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Farmers' perceptions of vegetation change, rangeland condition and degradation in three communal grasslands of South Africa

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Abstract: This study examined local people's perceptions of rangeland resources in three communal grasslands of South Africa and compared them with the views of ecologists. A total of 30 households that own livestock and two elder groups (eight elders per group) were selected in each communal area. Local respondents perceived that vegetation change mainly refers to change in species richness, diversity and abundance in vegetation that is not necessarily related to loss of productivity, feed shortage or rangeland degradation (deterioration). However, most ecologists used vegetation change and rangeland degradation synonymously to explain environmental changes. Most respondents regarded abiotic and biotic factors as the primary drivers of vegetation change and degradation, respectively. Respondents also mentioned a third group of factors, termed as 'institutional', which have been overlooked by most ecologists. One group of factors may be more important than the other but we argue that it is difficult to uncouple them to explain the determinants of vegetation change and degradation within the context of the 'commons'. The impact of human settlement expansion on grazing lands was less recognised by the respondents but we believe this poses a threat to rangelands by reducing and fragmenting grazing resources. About 50% of the elders rated the rangeland as being in poor, very poor, good or fair condition. We recommend incorporation of broader studies of farmers' perceptions in conjunction with scientific analyses in order to establish a sound communal-based rangeland development and restoration programme.

Key words: Drought, elders, overgrazing, rainfall variability, shrub invasion.

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Introduction

There are three main types of animal production systems in South Africa's extensive rangeland ecosystems, namely communal livestock, commercial livestock and wildlife (game ranching and nature conservation). These production systems vary in production goals, animal diversity and management of natural resources. Communal rangelands are almost exclusively located in the former homeland areas and account for about 13% of the total land mass and 25% of the human population of South Africa (Palmer & Bennett 2013). The grazing resource of communal areas is accessible to livestock belonging to all community members, but animal management decisions are made in most cases by the individual owners. Today, the debate about communal land

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use embraces issues of population growth, overgrazing, land deterioration and invasion by some indigenous and exotic shrub species that are considered to have degradation impacts.

Most communal livestock production systems have operated for decades rooted in the local farmers' perception and knowledge in making decisions. The farmers' knowledge is not stagnant; rather it evolves to keep pace with the changes that occur in the social, cultural, political and/or natural systems. Their perception relies mainly on current observation and recalling past events in order to foretell the socio-cultural and environmental trends and create awareness, adaptation and resilience strategies.

Rural communities in southern Africa countries have similar opinions on the range of goods and services obtained from livestock (Shackleton *et al*. 2005), but have different views on the relative importance of livestock and how their animals and rangelands are managed as well as on challenges and environmental degradation. Differences of opinion may be evident between communal groups at a finer local or geographic scale. Such instances have led many authors to draw contrasting conclusions as to the role of livestock and resource management practices in communal production systems (Shackleton *et al*. 2005).

Similar to other parts of South Africa, the communal grazing lands in the Eastern Cape Province are characterised by a complex history of state-controlled land-use planning that has impacted the resource use and management by the indigenous Xhosa people (Bennett *et al*. 2010). The interference was initiated in the mid-nineteenth century (by the apartheid authorities) by allocating communal people residential and arable land under title with access rights to a surrounding grazing area. This represented a fundamental shift in system from seasonal transhumance and shifting cultivation to one that was effectively agro-pastoral with crop production occurring on private plots and grazing on communal rangeland within fixed boundaries (Bennett *et al*. 2010). The Eastern Cape has about 3.1 million head of beef cattle, comprising almost one-quarter of the total cattle population in South Africa. Communal farmers throughout the province use their indigenous knowledge and perceptions to make decisions despite continued interference from outside. This has allowed farmers to maintain livestock for generations with little support from the government or non-governmental organisations. Nevertheless, vast communal grazing lands are threatened by rangeland degradation and encroachment by invasive species.

One invasive species that is widespread in many communal areas of the Eastern Cape is *Euryops floribundus*. This species is a multi-stemmed shrub that is believed to have a significant negative impact on the environment and on the carrying capacity of rangelands. With this in mind, a rehabilitation program was initiated in 2005 (Shackleton *et al*. 2005) to reduce the population of *E. floribundus* and consequently to facilitate recovery of the herbaceous vegetation. However, the program showed little success because critical and detailed assessment of the farmers' knowledge and views was not conducted. Examining farmers' perceptions in different community groups provides a broader understanding of the production system and major challenges including rangeland degradation. This in turn is crucial to enable appropriate decisions for intervention and policy recommendations to be made. The present study therefore was designed to assess and compare the knowledge and views of farmers from three communal areas: (1) on rangeland condition, causes of vegetation change, rangeland degradation, and invasion by *E. floribundus*; (2) on major constraints to livestock production; and (3) to compare their perceptions of rangeland condition assessment and degradation with the views of ecologists.

Materials and Methods

Description of the study area

The study was conducted in three communal areas located in the northern Eastern Cape province of South Africa. The three communal areas were Tsengiwe (31°34′S, 27°39′E; altitude 1164 m a.s.l), Upper Mnxe (31°33′S, 27°36′E; altitude 1440 m) and Manzimdaka (31°34′S, 27°42′E; altitude 1358 m). The average human population living in each village is approximately 2000. The average annual rainfall is 500 mm most of which falling in summer (November–March). The average mean temperature in summer and winter is 22 ºC and 12 ºC, respectively. The vegetation predominately comprises grasslands (Mucina & Rutherford 2011). The geology is characterised by a mosaic of mudstones and sandstones with dolerite intrusions. The soils are generally shallow and stony, except in the valley

Table 1. Baseline information on the socio-economic profiles (Mean ± SE) of the studied communities (n = 30 per communal area).

	Tsengiwe	Manzimdaka	Upper Mnxe
Household demography			
≤ 13 years old	2.3 ± 0.4[a]	2.5± 0.4[a]	2.9 ± 0.4[a]
> 13 years old	2.9 ± 0.2[b]	4.7 ± 0.5[a]	5.2 ± 0.9[a]
Total household size	5.1 ± 0.4[b]	7.2 ± 0.7[ab]	8.1 ± 1.1[a]
Education level (%)			
Illiterate	7	0	7
Primary (up to standard 5)	33	20	53
Secondary (up to standard 10)	57	80	40
Tertiary	3	0	0
Average livestock holdings (no/household)			
Cattle	7.2 ± 1.1[a]	6.4 ± 1.3[a]	5.2 ± 1.2[a]
Sheep	20.2 ± 4.8[a]	9.6 ± 2.5[b]	12.5 ± 4.1[b]
Goats	1.9 ± 1.1[b]	6.1± 1.3[a]	4.7 ± 0.8[b]
Major crop residues for feeding livestock	Maize, cabbage, oats, pumpkin	Maize, cabbage, spinach, pumpkin	Maize, cabbage
Periods of supplement	May–September	June–September, December	May–September

[*]Means with different superscripts within the same row (between villages) are significantly different ($P < 0.05$).

bottoms which are deeper. The primary livelihood activities in the communal areas are crop and animal farming as well as extraction of natural resources such as building materials, wood for fuel and fruits. Many people live in poverty as a result of high illiteracy (90%) and unemployment (80%) (Mlisa 2005). The communities have a high percentage of children and young people (<20 years old) and elderly people (>50 years old). The most economically active people (20–45 years old) comprise only 30% of the population (Beyene *et al.* 2014).

Sampling and survey approach

In each village, 30 households were selected giving a total of 90 households from the three villages. A household is defined as a husband and/or wife, or an adult man or woman with or without a child or children and/or any other person who is dependent for living and residence in the same house. Households that own livestock and headed by an adult (>35 years of age) were selected irrespective of their social or wealth status. In addition, two groups of elders which comprised eight elders per group were purposefully sampled in each communal area. The selection criteria for elders were age, the amount of time they spent in the village and livestock ownership. All elders were 60 years old or above who spent their entire lives in the area and own one or more livestock species. All elders were recommended by extension officers and local farmers.

Data collection

On the first day of data collection, an introductory workshop with extension officers, household members and elders was conducted to explain about the survey and to make appointments for interviews. Ethical clearance was then obtained from the University of Fort Hare to conduct the survey. All the interviewees were given a consent form to sign before the start of the interview. Individual households were interviewed using a structured, semi-structured, and open-ended questionnaire. Where possible, both male and

Table 2. Use of rangelands in order of importance as perceived by the elders in the three communal areas (n = 16 per communal area).

Activities	Tsengiwe	Manzimdaka	Upper Mnxe
Grazing	1.8[a]	2.2[a]	1.7[a]
Collection of Firewood/cow dung	3.1[b]	3.4[b]	3.1[bc]
Collection of building material	3.1[b]	2.8[ab]	2.1[b]
Medicine	2.3[a]	3.3[ab]	3.7[d]
Cooking	3.9[b]	3.4[b]	3.6[d]

Means with different superscripts within the same column are significantly different ($P < 0.05$).
Attributes were listed and ranked from most important (1) to least important (5).

female adults of the selected households participated in the interview. The household interview was conducted face to face in order to capture information on demography as well as livestock husbandry and importance. Semi-structured interviews and open-ended group discussions were conducted with each elder group in order to explore issues pertaining to (1) rangeland condition and trends, (2) perceptions of long-term vegetation change and rangeland degradation, and (3) causes of *E. floribundus* invasion. For data that required ranking, the respondents were initially requested to list the most important factors after which their opinions on the rankings were recorded. When it was felt that respondents' listing was inadequate, they were given additional lists for their consideration. Both household and elders' interviews were conducted between April and June 2012 using the local vernacular language.

Statistical analysis

Data were analysed using the SPSS statistical software program version 20 (SPSS 2011). For ranked data, Friedman's chi-square test was used. When this test revealed significant variation, a set of sign tests for multiple comparisons of means was performed. Descriptive statistics such as means, standard deviations and percentages were used where appropriate.

Results and Discussion

Demography

The average household size in the survey area ranged from five (Tsengiwe village) to eight (Upper Mnxe village) (Table 1). The majority of the household respondents in the three communal areas received formal education at elementary (range: 20.0–53.3%) and secondary (33.3–66.7%) school levels. The proportion of farmers who were formally employed outside the communal sector was between 3.3% (Upper Mnxe) and 10% (Tsengiwe). Household respondents owned livestock to fulfil their socio-economic and cultural needs.

The mean number of cattle head in the study areas ranged from five (Manzimdaka) to seven (Tsengiwe). The mean number of sheep was significantly higher ($F_{2,89} = 3.1$, $P = 0.05$) at Tsengiwe (20) than at Upper Mnxe (13) and Manzimdaka (10). The mean number of goats was significantly highest ($F_{2,89} = 5.8$, $P = 0.004$) at Manzimdaka (6). All household respondents revealed the seasonal fluctuation of livestock feed, both in terms of availability and quality, with a critical shortage occurring in the long dry period (May–September). The mitigation strategies in place were mainly supplemental feeding or sale of animals. The feed supplements were in the form of cereal grains, residues or by-products obtained from crops harvested in their backyards (Table 1).

Landscape classification, function and assessment

All elder groups from the three communities agreed that rangelands are primarily used for grazing. At Tsengiwe and Manzimdaka, use of rangelands to harvest medicinal plants and building materials (including household furniture and utensils), respectively were regarded as equally important as grazing (Table 2). Rangelands also provide other natural resources for direct use and/or income generation. These uses can be categorised as either primary or coincidental (secondary) and include edible wild foods, reeds, thatch grass, fuel wood, carving woods and wood roses.

About 50% of the elders from each communal area indicated that they used topography to classify their grazing lands. They divided their grazing lands mainly into bottom and upland areas. Located at higher elevations, upland grazing areas are far from the homesteads and are mainly used for grazing during the summer season when ample rainfall ensures that adequate forage

Table 3. Landscape classification, current range condition and indicators as perceived by elders in the three communal areas (n = 16 per communal area; 8 individuals per group).

Communal Areas	Land Classification	Classification Criteria	Range Condition	Indicators
Tsengiwwe				
Elder group-1	Yes	Topography	Poor	Poor grass, high selective grazing
Elder group-2	No		Very Poor	High bush encroachment
Manzimdaka				
Elder group-1	No		Good	Good body conformation of cattle
Elder group-2	Yes	Topography	Fair	Some *E. floribundus* free areas
Upper Mnxe				
Elder group-1	No		Good	Good body conformation of cattle
Elder group-2	Yes	Topography	Fair	Still able to support livestock production

production and dietary energy is available. Bottom grazing lands are located close to the homesteads at lower elevation and are used mainly for grazing in winter when forage supply is inadequate. Keeping animals close to homesteads during this critical period may be a strategic decision that allows easy inspection and monitoring of livestock, and provision of supplemental feeding and water on a regular basis. By gathering animals close to the homestead during the dry winter period, the time saved in commuting a long distance may help animals to spend more time on grazing to maximise intake of the limited energy available relative to the amount of energy spent. Gxasheka (2014) attested that the area close to a homestead is more severely degraded than areas further away because the grazing radius around the homestead is smaller, causing a higher livestock concentration per unit area and, consequently, inducing heavy grazing pressure. Most African communal farmers, including those surveyed in the current study, use their landscape knowledge to group grazing lands into homogeneous units to enable temporal and spatial relocation of livestock grazing (Oba 2012).

Compared to many other traditional pastoralists in Africa (Oba 2012), elder respondents in the present study showed less elaborate knowledge of landscape assessment, classification and grazing potential determination. The main reason may be that many African pastoralists have stronger dependency on livestock and rangeland resources for their livelihood spending more time in observation and resource assessment. This provides them in-depth knowledge of their environment enabling them to develop stronger skills of land classification, ecological and grazing potential determination.

Elders' perceptions of the current rangeland condition varied between and within each community (Table 3). In all cases, indicators were related to the key components of the system, which are livestock and pasture productivity. Useful indicators for pasture productivity included carrying capacity, forage biomass and shrub invasion whereas for livestock it mainly included body condition and foraging behaviour. This finding supports the view of Oba *et al*. (2008) and Oba (2012) who reported that African communal pastoralists combine ecological and anthropogenic indicators in rangeland condition assessments. At Tsengiwe, 50% of the elders rated the rangeland as being in poor or very poor condition. At Manzimdaka and Upper Mnxe, 50% of the elders rated the rangeland as being in good or fair condition. Elder respondents relate poor rangeland condition to low forage production, high woody plant invasion (mainly *E. floribundus*) and deteriorated animal condition. Fair range condition was related to a scattered invasion of *E. floribundus* with sufficient grazing to support livestock. Elders associated good rangeland condition to superior livestock body condition, especially that of cattle. The report of Mapiye *et al*. (2009) from the Eastern Cape province included soil condition (erosion), herbaceous basal and litter cover as well as the abundance of key forage species as indicators of rangeland condition. In Botswana, communal herders relate rangeland condition to livestock body condition, grass cover and the abundance of key palatable forbs and grass species (Reed & Dougill 2002).

Contrary to the conventional concepts and ecologists' view, the local knowledge in the present

Table 4. Attributing factors (mean rank) of vegetation change as ranked by elders in the three communal areas (n = 48).

Number	Mean rank	Attributes
1	1.80[a]	Drought
2	2.00[a]	Shrub invasion
3	3.92[b]	Grazing
4	5.00[c]	Human settlement
5	5.58[c]	Land alienation
6	5.75[cde]	Water points
7	5.75[cde]	Crop farming
8	6.17[e]	Absence of fence

Means with different superscripts within the same column are significantly different ($P < 0.05$). Attributes were listed and ranked from most important (1) to least important (8).

study provides little account of the stability and resilience of the rangelands when judging the condition. In addition, the respondents did not rank the indicators neither did they provide well-defined measurement scales and assessment scores. Yet, the inclusion of the animal component makes the assessment more realistic than the methods adopted by some ecologists. Many ecologists include the three ecosystem components (soil, grass and woody vegetation) collectively for range condition assessment. For instance, based on ranchers' opinions, Milton *et al.* (1998) suggested subjective scoring of rangeland condition using vegetation cover, forage value, utilisation intensity, plant demography, soil health and protection. According to Solomon *et al.* (2007), useful indicators for grass productivity include carrying capacity, biomass, pasture composition and quality; those for soil include erosion, ground cover and nutrients; and those for woody vegetation comprise cover and density. Such assessments that do not consider the animal component may have shortcomings because first, some forage species regarded as having poor forage quality provide adequate forage nutrients when they represent the bulk component of the grazing forage or when they are heavily and non-selectively grazed (Vetter 2013). Second, animals may perform well on rangelands with high bush density because these rangelands provide adequate supply of accessible nutritious browse and grasses beneath the canopy.

Elders' perceptions of vegetation change and rangeland degradation

Elder groups in the present study were careful to distinguish between vegetation changes and rangeland degradation. They perceived that vegetation change mainly refers to change in species richness, diversity and abundance in vegetation that is not necessarily related to loss of productivity, feed shortage or rangeland degradation (deterioration). These views of elders differ from those of pastoral herders in northern Tanzania who defined vegetation changes collectively as the gradual replacement of desirable forage species by less desirable species (Oba & Kaitira 2006). Elders in the present study recognised degradation on parts of their rangelands and described it as losses in rangeland productivity and feed supply owing to a decrease in grass cover and increased soil erosion. This finding shows that the respondents defined degradation in the context of the potential that the rangeland offers to livestock production. This definition is not as specific as that given by herders in northern Tanzania which is a decline in key forage species or an increase in the composition of increaser species (Oba & Kaitira 2006). However, it is similar in context but differs in content from the broader concepts given by some ecologists which states that degradation is a deleterious change in the rangeland for livestock production (Palmer & Bennett 2013) or persistent decrease in the capacity of an ecosystem to supply a variety of goods and services including fuel, timber, fresh water, wild foods, biodiversity habitat and tourism opportunities (Scholes 2009; Vetter 2013).

All elder respondents from the three communal areas unanimously agreed that vegetation change has occurred since they settled in the area, whereas they perceived rangeland degradation to be a recent phenomenon. They held similar opinions on the listing and ranking of the factors contributing to vegetation change (Table 4). For rangeland degradation, the factors perceived to be responsible were similar between communal areas, but the rank on the order of importance was different (Table 5). Five contributing factors (shrub invasion, grazing, human settlement, water points and absence of fencing) listed under vegetation change overlapped with land degradation, although they were not ranked in the same order of importance. Elder respondents ranked recurrent drought and shrub invasion (*E. floribundus*) as the primary factors contributing to vegetation change

Table 5. Attributing factors (mean rank) of rangeland deterioration as ranked by elders in three communal areas (n = 16 per communal area).

	Communal areas		
	Tsengiwe	Manzi-mdaka	Upper Mnxe
Frequent natural fire	8.0 ± 0.1^{d}	9.0 ± 0.0^{e}	3.5 ± 1.5^{b}
Shrub invasion	1.5 ± 0.5^{a}	2.0 ± 0.1^{a}	3.0 ± 0.0^{b}
Absence of fencing	2.0 ± 0.1^{a}	3.0 ± 0.1^{b}	7.0 ± 1.1^{e}
Human settlement	9.0 ± 0.0^{e}	9.0 ± 0.0^{e}	6.5 ± 0.5^{e}
Overgrazing	5.5 ± 2.9^{c}	4.5 ± 1.5^{c}	5.0 ± 1.1^{cd}
Rainfall variability	5.5 ± 2.5^{c}	5.5 ± 0.5^{c}	1.0 ± 0.0^{a}
Soil depth	6.5 ± 2.5^{cd}	5.5 ± 1.5^{c}	9.0 ± 0.0^{f}
Topography	4.5 ± 0.5^{bc}	3.0 ± 1.1^{acb}	5.0 ± 2.1^{cd}
Water point development	7.5 ± 1.5^{d}	8.5 ± 0.5^{d}	6.5 ± 2.5^{de}

Means with different superscripts within the same column are significantly different ($P < 0.05$). Attributes were listed and ranked from most important (1) to least important (9).

followed by grazing, expanding human settlements and land alienation, respectively. There is ample evidence to support the change in vegetation in response to shrub invasion (Pihlgren & Lennartsson 2008) and grazing (Palmer & Bennett 2013; Todd 2006; Vetter 2005). Other factors included the use of drinking water points for animals, increased crop farming and absence of fencing on the grazing lands. These factors are given lower ranks by the elders probably because they have indirect effects via modification of the livestock concentration and distribution. The contribution of water-point development to vegetation change as observed by respondents is consistent with many previous reports (e.g. Bennett *et al*. 2010; Palmer & Bennett 2013; Todd 2006).

Elders' perception in the present study did not relate drought, land alienation and crop farming to rangeland degradation. Rather, with reference to drought, degraded areas are prone to physiological stress and as a result, pseudo-drought may occur. On the other hand, Borana elders in southern Ethiopia (Solomon *et al*. 2007) stressed that recurrent drought causes low forage production with eventual consequences of overgrazing and degradation.

Elders from Tsengiwe and Manzimdaka villages perceived that shrub invasion and absence of fencing are the primary factors contributing to degradation followed by topographic features (grazing lands with different landscape positions possess different resistance to degradation), overgrazing (leading to decreased herbaceous cover), rainfall variability and soil depth. As already mentioned, shrub invasion is perceived to cause changes in vegetation without having a detrimental effect on land productivity, but as it advances, grazing lands will be transformed into a state of degradation. Indeed, some shrub species can benefit the ecosystem by enriching the soil organic matter and nitrogen. They can also provide feed for livestock, wood for fire and construction and leaves and bark for medicinal purposes.

The most probable explanation of elders for ranking the absence of fencing as the primary factor contributing to degradation is that fencing hinders undesired livestock movement, concentration and distribution and their negative consequences. The perceived views of elders on the absence of fencing could be explained further by the positive impacts that fencing may have 1) on effective and sustained utilisation of heterogeneous land units, 2) on the control of cross-border livestock movement between communities and, therefore, significant reduction in grazing intensity, 3) on provision of forage/fodder reserves to relieve grazing pressure during periods of low rainfall, 4) on reduction of grazing land invasion by unplanned settlements and crop farming, and 5) by serving as a catalyst to create functional local management institutions through developing communities' sense of 'community' and control over their resources. Construction of fencing could promote conservation, restoration and utilisation of forage resources through improved pastoral management strategies (Twyman *et al*. 2001).

Elders from the above two villages perceived that overgrazing result in degradation by decreasing the abundance and cover of perennial grass species that have strong stability effects. Kairis *et al*. (2013) and Kosmas *et al*. (2013) observed that loss of vegetation cover through overgrazing was the leading indicator of rangeland degradation in Botswana

Elders from the third village (Upper Mnxe) had different views from the aforementioned two communities. They regarded rainfall variability as the most critical factor contributing to rangeland degradation followed by fire, shrub invasion, overgrazing and topography. Their perception of rainfall challenges the assumption of Behnke *et al*.

Table 6. A summary of drivers of vegetation change, rangeland degradation, average scores and their intervention and policy implications.

Drivers	Components	Average score attributing to VC	Average score attributing to RD	Interventions/policy
Abiotic	Drought Rainfall variability	1.8	5.5	Create range resource and weather monitoring program; Resilience: plan destocking-restocking scheme by considering socio-economic and cultural values of livestock: Schemes to access inputs and markets (Vetter 2013); supplementation to relief grazing pressure; develop forage/ fodder reserves; policy to support crop-livestock interactions (Letty and Alcock, 2013), government support to establish and maintain effective local resource management (Bennett *et al.* 2010; Bennett 2013).
Biotic	Animal related: over grazing	2.9	3.7	Grazing management to encourage fair concentration and distribution of animals to avoid selective and over-grazing; create effective local institutions for governance of local rangeland resources and training of farmers to equip with the training and means to monitor and manage the rangeland resources (Vetter 2013); develop local resource management rules (Bennett *et al.* 2010); policy to create communities' sense of 'community', security of tenure and gain over their local resources; formulate policy to prevent rangeland degradation and restoration interventions (Bennett *et al.* 2013); establish clear boundaries between communities.
	Plant related: shrub Invasion			Practice shrub control, deferred grazing to restore grass cover, and apply suitable grazing management; establish trials to find new ways to control bush/shrub encroachment; apply holistic management to maintain the health of rangelands. Policy to allocate lands locally to carry out trials and for demonstration purposes.
Institutional	Local issues: absence of fencing and water development; crop farming	5.6	6.5	Clear legislation on land use and development; Involve local people in planning and making decision.
	National issues: human settlements, land alienation			Clear national policy on land use planning

Attributes were listed and ranked from most important (1) to least important (8) for vegetation change (VC) and from (1) to (9) for rangeland degradation (RD).

(1993) who claimed that it is only arid rangelands that are driven by the erratic nature of rainfall.

Debates on drivers of rangeland ecology: policy and intervention implications

Elders' perceptions of vegetation change and rangeland degradation contribute to the on-going scientific debate on the drivers of African rangeland ecosystems in the context of communal land-use. Unlike most ecologists who discuss vegetation change and degradation synonymously, farmers in this study drew a clear distinction between these two phenomena. Also, many ecologists consider drought and rainfall variability

to have an overlapping influence on vegetation dynamics and rangeland degradation. However, respondents in the current study provided a different insight. They perceived that drought occur over long time intervals and represents an extended period (e.g. a full season or multiple seasons) of extremely low or absence of rainfall with negligible impact on rangeland degradation. On the other hand, rainfall variability may be a recurrent phenomenon referring to the variation in the amount of rainfall across years within acceptable high or low coefficient of variation. This phenomenon may result in an imbalance between forage supply and livestock density in a recurrent manner and may eventually lead to overgrazing and degradation.

Based on the current study and reviews of previous studies, Table 6 summarises the drivers of vegetation change and rangeland degradation, and their implications for policy and interventions. Most elders in the present study consider abiotic (drought) more than biotic factors as the main drivers of vegetation change, whereas they favour the later over the former as drivers of rangeland degradation. Several researchers agree that livestock density drives equilibrial responses in vegetation change in semi-arid rangelands, and land degradation is an invariable outcome of keeping livestock numbers beyond the ecological carrying capacity (Smet & Ward 2005). Hardin (1968) proposed the "tragedy of commons" theory, which stated that heavy stocking together with little or no management of the common resources have caused rangeland degradation on African rangelands. Other researchers such as Ellis & Swift (1988) and Westboy *et al.* (1989) proposed a non-equilibrium model to show that abiotic events, in particular rainfall, are more detrimental than livestock. Indeed, many ecologists consider rainfall variability to be a key driver although they are not transparent if this leads to rangeland degradation. Supported by the views of some elders, we challenge the aforementioned authors' theory by emphasising that grazing pressure is more detrimental than rainfall variability. We hypothesise that plants are less damaged and recover more quickly after a period of low rainfall if they are not subjected to moderate or heavy grazing pressure before, during or after the low-rainfall year. However, recovery may be slow or irreversible if the plants are repeatedly grazed during low rainfall periods resulting in a net loss of vegetation cover that will lead to degradation.

Recent reports of Vetter (2005), Solomon *et al.* (2007) and Tefera (2013) indicated that semi-arid African rangelands exist as complex ecosystems where both equilibrial and non-equilibrial elements interplay and act together. The authors argued that communal grazing *per se* should not be considered a tragedy, rather a combination of anthropogenic and abiotic factors are responsible. The importance of one or combinations of the driving elements may depend on the local (small), intermediate or regional (large) land-scale levels as well as on the land use and management practices. In addition, other drivers of vegetation change such as elevated CO_2, increased surface temperature (Hoffman *et al.* 2011) and reduced potential evapotranspiration (Eamus & Palmer 2007) have been recently suggested.

Respondents in the present study also emphasised a third group of factors, collectively termed as 'institutional' (Table 6), as drivers of vegetation change and rangeland degradation. These factors have been overlooked by most ecologists. Among the institutional factors, growing of human settlements was largely underestimated by the elder respondents as the cause of land degradation. However, we believe that this may pose a serious threat to rangelands by reducing and fragmenting grazing lands. A recent study in Botswana (Mulale *et al.* 2014) concluded that implementation of unsuitable land-use policy and legislation contributed significantly to communal land degradation.

In sum, we agree that one factor may be considered more important than the other, but contend that it is difficult to uncouple their effects because of their co-existence in the complex system (Allsopp 2013). We also suggest that these complex systems do not operate in conditions far from equilibrial theory. However, the management and restoration of rangelands require multi-faceted proactive interventions by considering the interaction of these driving factors. Therefore, more understandings of the links between the institutional issues, biotic and/or abiotic determinants are needed to develop guide for effective management, restoration and resource utilization decisions.

Euryops floribundus *invasion as a constraint to livestock production*

Elder groups from the three study areas perceived that invasion of *E. floribundus* and low herbage production were regarded as the most

Table 7. Constraints to livestock production as ranked by elders in the three communal areas (n = 48).

Number	Mean rank	Attributes
1	1.83[a]	High shrub density (*Euryops floribundus*)
2	2.17[a]	Low grass yield
3	3.00[ab]	Recurrent drought
4	3.67[bc]	Low forage quality
5	4.33[c]	Soil erosion
6	6.00[d]	Crop farming

Attributes were listed and ranked from most important (1) to least important (6).

important constraints to livestock production followed by recurrent drought and low forage quality (Table 7). Invasion by *E. floribundus* restricts livestock movement and fragments the grazing lands. It makes access to grazing areas more difficult and time-consuming and consequently, the total daily forage intake by animals may be lowered. Farmers were unanimous in their opinion that *E. floribundus* is an unpalatable plant. In addition, twigs of the shrub remove wool from the sheep reducing both the quantity and quality of production. Invasion may cause damage to herbaceous plant diversity as well as to the soil, and therefore may disrupt the food-chain relationships within the ecosystem. *Euryops* invasion may reduce the social amenities and recreational values of the rangelands including the cultural, spiritual, ceremonial and aesthetic values that are enjoyed by the community. Such non-marketable and indirectly usable outputs are difficult to quantify and are often underestimated.

All elders from the three communities agreed that they did not observe *E. floribundus* shrub in the grasslands when they were teenagers. They indicated that the shrub was first observed about 20 years ago, increased to a moderate cover about 10 years ago and have become more abundant only in recent years. This supports the hypothesis that widespread and massive shrub invasion occurs gradually over several decades (Solomon *et al*. 2007).

Conclusion

The communal production system in the study areas is characterised by the use of rangeland resources for livestock production. Rangelands also provide other goods and services that optimise livelihood security. Most elders in the present study believe abiotic (drought) and biotic factors to be drivers of vegetation change and rangeland degradation, respectively. Certainly, one group of factors may be considered more important than the others but we argue within the context of the 'commons' that it is difficult to uncouple them to explain the determinants of vegetation change and degradation. The impact of settlements expansion on grazing lands was less frequently recognised by the respondents, but we believe this poses a threat to rangeland ecosystems by reducing and fragmenting grazing resources. With regard to environmental changes, local people's perceptions and the views of ecologists show many differences. Most ecologists consider drought and rainfall variability to have an overlapping influence on vegetation dynamics and rangeland degradation. In contrast, local respondents perceived that the two factors influence the rangeland ecosystem differently. Low forage supply and *E. floribundus* invasion appeared to be most detrimental to livestock production. We recommend broader studies of farmers' perceptions in conjunction with scientific analyses in order to establish a sound communal-based rangeland development and monitoring strategy. Understanding the links between institutional issues (including infra-structure, policy and legislation issues) and biotic and/or abiotic determinants will help develop effective rangeland management and restoration programmes.

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