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The Effect of Land-Use on the Species Composition and Rangeland Condition in the Molopo District of the North West Province, South Africa

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Abstract: In this paper the effect of commercial and communal land-uses on the species composition and rangeland condition, expressed in grazing value, in the Molopo district of the North West Province, South Africa was investigated. Herbaceous species composition data was gathered in benchmarks sites as well as grazed sites outside the benchmarks in both land-use systems. Rangeland condition scores, based on the grazing value of the herbaceous species, were calculated. Results showed that land-use had a definite influence on the herbaceous species composition as well as the rangeland condition. However, it was also shown that broad management extrapolations between the land-use systems would be unscientific as new vegetation states, with unique compositions and dynamics, developed in the communal land-use system.

Key words: and-use, commercial, communal, species composition, rangeland condition, state-and-transition model, restoration

1. Introduction

Extensive livestock production from natural rangeland areas remains an important aspect of agriculture in commercial and communal livelihoods in many parts of the world [1, 2]. Rangeland is defined as lands on which the indigenous vegetation is predominantly grasses, grass-like plants, forbs, or shrubs and are managed as a natural ecosystem [3]. If properly managed rangelands can provide food security and poverty alleviation to millions of people [4]. Although rangelands are one of the Earth's major ecosystems, estimates of the amount of the Earth's land surface covered by rangelands vary from 18% to 80% [4]. According to Thomas [5] approximately 50% of the land surface of the Earth is rangeland. Of the total agricultural land in South Africa, 84 million hectares or 68.6% is rangeland [6, 7]. In the North West Province of South Africa, rangelands comprise 56% of the Province's surface [8].

It is thus clear that rangelands play an important role in extensive livestock production, not only in the North West Province of South Africa, but in the country as a whole. The following statement is often made to livestock producers at information days: *Rangeland is the farmer's cheapest fodder source*. Although this statement is not wrong, it is incomplete as rangeland is only a cheap fodder source if the rangeland condition is good or the rangeland can be described as healthy. Rangeland in good condition or a healthy rangeland is defined as the degree to which the integrity of the soil, the vegetation, the water and air as well as the ecological processes of the rangeland ecosystem are balanced and sustained [9, 10].

There are three main types of animal production systems (land-uses) in South Africa's extensive rangeland ecosystems, namely communal livestock, commercial livestock and wildlife (game ranching and

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nature conservation) These production systems vary in production goals, animal diversity and management of natural resources and everyone has a distinctive influence on the condition/health of the rangeland [11].

Land degradation, as an issue in South Africa, has been around for more than a century [12] and many authors blamed land-use practices and especially communal land-use practices for this degradation [13-17]. In 1999 a comprehensive study was done in 367 magisterial of South Africa, where experts of these districts had to give inputs, amongst other things, about the rangeland condition, soil condition, and reasons for the status of the rangelands and soils in these districts [18]. Results from this study showed that the mean values, for the severity of rangeland degradation, in all communal magisterial districts in South Africa, were 66% higher than the mean for commercial districts [19]. In the North West Province of South Africa the severity of rangeland degradation was almost three (3) times (63%) higher in the communal areas than in the commercial areas [19, 20]. The mean values for the severity of soil degradation in all the communal districts in South Africa were 65% higher than the mean for the commercial districts [21]. In the North West Province the severity of soil degradation was four (4) times (±80%) higher in the communal areas than in the commercial areas [20, 21]. The results also showed that there was an order of magnitude difference for the mean rate of rangeland degradation between the commercial and communal areas. Values for the commercial districts were little different from zero, indicating no change in the rate of rangeland degradation over the last 10 years. For the communal areas, however, the mean values suggest that rangeland degradation is increasing at a rate somewhere between "slow" and "moderate" [19]. Some of the reasons cited by the experts who participated in this study were as follows [19, 21]:

- An overestimation of the carrying capacity of the region resulting in loss of vegetative cover and increased soil erosion;
- Increase in stock numbers because more people require more livestock;
- Poor education programs concerning natural resource management;
- No infrastructure and neglect or destruction of existing infrastructure, especially fencing;
- Inappropriate rangeland management programs;
- Deforestation on the grazing lands has increased levels of soil erosion;
- Historical impacts of overgrazing in some areas makes restoration very difficult;
- The communal system of land tenure *per sé* was frequently also raised as a major stumbling block in the rehabilitation of degraded grazing areas. The lack of institutional control and lack of responsibility were often cited as reasons for the high levels of rangeland degradation in communal areas.

Most of these reasons are often also cites in other studies in South Africa an Africa as a whole as the culprits of rangeland and soil degradation [1, 2, 3, 16, 17, 19, 20, 21, 22].

The aim of this paper is not to compare commercial and communal rangeland systems with each other in order to see if one is better than the other, but it is purely to evaluate what the effect of the two systems (land-uses) on the species composition and rangeland condition was. Since the geology, soil, vegetation type and rainfall of both the commercial and communal areas are the same, changes in the measured variables can mostly be attributed to land-use.

2. Materials and Methods

2.1 Study Area

The study area falls within the Eastern Kalahari Bushveld [23] of the North West Province (Fig. 1), South Africa. This vegetation type falls within the Savanna Biome. This Biome is characterized by a grassy ground layer and a distinct upper layer of woody plants [24].

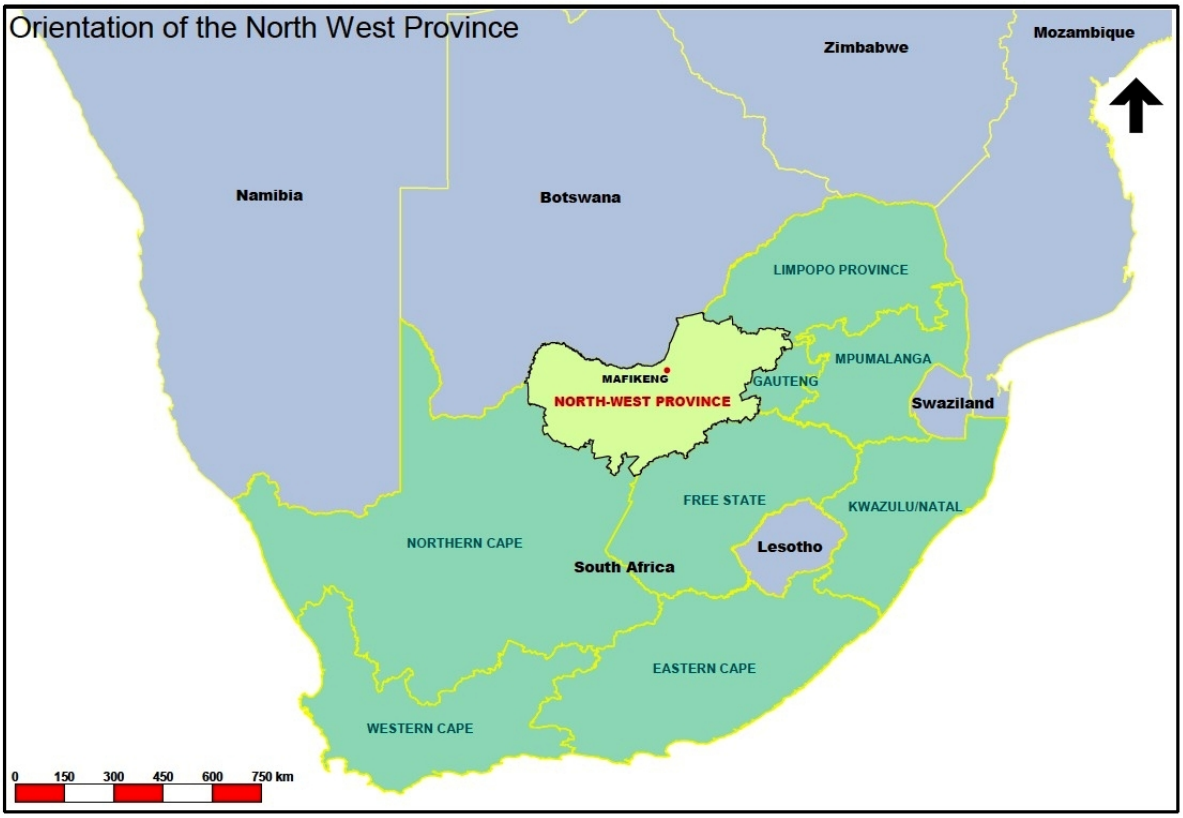

Fig. 1 Orientation of the North West Province in South Africa.

The geology and soils can be described as Aeolian Kalahari sand of Tertiary to Recent age on flat sandy plans — the soils are more than 1.2 m deep [23]. The study area receives summer rainfall, whilst the winters are very dry. The mean annual precipitation (MAP) is approximately 350 mm to the west and ±450 mm to the east [23]. The bulk of the rainfall in the study area is between January and March. The study area is characterised by great seasonal and daily variations in temperature. Mean monthly maximum and minimum temperatures are 35.6°C and -1.8°C in November and June, respectively [23]. The absolute maximum temperatures range up to 42°C [24], with the absolute minimums ranging between -8.3°C and -9.7°C [25, 26].

As was mentioned, the study area has well developed tree and shrub layers and a grassy ground layer [24]. Rangelands in good condition are normally dominated by grass species like *Anthephora pubescens, Schmidtia pappophoroides* and *Brachiaria nigropedata,* whilst the rangelands in poor condition are dominated by grass species like *Aristida stipitata, Schmidtia kalahariensis* and *Pogonarthria squarrosa* [23, 25, 27].

2.2 Experimental Outlay

The study area falls within the Kagisano-Molopo municipal district (agricultural area). Within this area three (3) commercial land-users and three (3) communal villages were identified (Fig. 2). The three communal villages were specifically chosen because the tribal authorities gave their permission for and cooperation with the project. They have also promised to put measures in place to ensure that the fencing material of the benchmark sites are not stolen. On each of the commercial farms rangeland in good and poor condition was identified. The identification of good and poor rangelands in the study area was based on the expert knowledge of researchers, technical staff, extension personnel and farmers of the area.

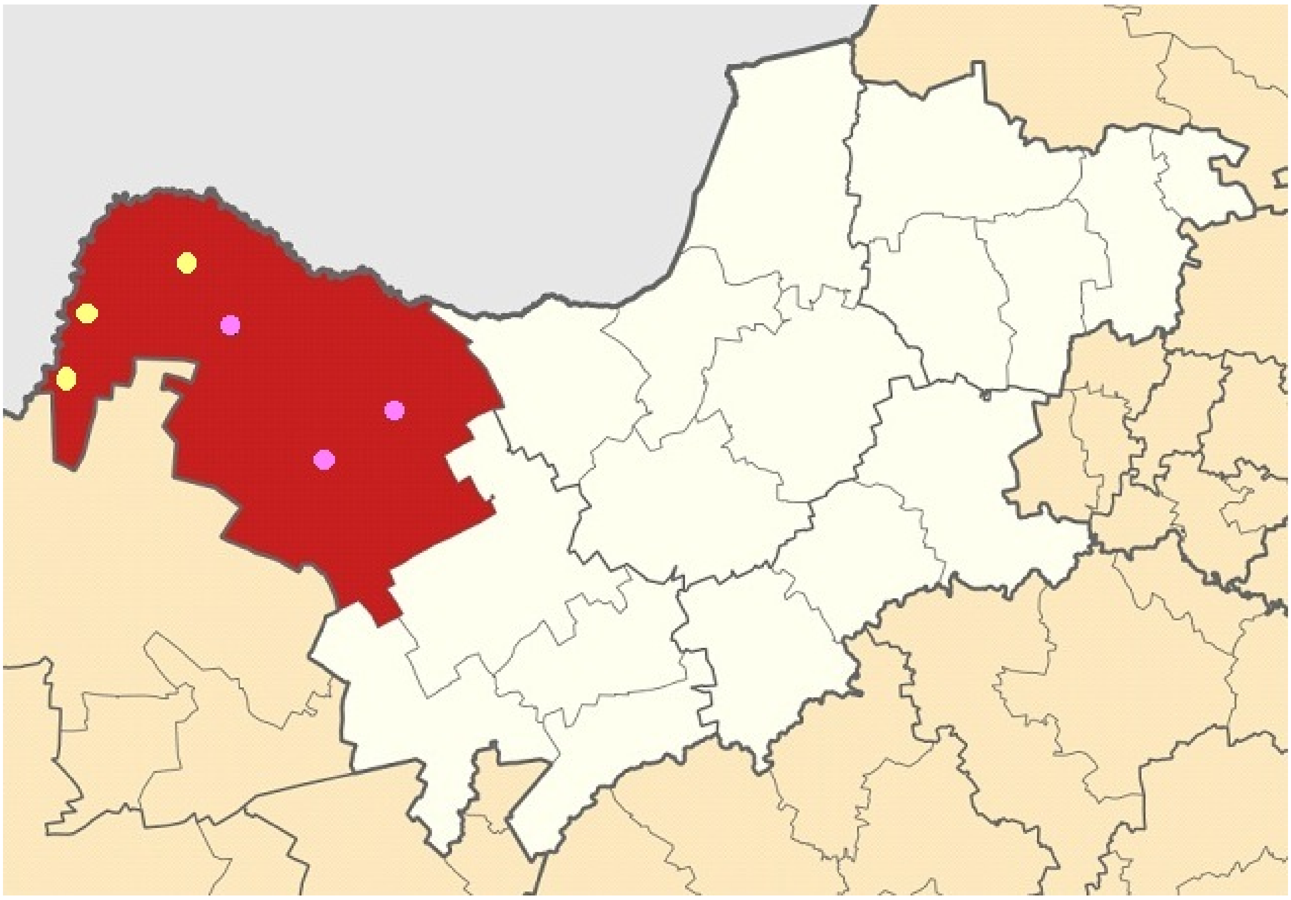

Fig. 2 The study area in the Kagisano-Molopo municipal district (red part). Yellow dots = commercial land-use; pink dots = communal land-use.

On each farm eight (8) survey sites were identified — three sites in good rangeland; three sites in poor rangeland and one benchmark site in good condition and one benchmark in poor condition. The same rational was followed in the communal villages. The size of a benchmark site was 120 m ×30 m. In total 48 survey sites were identified — 12 benchmark sites and 36 sites outside the benchmark sites (will further be referred to as *grazed sites*).

2.3 Data Sampling and Data Analysis

Herbaceous species composition surveys were done on fixed transects in both the grazed and benchmark sites. These surveys were done at the end (May) of the rainy (growing) season for this area using the descending point, nearest-plant method [25, 28]. Frequency of occurrence was established with the wheel point apparatus [29] and by using the Psion Monitor. The Monitor statistically determined the number of points that should be surveyed at each survey site in order to give a significant reflection of the species composition. Hence, the surveys on the fixed transects did not have a specific number of survey points, since surveys were completed once 98% of the variation had been sampled. Nearest plant point surveys within a radius of 45 cm of that point were performed. When an annual herbaceous species or a bare patch was pointed out, the nearest perennial species within a radius of 45 cm from the point was also recorded. When the nearest plant was further than

45 cm from the marked wheel point, it was recorded as a bare patch. Bare ground was thus recorded as a "vegetation species", and equates to the lack of herbaceous cover within that point (radius of 45 cm for this study) [25, 30]. Point observations were spaced by 1 m intervals and records were made over the length of the survey site, moving in straight parallel lines and with approximately 1 m distance among them.

The first step in the data analysis was to use different ordinations within the CANOCO 4 package [31] in order to determine if differences do occur between the two land-use types as well as what the movement and thus stability of the sites within each land-use was.

For the calculation of the rangeland condition index the classification of the grasses for this paper was based on the quantitative climax method of Dyksterhuis [32] and adapted according to the ecological information for the arid to semi-arid regions of South Africa [33-40]. For this paper the species were classified according to the grazing-index and rangeland condition scores were calculated to convey multivariate information about the current state of the vegetation at a site. Classification according to the grazing-index grouped species into: (i) highly desirable species (HD), (ii) desirable species (DE), (iii) less desirable species (LD), (iv) undesirable species (UD) and bare patches (BP). The grouping of the species was also based on specialists' knowledge for the particular survey area [25]. Each class was given a relative index value: highly desirable species = 10; desirable species = 7; less desirable species = 4 and undesirable species = 1 [36]. The range condition index was calculated by summing the percentage composition of grass species in each class, after which the sum for each class was multiplied by its relative index value.

Although this is an ongoing project, herbaceous species composition data from the 2003/2004 to the 2017/2018 seasons (data of 15 years) will be discussed in this paper.

3. Results

3.1 Rainfall

The results of the rainfall data for the 2003/04 to 2017/18 are shown in Figs. 3 and 4. The mean average rainfall for the commercial and communal areas were 366mm and 431mm respectively. These averages corresponds well with long term rainfall figures obtained from the farmers of these two areas — a figure of 350 mm was given by the framers for the commercial areas and 431mm for the communal areas. From these figures it is further clear that seven (7) seasons can be described as receiving below average rainfall and eight (8) seasons receiving above average rainfall. Although seasons 2006/07 and 2014/15 in the communal areas (Fig. 4) appear to be average rainfall years, the distribution of the rainfall throughout the seasons was very erratic — in both seasons the active growing period (January-March) received below average rainfall and was thus identified as "dry" years. The same tendency occurred during the 2017/18 season in both areas (Fig. 3 & 4). From these figures it appears that above average rainfall occurred, but again below average rainfall was received during the growing season in both areas.

3.2 Ordination

The ordination results of the Detrended Correspondence Analysis (DCA) of the whole data set is shown in Fig. 5. From this figure it is clear that, with the exception of a few sites in the middle of the ordination, the two land-use form two distinct groups which is a clear indication that the two land-uses had a definite influence on the herbaceous species composition. There is also a degradation gradient visible with the poor sites on the one side and the good sites on the other side (Fig. 5).

3.3 Herbaceous Species Composition

For the herbaceous species composition the results of both the benchmark sites and the grazed sites (outside the benchmark sites) are given in Table 1. In the results the distinction is not only between the grazed and benchmarks sites of the two land-uses but a distinction is also made between the above average rainfall (referred to as wet seasons — average rainfall for the study period = 550.6 mm/annum) and the below average rainfall (referred to as dry seasons — average rainfall for the study period = 310.4 mm/annum).

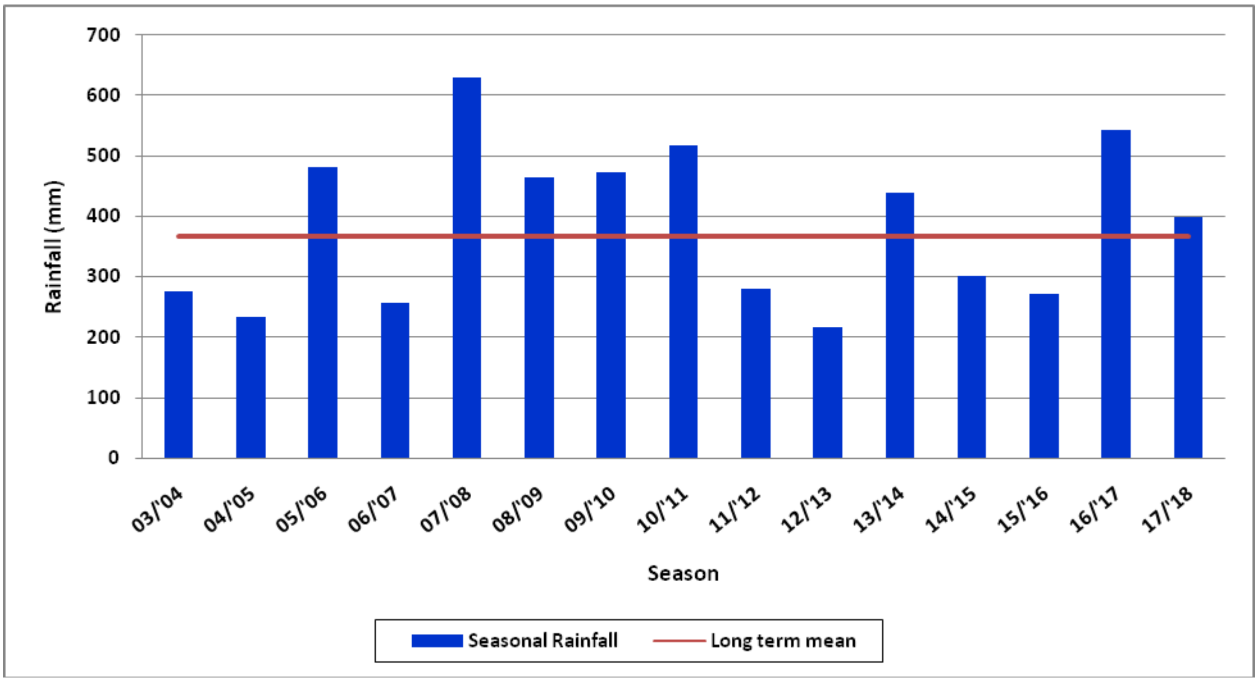

Fig. 3 Rainfall data for the commercial areas for the period from 2003/04 to 2017/18.

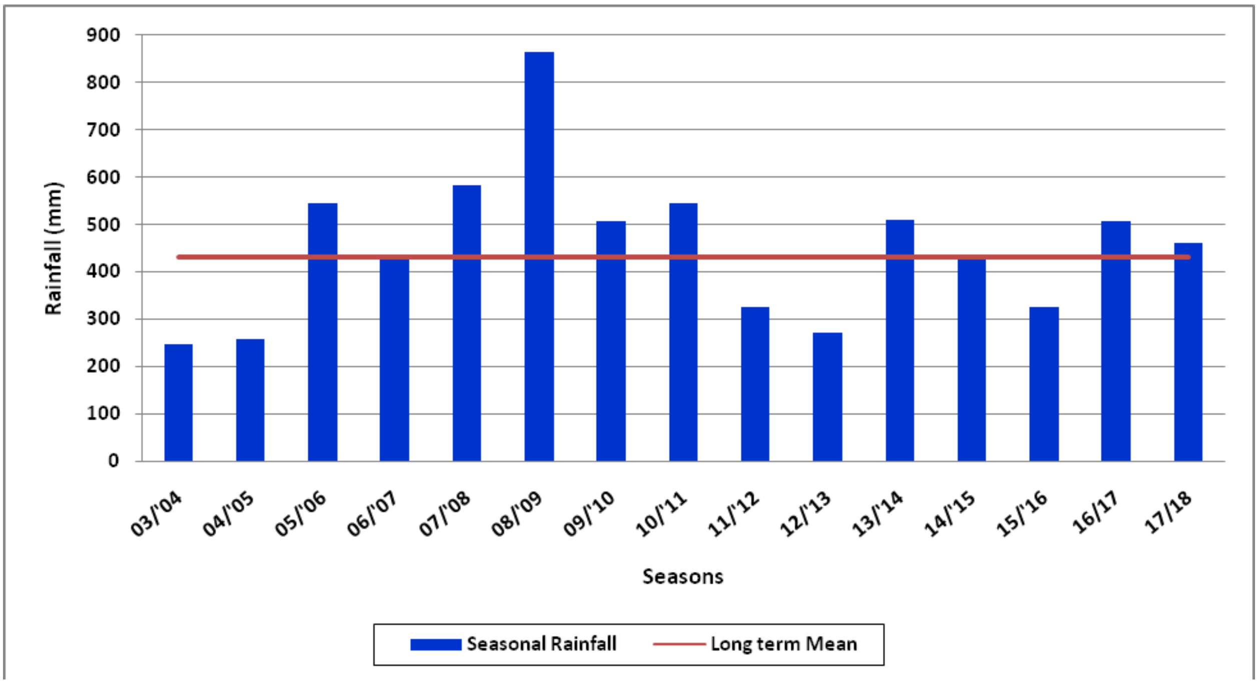

Fig. 4 Rainfall data for the communal areas for the period from 2003/04 to 2017/18.

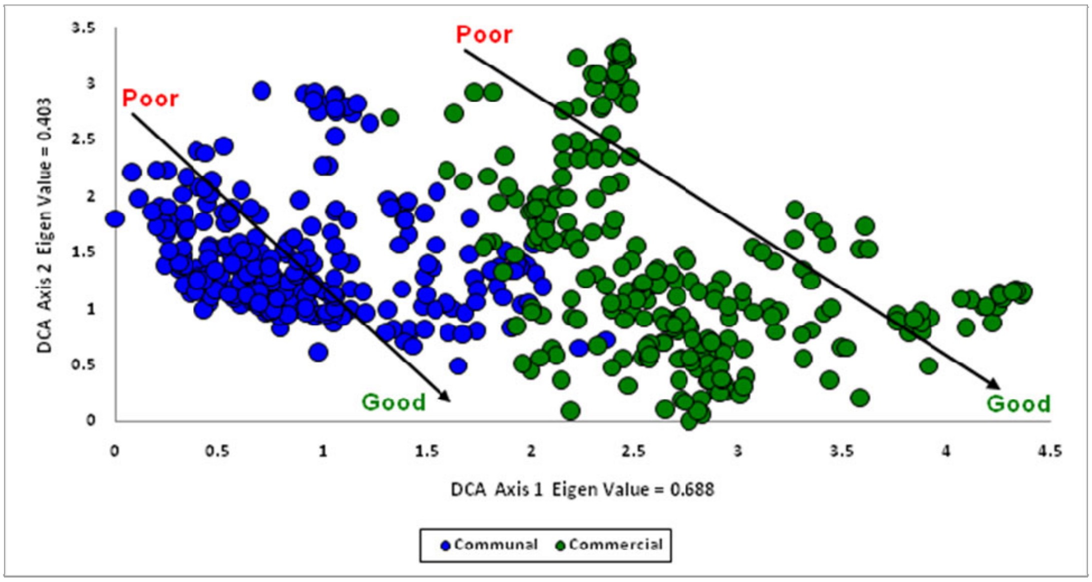

Fig. 5 Detrended Correspondence Analysis of the herbaceous data of the communal and commercial land-uses

Table 1 The effect of two different rainfall regimes on the herbaceous species composition (%) of the good grazed and good benchmark sites in the commercial and communal land-uses (data from 2003/04 to 2017/18) (BM = Benchmark sites; GRZ = grazed sites outside benchmarks).

	Grass species	Wet season (550.6 mm/annum)				Dry season (310.4 mm/annum)			
		Commercial		Communal		Commercial		Communal	
		BM	GRZ	BM	GRZ	BM	GRZ	BM	GRZ
HD	*Anthephora pubescens*	17.1	14.6	-	-	15.9	17.3	-	-
	Brachiaria nigropedata	5.0	4.6	0.1	0.1	3.8	4.5	0.1	0.1
	Centropodia glauca	0.3	1.5	-	-	0.3	1.1	-	-
	Digitaria eriantha	-	0.1	17.6	4.1	-	0.4	12.4	2.9
	Schmidtia pappophoroides	57.6	40.6	23.1	7.2	54.3	38.2	21.2	8.2
	Sub total	**80.0**	**61.4**	**40.8**	**11.4**	**74.3**	**61.5**	**33.7**	**11.2**
DE	*Eragrostis lehmanniana*	9.9	16.2	4.7	16.1	10.4	13.1	6.5	15.6
	Stipagrostis uniplumis	8	11.5	2.9	6.8	9.8	14.0	2.0	7.6
	Sub total	**17.9**	**27.7**	**7.6**	**22.9**	**20.2**	**27.1**	**8.5**	**23.2**
LD	*Aristida stipitata*	0.	2.4	19.9	19.8	0.5	2.5	17.8	16.4
	Eragrostis trichophora	0.1	0.1	7.8	8.7	-	-	6.4	8.5
	Schmidtia kalahariensis	0.2	2.0	-	0.1	1.9	1.9	1.3	0.1
	Sub total	**0.6**	**4.5**	**27.7**	**28.6**	**2.4**	**4.9**	**25.5**	**25.0**
UN	*Aristida congesta*	0.3	0.8	7.6	14.0	0.3	0.4	7.2	11.2
	Aristida meriodinalis	-	0.7	2.6	2.7	-	0.6	3.5	2.7
	Brachiaria marlothii	-	-	-	0.5	-	-	-	0.4
	Eragrostis pallens	-	-	3.2	5.3	-	0.2	5.5	6.7
	Melinis repens	0.4	1.0	2.7	2.5	0.5		3.3	3.0
	Perotis patens	-	-	0.5	1.6	-	-	0.5	1.7
	Pogonarthria squarrosa	0.2	0.6	5.1	5.1	0.1	0.5	7.2	5.0
	Triraphis andropogonoides	-	-	1.0	1.0	-	-	1.0	1.4
	Urochloa brachyura	0.3	2.2	0.1	0.7	0.5	1.4	0.3	0.9
	Sub Total	**1.2**	**5.3**	**22.8**	**33.8**	**1.4**	**3.7**	**28.5**	**33.0**
	Bare Ground	0.2	1.1	1.1	3.3	1.7	2.8	3.8	7.6
	Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

From Table 1 it is clear that the tendency for the benchmark sites of the commercial and communal land-uses is the same for the wet and dry seasons. In the benchmark sites of both land-uses there is a slight decrease in the abundance of the highly desirable (HD) and a slight increase in the abundance of the desirable (DE) species from the wet to the dry season. There is also an increase in the abundance of the less desirable (LD) and undesirable (UD) species in the benchmark sites. The biggest difference in the species composition of the benchmark sites is however, between the commercial and communal land-uses, irrespective of the rainfall (Table 1). The herbaceous species composition of the commercial land-use comprises mainly of HD and DE species (±98% during wet seasons and 94.5% during dry seasons), whilst the LD and UD species only contribute 1.8% (wet seasons) and 3.8% (dry seasons). However, in the communal land-use the contribution of the HD and DE species is only 48.4% (wet seasons) and 42.2% (dry seasons), whilst the contribution of the LD and UD species is 50.5% (wet seasons) and 54% (dry seasons). Species like *Anthephora pubescens, Brachiaria nigropedata* and *Schmidtia pappophoroides*, which are indicative of rangeland in good condition [23], are either not present or present in a low abundance in the communal land-use. *Aristida stipitata, A. congesta, Eragrostis pallens* and *Pogonarthria squarrosa* are indicative species of rangeland in a poor condition [23]. The contribution of these species to the total species composition of the benchmark sites of the communal land-use (wet and dry seasons) is between 3% and almost 20%. In the benchmark sites of the commercial land-use the abundance of these species is either low or they are totally absent from the composition. *Digitaria eriantha* (HD species) which is present in the benchmark sites of the communal land-use was formerly known as *D. pentzii*, a stoloniferous species which is known to colonise sandy soils that is heavily grazed. Although the percentage bare ground was relatively low in the benchmark sites of both land-uses in both the wet and dry seasons, it is clear that the percentage bare ground for the communal land-use is higher than that of the commercial land-use.

Results of the grazed rangeland indicate that there is a 12%-19% decrease in the HD species of the commercial land-use (dry and wet seasons), whilst the abundance of the DE species increased between 7%-10% for the different seasons (Table 1). This is mainly due to the fact that the abundance of *S. pappophoroides* (a highly palatable species) is lower in the grazed rangeland as in the benchmark sites, whilst the abundance of *E. lehmanniana* (a palatable sub-climax species) is higher in the grazed sites than in the benchmark sites. However the HD and DE species of the grazed rangeland still comprises 89.1% (wet season) and 88.6% (dry season) of the total species composition. These figures correspond well with figures of the benchmark sites, namely 97.9% (wet season) and 94.5% (dry season).

In the communal land-use the decrease in abundance of the HD species is more drastic than in the commercial land-use. The abundance of the HD species in this land-use decreased from 40.8% to 11.4% (a 29.4% decrease) during the wet seasons, whilst the decrease was from 33.7% to 11.2% (a 22.5% decrease) during the dry seasons. *Schmidtia pappophoroides* and *D. eriantha* are the two species that are heavily grazed outside the benchmarks. It is further evident from Table 1 that the LD and UD species contribute the most to the species composition of the grazed communal land. During the wet season the contribution of these two species groups is 62.4% whilst it is 58% during the dry seasons.

The herbaceous species compositions of the poor benchmark sites of the commercial and communal land-uses are shown in Table 2.

From Table 2 it is clear that the benchmark and grazed sites in both the wet and dry seasons in the commercial land-use are dominated by LD and DE species. *Schmidtia kalahariensis* is the dominant grass in the grazed and benchmark sites of the commercial land-use. This species is described as an aggressive pioneer who will increase drastically at the expense of perennial species if long term overgrazing prevails [41]. Because of the volatile oils present in this grass, it is seldom grazed during summer, but it provides valuable grazing material during winter. The abundance of this species is much less in the grazed sites, compared to the benchmark sites, during the dry years (25.1% vs. 42.5%, Table 2) This phenomenon can be ascribed to the fact that the species did not germinate because of the low rainfall, or it was grazed by animals irrespective of the volatile oils present. During dry seasons the percentage bare ground in the benchmark and grazed sites of the commercial land-use varies between 10% and 15%, whilst it is only between 0% and 3.7% during wet seasons.

Table 2 The effect of two different rainfall regimes on the herbaceous species composition (%) of the poor grazed and poor benchmark sites in the commercial and communal land-uses (data from 2003/04 to 2017/18) (BM = Benchmark sites; GRZ = grazed sites outside benchmarks).

	Grass species	**Wet season (550.6 mm/annum)**				**Dry season (310.4 mm/annum)**			
		Commercial		**Communal**		**Commercial**		**Communal**	
		BM	**GRZ**	**BM**	**GRZ**	**BM**	**GRZ**	**BM**	**GRZ**
HD	*Anthephora pubescens*	-	-	-	-	-	-	-	-
	Brachiaria nigropedata	-	-	-	-	-	-	-	-
	Centropodia glauca	-	0.1	-	-	-	0.1	-	-
	Digitaria eriantha	-	0.1	3.5	2.5	-	-	3.6	2.4
	Schmidtia pappophoroides	8.4	4.1	3.2	2.2	3.2	2.2	-	-
	Sub total	**8.4**	**4.3**	**6.7**	**4.7**	**3.2**	**2.2**	**3.6**	**2.4**
DE	*Eragrostis lehmanniana*	18.5	26.7	12.3	9.4	17.9	21.5	11.6	9.4
	Stipagrostis uniplumis	19.4	13.8	1.3	2.2	18.0	16.4	1.7	2.8
	Sub total	**37.9**	**40.5**	**13.6**	**11.6**	**35.9**	**37.9**	**13.3**	**12.2**
LD	*Aristida stipitata*	2.4	4.6	20.2	21.7	5.0	3.1	19.7	19.8
	Eragrostis trichophora	0.1	-	2.2	8.3	-	-	2.7	7.2
	Schmidtia kalahariensis	50.1	44.6	2.4	0.2	42.5	25.1	0.5	-
	Sub total	**52.6**	**49.2**	**24.8**	**30.2**	**47.5**	**28.2**	**22.9**	**27.0**
UN	*Aristida congesta*	1.1	0.7	12.2	15.7	4.8	8.0	8.8	13.3
	Aristida meriodinalis	-	0.5	0.6	0.1	-	0.2	0.6	0.2
	Brachiaria marlothii	-	-	0.9	3.6	-	-	1.2	1.8
	Eragrostis pallens	-	-	5.4	7.8	-	2.0	4.2	7.8
	Melinis repens	-	0.2	3.9	1.3	0.2	1.5	5.3	1.4
	Perotis patens	-	-	2.6	1.8	-	-	3.0	1.6
	Pogonarthria squarrosa	-	0.3	16.5	8.8	1.0	3.2	17.0	6.6
	Triraphis andropogonoides	-	-	2.2	1.3	-	-	2.3	1.5
	Urochloa brachyura	-	0.6	0.3	1.4	0.4	1.8	0.5	0.9
	Sub total	**1.1**	**2.3**	**44.6**	**41.8**	**6.4**	**16.7**	**42.9**	**35.1**
	Bare Ground	-	3.7	10.3	11.7	10.2	15.0	17.3	23.3
	Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

The poor sites of the communal land-use is dominated by UN and LD species (Table 2). Species like *Aristida stipitata, A. congesta, Eragrostis pallens* and *Pogonarthria squarrosa* dominate these classes. All these species are known as less palatable species with a low biomass production or they are classified as totally unpalatable species [41]. The occurrence of the aggressive pioneer, *S. kalahariensis*, is very low or this species is totally absent. Seedbank studies of the communal land-use, showed that seed of this species is almost absent from the soil. Because of the absence of this species, the percentage bare ground in the communal land-use is often higher than in the commercial land-use, especially during dry seasons.

3.4 Rangeland Condition Score/Index

The rangeland condition score or index value for the benchmark sites of the two land-uses in the wet and dry seasons is indicated in Fig. 6. It is clear that the rangeland condition score of the commercial land-use is, in both the rainfall seasons, much higher than that of the communal land-use (930 vs. 623 (wet season) and 895 vs. 560 (dry season)). This can be ascribed to the fact that the commercial land-use is dominated by HD and DE species, whilst the communal land-use is dominated by LD and UD species (Table 1).

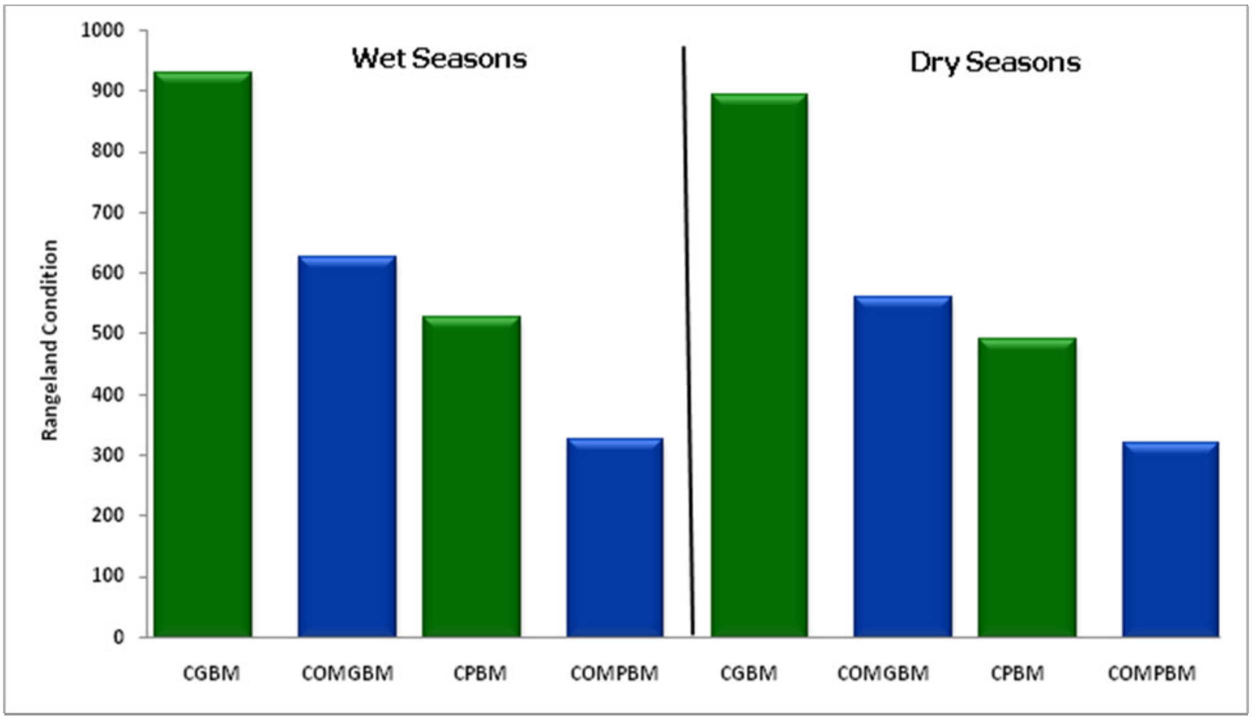

Fig. 6 Rangeland condition score or index value of the benchmark sites of the commercial and communal land-uses in wet and dry seasons. (CGBM = Commercial Good Benchmark; CPBM = Commercial Poor Benchmark; COMGBM = Communal Good Benchmark; COMPBM = Communal Poor Benchmark).

It is also clear that the rangeland condition score of the good benchmark sites in the communal land-use is not much higher than the score of the poor benchmark sites of the commercial land-use (627 vs. 528 (wet season) and 560 vs. 492 (dry season)). If the poor benchmark sites are compared, it is clear that the difference in the rangeland condition scores are the biggest during the wet season (528.4 (commercial land-use) vs. 325.1 (communal land-use). This phenomenon can especially be ascribed to the presence of *S. kalahariensis* in the commercial land-use and the absence thereof in the communal land-use.

The rangeland condition score or index value for the grazed sites of the two land-uses in the wet and dry seasons is indicated in Fig. 7. From this figure it is clear that the rangeland condition score of the poor grazed sites of the commercial areas is higher than that of the good grazed sites of the communal land-use — this phenomenon is especially visible during the wet seasons. This can be ascribed to the fact that the poor grazed sites of the commercial land-use comprises of ±45% HD and DE species, whilst these two species classes comprise only 34% of the communal land-use (Tables 1 & 2). *Schmidtia kalahariensis* also comprises almost 45% of the poor commercial sites during wet seasons, whilst it is almost absent in the good communal sites (only 0.1%). Although the rangeland score of the poor grazed sites of the commercial land-use is also higher than the score of the good communal grazed sites during the dry season, the difference is much lower — rangeland condition score of the poor commercial sites is 469, whilst it is ±444 for the good communal sites (Fig. 7). Overall it is clear that, irrespective of the type of rainfall season experienced, the rangeland condition scores of the commercial land-use are better than that of the communal land-use.

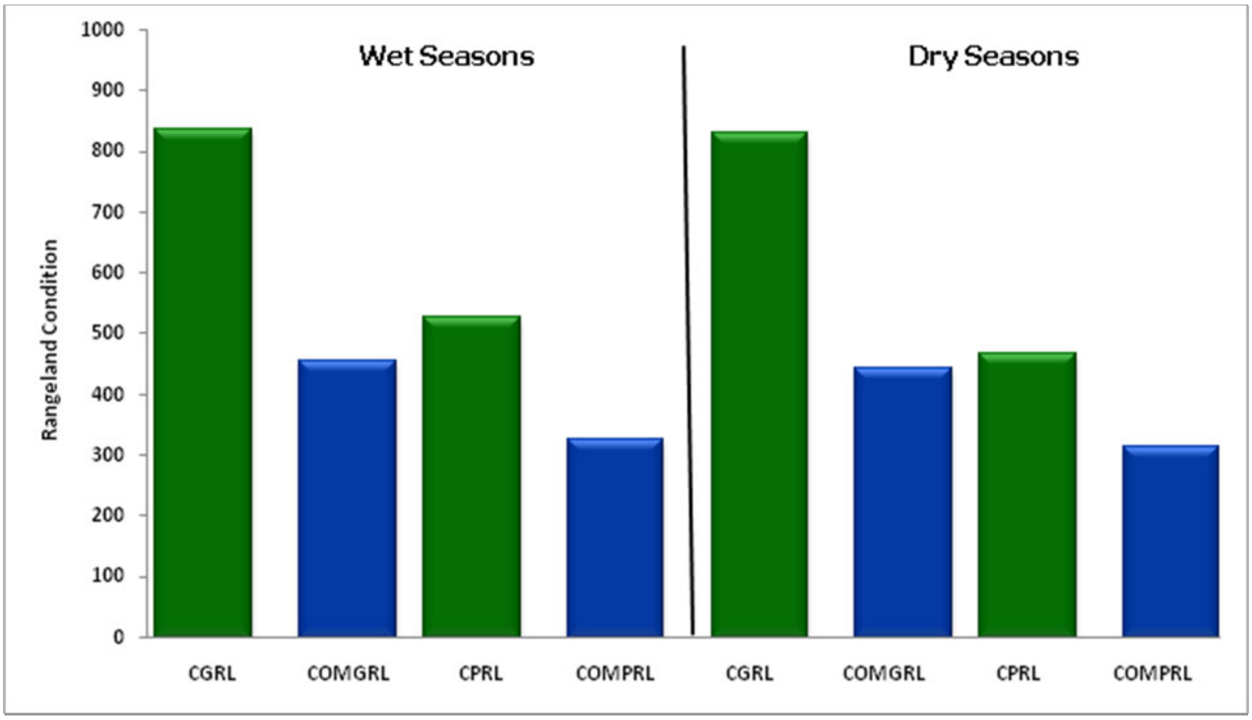

Fig. 7 Rangeland condition score or index value of the grazed sites of the commercial and communal land-uses in wet and dry seasons. (CGRL = Commercial Good Grazed Sites; CPRL = Commercial Poor Grazed Sites; COMGRL = Communal Good Grazed Sites; COMPRL = Communal Poor Grazed Sites).

4. Discussion

From the results presented (Tables 1 & 2 and Figs. 6 & 7) it is clear that there is a definite change in the species composition between the two land-uses and these changes have a distinct influence on the rangeland condition scores between these two land-uses. The rangeland condition, with regards to grazing value, is much lower in the communal land-use than in the commercial land-use — it can thus be said that the communal rangelands are less "healthy" for grazing than the rangelands in the commercial land-use. The question that arises is: Can this situation be reversed, and can it either be done by merely reducing the animal numbers in the communal land-use, or imposing commercial land-use management strategies on these communal areas? Although the question is fairly simple, the answer is not that simple.

Semi-arid systems, of which the study area forms part, are normally classified as non-equilibrium systems because vegetation changes are mostly climatically driven and it lacks the density-dependence, which is found in equilibrium systems, between vegetation and herbivore populations [25, 42-44]. However, recent studies have indicated that most semi-arid rangelands encompass elements of both the equilibrium and non-equilibrium systems at different scales [25, 45]. This dichotomy is a complex relation, and should take into consideration temporal variability and spatial heterogeneity. Rainfall and stocking rate interact, with low rainfall exacerbating the effects of high stocking rate, while high rainfall mitigates it [25, 45]. Because of this dichotomy the usefulness of the Clementsian successional model has been questioned by several authors [46], especially with regard to utility of it in semi-arid rangelands [46, 47]. The Clementsian succession theory [48] states that rangelands are equilibrium systems driven by biotic effects along a series of successive stages until reaching a climax stage. The results from this study does not show vegetation succession patterns from pioneer to climax states — it rather shows a transition towards another vegetation state as a result of certain triggering events. The species composition changes that took place during this study, can thus best be described by the state-and-transition model [46]. According to this model continuous and reversible vegetation dynamics prevail within stable vegetation states, but are irreversible and discontinued when thresholds or limits of resilience are surpassed and one stable state (domain of attraction) replaces another [25,46]. From the results it is clear that the good rangeland of the communal land-use is a new stable state with a different species composition than the good rangeland of the commercial land-use (the composition of the good commercial rangeland corresponds with the description of the best rangeland for the area [23]). Even during wet seasons, the species composition of the best communal land-use does not change to that of the good commercial land-use (according to the Clementsian succession theory) — there is only a change in the abundance of the species present in the current state. This is a clear indication that a threshold or limit of resilience has been surpassed (state-and transition model). In the new stable state of the communal land-use (good rangeland), climax species like *Anthephora pubescens, Brachiaria nigropedata, Panicum kalaharense* and *Centropodia glauca* are totally absent whilst the abundance of *Schmidtia pappophoroides* is constantly reducing. These species are mostly replaced in the communal land-use by other climax, sub-climax and pioneer species with a lower grazing value.

The rangeland condition, in terms of grazing value, of the communal land-use can be restored or improved by the re-introduction of species like *A. pubescens* and *B. nigropedata* who both are also available as planted pasture species. However, the communal system of land tenure *per sé* is often raised as a major stumbling block in the rehabilitation of degraded grazing areas. The communal areas studied in this paper make use of an open access grazing system - this means grazing management decisions are essentially taken on an individual or 'clique' basis with the sole intention of maximizing benefit to the individual and there is little or no incentive to manage the resource productively and sustainably in the long term [49]. It was observed in areas where the communal tenure system and weak traditional local institutions, controlling land tenure and land-use, was not effective, the results were almost always high stocking rates and eventually degradation [50, 51]. The success of any intervention to improve communal area grazing management depends thus on the presence and effectiveness of local-level institutions and organizations [51, 52].

5. Conclusion

It is clear that land-use had a definite influence in the herbaceous species composition in the study area. It is further clear that broad extrapolation in terms of management principles cannot be made between different land-uses due to the fact that unique ecosystems can develop out of a specific land-use. There is, therefore, a need in communal areas to understand the practical and institutional processes in operation, the tenure of the land, the land-use purpose, and the education and understanding of the landholders [51]. It is of the utmost importance that all these aspects should be incorporated into any proposed intervention or policy for improved and sustainable rangeland management in communal areas.

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