCDA

	Communal livestock grazing (US\$/yr)	Private cattle ranches (US\$/yr)	Private game ranches (US\$/yr)	Wildlife Management Areas (US\$/yr)	Total (US\$/yr)	Valuation/collection methods
Food (commercial)						
<i>Net profit of meat production</i>	944,574	1,072,764	-165,456	0	1,851,882	Interviews & market prices
Ground water						
<i>Value of water extracted</i>	1,238,080	860,537	11,674	0	2,110,291	Interviews & market prices
Climate regulation						
<i>Value of carbon sequestration (net additional carbon/annum)</i>	9,077,029	5,471,053	393,424	1,819,586	16,761,092	Benefit transfer & market prices
Recreation						
<i>Revenues from CBNRM trophy hunting & photographic safari</i>	0	0	0	30,939	30,939	Interviews & benefit transfer

TABLE 5

Criteria weighting

Criteria	Food commercial	Ground water	Food (wild)	Construction material	Fuel	Recreation	Genetic diversity	Climate regulation	Spiritual inspiration	Total
Mean weight	0.19	0.16	0.11	0.10	0.10	0.09	0.09	0.09	0.07	1.0

T A B L E 6

Final scoring of the MCDA (scale 0-100) (weighted values in brackets)

Criterion	Indicator / ecosystem service category	Communal livestock grazing	Private cattle ranches	Private game ranches	Wildlife Management Areas
Provisioning					
Food (commercial)	Net profit of meat production	73 (14)	78 (15)	50 (9)	68 (13)
	Stocking level	98 (18)	96 (18)	99 (18)	20 (4)
<i>Mean</i>		86 (16)	87 (16)	75 (14)	44 (8)
Food (wild)	Gathering of veld products	75 (9)	25 (3)	25 (3)	50 (6)
	Subsistence hunting	75 (9)	0 (0)	0 (0)	75 (9)
<i>Mean</i>		75 (9)	13 (1)	13 (1)	63 (7)
Fuel	Firewood collection	100 (10)	50 (5)	50 (5)	75 (7)
Construction material	Collection of thatching grass and poles for fencing	100 (10)	50 (5)	25 (2)	75 (7)
Ground water	Value of water extracted	49 (8)	57 (9)	9 (1)	0 (0)
Genetic diversity	Genetic diversity between forage species	25 (2)	50 (5)	75 (7)	100 (9)
	Genetic diversity between livestock breeds	25 (2)	75 (7)	0 (0)	25 (2)
<i>Mean</i>		25 (2)	63 (6)	38 (4)	63 (6)
Regulating					
Climate regulation	Value of carbon sequestration	68 (6)	68 (6)	54 (5)	13 (1)
Cultural					
Recreation	Revenues from CBNRM trophy hunting and photographic safari	0 (0)	0 (0)	0 (0)	44 (4)
	Ecotourism potential	25 (2)	0 (0)	75 (7)	100 (9)
	Wild animals diversity	50 (5)	0 (0)	100 (9)	100 (9)
<i>Mean</i>		25 (2)	0 (0)	58 (5)	81 (8)
Spiritual inspiration	Presence of landscape features or species with spiritual value	100 (7)	0 (0)	50 (3)	100 (7)
TOTAL (weighted)		(69)	(48)	(41)	(51)

(as discussed in Section 5). When the full costs are considered over time (i.e. drilling, desalinisation and water transportation), profitability and sustainability of ground water extraction are seriously challenged.

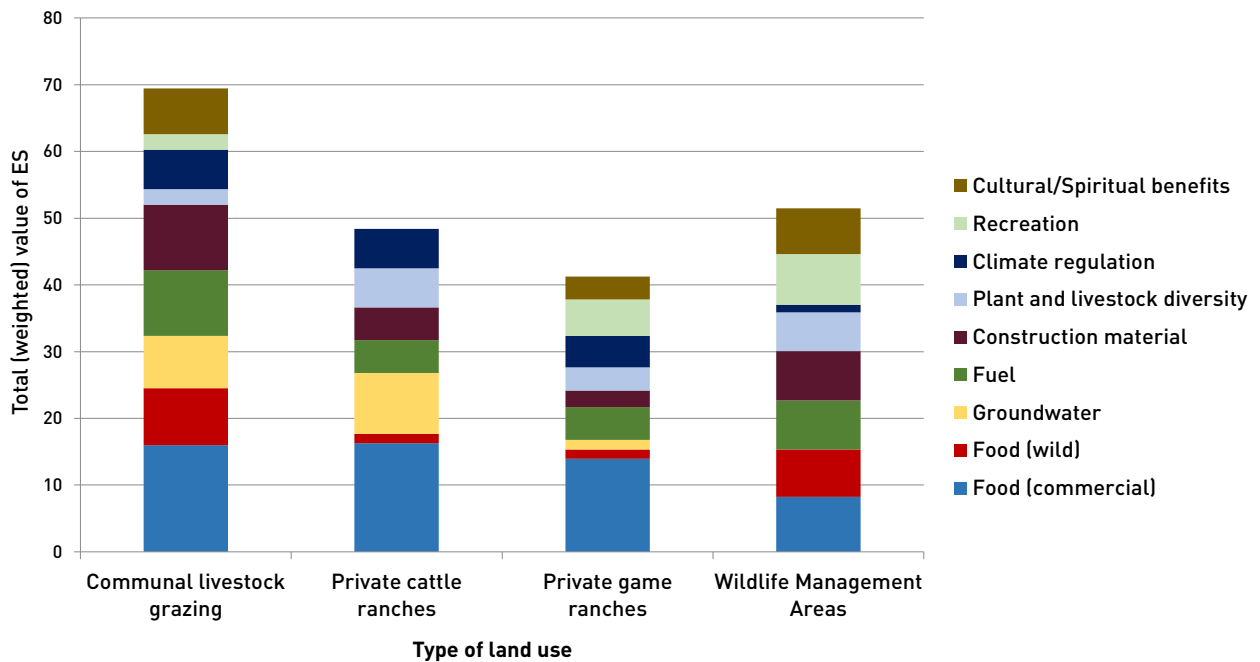
Table 5 details the weights attributed to each criterion. The standardised values indicate that commercial food production ranks highest, followed by ground water, wild food, construction material and fuel. Recreation, genetic diversity, climate regulation and spiritual inspiration were ranked lowest. The final scores (quantitative and qualitative criteria ranked on a 100-point scale) are outlined in Table

6. The weighted values (single options' scores multiplied by weight, as per Table 5) are indicated in brackets.

The performance of each land use alternative with regard to its capacity to deliver the range of ecosystem services under consideration is shown in Figure 2. Communal livestock grazing was identified as the preferred land-use alternative ($S=69$) as it delivered the widest range of ecosystem services, followed by Wildlife Management Areas ($S=51$), private cattle ranches ($S=48$) and private game ranches ($S=41$). High scores achieved by communal grazing areas are mainly linked to their use for commercial food

FIGURE 2

Weighted performance of the four alternative land uses



production, with the management practices used in these areas also allowing wild food production, fuel, construction material, climate regulation and spiritual use values to be retained.

These results and trade-offs between the four different land uses are discussed in detail in Section 5, where the caveats associated with the findings are also presented.

05

Discussion

The analysis of the single indicators shows that competing outputs in terms of ecosystem services provision are delivered depending on the land management strategies and policies adopted. Different impacts of land use options also depend on their spatial locations. The following discussion attempts to unravel the complexity of ecosystem resilience and sustainability in southern Botswana's rangelands, with a view to providing improved information to land managers and policy makers such that they can promote SLM.

Livestock production is the major use value across Kalahari due to the intense policy support (i.e. Tribal Grazing Land Policy (TGLP), 1975 and National Policy on Agricultural Development (NPAD), 1991) and subsidy schemes (e.g. Services to Livestock Owners in Communal Areas (SLOCA), 2002, Livestock Water Development Programme (LWDP), 2002 and the Livestock Management and Infrastructure Development Programme (LIMID), 2007) granted to the livestock sector. With the aim of reducing and reversing land degradation, national policies have widely promoted fencing and privatisation of land for livestock production under the assumption that private ranches would adopt more sustainable and profitable land management practices through e.g. adoption of rotational grazing and reduced stocking levels leading to higher secondary productivity when compared with communal grazing land use. The literature suggests that these policies have been largely unsuccessful and our empirical findings support this assertion.

When the net profit of meat production is the only indicator used to assess the value of ecosystem services, private cattle ranches achieve a higher economic return (i.e. mean 1.21 US\$/ha/yr) and lower stocking levels (14 ha/Livestock Unit (LSU)) than communal grazing (i.e. 0.64 US\$/ha/yr and 11 ha/LSU) (see Table 3). In contrast, private game ranches generate a mean loss of -2.07 US\$/ha/yr and maintain higher stocking levels (9.5 ha/LSU), showing that private tenure does not necessarily deliver the most profitable nor desirable outcomes. The overall MCDA score of commercial food was calculated by integrating the net profit of meat production and stocking level indicators. Mean scores were

weighted according to the criterion's relative importance over the other criteria. Figure 2 shows that communal grazing and private cattle ranches achieve the same score ($S=16$). It was calculated that commercial food production in southern Kgalagadi district accounts for a total value of 1.8 million US\$/yr, with 1.1 million US\$/yr being generated by private cattle ranches and 0.9 million US\$/yr by communal livestock grazing (Table 4).

Commercial food production is complementary to genetic diversity when considered as an ecosystem service³³. Diversity between forage species^{46 47} and livestock breeds⁴⁸ is vital for the nutritional status of cattle and to ensure their resilience, particularly during droughts. The highest scores under the genetic diversity criterion are achieved by private cattle ranches ($S=6$) and Wildlife Management Areas ($S=6$) as opposed to private game ranches ($S=4$) and communal grazing areas ($S=2$). In the Wildlife Management Areas the land is not grazed by livestock (apart from areas in close proximity to communal land use), so degradation induced by cattle rearing is limited, while forage species are preserved. This is supported by findings from the ecological assessments undertaken as part of this study, although species diversity was lower than expected in all land uses due to poor rainfall at the time of data collection. Results instead showed a high proportion of bare ground and forbs, low grass cover and diversity, with little contrast between the different land uses. The private cattle ranches support the use of SLM practices by implementing management strategies that aim to conserve grazing surfaces: "*Since we increased the resting period across paddocks to 90 days, the land condition has drastically improved and we have plenty of grass...new perennial grasses are growing such as Brachiaria nigro-pedata, Digitaria eriantha and Schmidtia pappophoroides*", (interview data, private cattle ranch, Werda, 2013) (Figure 3). Despite these good practices employed in some parts of the District, our ecological assessments show that the Molopo ranches are generally heavily encroached with species such as *Acacia mellifera* and *Dichrostachys cinerea*.

SLM practices are supported by sizeable investments made by private ranchers to remove

encroaching bushes so as to increase the grazing surface and enhance the grass quality. The cost of this accounts for US\$ 22.9/ha through selective spraying done by hand or US\$ 36.6/ha through spraying from the air. Only a minority of farmers can afford such investments, despite its encouraging results: “Some people do not de-bush as they have no money. I am borrowing [the money used for treat-

ment]... removing bushes pays back shortly” (interview data, private cattle ranch, Werda, 2013). Land management practices such as de-bushing can help enhance provisioning ecosystem services through improved cattle production resulting from better forage, but at the same time, it reduces the amount of carbon stored in above ground biomass.

FIGURE 3

Perennial grasses: (a.) *Brachiaria nigro-pedata*; (b.) *Digitaria eriantha*; (c.) *Schmidtia pappophoroides*

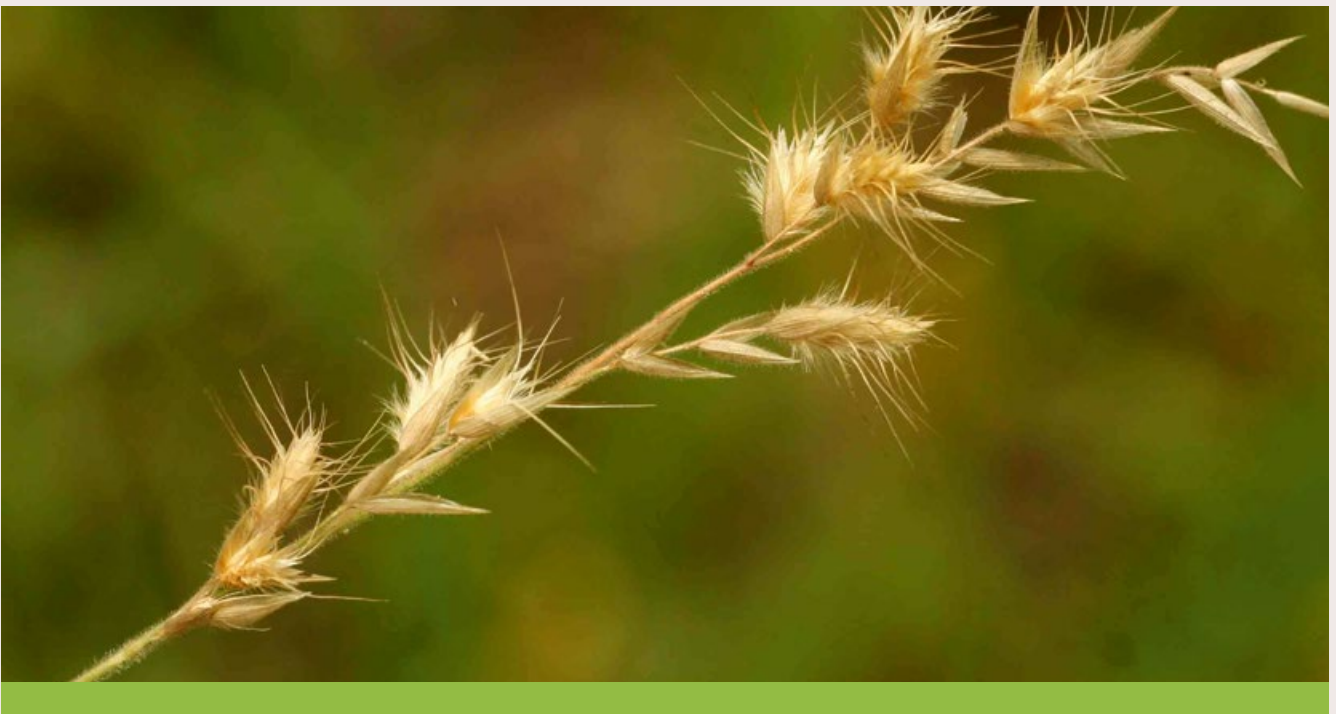
Sources: (a.) and (c.) www.zimbabweflora.co.zw; (b.) www.fao.org



a.



b.



c.

High levels of investment also allow the management of mixed cattle breeds in private ranches. Interviewees suggested the most common breeds include Brahman, Sussex, Simmental, Bonsmara and Charolais. In contrast, mixed breeding is less common in communal areas due to a lack of fences: “*We are not able to keep specific breeds other than Tswana because our cattle are mixed with the one owned by other farmers... our cows get constantly fecundated by random bulls*” (interview data, communal farmer, Werda, 2013) (Figure 4).

Fresh water is a very scarce resource and ground water extracted through boreholes is often highly saline, so while Figure 2 suggests that groundwater extraction has the second highest economic value, the figures need to be interpreted with a large element of caution. Extraction through borehole technology is expensive, and drilling investments translate into an economic loss when the water found is not usable, either due to excessive salinity (even too saline for cattle use) or because the quantity of water found is very small: “*In 2011 we drilled 5 boreholes, but 2 have too salty water and 3 are empty*” (interview data, communal farmer, Khawa, 2013). Borehole investments are better supported by private cattle ranches, which have higher access to financial capital and achieved the highest score ($S=9$) under the ground water criterion. Interview data indicate that on average a single private cattle rancher uses 5 boreholes with a mean extraction capacity of 4,400 L/hr while a communal farmer uses 2 boreholes (of which 1 commonly belongs to a syndicate) with a mean extraction capacity of 2,500 L/hr. Pumping time ranges from 9 hr/day in winter to 24 hr/day in summer for both communal and private users (despite government recommendations that for adequate groundwater recharge, pumping should not exceed 8 hr/day). The costs of water for livestock in communal grazing areas have been intensively subsidised through a range of financial support programmes (i.e. LIMID, LWDP and SLOCA). The subsidies cover up to 60% of the borehole drilling costs⁴⁹, allowing a positive MCDA score ($S=8$) for this land use to be achieved. The lower score of private game ranches ($S=1$) links to the fact that game have a lower water demand than cattle, so a lower quantity of water is extracted. No boreholes are allowed to be drilled in the Wildlife Management Areas, which achieved a score of 0. Annual water yields were estimated and valued using market prices. The total value of ground water extracted in the study area accounts for 0.9 million

US\$/yr (0.97 US\$/ha/yr) under private cattle ranch use, 1.3 million US\$/yr (0.84 US\$/ha/yr) under communal areas and 0.01 million US\$/yr (0.15 US\$/ha/yr) under private game ranches (Table 4). As stressed earlier, these values do not take into consideration the major ground water costs (both economic, i.e. drilling, desalinisation and water transfer, and environmental, i.e. impacts of over-extraction on soils). These costs seriously hamper the profitability and sustainability of ground water extraction and use over time. A more detailed cost-benefit analysis is needed so that these dimensions are considered. Important trade-offs between commercial food production (including ground water extraction) and the conservation of genetic diversity (particularly of forage species), are observed in the MCDA through the ecological assessments and literature review. The policy-led expansion of boreholes across arid and semi-arid communal grazing areas identified in the policy analysis has led to a high concentration of cattle around water points. This concentration was furthered by the expansion of Wildlife Management Areas, fencing (i.e. through NPAD) and private ranches (i.e. via the TGLP). Together, these measures have reduced the amount of communal grazing land available to livestock⁵⁰. The ecological assessments indicate that this produces a noticeable retreat of grass cover as well as bush encroachment up to at least 5000 m away from the water point. This piosphere effect is observed particularly during dry seasons and in areas that are less favourable to cattle production (e.g. next to Wildlife Management Areas). Our ecological surveys further suggest that in the southern Kalahari, where there is less bush encroachment due to low rainfall, piospheres are characterised by the reactivation of sand dunes within the sacrifice zone (0–400 m from the borehole), with the activation of sand dune crests observed at a distance of 1200 m.

Apart from livestock production, communal and Wildlife Management Area land uses are important sources of a range of veld products for the villagers. These provide a supplementary source of (wild) food (and water), particularly in the dry season or during times of drought. Major edible veld products include: *moretlwa* (berry), *motsotsojane* (berry), *mahupu* (truffle), *gengwe* (Tsamma melon), *okawa* (wild melon), *mosumo* (gemsbok cucumber), *motlopi* (berry/fruit) (interview data across study sites, 2013, integrated with the 2005 Land Use and Management Plan of the Khawa community) (Figure 5). Veld products are also used as medicines (e.g. Hoodia is

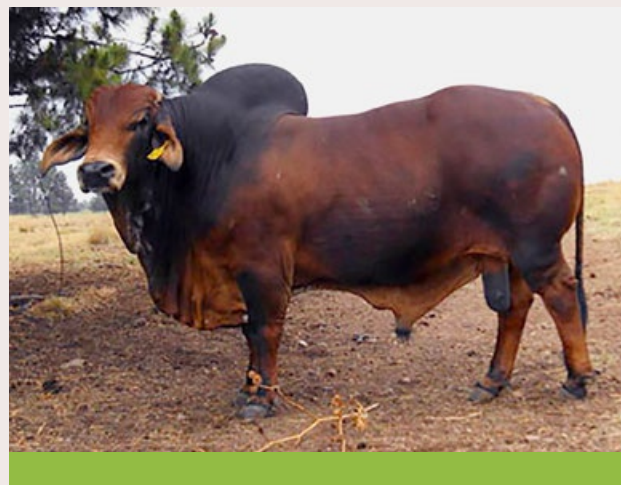
FIGURE 4

Varied cattle breeds: (a.) Bonsmara; (b.) Brahman; (c.) Tswana

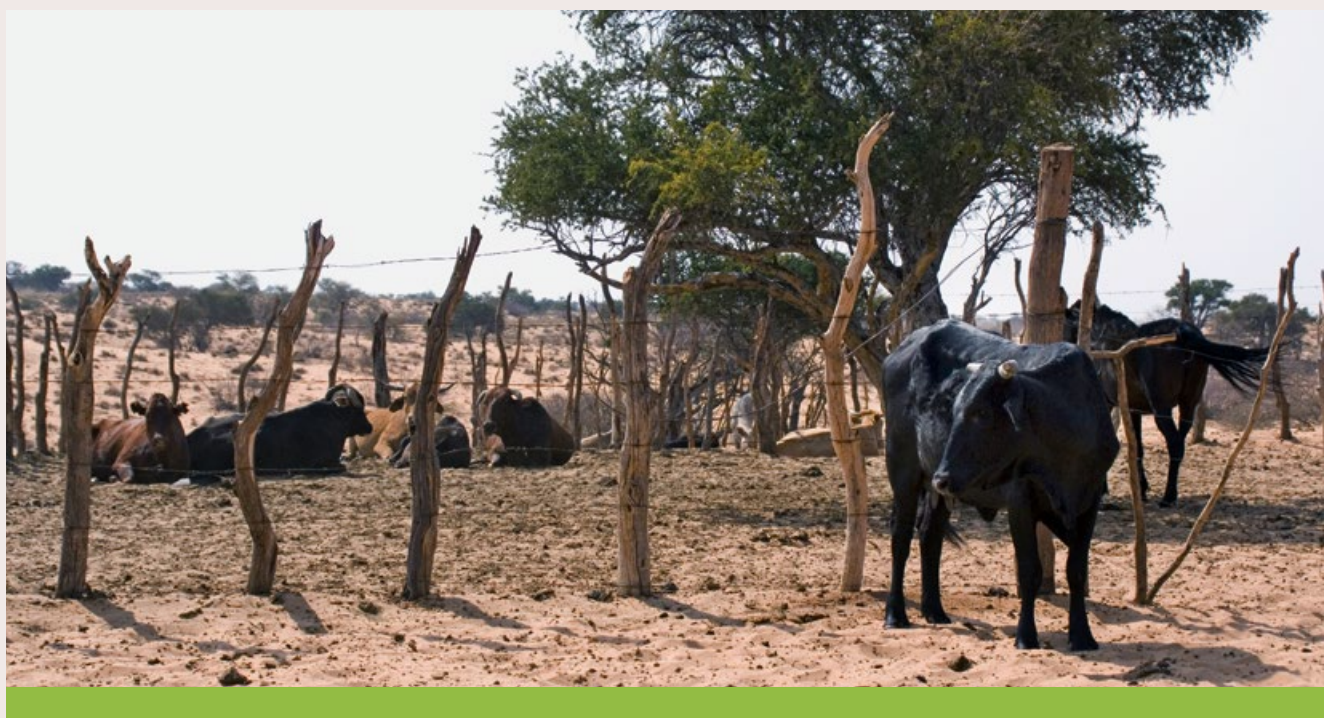
Sources: (a.) and (c.) Nicola Favretto, field visits in Werda and Khawa, 2013; (b.) www.smartkitchen.com



a.



b.



c.

used as an appetite suppressant and Devil's Claw (*Harpagophytum procumbens*) is an analgesic, sedative and anti-inflammatory (ibid).

Trade-offs between cattle farming and veld products are also observed. The economic value and availability of veld products have declined with the degradation induced by the expansion of borehole drilling. As a consequence, these products are found increasingly further away from communal

settlements. Land privatisation has exacerbated this loss at the expense of communal land users. Villagers' willingness to invest time in veld product collection is limited by the lack of a formal market in both the District and the wider Kalahari, which hampers the generation of financial returns: "We do not harvest for sale because it is very difficult to sell these products...we only consume them in the household" (interview data, communal farmer, Khawa, 2013).

Similar trade-offs are observed between policy-driven cattle production and the utilisation of construction material (i.e. thatching grass and poles for fencing) and fuel (firewood).

These two ecosystem services rank higher under communal grazing (S=10) and in Wildlife Management Areas (S=7), showing their importance in the management strategies adopted under these land uses. Construction material is used for traditional house building, fencing or building kraals and thatching roofs (Figure 6). Fuelwood is a major source of energy for traditional households. The supply of these ecosystem services is threatened, as observed in the case of veld products, by increasing levels of degradation and privatisation.

The MCDA shows that, to communal farmers rangelands are important for a broader range of ecosystem services than commercial food production, despite that their value is underestimated from an economic perspective. When non-marketed ecosystem services are taken into account and weighted in accordance with the relative importance to other ecosystem services, communal grazing areas rank as the land use that generates the highest value (both in provisioning and cultural terms). This indi-

cates that the value of a land use is not only linked to the availability of an ecosystem service, but also to its relative importance to society. Adequate policy and economic mechanisms are needed (e.g. a functioning market for all ecosystem services or Payments for Ecosystem Services schemes) so that this value can be translated into concrete economic benefits.

Subsistence hunting plays a significant role in Wildlife Management Areas and the neighbouring communal grazing areas and, together with the gathering of veld products, contributes to the highest values achieved by these land uses under the criterion 'wild food production'. This activity is regulated through a licensing system through the Department of Wildlife and National Parks (DWNP). Interviews indicate that strict government control discourages the villagers to pursue this management strategy: "*There are too many rules that constrain hunting*" (interview data, communal farmer, Khawa, 2013). The hunting ban, applied since January 2014, with the aim to stop an observed decline in wildlife numbers⁴³, has further reduced the hunting activities across the country. Since January 2014, hunting has only been allowed within private game ranches.

FIGURE 5

Veld products: (a.) Moretswana; (b.) Tsamma melon; (c.) Gemsbok cucumber

Sources: (a.) www.pinterest.com; (b.) www.visualphotos.com; (c.) www.projectnoah.org



a.



b.



c.

FIGURE 6

Construction material: (a.) thatching grass; (b.) poles for fencing*Sources: Nicola Favretto, field visit, Khawa, 2013*

a.



b.

Community Based Natural Resource Management approaches have been developed through the NPAD since the 1990s with the aim of putting the local communities adjacent to Wildlife Management Areas in charge of managing wildlife so that resource conservation and financial returns could be simultaneously promoted. Exclusive rights were granted over a wildlife quota. The community could decide whether to hunt the quota for subsistence

use or to sell the quota rights to a private operator (e.g. safari company). CBNRM trophy hunting and photographic safaris have generated tangible benefits to the Wildlife Management Area community. As shown in Table 4, these activities can generate up to US\$ 31,000 annually: *“Hunting is our only source of revenue. It allows us to sustain our livelihoods”* (interview data, communal farmer, Khawa, 2013). CBNRM approaches also offer opportunities to generate

economic benefits from the ecotourism sector, where tourists are attracted by wildlife diversity and cultural experiences (e.g. guided visits and 4x4 driving as identified in the 2005 Khawa Land Use Plan). The Wildlife Management Areas also aimed to conserve wildlife diversity so that these recreational and cultural values can be preserved and enhanced. Conversely, CBNRM activities and natural resource use diversification in Botswana's Kalahari rangelands (i.e. through the use of veld products, construction material and fuelwood) remain constrained by the policy and market incentives in the livestock sector. Declines in wildlife numbers and diversity are caused by the expansion of livestock production and exacerbated by the promotion of the fencing system which, together with the establishment of veterinary cordon fences (as a control on foot and mouth disease), have blocked wildlife migration routes. The policy incentives within the livestock sector, alongside recent decisions on hunting, contrast with the Wildlife Management Areas' wildlife conservation objective, and limit the economic viability of CBNRM as a management strategy under this land use: *"Wildlife numbers are declining. The government took key animals – lions and leopards – out of the hunting quota for conservation purposes. Since then, the safari hunting business has not any more been profitable, neither for the private operators or the community"* (interview data, private safari operator, Werda, 2013).

The hunting ban and climatic constraints (especially during severe droughts) will further constrain CBNRM development. Low levels of rainfall and high inter-annual variability as presented in Table 1 exacerbate the degradation observed as a result of suboptimal land management strategies: *"The area is vulnerable to drought. When it rains the veld is fine even if we are overgrazed, but during droughts many of our cattle die"* (interview data, communal farmer, Kokotsha, 2013). While climate change requires long-term approaches so that rangeland users can adapt to the changing environment, policy fails to provide strong support and guidance away from livestock production into alternative livelihoods. Declining opportunities for hunting and gathering are linked to the reduction of wildlife numbers and the loss of genetic diversity resulting from intensive cattle rearing in remote arid and semi-arid areas. This situation, together with a limited capability to develop tourism and CBNRM activities, translates into increased poverty for the rangeland users and higher levels of depend-

ency on government support and drought relief programmes. Relief interventions address only short-term needs (i.e. through the creation of temporary rural employment or through cattle purchase schemes which help the farmers to retain their assets during times of stress). Such measures fail to create a longer term drought-resistant socio-economic structure⁵¹. There is an urgent need to promote alternative land management strategies that improve SLM and the welfare of the communities through economic and livelihood diversification. Achieving this requires an assessment of the ways in which different policies and incentives interact and conflict, such that a more enabling policy context can be developed through the promotion of synergies.

In addition to the provisioning and cultural services identified, the study area also provides other values through climate regulation. According to the carbon sequestration indicator assessed through the benefit transfer method and ecological surveys, communal grazing and private cattle ranches land uses achieve the highest MCDA scores (S=6 and S=6) (Figure 2). The intensive cattle grazing observed under communal grazing results in the most extensive spread of bush encroachment^{39 40}. The total estimated net annual value of carbon sequestration under communal grazing land use accounts for US\$ 9.1 million per year. Whether carbon sequestration can be profitable in reality is questionable, due to low global prices, uncertainty over markets and standards, and poorly developed methodologies, particularly for monitoring, reporting and verification. Care needs to be taken that increased woody biomass resulting from land degradation is not encouraged through market incentives for carbon sequestration.

This discussion has shown that ecosystem service resilience and sustainability across southern Botswana's rangelands pose complex land management challenges in terms of the identification of SLM practices, particularly when some ecosystem services are providing current economic benefits whereas the potential of others is yet to be tapped. Successful outcomes (both socio-economic and environmental) depend not only on the type of land use promoted by policy, but also on the range of management strategies that are adopted under each land use and the interactions between them. Ways forward to help move towards sustainable ecosystem service provision are summarised in the concluding section.

Conclusions and ways forward for SLM

MCDA is a valuable multidisciplinary analytical framework that can identify preferred land uses and assess the socio-economic and ecological dimensions of ecosystem service alternatives, for which a more detailed economic valuation can be carried out in further studies. By highlighting which land uses are best placed to deliver specific ecosystem services in our case study, it provides useful information that can inform the development of policy, markets and incentives that can influence ecosystem service delivery.

A range of approaches and land uses are promoted by national policy to fight land degradation and enhance ecosystem services delivery. However, by focusing upon certain provisioning services (intensive commercial food production and ground water extraction) policy incentives compromise the delivery of other provisioning services (wild food, fuel, construction material and genetic diversity) as well as cultural services (recreation). These services are important to sustain people's livelihoods, particularly under communal grazing and Wildlife Management Area land use. While private land use enables the generation of higher incomes that can be invested towards SLM practices (e.g. rotational grazing and de-bushing favour the conservation of nutritional perennial grasses), these findings contrast with the common perception that communal grazing leads to rangeland degradation. Overall, communal livestock grazing was identified as the most appropriate land-use option as it delivered the widest range of ecosystem services, followed by Wildlife Management Areas, private cattle ranches and private game ranches.

The following considerations emerge from the MCDA:

(i) Cattle production in southern Botswana's rangelands tends to provide the largest financial benefits to private land users, while its negative environmental externalities affect all users of communal rangelands. The significant government support provided to the cattle sector in the form of borehole technology for ground water extraction and

through the promotion of a fencing system (i.e. land privatisation) has increased cattle populations and degradation around water points. This damages the resilience of the grazing lands and hampers the conservation of genetic diversity, at the expense of the nutritional and economic values of ecosystem services provided to society. The current policy approach to land management and the livestock sector should be revised so that a broader range of ecosystem services is supported, allowing livelihood diversification and promoting SLM.

(ii) Veld products, construction material, and fuelwood remain undervalued from an economic perspective due to the lack of a market. Access to these ecosystem services is negatively affected by the fencing policy and the intensive support provided to borehole drilling. As such, utilisation of these services under communal grazing land use is decreasing. The creation of a market with commercial potential is needed so that the provisioning values of these ecosystem services are translated into wider economic benefits to society. In order for this potential to be achieved, there is a need to identify commercially promising veld products and assess their potential markets and related values.

(iii) Similarly, the conservation of wildlife diversity across Wildlife Management Areas and communal areas is hampered by the problems identified above (i.e. livestock encroachment and rangeland degradation). Obstructed herd mobility due to fencing, both seasonal and as a response to drought, translates into declining wildlife numbers. This limits the capacity to adapt to climatic variations and decreases the economic viability of CBNRM and ecotourism activities. Livestock production and wildlife areas should be clearly separated by limiting borehole development within communal grazing land use in areas in proximity to Wildlife Management Areas. This would not only contribute positively to wildlife conservation, but would also increase livelihood diversification opportunities to the poorest households (who partially depend on subsistence hunting and gathering) by increasing the land management opportunities derived from

provisioning services, as well as potentially rewarding cultural services (i.e. recreation – trophy hunting and non-consumptive wildlife utilisation). A more diversified economy across the rangelands would also help people to decrease their growing dependence on short-term solutions such as government support. Such quick-fixes fail to address the longer-term, underlying environmental problems. Whether such diversification could feasibly include revenues from the trading of carbon credits remains unclear and requires further methodological development in terms of monitoring, reporting and verification, alongside the development of safeguards such that degradation through the encroachment of woody species is not seen to be financially rewarding.

The MCDA undertaken in this study has provided useful insights that can help focus future cost-benefit analyses for different land uses across Botswana's rangelands and in rangelands in other parts of the world. In promoting SLM practices, the economic focus of these studies should go beyond the profitability of commercial food production (where private cattle ranches land uses achieve a higher economic value) and consider the broader livelihood impacts (the social distribution of wealth and diversification), and the ecological implications of all the ecosystem services analysed (including non-marketed provisioning services and cultural values). The wider economic contributions of each land use to the national economy should also be considered as different costs and benefits accrue at different scales, both temporal and spatial.

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