EFFECTS OF CLIMATE VARIABILITY ON LIVESTOCK POPULATION DYNAMICS AND COMMUNITY DROUGHT MANAGEMENT IN KGALAGADI , BOTSWANA

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EFFECTS OF CLIMATE VARIABILITY ON LIVESTOCK POPULATION DYNAMICS AND COMMUNITY DROUGHT MANAGEMENT IN KGALAGADI, BOTSWANA

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DECLARATION

I, Olaotswe Ernest Kgosikoma, declare to the senate of the Norwegian University of Life Sciences that this thesis is my original work and all materials other than my own are duly acknowledged and, that the work has not been submitted to any other university for an award of any academic degree.

……………………………………………..
Signature
May, 2006

DEDICATION

This work is dedicated to my son Katlo and fiancée Keneilwe. Ke le ratjago.

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General introduction

This thesis examines the effect of climate variability on livestock population dynamics and community drought management in Kgalagadi. The thesis is divided into two papers. In Paper 1, the objective was to determine the influence of global and local climate variability on livestock population dynamics. The indices on North Atlantic Oscillations (NAO), El Niño Southern Oscillations (ENSO) and Sea surface Temperature (SSTs) were related to regional rainfall and livestock populations. In addition, the regional rainfall was regressed and correlated with livestock population dynamics. It was observed that NAO, ENSO and SSTs were poor predictors of rainfall and livestock population dynamics ($P > 0.05$). These results contradict the findings of other studies that NAO, ENSO and SSTs have influence on African rainfall and agricultural productivity (Stige et al., 2006; Nicholson and Kim, 1997; Paeth and Friederichs, 2004). However, the regional rainfall accounted for variability in cattle and goat population ($P < 0.05$) but not sheep. The fluctuations on cattle and goat populations are probably responses to nutritional limitations during drought which induces increased mortality. In general, the results imply that global climate oscillating systems are not consistent enough to be used for agricultural planning at regional level. However, the regional rainfall variability had influence on livestock population dynamics and therefore proper management is required to buffer impact of drought on livestock and livelihood of pastoralists.

Paper 2 examines the management practices used by pastoralists in response to climate variability. Data collected through a structured questionnaire was analyzed to determine management practices used by pastoralists and constraints faced during drought. Pastoralists practiced destocking, supplementary feeding and mobility to cope with drought. However, lack of funds, and forage shortage were major constraints. Subsequently, integrated livestock market and flexible use of rangeland are necessary to reduce pastoralist's vulnerability to drought.

References

Nicholson SE and Kim J 1997. The relationship of the El nino- Southren oscillation to African rainfall. International Journal of Climatology17: 117 – 135.

Paeth H, and Friederichs P 2004. Seasonality and time scales in the relationship between global SST and African rainfall. Climate Dynamics 23:815-837.

Stige LC, Stave J, Chan K, Ciannelli L, Pettorelli N, Glantz M, Herren HR and Stenseth NC 2006. The effect of climate variation on agro-pastoral production in Africa. PNAS 9:3049-3053.

PAPER I

Influence of global and local climate variability on livestock population dynamics in Kgalagadi district, Botswana.

Abstract

A study was conducted to determine the influence of climate variability on livestock population dynamics in Kgalagadi district. Data on NAO, ENSO and SSTs indices were regressed and correlated against regional rainfall for kgalagadi region and livestock populations. Regional rainfall data was also related to livestock population dynamics. The results suggested that NAO, ENSO and SSTs were not good predictors of regional rainfall variability and livestock population dynamics ($P > 0.05$). The regional rainfall was highly variable and accounted for fluctuations on cattle and goat populations ($P < 0.05$) but not sheep population. Goat population appeared more sensitive to rainfall variability than other livestock species. Cattle death rate was also strongly influenced by rainfall variability whereas other livestock performance indicators were not significantly accounted for by rainfall variability. The results suggest that management need to be improved to buffer impact of climate variability on livestock population.

Keywords: NAO, ENSO and SSTs indices, Rainfall variability, Livestock populations, Kgalagadi district.

1.0 Introduction

The climate variability in Africa has been linked to global climate oscillating systems (Knippertz et al., 2003; Stige et al., 2006). The North Atlantic Oscillations (NAO), El Ix o – Southern Oscillations (ENSO) and sea surface temperatures (SSTs) are major factors responsible for interannual variability in African rainfall (Nicholson and Kim, 1997; Paeth and Friederichs, 2004). Therefore, understanding the influence of global climate oscillating systems on regional rainfall variability and livestock population dynamics will significantly contribute towards development of effective pastoral management strategies to cope with drought (Stige et al., 2006).

The NAO refers to change in atmospheric mass over the Atlantic (Lamb and Pepper, 1987). Research has shown that NAO is related to rainfall variability in some African regions such as north-western Africa which experiences dry seasons during the positive NAO phase (Knippertz et al., 2003). Another climatic oscillating system associated to African rainfall variability is ENSO (Paeth and Friederichs, 2004; Rasmusson, 1988). The ENSO refers to warming of sea surface temperatures (SSTs) and changes in sea-level atmospheric pressure across the eastern equatorial pacific (Rasmusson, 1988). ENSO effects on rainfall fluctuations are well documented and in Southern Africa, it is reported to cause negative departures from normal rainfall levels and thus increase drought frequency and severity (Ellis, 1996). Furthermore, African rainfall is associated with sea surface temperatures (SSTs). Previous studies suggest that equatorial Indian Ocean SSTs, partly associated with ENSO, strongly influence rainfall variability in Southern Africa (Paeth and Friederichs, 2004).

The high climate variability is a major limiting factor to human land use (Ellis and Galvin, 1994). Previous studies have shown effects of both global climate oscillating systems and rainfall variability on rangeland productivity and agricultural production systems (e.g. Stige et al., 2006; Oba et al., 2001). A study by Oba et al., (2001) showed that combined effects of NAO and ENSO account for 40 % of the vegetation productivity in Botswana based on remotely sensed NDVI. In light of that research suggested that NAO and ENSO influence rainfall variation in Southern Africa (Ellis, 1996), it follows therefore that NAO and ENSO strongly influence rangelands productivity. It is well established that rainfall variability which characterizes arid areas significantly affects the amount and quality of forage available for herbivores consumption (Fynn and O'connor, 2000). Hence, herbivores responses to climate variability are indirect and mediated by primary production (Hulme, 2005). As a result, primary productivity is a major limiting factor to livestock productivity during drought years. So, could NAO, ENSO, SSTs and long-term rainfall account for variability in livestock population dynamics?

Previous studies had reported that relationships exits between rainfall variability and livestock population dynamics (Desta and Coppock, 2002; McCane, 1987; Begzsuren et al., 2004). Rainfall modulates livestock populations through drought impact on rangeland productivity. These relationships are explained by nutritional limitations during drought as a result of loss of rangeland productivity (Coppock and Reed, 1992; Oba, 2001). As dry periods progress, livestock are obliged to mobilize body fat reserves to balance for the nutrients deficiency in the diet. Eventually, droughts cause livestock population fluctuations through increased mortality and reduced birth rates (Ellis and Swift, 1988; Oba, 2001). Given that livestock management practices are aimed at protecting economic interests of pastoralists, it is also expected that off-take rates are likely to increase during drought in an attempt to reduce loss through die-offs. In fact, Stige et al., (2006) found no effects of climate variation on livestock in some regions and suggests that management interventions may have a buffering effect. It can therefore be argued that livestock management practices partly influence livestock population response to climate variability.

Despite literature on livestock response to climate variability increasing, most drought impact studies have not used time series data from communal areas. The management of rangelands and livestock in communal areas differ from commercial livestock ranching (Smet and Ward, 2005) and hence, livestock population in communal areas may respond differently to climate variability. In Botswana, the communal livestock management is mostly based on traditional production systems. The animals are allowed to move freely around the borehole without being herded (Perkins, 1996). Goats and calves are kraaled at night to protect from the predators. In the past, livestock mobility was a key strategy to cope with drought and exploit heterogeneous habitats (Hitchcock, 1978). In addition, the management production system in communal areas was extensive. However, the introduction of Tribal Grazing Land Policy (TGLP) had resulted in shrinking of communal land and consequently, livestock mobility is limited.

Furthermore, it has been suggested that different livestock species respond to drought differently (McCabe, 1987) and this implies that mixed stocking acts as insurance against total loss of livestock (IIRR, 2002). McCabe (1987) found that cattle were more resistant to stress caused by drought than small stock. The explanation was that cattle mobility allows expansion of the spatial scale of exploitation whereas small stock's mobility was limited to areas close to homestead (Illis and Swift, 1988; McCabe, 1987).

Therefore, increased knowledge on effects of climate variability on livestock population dynamics will ensure that appropriate management practices are adopted to cope with recurring problem of droughts. The aim of this study was therefore to investigate the influence of climate variability on livestock population dynamics under traditional production systems in Kgalagadi district. The study considered effects of global climate variability on regional rainfall variability as well as livestock populations which have not been considered in most studies. The aim of this study was achieved by answering the following research questions: (i) What were the associations between global climate oscillating systems and regional mean annual rainfall as well as livestock population dynamics? (ii) What were the coefficients of variation (% CV) of rainfall for different stations in Kgalagadi district? (iii) What were the relationships between long-term rainfall variability and livestock populations? (iv) What were the relationships between long-term rainfall variability and livestock production performance indicators? (v) What were the associations of production performance indicators with different livestock species populations?

2.0 Methods

2.10 Study area

The regional data of rainfall and livestock population used in this study was for Kgalagadi district in the south-west of Botswana. Kgalagadi district covers a total area of 105 200 km^2 and forms part of kgalagadi (Kalahari) desert ecosystem. An important characteristic of Kgalagadi district is that rainfall variability is very high both in space and time. The Kalahari is a heterogeneous ecosystem varied from sandveld with bare rolling dunes covered by grasslands to low shrub land and shrub savanna along Nossop and the Molopo in the extreme south west of Botswana (Burgess, 2003). The region is characterized by lack of surface water for the most part of the year. About one-third of total area of the district is part of Kgalagadi Transfrontier Park. The rest of the area is used for settlement, pastoral farming and a limited arable farming. About 42 000 people live in the kgalagadi district (CSO, 2001). Tsabong is the administrative center for the district (Figure 1).

The pastoral farming in Kgalagadi district is dominated by traditional production systems. Livestock are kept at cattle - posts established within the communal areas and owned by either individuals or syndicates. Commercial ranching is another form of pastoral farming that is practiced in Kgalagadi district, which were established as an alternative to traditional land use for grazing. Addition to pastoral farming, land use in kgalagadi includes rain-fed arable agriculture for subsistence purpose in the traditional sector. During good years, some farmers grow crops. But, there are some areas with high rainfall variability such as Bokspits where arable farming is not practiced at all.

2.20 Data description

Global climate variability indices

The data on global climate oscillating systems, which include North Atlantic Oscillation (NAO) and the El 1 Ixo Southern Oscillation (ENSO) indices, used in this study were previously used in Oba et al., (2001). The NAO index is calculated as differences of normalized sea level pressure of stations to the north (Iceland) and south (Azores) (Tadesse et al., 2004). The ENSO index is "based on monthly average of SST anomalies in the tropical East Pacific" (Knippertz et al., 2003:1294). The El Niño region 3 SSTs indices data used was obtained from the National Center for Atmospheric Research Website: http://www.cgd.ucar.edu/. The SSTs for the month of February, May, July, September and November were used in an attempt to capture effects of different phases of El Niño. In this study, the data on regional rainfall, NAO winter index, and ENSO region 3 annual indices were for the period from 1979 to 1997.

Long-term regional rainfall data

The long-term rainfall data for kgalagadi region used in this study was obtained from Department of Meteorological services. The long-term rainfall data for six villages were from Bokspits, Kang, Hukuntsi, Mabuasehube, Struizendam and Tsabong (Figure 1). These villages were selected because they had long-term data and provided an opportunity to assess the spatial differences within the district. There was a variation on the range of rainfall information recorded in different stations (villages). However, only the data from 1979 to 2003 was used to calculate the average annual rainfall for the district. The mean annual rainfall data for the six villages were aggregated to establish mean annual rainfall for the region (district).

Livestock population data

District time series livestock population data was obtained from Statistics Unit in the Ministry of Agriculture. The data was from annual surveys undertaken by the Agricultural Statistics Unit of the Central Statistics Office (CSO) in collaboration with the Division of Agricultural Planning and Statistics (DAPS). The data included cattle, goats and sheep populations, and production performance indicators for each livestock species. The production performance indicators in this study referred to birth rates, death rates and off-take rates for each livestock species. The birth rate was the ratio of total number of births to total numbers of female animals (e.g. cows) during the survey year. Death rate is ratio of total number of deaths over total number of animals during the survey year; while off-take rate is the ratio of off-take (Sales- purchase + home slaughter) total number of animals during the survey year. All definitions of production performance indicators were adopted from the agricultural statistic report (CSO, 1996).

The long-term livestock data under the traditional production system was available for a period of 20 years from 1980 to 2003 with data gaps for 1991, 1992, 2000, 2004 and 2005. The data for livestock under commercial system was limited and therefore was not included in the present analysis. The numbers of livestock populations were converted to tropical livestock units (TLU) to aggregate the populations for cattle, goats and sheep under communal grazing area in a standardized way. The conversion factors used were 0.7 for cattle and 0.1 for both goats and sheep (Jahnke, 1982). In light that I did not have specific weights for animals recorded, it was assumed that all livestock were of equal live body weight equivalent to the conversion factor for each species (e.g. cattle = 250 kg live body weight).

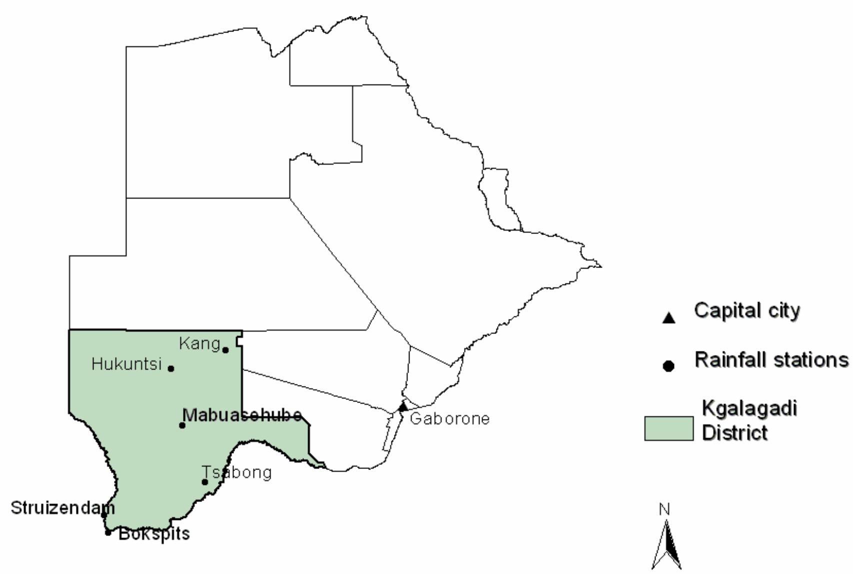


Figure 1: Map showing Kgalagadi district and rainfall stations

2.30 Statistical analysis

A number of statistical analyses were used to assess relationships between independent and dependent variables. Global climate indices were regressed against regional mean annual rainfall. The NAO, ENSO and SSTs indices were further correlated with livestock production performance indicators and the global climate effects were lagged to livestock population. Regression and correlation matrix was conducted to determine the association between global climate Oscillating systems and livestock population dynamics. Descriptive statistics was used to determine mean annual rainfall and coefficient of variation for six villages and for the district and mean livestock population dynamics. Simple linear regression was also used to determine the relationship between mean annual rainfall for the region and livestock population and livestock production performance indicators. The rainfall effects were lagged (delayed) to the livestock population data for some analysis to account for the fact that livestock population growth in a particular year was influenced by rainfall from previous year. The relationships were further tested by non-lagged rainfall- livestock population data. Correlation matrix was used to assess the influence of production performance indicators on livestock species populations under the traditional production system. Two sample t-tests were used to compare death rates during drought and non drought years. All test considered significant were at $P < 0.05$ level.

3.0 Results

3.10 Associations of global climatic oscillating systems with regional rainfall variability and livestock population dynamics

There was no significant association between mean rainfalls for kgalagadi district with either of the global climatic oscillating systems (Table 1). The NAO index accounted for about 10 % of rainfall variability in Kgalagadi district but failed to pass 0.05 significant test. The ENSO index only explained about 5 % of rainfall variability of kgalagadi district but the association was statistically insignificant. The combined effects of NAO and ENSO indices failed to show strongly influence on regional rainfall variability. Even the SSTs for different months did not have significant influence on regional mean annual rainfall (Table 1). However, the SSTs for the month of May were better predictors of rainfall variability relative to other months. However, NAO was a better predictor of regional rainfall variability as compared to ENSO and the combined effects of NAO and ENSO as well as the SSTs for different months.

Table 1: Coefficients of determination (R^2) for relationships between regional mean rainfall and global climatic oscillating systems.

Global climatic oscillating systems	R^2	P-value
NAO	0.101	0.198
ENSO	0.050	0.355
NAO + ENSO	0.063	0.274
SSTs $_{(t-1)}$ (Feb)	0.026	0.474
SSTs $_{(t-1)}$ (May)	0.045	0.341
SSTs $_{(t-1)}$ (July)	0.010	0.660
SSTs $_{(t-1)}$ (September)	0.003	0.799
SSTs $_{(t-1)}$ (November)	0.002	0.833

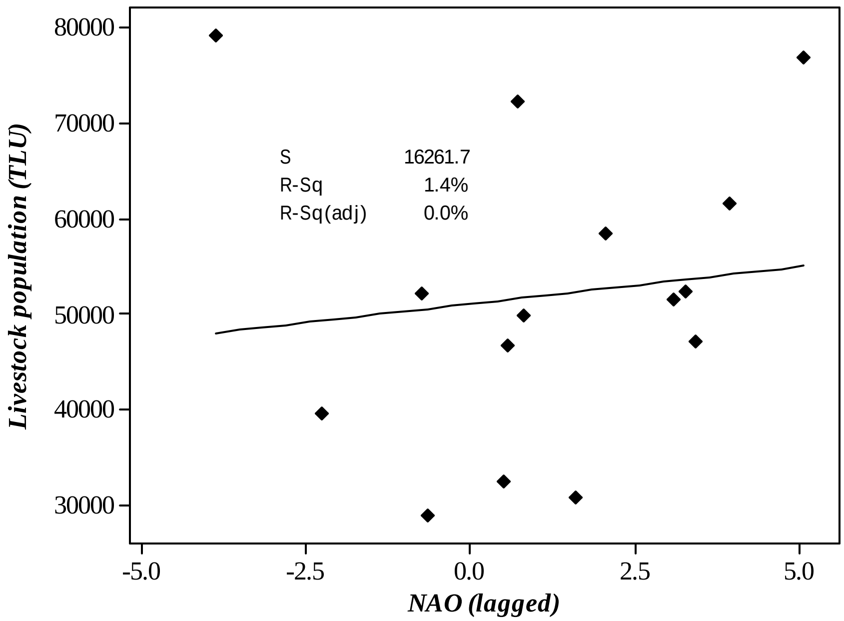
The livestock population dynamics were not strongly accounted for by any of the global climate oscillating systems (Table 2). Though, all tests failed to pass the 5 % significance level, cattle population was more explained by NAO index, while the goat and sheep populations were more explained by the ENSO index. Furthermore, the NAO and ENSO were poorly related to total livestock population in communal grazing area (Figure 2a & b). Cattle population was poorly accounted by SSTs for all months though SSTs for February accounted for about 11 % of variation in cattle population. Goat population was poorly explained by SSTs. On the contrary, sheep population was best accounted for by the SSTs especially for September.

In addition, the global climate oscillating systems had poor correlation with livestock production performance indicators (Table 3). The associations between NAO and production indicators for different livestock species fluctuated from positive to negative, but none of the associations were statistically significant ($P > 0.05$). In spite of that, NAO had fair linear relationship with sheep death rates and goat off-take rates. ENSO had significant linear relationship with goat death rate ($P < 0.05$), but ENSO associations with goat off-take, sheep off-take and goat birth rate were fair. The SSTs for February were significantly correlated to goat death rate ($P < 0.05$), and had a fair association with sheep death rates and rest of associations with production indicators were all weak. The SSTs for May was also significantly correlated to goat death rate, whereas the SSTs for July and September were significantly related to cattle off-take rates ($P < 0.05$). The SSTs for November were not significantly related to any of production indicators ($P < 0.05$), but had fair linear associations with cattle off-take rates and goat birth rates. Overall, the results indicated that NAO, ENSO and SSTs indices were not consistent predictors of livestock population dynamics under communal grazing areas in Kgalagadi district (Tables 2 & 3).

Table 2: Coefficients of determination (R^2) for relationships between livestock population and global climate indices

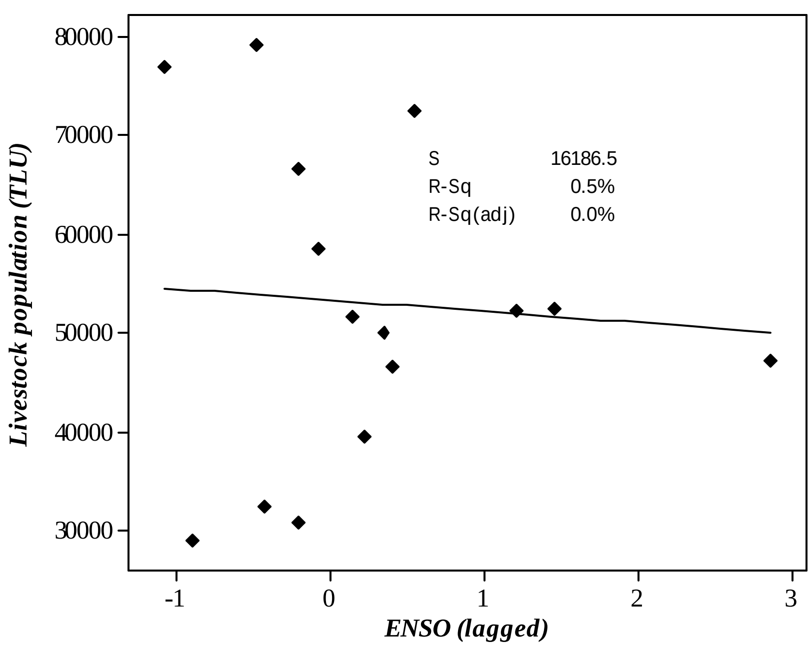
Livestock species	NAO $_{(t-1)}$	ENSO $_{(t-1)}$	SST $_{(t-1)}$ (Feb)	SST $_{(t-1)}$ (May)	SST $_{(t-1)}$ (July)	SST $_{(t-1)}$ (September)	SST $_{(t-1)}$ (November)
Cattle	0.015	0.002	0.111	0.009	0.002	0.008	0.016
Goat	0.010	0.044	0.004	0.023	0.051	0.048	0.071
Sheep	0.026	0.033	0.044	0.144	0.176	0.192	0.172

($P > 0.05$ for all associations)



Y = 51068 + 781X (X = NAO, Y = Livestock population)

Figure 2a: The relationship between NAO and total livestock population under traditional grazing area in Kgalagadi district



Y = 53202 - 1120 X (X = ENSO, Y = Livestock population)

Figure 2 b: The relationship between ESNO and total livestock population under traditional grazing areas in kgalagadi district

Table 3: Correlation coefficients (r) for associations between global climate indices and livestock production performance indicators

	NAO $_{(t-1)}$	ENSO $_{(t-1)}$	SST $_{(t-1)}$ (February)	SST $_{(t-1)}$ (May)	SST $_{(t-1)}$ (July)	SST $_{(t-1)}$ (September)	SST $_{(t-1)}$ (November)
ENSO $_{(t-1)}$	0.205						
SST $_{(t-1)\ (Feb)}$	0.207	0.998**					
SST $_{(t-1)\ (May)}$	0.160	0.665**	0.692**				
SST $_{(t-1)\ (July)}$	0.008	0.369	0.321	0.880**			
SST $_{(t-1)\ (September)}$	-0.130	0.093	0.053	0.678**	0.936**		
SST $_{(t-1)\ (December)}$	-0.114	-0.037	-0.119	0.512*	0.822**	0.952*	
Cattle birth rate	0.028	0.147	0.132	0.195	0.179	0.111	0.026
Goat birth rate	- 0.019	- 0.442	- 0.154	- 0.176	-0.064	0.141	0.318
Sheep birth rate	- 0.173	0.036	0.059	0.100	0.108	0.069	0.077
Cattle death rate	0. 174	- 0.082	- 0.166	- 0.240	-0.278	-0.276	-0.234
Goat death rate	0.183	0.562*	0.515*	0.502*	0.302	0.112	0.050
Sheep death rate	0.373	0.379	0.369	0.349	0.202	0.135	0.177
Cattle off-take rates	- 0.046	0.099	0.084	0.406	0.537*	0.557*	0.460
Goat off-take rates	0.359	0.435	0.251	0.170	0.017	-0.090	-0.054
Sheep off-take rates	0.125	0.431	0.251	0.165	0.089	-0.051	-0.092

* Significant at 0.05 level ** significant at 0.001 level

3.20 Rainfall variability in Kgalagadi region

The mean annual rainfall for Kgalagadi district over 20 years was 214 mm with a coefficient of variation (CV) of 34.5 % (Table 4). The CV of mean rainfall for the region is high and implied that the ecosystem is non-equilibrial (Ellis and Galvin, 1994). There was high rainfall variability between villages and inter-annual rainfall for different villages. Bokspits village received the least rainfall in the district and Kang received the highest rainfall. The results also showed that villages with low mean annual rainfall also experienced high variability. Bokspits had the highest % CV and Kang had the lowest CV. The rainfall time series for kgalagadi region is characterized by year-to-year variability (Figure 3a). During the period of 1979-2003, 13 years received below average precipitation (Figure 3b). The results also showed that years 1980-1985 were periods of prolonged droughts. Overall, there was no clear pattern in rainfall variability suggesting that rainfall in Kgalagadi district was unpredictable.

Table 4: Mean annual rainfall (mm) and coefficient of variation (%) for kgalagadi

Village	Mean annual rainfall (mm)	Coefficient of variation (%)
Bokspits	145.2	62.4
Hukuntsi	210.1	48.3
Kang	339.1	40.4
Mabuasehube	160.1	58.9
Struizendam	148.0	46.3
Tsabong	284.4	40.5
District	214.0	34.5

*Non-equilibrium systems have CV of 33 % or higher (Ellis and Galvin, 1994)

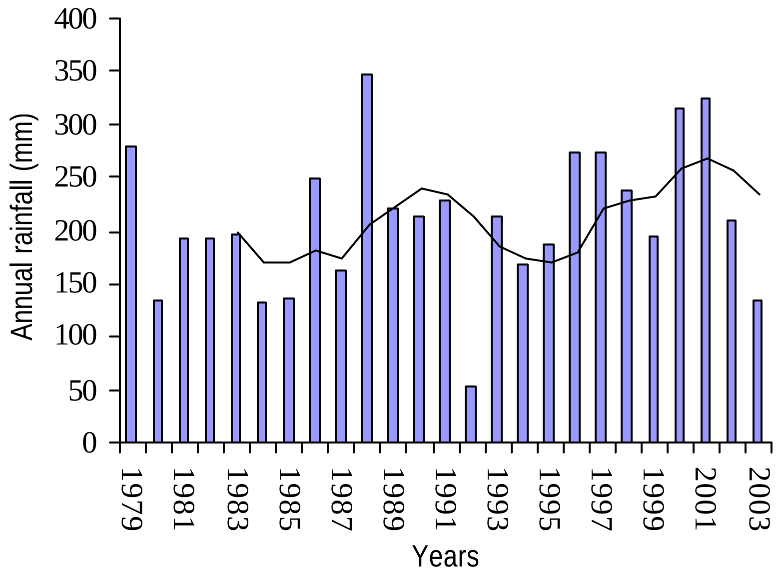


Figure 3a: The regional annual rainfall with a running mean of 5 years for Kgalagadi district (1979-2003)

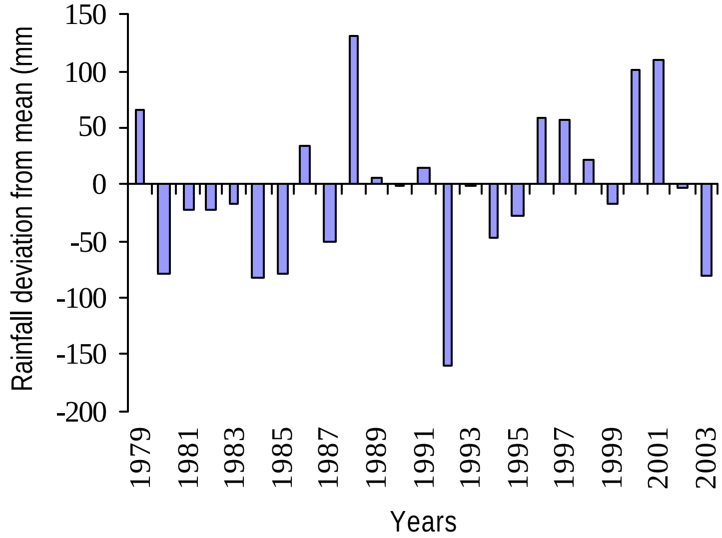


Figure 3b: The annual rainfall deviation from long-term mean for Kgalagadi district (1979-2003)

3.30 Livestock population dynamics and its relationship with rainfall variability

For the periods 1980-1982, the total tropical livestock unit (TLU) under traditional production system increased steadily and it could be speculated that the population was recovering from previous drought (Figure 4a). The population then declined by approximately 50.5 % between 1982 and 1986 because of die-off induced by the severe droughts of 1982-86. Then the population started to recover, and steadily increased from 1987 to 1990 and crashed again with mean mortality of 33.1 % between 1990 and 1995. This population crash was followed by population growth until 1997. During the period of 1998-2003, the total livestock population in the communal grazing areas continued to fluctuate, though overall, the population continued to increase until it reached maximum livestock population of 119 902 TLU in 2002 and then declined slightly. From 1980 to 1998, the livestock population was below the average and became positive between 1989 and 1990 (Figure 4b). The livestock population then declined again for the period of 1993 – 1996 and rose steadily again. The mean total tropical livestock units for the district for the period of 1980-2003 under the traditional production system was 63, 314 TLU.

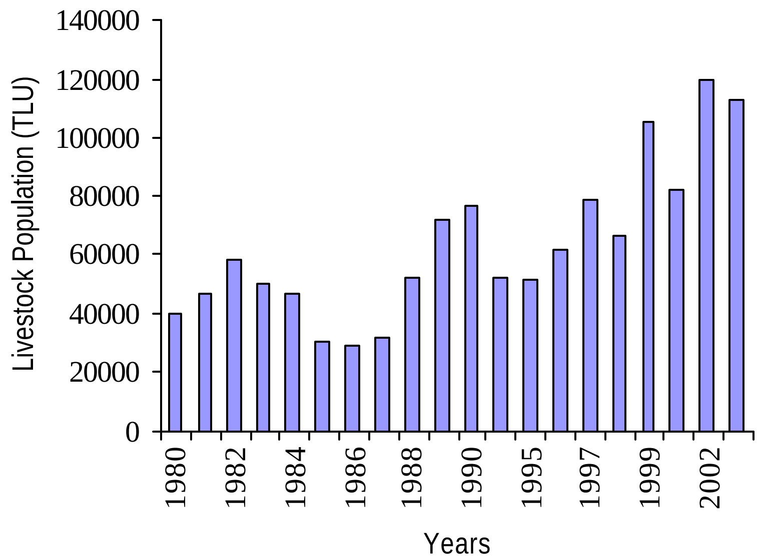


Figure 4a: Total tropical livestock units under the traditional production system

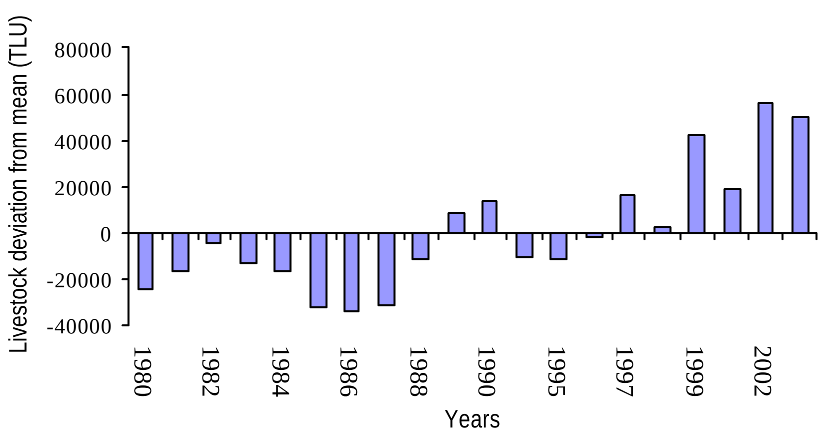


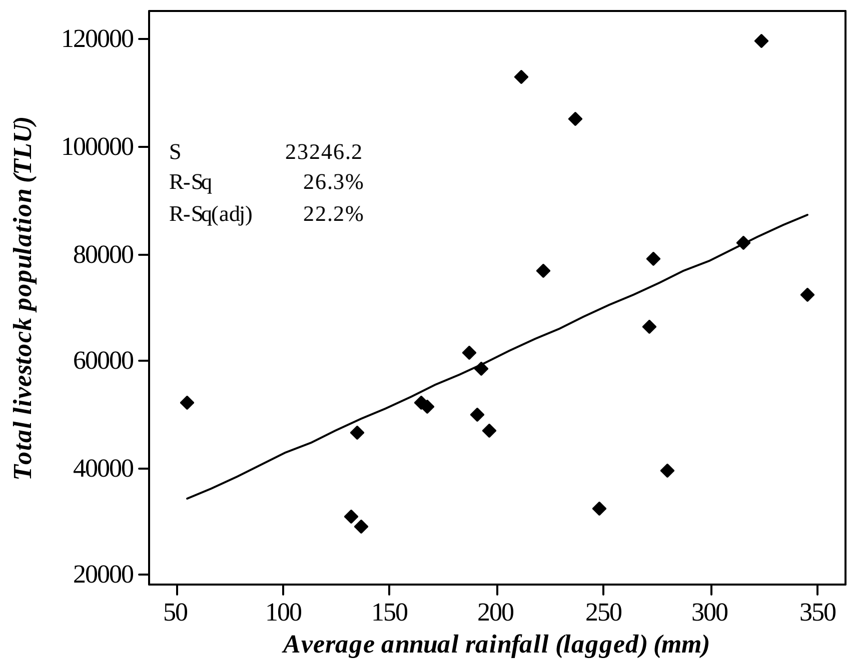
Figure 4 b: The deviation of total tropical livestock units from mean under traditional production system

There was a linear relationship between cattle population and mean annual rainfall for the previous year (Table 5). Goat population also had a significant relationship with mean annual rainfall, but sheep population had no significant linear relationship with mean annual rainfall. The total livestock population in communal area had a significant linear relationship with mean annual rainfall ($F_{1, 19}$ = 6.43, P = 0.021) (Figure 5). Among all livestock species, goat population appeared to be the most sensitive to rainfall variability while sheep was list sensitive (Table 5).

Table 5: Coefficients of determination (R^2) for relationship between total livestock population (TLU) and mean annual rainfall $_{(t-1)}$

Livestock species	R^2	P-value
Cattle population (TLU)	0.247	0.026
Goat population (TLU)	0.297	0.013
Sheep population (TLU)	0.014	NS

NS not significant at 0.05 confidence level



Y = 24152 + 183.0 X (X = average annual rainfall (lagged) mm, Y= Livestock population)

Figure 5: The relationship between total livestock population and average annual rainfall for kgalagadi district

3.40 Relationships between long-term rainfall variability and livestock production performance indicators

The death rates for different livestock species responded differently to long-term annual rainfall (Table 4). There was a significant linear relationship between percent cattle mortality rate and delayed annual mean rainfall (Table 4). Unlike cattle death rate, goat's death rate was significantly related to direct annual mean rainfall rather than delayed annual mean rainfall. Sheep death rate was not significantly and linearly related to mean annual rainfall. Birth rates and off-take rates for all species were not significantly related to delayed or direct mean annual rainfall, but were strongly associated with the current mean annual rainfall.

Table 4: Coefficients of determination (R^2) for relationship between livestock production performance indicators (%) and mean annual rainfall

Livestock response	R^2	P-value
Death rate		
Cattle	0.488	0.001
Goats*	0.306	0.011
Sheep	0.127	NS
Birth rate *		
Cattle	0.149	**
Goats	0.050	NS
Sheep	0.008	NS
Offtake rate*		
Cattle	0.097	NS
Goats	0.142	NS
Sheep	0.069	NS

* mean regional rainfall is not lagged   ** significant at 0.1 level   NS not significant at 0.05 level

3.50 Influences of livestock production performance indicators on livestock species populations

The correlation results showed that cattle population was strongly associated to goat population. Furthermore, cattle population was negatively influenced by death rate (Table 5a). Death rates for cattle were significantly higher (23.6 %) during drought years than years of good rains (12.32 %) (P = 0.022). Birth rates and off-take rates were not significantly correlated with cattle population. In addition, cattle off-take rate was fairly correlated to sheep population. The goat population was not strongly affected by death rates (Table 5b). Goat mortality rates during drought periods and years of good years were not significantly different and the mean death rate for goats was 29.1 %. The maximum death rate for goats was 62.2 % and occurred in 1984 during the 1982-86 droughts. Sheep population was not significantly influenced by any of the production performance indicators though it responded to birth rates than death rates and off-take rates (Table 5c). However, the results showed that sheep off-take rates were significantly correlated to birth rates. In addition, it was observed that sheep had the highest mean off-take rates of 16.2 % while cattle and goats were approximately 11 %. Though, cattle death rates was significantly less than goats (P < 0.001), death rate had stronger influence on the cattle population than for goat population. The results also indicated that goat death rates during 1982-86 drought period reached maximum levels earlier than cattle death rates.

Table 5: Correlation coefficient matrix for associations between production performance indicators with livestock species population (a) cattle population (b) Goat population (c) Sheep population

(a)

	Cattle population	Sheep population	Goat population	Death rates	Off-take rates
Sheep population	0.039				
Goat population	0.799**	0.321			
Death rate	-0.551*	0.173	-0.370		
Off-take rate	0.214	-0.499*	0.122	-0.158	
Birth rate	-0.175	-0.028	0.110	0.331	0.329

(b)

	Goat population	Cattle population	Sheep population	Death rates	Off-take rates
Cattle population	0.799**				
Sheep population	0.321	0.039			
Death rates	-0.439	-0.188	-0.385		
Off-take rates	-0.136	-0.136	0.087	0.416	
Birth rates	0.086	0.255	-0.125	-0.061	0.017

(c)

	Sheep population	Cattle Population	Goat population	Death rates	Off-take rates
Cattle population	0.039				
Goat population	0.321	0.799			
Death rates	-0.244	-0.085	-0.165		
Off-take rates	0.115	-0.313	-0.351	0.010	
Birth rates	0.320	0.056	-0.059	0.149	0.541*

** Significant at 0.001 level * Significant at 0.05 level

4.0 Discussion

4.10 Associations of global climatic oscillating systems with regional rainfall variability and livestock population dynamics

The NAO, ENSO and SSTs indices failed to show significant association with the mean annual rainfall for kgalagadi district. The implication was that NAO, ENSO and SSTs indices are not good predictors of rainfall for Kgalagadi region and therefore could not be used to predict the drought and non drought years. The results of this study do not conform with results of other studies which found that NAO, ENSO and SSTs indices were linked with climatic variability in Africa (Stige et al., 2006; Paeth and Friederichs, 2004) and has a potential to be used to monitor climate change in sub-Sahara Africa (Oba et al., 2001). It is possible that the period of data coverage of this study may be responsible for lack of association between regional mean annual rainfall and NAO, ENSO as well as SSTs. Previous study illustrate that NDVI for different periods responded differently to NAO (Wang, 2003). Therefore, ENSO, NAO and SSTs are not consistent on predicting rainfall pattern but this finding is not in line with results from other studies which suggest that NAO is a good predictor of rainfall (Lamb and Pepper, 1987). A study by Fernandez et al., (2003) was also sceptical on the use of NAO to predict climate changes.

The NAO, ENSO and SSTs indices had no significant relationship with livestock populations. Thus, global climate oscillation systems do not account for variation livestock population and therefore can not be used to predict livestock population's responses in the future. A study by Oba et al. (2001) found that combined effects of NAO and ENSO explained 40 % of changes on rangeland production in Southern Africa. Hence, it was expected that NAO and ENSO had indirect influence on livestock population. A study by Stige et al., (2006), found climatic effects on pasture productivity but not on livestock. It was suggested by that study that livestock management practices may be responsible for buffering effects of NAO and ENSO. Furthermore, the NAO, ENSO and SSTs failed to show consistent associations with livestock performance indicators. The ENSO was related to goat performance indicators and sheep off-take rates. Given that the global climate oscillating systems were not related to mean annual rainfall, it is difficult to understand how they could be related to livestock performance indicators. The livestock performance indicators responded differently to SSTs for different months. Cattle off-take rates and goat death rates responded fairly to SSTs for some months but that could not be explain in the sense that SSTs showed no influence on rainfall. In light of the results of this study, NAO, ENSO and SSTs did not have consistent relationship with livestock production indicators; hence it is not easy to make a firm conclusion. Nevertheless, it is concluded that the results of this study showed that NAO, ENSO and SSTs indices do not directly account for variation in livestock population in Kgalagadi district. The possible explanation may be that the period covered by livestock populations used in this study corresponded with opposite phases of NAO and ENSO indices.

4.20 Annual rainfall variability in different villages of Kgalagadi

Rainfall in Kgalagadi district varies spatially and temporally as indicated by rainfall variation between villages and percent coefficient variation of rainfall. In this study, coefficient of variation for rainfall in kgalagadi on average was 34.5 % and less than 45 % reported by Thomas (2002). The high CV implies that droughts are frequent in Kgalagadi and therefore, the livestock population is likely to exhibit non-equilibrium dynamics (Ellis and Galvin, 1994). The implication of these results is that livestock and range management should be flexible and opportunistic to avoid hazards associated with drought (Oba et al., 2000). In addition, rainfall variation among villages and between years supports formation of heterogeneous range productivity within the district and variability of forage availability for grazing animals (Scoones, 1995). Therefore, livestock mobility is necessary to effectively utilize the heterogeneous vegetation. In this study, it was also observed that there was high rainfall variability at local levels and variation is buffered when the data was aggregated. As a result, the effects of rainfall may be best understood at local level while generalization should be treated with caution. Overall, the result implies that policies of range and livestock management should be flexible to account for differences in systems and probably allow livestock mobility in response to forage variability.

4.30 Livestock populations and its association with mean annual rainfall

The total livestock population in Kgalagadi followed "boom and burst" pattern whereby the population increases for a couple of years and then crashed. Similar results have been reported in Botswana (Perkins, 1991) and elsewhere (McCabe, 1987; Desta and Coppock, 2002). The increase in population could be explained by abundance of forage during rainy years which in turn results in increased livestock birth rates and reduced mortality rates. Conversely, the population crashes are due to shortage of forage which cause increased mortality and reduced birth rates. The results also suggested that livestock populations were likely to be influenced by multiple drought years than single drought years as reported in other studies (Ellis and Galvin, 1994; Oba, 2001). The livestock population in Kgalagadi district continued to fluctuate continuously without stabilizing. Thus, the results support the argument that if rainfall variability is high, the livestock populations are modulated by frequent droughts and subsequently never reaching equilibrium (Ellis and Galvin, 1994). But since the relationship is mediated by primary production, the livestock responses were lagged behind rainfall pattern.

Mean annual rainfall explained about a quarter of the variation in the cattle population under the traditional production system. That means that 75 % of cattle population variation was unexplained by rainfall. The management intervention such as supplementary feeding may be responsible to poor livestock population responses to rainfall variability (Stige et al., 2006). Annual rainfall also accounted for about a third of the variation in goat population but was not significantly related to sheep population. In addition, mean annual rainfall explained about 26 % of variation in total livestock population in communal areas of Kgalagadi district. The lower p-value for association between goat population and mean annual rainfall indicated that goats were more sensitive to rainfall variability as compared to other livestock species. On the contrary, the literature suggests that goats are resilient to harsh conditions (Toulmin, 1996). The current results support findings that goat populations were more responsive to rainfall variability because they could not forage far from the degraded homesteads (McCabe, 1987).

4.40 Relationships between long-term rainfall variability and livestock production performance indicators

About 48.8 % of cattle mortality was explained by delayed mean annual rainfall. That means that large population of cattle died during droughts probably due to shortage of forage. A recent study also found that cattle mortality was related to rainfall though in that study, effects of drought were coupled with winter storms (Begzsuren et al., 2004). In addition, this study also showed that a third of goat mortality was accounted for by direct mean annual rainfall which also showed that goats were more sensitive to annual rainfall variability than cattle. This can be explained by goats being less able to utilize low quality fodder available during drought than other livestock populations and hence, likely to be affect most by decline in forage quality. Previous studies had suggested that high mortality rate of small stock in Botswana was mainly caused by poor management (Seleka, 2001). Sheep mortality was not significantly associated with either direct or delayed rainfall. This implies that sheep were more suitable for arid areas of Kgalagadi than both cattle and goats.

The birth rates for all livestock species were not significantly related to mean annual rainfall though cattle birth rates responded at 90 % significance level. That means that birth rates for sheep and goats did not fluctuate between years. It was possible that goats and sheep which have shorter gestation periods than cattle always managed to conceive and give birth before the drought progressed. Cattle have long gestation periods and therefore have high possibility of being affected by shortage of forage during the drought year. In addition, livestock off-take rates were not associated with rainfall and hence, herders did not appear to sell more livestock during drought. That dispute the idea that pastoralists in Kgalagadi tend to destock during drought (see paper 2 in this thesis). Instead, low off-take rates could be explained by the customary value of livestock in Botswana as store of wealth instead of being commercial assets (Seleka, 2001).

4.50 Association of livestock production performance indicators with livestock population

The results showed that cattle and goat population were strongly associated and that could be explained by their feeding habits. Cattle are mainly grazers while goats are browsers and hence complemented each other well (IIRR, 2002). Actually, it has been suggested that goats reduced bush encroachment and hence opened space for grass growth to support increased cattle population (Wilson et al., 1975). The results of this study suggest that cattle population decreased as death rates increased during drought periods. This can be attributed to poor nutritional supply due to shortage of forage during drought (Coppock and Reed, 1992; Oba, 2001). Thus, there is a need for management to be improved so that livestock losses are reduced because population recovery after drought is normally delayed (Oba, 2001). Death rate had more influence on cattle population than goats although goat death rate was higher than that of cattle. The reason could be that goats reproduce quicker than cattle and therefore more likely to recover faster than cattle. The cattle population was not affected by birth rates and off-take rates because these indicators did not fluctuate in response to rainfall. Besides, off-take rates in communal grazing areas were low (11.1 %) to have much influence on cattle population. Goats and sheep populations did not respond to any of performance indicators. On the contrary, it has been suggested that sheep off-take rates increases in response to population growth; whereas goat off-take rates were not related to population increase which agrees with results of the current study (Seleka, 2001).

5.0 Conclusion

The results of this study suggest that global climatic oscillations systems are not good predictors of rainfall variability in Kgalagadi region and hence, could not be used to predict drought years. In addition, NAO, ENSO and SSTs had no direct significant influence on livestock population dynamics even though the NAO and ENSO indices had been shown to have moderate influence on rangeland productivity in the Kalahari (Botswana). Kgalagadi district is characterized by high rainfall variability which indicates that rainfall is less reliable and unpredictable. The high rainfall variability (CV >33 %) reflects that livestock population was unlikely to reach equilibrium. The livestock populations responded to rainfall variations differently. Cattle and goats populations responded weakly to rainfall variability while sheep population did not. Goats were more sensitive to rainfall variability and therefore may not be suitable for the ecosystem of Kgalagadi. Given that regional rainfall variability influenced livestock population dynamics, it is essential that management practices be improved to buffer impact of drought and reduce loss of income by the pastoralists.

6.0 References

Begzsuren S, Ellis JE, Ojima DS, Coughenour MB and Chuluun T 2004. Livestock responses to droughts and severe winter in the Gobi Three Beauty National Park, Mongolia. Journal of Arid Environments 59: 785-796.

Burgess J 2003. Country pasture/ Forage resource profiles (Botswana). www. Fao. Org.

Coppock DL and Reed JD 1992. Cultivated and Native browse legumes as calf supplements in Ethiopia. Journal of Range Management 45: 231-238.

Central Statistics Office 2001. Ministry of Finance and Development Planning, Gaborone. www.cso.gov.bw/cso

Desta S, and Coppock DL 2002. Cattle population dynamics in the southern Ethiopian rangelands, 1980-1997. Journal of Range Management 55: 439-451.

Ellis J 1996. Climate variability and complex ecosystem dynamics: implication for pastoral development. In: Living with uncertainty (Scoones I eds). International Institute for Environmet and Development. London.

Ellis J and Galvin KA 1994. Climate Patterns and Land-use Practices in the Dry Zones of Africa. BioScience.44:340-349.

Ellis JE and Swift DM 1988. Stability of African pastoral ecosystem: Alternate paradigms and implications for development. Journal of Range Management 41: 450-459.

Fernandez I, Hernandez CN and Pacheco JM 2003. Is the North atlantic Oscillation just a pink noise? Physica A 323: 705-714.

Fynn RWS and O'connor TG 2000. Effect of stocking rate and rainfall on rangeland dynamics and cattle performance in a semi-arid savanna, South Africa. Journal of Applied Ecology 37: 491 – 507.

Hitchcock RK 1978. The traditional response to drought in Botswana. In: Botswana Drought Symposium (Hinchey M.T eds), Gaborone, Botswana.

Hulme PE 2005. Adapting to climate change: is there scope for ecological management in the face of a global threat? Journal of Applied Ecology 42: 784-794.

IIRR 2002. Managing Dryland Resources- An extension manual for Eastern and Southren Africa. International Institute of Rural Reconstruction, Nairobi, Kenya.

Jahnke HE 1982. Livestock Production Systems and Livestock Development in Tropical Africa: Kieler Wissenschaftsverlag VAUK.

Knippertz P, Ulbrich U, Marques F and Corte-Real J 2003. Decadal changes in the link between El NINO and springtime North Atlantic Oscillation and European –North African rainfall. International Journal of Climatology 23: 1293-1311.

Lamb PJ and Pepper RA 1987. North Atlantic Oscillation: Concept and Application. American Meteorological Society 68:1218.

McCabe JT 1987. Drought and Recover: Livestock Dynamics among the Ngisonyoka Turkana of Kenya. Human Ecology 4: 371-388.

Nicholson SE and Kim J 1997. The relationship of the El nino- Southren oscillation to African rainfall. International Journal of Climatology17: 117 – 135.

Oba G 2001.The effect of multiple droughts on cattle in Obbu, Northren Kenya. Journal of Arid Environments 49: 375-386.

Oba G, Post E and Stenseth NC 2001. Sub-saharan desertification and productivity are linked to hemispheric climate variability. Global Change Biology 7: 241-246.

Oba G, Stenseth NC and Lusigi WJ 2000. New perspectives on sustainable grazing management in arid zones of sub-Saharan Africa. Bioscience 51: 35- 51.

Perkins JS 1991. Drought, cattle-keeping, and range degradation in the Kalahari, Botswana. In: Pastoral economics in Africa and long term responses to drought (Stone J.C eds). Proceedings of a colloquium at the Univesity of Aberdeen.

Perkins JS 1996. Botswana: fencing out the equity issue. Cattleposts and ranching in the Kalahari Desert. Journal of Arid Environments 33: 503 – 517.

Paeth H, and Friederichs P 2004. Seasonality and time scales in the relationship between global SST and African rainfall. Climate Dynamics 23:815-837.

Rammusson EM 1988. Global climate change and variability: Effects on drought and desertification in Africa. In: Drought and hunger in Africa: Denying famine a future (Glantz M.H eds). Cambridge University Press.

Scoones I 1995. Exploiting heterogeneity: habitat use by cattle in dryland Zimbabwe. Journal of Arid Environments 29: 221-237.

Seleka TB 2001. Determinants of short-run supply of small ruminants in Botswana. Small Ruminants Research 40: 203 – 214.

Smet M and Ward D 2005. A comparison of the effects of different rangeland management systems on plant species composition, diversity and vegetation structure in a semi-arid savanna. African Journal of range & forage science 22(1): 59-71.

Stige LC, Stave J, Chan K, Ciannelli L, Pettorelli N, Glantz M, Herren HR and Stenseth NC 2006. The effect of climate variation on agro-pastoral production in Africa. PNAS 9:3049-3053.

Tadesse T, Wilhite DA, Harms SK, Hayes MJ and Goddard S 2004. Drought Monitoring Using Data Mining Technigues: A Case Study for Nebraska, USA. Natural Hazards 33: 137-159.

Thomas DSG 2002. Sand, Grass, Thorns, and…..Cattle: The Modern Kalahari Environment. In: Sustainable Livelihoods in Kalahari Environments: contributions to global debates (Sporton D, Thomas D eds). Oxford University Press Inc., New York.

Toulmin C 1996. Tracking through drought: options for destocking and restocking. In: Living with uncertainty (Scoones I eds). International Institute for Environmet and Development. London

Wang G 2003. Reassessing the impact of North Atlantic Oscillation on the sub-Saharan Vegetation productivity. Global Change Biology 9: 493-499.

Wilson AD, Leigh JH, Hindley NL and Mulham WE 1975. Comparison of the diests of goats and sheep on a Casuarina cristata- heterodendrum oleifolium woodland community in western New South Wales. Australian Journal of Experimental Agriculture and Animal Husbandary 15: 45 – 53.

PAPER 2

Livestock management practices and constraits during drought in Kgalagadi south, Botswana.

Abstract

A study was carried out to determine the livestock management practices used in response to drought and constraints encountered by pastoralists in two villages in Kgalagadi. A structured questionnaire was used to collect data on perceived trends of grazing resources and livestock population and management practices as well as constraints to drought management. The results showed that pastoralists had different perceptions of droughts and subsequently used different management practices. The results also showed that pastoralists practiced destocking, supplementary feeding and mobility in response to drought. The lack of funds was a major constraint to pastoralist's ability to cope with drought because they needed money to purchase supplementary feed. It is therefore suggested that policies should incorporate practices adopted by pastoralists and promote flexibility in management in response to rainfall variability.

Key words: drought, livestock management practices, Kgalagadi South.

1.0 Introduction

Livestock production in drylands of Africa is limited by forage shortage during drought (Coppock and Reed, 1992). In response to drought, pastoralists use different management practices to mitigate drought impacts on livestock dynamics. The use of livestock management practices is influenced by its benefits to herders (Coppock and Birkenfeld, 1999) and herder's perception of ecological systems (Ellis and Swift, 1988). Previous studies have demonstrated that pastoralists are knowledgeable of their ecological systems (Mapinduzi et al., 2003) and hence, management responses are in accordance with perceived threats of drought (Toulmin, 1996). Diversity in social and economic characteristics of pastoralist may affect use of livestock management practices (Coppock and Birkenfeld, 1999). It is therefore essential to understand the socio-economic and perception of pastoralists on impacts of drought on livestock.

Livestock populations in drylands are characterized by fluctuations in response to rainfall variability (McCabe, 1987; Desta and Coppock, 2002; Oba, 2001). As shown in paper 1(this thesis), rainfall variability influence livestock population dynamics weakly. Given that livestock populations depend on rangeland and primary productivity is correlated with rainfall, it is possible that management practices have buffering effect on livestock population (Stige et al., 2006). Traditionally, pastoralists in arid areas responded to drought by mobility to ensure that their livestock got enough forage during drought (Galvin et al., 2001, Hitchcock, 1978). It is argued that the practice of mobility is an appropriate and effective way to utilize heterogeneous drylands habitats (Toulmin, 1996). However, changes in land tenure and privatization of communal grazing areas have weakened the traditional practices (Taylor, unpubl) and the traditional practices have been replaced by practices suitable for equilibrium systems (Oba et al., 2001). Subsequently, pastoralists have become more vulnerable to climate variability (Galvin et al., 2001). Nevertheless, pastoralists had adjusted their management practices and adopted other practices that enable them to cope with drought.

The literature suggests that opportunistic pastoral strategy can buffer livestock population from drought effects (e.g. Horowitz and Little, 1988; Toulmin, 1996). The livestock population is continuously adjusted to match the variability of grazing

(Toulmin, 1986). It is acknowledged that lack of livestock population adjustments in accordance with forage condition increases vulnerability during periods of stress (Turner and Williams, 2002). Therefore, pastoralists are encouraged to destock livestock during drought to reduce livestock losses. In the post drought period, pastoralists restock to maximize use of abundant grazing. However, livestock marketing systems may limit the effectiveness of destocking practices during drought. The livestock prices are likely to drop during drought (Toulmin, 1996) as animals lose condition and all herders try to sell to save their investment. This is bound to substantially increase prices in post-drought when there are fewer animals to sell. Thus, regionally integrated markets and improved infrastructure might stabilize local prices (Turner and Williams, 2002; IIRR, 2002). But early destocking may also be more desirable as it affords market flexibility and better prices before market demands gets saturated (Gill and Pinchak, 1999). The problem remains that most pastoral communities are isolated and far from the market, making them not to be able to dispose of livestock during drought.

Pastoralists also use supplementary feeding to mitigate drought. The literature shows that supplementation improves animal performance during dry periods (Coppock and Reed, 1992; Schlecht et al., 1999). Supplemented animals exhibit improved reproductive performance during drought as compared to non-supplemented animals (Tedonkeng et al., 2006). The supplements provide nutrients deficient in the basal diet and thus buffer the variability in quality and quantity of pasture. However, the feasibility of supplementary feeding relies on accessibility of feedstuff by herders. Fodder could either be produced or purchased (Toulmin, 1996) but in view of evidence that plant growth in drylands is limited by lack of water, the most viable option will be to purchase the feedstuff. Other studies have suggested that indigenous plants have a potential to stabilize forage supplies (Coppock and Reed, 1996; Norton et al., 1996).

Given the high climate variability in drylands, the livestock management practices used by local communities in drought mitigation should be understood. The increased knowledge on livestock management practice and their constraints will ensure that appropriate policies are formulated to make pastoralists livelihood to be less vulnerable to drought. The goal of this study was therefore to investigate the livestock management practices and their constraints in Kgalagadi south where droughts are known to be recurring problem. The study addressed the following question: (i) What were the demographics of pastoralists and how did they relate to ownership of livestock? (ii) What were the pastoralists's perceptions of drought frequency, trends of forage availability and livestock population dynamics? (iii) What were the livestock management practices adopted by pastoralists to mitigate the effects of droughts? (iv)What were the main constraints that limited the livestock management practices?

2.0 Methods

2.10 Study area

The study was conducted in the Kgalagadi South demonstration sites of the GEF-Botswana, Indigenous Vegetation Project (IVP). My study site lies 257 Km from Tsabong which is the administrative center for Kgalagadi district. The IVP project focused on issues related to integrating local communities in management of the natural resources and conservation of local biodiversity. Among the project's aims was promotion of exchange of knowledge with local communities on their coping strategies. Drought coping strategies is one of the components of the targeted research to which my research will make a contribution. The household surveys on livestock management practices were conducted in the villages of Bokspits, and Vaalhoek (Figure 1). There were about 105 and 51 households in Bokspits and Vaalhoek, respectively (IVPBOT 03, 2004).

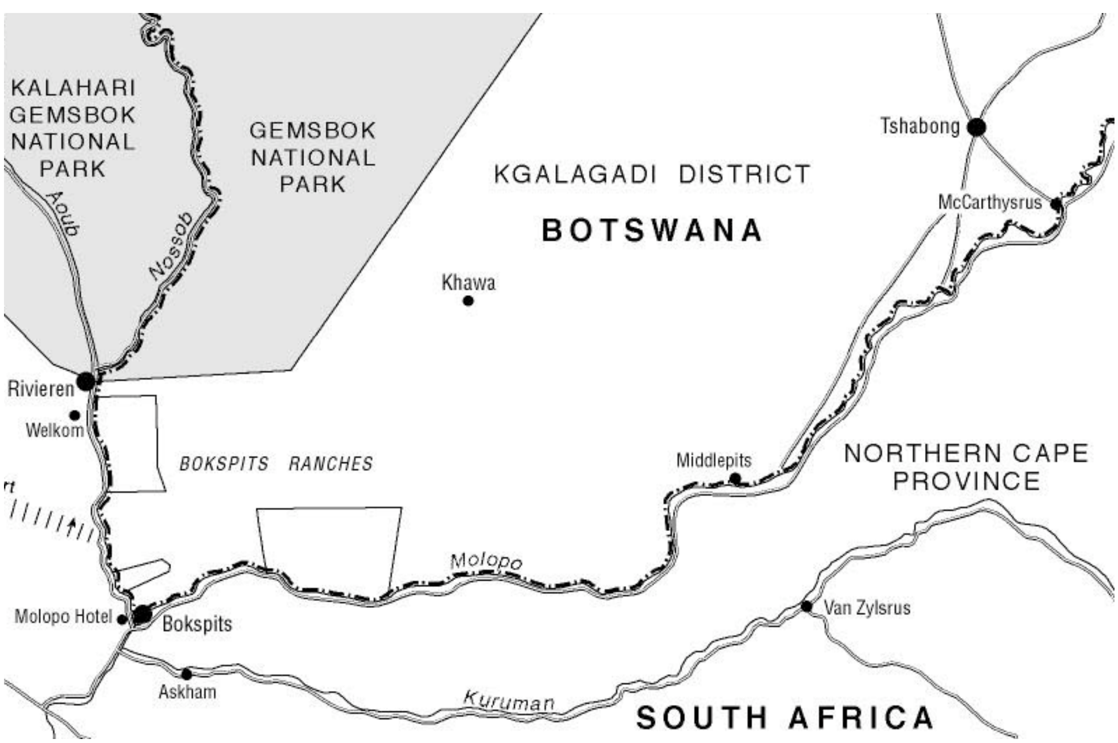


Figure 1: Map showing the study area (Source: IVP BOT04002- PID report (Mark Reed))

Generally, Kgalagadi South is climatically very arid (Thomas, 2002) with high rainfall variability. The average annual rainfall falls below 250 mm and varies between 225 to 250 mm (Field, 1978). Rainfall falls mostly from November to February with an extended dry season, which influences the fodder production. Coupled with the low rainfall are the high temperatures during summer (45 °C) and cold winters (-8 °C) (Matlhaku, 2004). The vegetation within local study sites (Bokspits and Vaalhoek) can generally be described as arid shrub savanna (Waere and Yalala, 1971). The grassland around the sand-dunes is dominated by *Aristida species, Eragrostis lehmanniana* and *Schmidtia kalahariensis* (Field, 1978). Trees, which are scattered predominately in the inter-dunes consist of *Acacia erialoba, Acacia mellifera, Boscia Albitrunca,* and *Terminalia sericea,* and *Acacia haematoxilon*. The area has recently been invaded by *Prosopis juliflora* which were planted as a source of forage, although presently the concern is that the species has had negative impacts on the indigenous vegetation.

Land use in local study sites includes wildlife and pastoral production. The livestock composition is dominated by small ruminants (goats and sheep) and there are few cattle, donkeys and horses. The traditional livestock production system is based in communal areas (Perkins, 1996) and can be categorized further as village-based communal grazing and borehole-based cattle-posts owned by individuals or syndicates (Darkoh, unpubl). The livestock in communal areas is allowed to roam freely around the boreholes or wells which are the only sources of water and therefore used to control livestock mobility (Perkins, 1996).

2.20 Data collection

This study used a structured questionnaire to collect information needed to answer the research questions (Appendix 1). The components of the questionnaire included questions on the following parameters; (i) demographic information of pastoralists, (ii) perception of pastoralists on drought frequency, trends of grazing pasture availability and livestock species population, (iii) livestock management practices used, and (iv) main constraints that affect management by pastoralists.

(i) Demographic information

This section sought descriptive information on demographics of pastoralists such as their age, years of education, village of residence and livestock ownership. It also included questions on cattle herd size, goats and sheep flock sizes. These data were to be used to establish demographic factors that affect livestock ownership.

(ii) Perception of pastoralists on drought issues

Information was collected on perception of pastoralists on several attributes related to droughts. These attributes included pastoralist's duration of grazing within the study area, and perception of drought frequency. In addition, this section sought information on pastoralist's perception on trends of grazing resource availability and livestock species population over the last five years. The attributes were required to establish the patterns of grazing resource and livestock population dynamics within the study sites.

(iii) Livestock management practices used during drought

The questions on this part of questionnaire dealt with livestock management practices used by pastoralists to cope with the impact of drought. The livestock management practices included destocking (herd reduction), supplementary feeding and mobility. For each management practices, there were several open-ended questions asked to allow the respondents to elaborate their answers. It was hypothesized that there will be some marketing challenges during drought and therefore the pastoralist were asked to list them under destocking practices. Information on attributes of supplementary feeding included feedstuff used and their sources. The practice of mobility was inquired in relation to areas which pastoralists had access during drought.

(iv) Constraints of management practices and support provided by the government

The last part of questionnaire consisted of questions on constraints to management practices. Pastoralists were asked to list all constraints they experienced during drought periods. In this paper, constraints referred to any factor that limited pastoralist's ability to buffer effects of drought on their livestock.

The field survey was conducted in October 2005. Four enumerators were trained for a day to familiarize them with the topic of interest, objectives of the study and contents of the questionnaire. A total of seventy-one pastoral households (40 and 31 household in Bokspits and Vaalhoek, respectively) were interviewed. Pastoralists interviewed were selected randomly by picking one pastoralist from every other household from randomly selected starting points in Bokspits and Vaalhoek.

2.30 Statistical Analysis

A number of bivariate comparisons of variables related to livestock management practices were done as explained below. (i)Analysis of variance (ANOVA) was used to compare means of variable on pastoralists demographic such as age and years of education for the pastoralists in Bokspits and Vaalhoek. Other variables compared between villages using ANOVA were cattle herd size, goat and sheep flock size. A correlation matrix was run for the relationship between pastoralists demographics and livestock ownership in Kgalagadi South. (ii) Chi-square test ($?^2$) was used to test cross-tabulated data on variables such as perception of pastoralists on trends of grazing pasture availability, and livestock population, management practices, and constraints of management practices for coping with drought. The test was used to assess for homogeneity or similarity on categorical response variables between the study villages (Bokspits and Vaalhoek). Variables that did not exhibit difference between the study villages were aggregated. Constraints of management practices were presented graphically using frequency data. All statistical differences presented as significant were at $P<0.05$ level.

3.0 Results

3.10 Demographics of pastoralists and how they relate ownership of livestock

The participants from both villages were mainly middle-aged. The demographic data showed no significant differences on average ages of pastoralists in Bokspits and Vaalhoek ($F_{1,70}$ = 0.292, P = 0.591) (Table 1). The results also showed that no significant differences existed between years of education for the pastoralists in both villages ($F_{1,71}$ = 128, P = 0.722). A large proportion of the pastoralists in Bokspits owned cattle whereas only a third of pastoralists in Vaalhoek owned cattle and consequently the pastoralists in Bokspits owned more cattle than the pastoralists in Vaalhoek ($F_{1,67}$ = 5.836, P = 0.019). There was no significant difference on goats herd sizes between Bokspits and Vaalhoek ($F_{1,67}$ = 0.868, P = 0.36). Majority of the pastoralists in Bokspits also owned sheep as compared to half of pastoralists in Vaalhoek (Table 1). The average sheep flock sizes were higher for Bokspits than Vaalhoek ($F_{1,67}$ = 7.71, P = 0.007).

Table 1 : Average age, years of education and herd sizes of livestock owned by pastoralist in Bokspits and Vaalhoek. (All data were expressed as per households)

	Villages	
Variables	Bokspits	Vaalhoek
Average age of respondent	55	49
Years of education	5	4.7
Proportion of cattle ownership (%)	62.5	32.3
Cattle herd size	8	2
Proportion of goat ownership (%)	97.5	90.3
Goat herd size	35	27
Proportion of sheep ownership (%)	80	51.6
Sheep flock size	55	18

Results from correlation matrix showed a negative correlation between age of participants and years of education (Table 2). The cattle ownership was significantly correlated to gender and village. Goat ownership was not significantly affected by any demographic variable. Meanwhile, sheep ownership was significantly correlated to village and cattle ownership. Other interactions between demographic variables and livestock ownership were not statistically significant.

Table 2: Correlation matrix to show relationship between pastoralist's demographics and livestock ownership

	Gender of participants	Years of education	Age of participants	Village	Cattle ownership	Goats ownership	Sheep Ownership
Gender of participants							
Years of education	- 0.086						
Age of participants	- 0.006	- 0.645**					
Village	0.124	- 0.043	- 0.064				
Cattle ownership	0.255*	- 0.168	0. 167	0.300*			
Goats ownership	0.204	0.045	- 0.129	0.154	0.019		
Sheep ownership	0.057	- 0.191	0.159	0.301*	0.321**	- 0. 039	

* correlation is significant at the 0.05 level
** correlation is significant at 0.01 level

3.20 Pastoralists' perception on drought frequency and trends of grazing resource availability and livestock population.

There was no statistical significance difference between duration of grazing in the area by pastoralists in both villages (?² = 0.849, df = 1, P = 0.357). Majority of the pastoralists in both villages (71.8 %) had been grazing in their respective grazing areas for 5 years and/or more, whereas the rest of pastoralists (28.2 %) had been grazing in the area for 4 years or less. There was no difference on perceptions on drought frequency in both villages (?² = 2.649, df = 1, p = 0.104). The majority of pastoralists (85.9%) perceived that drought reoccurred every 2 years; while 14.1 % of pastoralists perceived drought frequency to be 3 plus years.

The pastoralists in Bokspits and Vaalhoek had different perceptions on trends of grazing pasture, cattle, sheep and goats population trends (Table 3). The perceptions of pastoralist in Bokspits on trend of grazing pasture availability differed significantly from that of pastoralist in Vaalhoek (?² = 37.333, df =1, P<0.001). All pastoralists in Bokspits believed that the availability of grazing pasture had been fluctuating continuously during the last five years; whereas, majority of pastoralists in Vaalhoek had a perception that forage availability had decreased in the last five years. Only a fewer pastoralists interviewed in Vaalhoek believed that grazing pasture availability had fluctuated continuously in the last five years.

In addition, there was a significant difference on the perceived trends of cattle population by pastoralists in the two study villages (?^{2} = 13.895, df = 3, P = 0.003). Majority of pastoralists in Vaalhoek believed that cattle population had increased in the last five years whereas most pastoralists in Bokspits perceived that cattle population had fluctuated continuously in the last 5 years (Table 3). The rest of respondents in both villages believed that cattle population had either increased, or they had no idea of the trends of cattle population (Table 3).

However, no significant differences existed between the perceptions of pastoralists in both villages on trends of sheep population in the last 5 years (?^{2} = 6.300, df = 3, P = 0.098). Most herders in Bokspits and Vaalhoek perceived that sheep population had increased in the last five years (Table 3). A sizeable proportion of pastoralists in Bokspits and Vaalhoek believed that the sheep population had either decreased or fluctuated continuously over the same period. Meanwhile, significant difference existed on perception of goats population trends between herders in the two villages (?^{2} = 9.763, df = 3, P = 0.021). But the majority of pastoralists in Bokspits and Vaalhoek believed that goats' population had increased over the last five years (Table 3). In Bokspits, a moderate proportion of pastoralists believed that goat population had fluctuated continuously in the last years while about equal numbers in Vaalhoek had a perceived that the goats population to have decreased within the same period (Table 3).

Table 3 : Percent frequency of pastoralist perception on trends of grazing pasture availability and livestock (cattle, sheep, goats) population in the last 5 years

		Trends			
Variables		Increased	Decreased	Fluctuate continuously	Not applicable
		-----------------------%----------------------			
Grazing pasture	Bokspits	-	-	100	0
	Vaalhoek	-	66.7	33.3	0
Cattle population	Bokspits	20	22.5	32.5	25
	Vaalhoek	50	33.3	3.3	13.3
Sheep population	Bokspits	45	15	30	10
	Vaalhoek	56.7	26.7	6.7	10
Goats population	Bokspits	52.5	12.5	32.5	2.5
	Vaalhoek	53.3	36.7	6.7	3.3

3.30 Livestock management Practices during drought

3.31 Destocking (herd reduction)

Destocking (herd reduction) during drought was highly practiced in both villages (Table 4). The use of destocking practice was comparable in Bokspits and Vaalhoek (?^{2} = 0.023, df = 1, P = 0.878). Despite the fact that the practice was common, the pastoralists acknowledged several factors considered as livestock marketing challenges. There was a significant difference on factors that were considered a marketing challenge (?^{2} = 41.491, df = 2, $P < 0.001$). All pastoralists who used destocking practice in Bokspits indicated that prices offered by buyers were too low; but only few pastoralists in Vaalhoek complained of low prices. Rather, most pastoralists in Vaalhoek indicated that there was no market for their livestock. There was also a significant correlation between the practice of destocking and sheep production ($P<0.05$).

Table 4: percent of pastoralists who destocked and marketing challenges during drought

	Villages	
Practice	Bokpits (n=40)	Vaalhoek (n=31)
	-----------------------------------%	-------------------------------
Destocking (herd reduction)	82.5	83.9
Marketing challenges		
Low prices	82.5	16.1
No market	0	67.8
None	17.5	16.1

3.32 Supplementary Feeding

There was a significant difference between use of supplementation in Bokspits and Vaalhoek (Table 5). Supplementation was highly practiced in Vaalhoek than in Bokspits. The common feedstuff used for supplementation included molasses, veldt products, winter block, salt and drought pellets. Majority of pastoralists in Bokspits used molasses as compared to those in Vaalhoek. Instead, majority of pastoralists in Vaalhoek used veldt products for supplementation as compared to those in Bokspits. Winterlick was used by few pastoralists in both villages and there was no significant difference between the uses in Bokspits and Vaalhoek. Salt was mostly used for supplementation in Vaalhoek but not in Bokspits. Drought pellets was used for supplementation by few pastoralists in both Bokspits and Vaalhoek (Table 5).

Table 5: percent of pastoralists who supplement their livestock and feedstuff used during drought

	Village			
Practice	Bokspits (n=40)	Vaalhoek (n=31)	$?^2$	P-value
	---------------%---------------			
Supplementation	80.0	100	6.987	0.008
Feedstuff				
i) Molasses	53.8	16.1	10.527	0.001
ii) Veldt products	41.0	74.2	7.701	0.006
iii) Winter lick	20.0	29.0	0.782	0.376
iv) Salt	27.5	61.3	8.173	0.004
v) Drought pellets	46.2	29.0	2.137	0.144

There was a significant difference on sources of feedstuff used for supplementary feeding between the two villages ($?^2$ = 11.6, df = 3, P = 0.009). Majority of pastoralists in Bokspits indicated that they purchased the feedstuff for supplementation; while few in Vaalhoek indicated that they also purchased feedstuff used for supplementation (Table 6). Fewer pastoralists in Bokspits used wild products only for supplementation as compared to pastoralists in Vaalhoek. Majority of pastoralists in Vaalhoek used a combination of veldt products and purchased feedstuff to supplement their livestock; while small proportion of pastoralists in Bokspits used a combination of wild products and purchased feedstuff.

Table 6: percent of source of feedstuff used for supplementation by pastoralists during drought

	Villages	
Source of feed	Bokspits (n=40)	Vaalhoek (n=31)
	-----------------------------%--------------------------------------	
Purchase them	40	25.8
Wild products only	7.5	22.6
Wild products & purchase	32.5	51.6
Not applicable	20	11.3

3.33 Mobility

Mobility was another livestock management practice used by pastoralists to mitigate drought and there was significant difference on the use of this practice by pastoralists in Bokspits and Vaalhoek ($?^2$ = 4.6, df = 1, P = 0.031). Mobility was used by a large proportion of pastoralists in Bokspits and by less than half in Vaalhoek (Table 7). All pastoralists (100%) who practiced mobility acknowledged that they moved their livestock in search of better grazing resources. There were significant differences on areas exploited by pastoralists during drought ($?^2$ = 13.766, df = 3, P = 0.003). About a quarter of pastoralists in Vaalhoek moved their livestock to the cattle-post (Moraka) during drought, as compared to few pastoralists in Bokspits. Small proportions of pastoralists in Bokspits indicated that they moved their livestock to Tshane-tshane (community ranch) during drought; whereas no pastoralists from Vaalhoek mentioned Tshane-tshane. Majority of pastoralists in Bokspits moved their livestock to "other grazing areas" (e.g. Homestead) but only few pastoralists in Vaalhoek indicated "other grazing areas". The rest of pastoralists did not move their livestock during drought.

Table 7: Percent of use of mobility as livestock management practices and areas used during drought.

	Village	
Practice	Bokspits (n=39)	Vaalhoek (n=31)
	-----------------------%	--------------------
Mobility	67.5	41.9
Accessible areas during drought		
Cattle-post	10.0	25.8
Tshane-tshane	15.0	0
Other grazing areas	42.4	16.1
Not applicable	32.5	58.1

3.40 Constraints of livestock management practices during drought

There was no statistically supported differences between constraints faced by pastoralists in both villages ($?^2$ = 7.32, df = 5, P = 0.198) and therefore constraints for both villages were aggregated. The frequencies of different constraints of livestock management in Bokspits and Vaalhoek are given in Figure 4. The majority of pastoralists indicated that lack of funds was a major constraint to livestock management. Lack of pasture was another factor and a combination of animal poor condition, lack of funds and market were indicated as constraints during droughts. Few pastoralists indicated that lack of water was a constraint to their livestock management practices during drought; and the rest indicated that they did not have any constraints to livestock management practices.

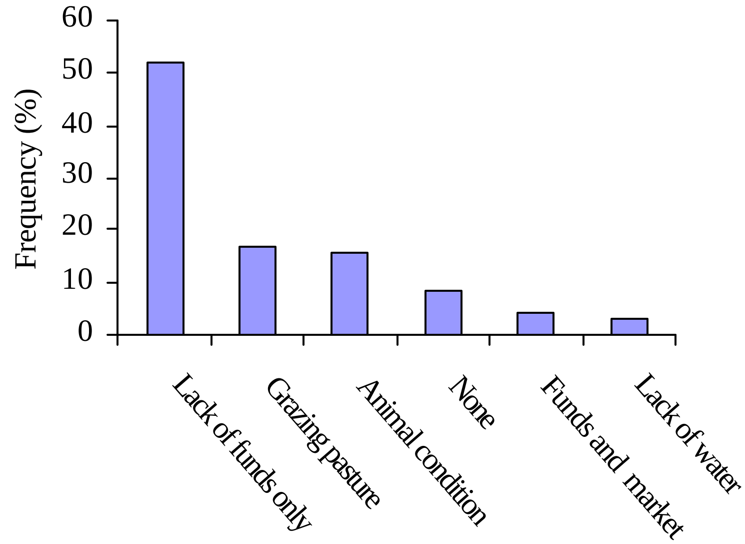


Figure 4: percent frequency of constraints of livestock management practices

4.0 Discussion

4.10 Demographics of pastoralists and how they relate to ownership of livestock

Pastoralist in Bokspits and Vaalhoek were not significantly different in respect of social aspects such as age and years of formal education. Therefore, it is assumed that the use of management practice was not affected by either age or education. On the contrary, the literature suggests that person's education and age are some of factors that may affect use of livestock management practices (Coppock and Birkenfeld, 1999). It was also evident that most pastoralists relied more on local knowledge to manage their livestock than formal education. In addition, it was observed that mixed herding was highly practiced in Bokspits and Vaalhoek. It had been suggested that mixed stocking reduced risk of losing all livestock during drought (IIRR, 2000). Therefore, it is argued that pastoralists in Bokspits and Vaalhoek were aware that different livestock species had different feeding habits and could complement each other when kept together. However, goats and sheep flock sizes in Bokspits and Vaalhoek were higher than the normal flock sizes (20 goats and 13 sheep per farm) in the traditional system in Botswana (Seleka, 2001). That could reflect a shift in animal ownership in an attempt to adapt to climate variability because small stock especially goats are more resilient under adverse conditions (Toulmin, 1996). However, results from my study (Paper 1) showed that goats were sensitive to climate variability and hence, it may be kept for cultural needs. In addition, my study revealed that sheep were not affected by rainfall variability and that could be the reason sheep were more popular in Bokspits and Vaalhoek than cattle.

4.20 Pastoralist's Perception on drought frequency and trends of grazing resource availability and livestock population.

The majority of pastoralists had been grazing their livestock in the areas for a long duration and therefore their perceptions were more likely to reflect accurate accounts of grazing resources availability and trends of livestock populations. Results revealed that drought was perceived as a recurring problem by herders in Bokspits and Vaalhoek. The herder's perception on drought frequency was in line with results of Paper 1 which disclosed that rainfall variability was high in Bokspits (CV = 62.4 %). The high rainfall variability implied that recurring droughts is a common phenomenon which pastoralists have to adapt in order to survive. Herder's perception on drought frequency agrees with what had been reported in other arid areas such as Namibia (Rothauge, unplubl). Given that pastoralists had survived recurring droughts, it can be argued that they are aware of threats and opportunities of the ecological system and would adjust their practices to reduce impact of droughts. As shown in paper 1, rainfall variability had weak influence on livestock dynamics. The implication is that other factors including management are accountable for large portion of the variability in livestock population dynamics.

Pastoralists in Bokspits and Vaalhoek had different perceptions on trends of grazing resource availability. The results were consistent with the research findings of other studies which reported that rangeland ecosystems in arid areas displayed spatial variability of vegetation resource in response to rainfall variability (Thomas et al., 2000; Scoones, 1995). Therefore, herders exploiting spatial separated pastures will probably have different perceptions on forage availability and that is the reason it is argued that spatial distribution of resources buffered drought impact (Illius and O'Connor, 2000). A study by Bollig and Schulte (1999), suggests that pastoralists assessment of rangelands is also based on value of plant species suitable for grazing and therefore herders who rear different livestock species are likely to rank the grazing condition differently. The pastoralists in Bokspits and Vaalhoek had different perceptions on trends of livestock population. It was possible that the degree of nutrition limitation may vary in different areas and in turn livestock populations responded differently. Therefore, perceptions of pastoralists were generally consistent with the findings of other studies in similar ecosystems (McCabe, 1987; Begzsuren et al., 2004). Given that pastoralists had different perceptions on trends of forage resource and livestock populations, it was expected that different management practices were used in response to perceived grazing resource changes. Pastoralists that feel that grazing was declining will probably adjust their livestock management practices to buffer threats of drought.

4.30 Livestock management practices during drought

The pastoralists in Bokspits and Vaalhoek used different livestock management practices to cope with drought. Results showed that destocking during drought was common in Bokspits and Vaalhoek. The possible explanation was that the pastoralists matched livestock numbers with fluctuations in forage yield (Toulmin, 1996; Gill and Pinchak, 1999). Destocking during drought enabled pastoralists to save their investment in order to re-establish their herds in the post drought period. Low prices and limited market for livestock were major factors that affected destocking. Poor prices for livestock in Botswana (especially small stock) are well documented (Seleka 2001) and hence, pastoralist's complaints of poor prices were understandable. Given that Bokspits and Vaalhoek are far from the major market (Botswana Meat Commission), it seemed pastoralists were restricted to local market which results in livestock supply exceeding demand. Subsequently, pastoralists did not have a good chance to negotiate and ended up accepting low prices (Turner and Williams, 2002). However, the tendency of pastoralists to "wait and see" may also be contributing to poor prices because animals are eventually sold when in poor body condition and worth less. Thus, early destocking may enable pastoralists to get better prices for their livestock (Gill and Pinchak, 1999). Research also suggests that regionally-integrated markets and improved infrastructure such as roads may stabilize local prices (Turner and Williams, 2002; IIRR, 2002)

Additionally, supplementary feeding was practiced in both villages as a response to seasonal variations in the quality and quantity of pasture. Most probably, pastoralists are knowledgeable of limitation of forage quality and quantity during drought and therefore intervened to reduce animal death rates. The literature shows that supplementation may improve animal performance during dry periods (Coppock and Reed, 1992; Schlecht et al., 1999). Molasses was used as a source of energy (Lindsay and Laing, 1996). The veldt products such as pods of *acacia erialoba* and *prosopis juliflora* were also used by pastoralists for supplementation. Research had shown that pods of *acacia erialoba* are excellent fodder for small stock (Macala et al., 1995). Winterlicks were also used to provide minerals and protein but they could be replaced by cheaper molasses/ urea blocks. Other feedstuff used were salt and drought pellets. The variation in supplements used by pastoralists may be explained by pastoralist's income from livestock sales while those with large herds may afford to purchase more supplements. The practice of supplementary feeding may be popular because the government of Botswana subsidizes feeds during droughts.

The results of this study further showed that mobility was still practiced in both villages although it was no longer the key strategy to cope with drought. It is possible that the shrinking communal rangelands may have contributed to limitations on the mobility but that is beyond the scope of this study. It appeared that mobility depended on grazing resources accessible during drought. Some pastoralists moved their livestock to cattle-posts during drought while others moved them to other grazing areas such as homesteads. In Bokspits, some pastoralists had access to Tshane-tshane ranch which is a community ranch. The findings of this study agree with the thinking that livestock mobility is essential for exploiting different ecosystems (Scoones, 1995). The finding was consistent with what had been suggested as appropriate use of non-equilibrium ecosystems where flexibility in rangeland exploitation is the aim of managers. The current Tribal Grazing Land Policy which promotes fencing of communal rangeland for private probably limits pastoralist's ability to move livestock.

4.40 Constraints during drought and government support

The majority of pastoralists indicated that they experienced constraints during droughts. Lack of funds was considered as a major constraint and that can largely be explained by pastoralists needing money to purchase supplementary feed for their livestock. In addition, the pastoralists stated that lack of grazing was additional constraint and subsequently animals lost body condition. The lack of market contributed significantly towards vulnerability to drought because they were not able to sell their livestock in time to meet their economic needs. Lack of water was also a constraint because livestock was forced to forage only around the boreholes.

5.0 Conclusion

This study has shown that pastoralists are knowledgeable of their environment and their perceptions of trends of forage availability and livestock populations were consistent with what has been reported in the literature. The grazing land was exploited by a mixture of goats, sheep and cattle which complemented each other well. Given that pastoralists perceived drought as a recurring problem, the management practices were adopted to address threats of ecological system and buffer impact of droughts. Different livestock management practices were used to cope with drought. The pastoralists practiced opportunistic pastoral strategy to maximize benefits from rangeland and destock during drought to reduce risks of die-offs. Herders also supplemented their animals during dry periods to minimize nutritional limitations on livestock production. The results provided evidence that mobility is still practiced even though it is no longer the key strategy to cope with drought as reported in the past. Nonetheless, shortage of funds was a greater constraint because herders needed money to purchase supplementary feeds. Overall, the management practices used by pastoralists seemed flexible and opportunistic to suit the variability of the production environment.

6.0 Recommendation

Based on the findings of this study, it is recommended that policies should take into consideration the perceptions and practices used by pastoralists to cope with drought. More importantly, local livestock markets should be responsive and integrated to national market to stabilize prices offered for livestock. Access to organized market will enable pastoralists to get reasonable prices as they destock and therefore will be able to restock after drought. Some of the money will also be used to purchase feedstuff needed for supplementary feeding. Consequently, improvement of livestock market will reduce pastoralist’s susceptibility to drought.

7.0 References

Bollig M and Schulte A 1999. Environmental change and pastoral perceptions: Degradation and indigeneous knowledge in two African pastoral communities. Human Ecology 27: 492-515.

Begzsuren S, Ellis JE, Ojima DS, Coughenour MB, and Chuluun T 2004. Livestock responses to droughts and severe winter in the Gobi Three Beauty National Park, Mongolia. Journal of Arid Environments 59, 785-796.

Coppock DL and Birkenfeld AH 1999. Use of livestock and range management practices in Utah. Journal of Range Management 52. 7 – 18.

Coppock DL and Reed JD 1992. Cultivated and Native browse legumes as calf supplements in Ethiopia. Journal of Range Management 45: 231-238.

Darkoh, unplis. Desertification in Botswana. Rala Report No. 2000.

Desta S, and Coppock DL 2002. Cattle population dynamics in the southern Ethiopian rangelands, 1980-1997. Journal of Range Management 55: 439-451.

Ellis EJ, and Swift DM 1988. Stability of African pastoral ecosystem: Alternate paradigms and implications for development. Journal of range management 41. 450-459.

Field DI 1978. A handbook for basic ecology for range management in Botswana. MoA, Gaborone

Fynn RWS, and O'Connor. T.G., 2000. Effect of stocking rate and rainfall on rangeland dynamics and cattle performance in a semi-arid savanna, South Africa. Journal of Applied Ecology 37: 491-5007.

Galvin KA, Boone RB, Smith NM and Lynn SJ 2001. Impact of climate variability on East African Pastoralists: Linking social science and remote sensing. Climate Research 19: 161 - 172.

Gill R and Pinchak 1999. Destocking strategies during drought. Texas cooperative extension. AS Web -0668-99.

Hitchcock RK 1978. The Traditional Response to Drought in Botswana. In : Hinchey. M.T. Botswana Drought Symposium, Gaborone

Horowitz MM, and Little PD 1988. African pastoralism and poverty:some implication for drought and famine. In: Drought and hunger in Africa: Denying famine a future (Glantz M.H eds). Cambridge University Press.

Hulme PE 2005. Adapting to climate change: is there scope for ecological management in the face of a global threat? Journal of Applied Ecology, 42: 784-794.

Illius AW, and O'connor TG 1999. On the relevance of nonequilibrium concepts to arid and semiarid grazing systems. Ecological applications, 9: 798-813.

Illius AW, and O'Connor TG. 2000. Resource heterogeneity and ungulate population dynamics. OIKOS. 89: 283-294.

IIRR 2002. Managing Dryland Resources- An extension manual for Eastern and Southren Africa. International Institute of Rural Reconstruction, Nairobi, Kenya.

Lindsay JA and Laing AR 1996. The place for molasses in the drought feeding strategies. In Rowe. J, Cossins. N. (ed.). A Users Guide to Drought Feeding Alternatives. University of New England (UNE).

Macala J, Mosimanyana B and Kiflewahid B 1995. Nutrient composition of livestock feeds in Botswana. Ministry of Agriculture, Botswana.

Mapinduzi AL, Oba G, Weladji RB and Colman JE 2003. Use of indigeneous ecological knowledge of the Maasai pastoralists for assessing rangeland biodiversity in Tanzania. African Journal of Ecology 41: 329 -336.

Matlhaku, K. 2003. Situational Analysis of Kgalagadi South Site: In Situational Analysis of IVP Botswana Project site.

McCabe. J.T. 1987. Drought and Recovery: Livestock Dynamics among the Ngisonyoka Turkana of Kenya. Human Ecology, 15: 371.

Norton BW, Gutteridge RC, Johnson PW, Beale IF, Oldham CM, and McNeill. DM, 1996. Beyond the herb layer- shrubs and trees as drought reserves: In Rowe. J, Cossins. N. (ed.). A Users Guide to Drought Feeding Alternatives. University of New England (UNE)

Oba G 2001.The effect of multiple droughts on cattle in Obbu, Northren Kenya. Journal of Arid Environments 49: 375-386.

Oba G, Stenseth NC and Lusigi WJ 2000. New perspectives on sustainable grazing management in arid zones of sub-Saharan Africa. Bioscience 51: 35- 51.

Perkins JS 1991. Drought, Cattle-Keeping, and Range Degradation in the Kalahari, Botswana: In Pastoral Economies in Africa and Long term responses to drought, Proceedings of a Colloquium at the University of Aberdeen.

Perkins JS 1996. Botswana: fencing out the equity issue. Cattleposts and ranching in the Kalahari Desert. Journal of Arid Environments

Reed M 2004. Participatory Indicator Development: Preliminary Report. IVP Botswana.

Rothauge A unpubl. Drought management in Namibia. Neudamn Agricultural College. Namibia.

Schlecht E, Sangare M, and Becker K 1999. Supplementation of Zebu cattle grazing Sahelian pasture. I. Diet selection and intake. Journal of Agricultural Science 133: 69-81.

Scoones. I. 1995. Exploiting heterogeneity: habitat use by cattle in dryland Zimbabwe. Journal of Arid Environments, 29: 221-237.

Seleka TB 2001. Determinants of short-run supply of small ruminants in Botswana. Small Ruminants Research 40: 203 – 214.

Stige LC, Stave J, Chan K, Ciannelli L, Pettorelli N, Glantz M, Herren HR and Stenseth NC 2006. The effect of climate variation on agro-pastoral production in Africa. PNAS 9:3049-3053.

Taylor M Unplis. Tenure reform and the future of communal rangelands in Botswana. IVP/ UNDP. Botswana.

Tedonkeng P, Fonteh FA, Tendonkeng F, Kana JR, Boukila B, Djaga PJ and Fomewang II G 2006. Influence of supplementary feeding with multipurpose leguminous tree leaves on Kid growth and milk production in the West African dwarf goat. Small Ruminant Research 63: 142-149.

Thomas DSG 2002. Sand, Grass, Thorns, and…..Cattle: The Modern Kalahari Environment. In: Sustainable Livelihoods in Kalahari Environments: contributions to global debates (Sporton D, Thomas D eds). Oxford University Press Inc., New York.

Thomas DSG, Sporton D, and Perkins J 2000. The environmental impact of livestock ranches in the Kalahari, Botswana: Natural Resource use, ecological change and human response in a dynamic dryland system. Land Degradation & development, 11: 327-341.

Thurow TL, and Taylor Jr CA,. View point: The role of drought in range management. Journal of Range Management 52: 413-419.

Toulmin C 1996. Tracking through drought: options for destocking and restocking. In: Living with uncertainty (Scoones I eds). International Institute for Environmet and Development. London

Turner, D Matthew. 1999. Spatial and temporal scaling of grazing impact on the species composition and productivity of Sahelian annual grasslands. Journal of Arid Enviromnments 41:277-297.

Turner MD and Williams TO 2002. Livestock market dynamics and local vulnerabilities in the Sahel. World Development 30: 683-705.

UNDP .2001. Management of Indigenous Vegetation for the Rehabilitation of Degraded Rangelands in the Arid Zones of Africa. Project Document.

Waere PR, and Yalala A 1971. Provisional vegetation map. Botswana Notes and Records 3:131-152.

Westoby M, Walker BH, and Nor-Meir I 1989. Opportunistic management for rangelands not at equilibrium. Journal of Range Management 42:266-274.

Appendix 1: Drought management questionnaire

1. Personal details:

a) Name of Participant: ______________________
b) Sex: 1. Male____2. Female______
c) Age:______
d) Years of formal educ ation:_________
e) Village: 1. Bokspits______ 2. Vaalhoek _______
f) Date: ________________________

2. Which livestock do you own? (tick the answers)
   a) Cattle_____
   b) Goats_____
   c) Sheep_____
   d) Other______
3. How many of the following do you own?

Livestock	Numbers
Cattle	
Goats	
sheep	

4. How long have you been grazing in this area?
   a) = 2 years _____
   b) 3-4 years_____
   c) 5-6 years _____
   d) = 7 years _____
5. How often do you have drought in this area?
   a) every 2 years _____
   b) after 3-4 years_____
   c) after 5-6 years _____
   d) after 7 years _____

6. Have you noticed any change in availability of grazing pasture over the past 5 years? Yes______ No________

(*if the answer is No, please proceed to question 8)*

7. If yes, how can you describe the change in availability of grazing pasture?
   a) Increased
   b) Same
   c) Decreased
   d) Varies continuously

8. Have you noticed any change in livestock population in this area in the last 5 years? Yes_____No_____ (if no, go to question 10)

9. If yes, how can you describe the change in livestock population in the last 5 years? (Tick right answer)

i) **Cattle** a) increased ___b) Same____ c) Decreased___ d) Fluctuated all the time __
ii) **Sheep** a) increased ___b) Same___ _ c) Decreased___ d) Fluctuated all the time __
iii) **Goats** a) increased ___b) Same____ c) Decreased___ d) Fluctuated all the time __

Management Strategies:

10. Do you sell your livestock surplus to breeding herd during drought?
Yes ________No______

(if the answer is No, please proceed to question 12)

11. If yes, how easy is it to sell your livestock?
    a) Very difficult
    b) Difficult
    c) Not difficult
    d) Easy

12. Do you supplement your livestock during drought?
Yes _______No_______ *(if the answer is No, please proceed to question 15)*

13. If yes, please lists the feedstuff you use to supplement your livestock during drought?
____
____

14. Where do you get the feedstuff you use to supplement?
    a) Produce them ____
    b) Purchase them ____
    c) Stored supplies ____
    d) Supplied by government ____

15. Do you move your animals during drought to other grazing areas?
Yes______ No_______ (*if the answer is No, please proceed to question 18)*

16. If yes, where do you move your livestock to?
____
____

17. What are the reasons for moving your livestock to that particular area?
____
____

18. What are the constraints that limit your ability to cope with drought?
____
____

19. What role does the government play on assisting you to cope with drought?
    a) Subsidised feed
    b) Technical information
    c) Purchase livestock
    d) Nothing

Thanks for your time!!!!!!!!! Ke lebogela nako ya gago!!!!!!