

Maintaining opportunism and mobility in drylands: The impact of veterinary cordon fences in Botswana

Daniel J McGahey

School of Geography and the Environment
University of Oxford

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Abstract

The recent revival of debates concerning livestock development in Africa follows the more widespread acceptance of paradigm shifts within rangeland science, and maintaining pastoral mobility is now recognised as fundamental for the future survival of pastoralism and sustainability of dryland environments. However, in southern Africa communal pastoral drylands continue to be enclosed and dissected by large-scale barrier fences designed to control livestock diseases, thus protecting lucrative livestock export agreements. This interdisciplinary research examines the extent to which these veterinary cordon fences have changed people's access to, and effective management of, natural resources in northern Botswana and how fence-restricted resource use by livestock, wildlife and people has changed the natural environment.

Critical political ecology informed the approach, given its emphasis on socio-political and historical influences on resource access, mobility and user relationships. This enabled the biophysical effects of social changes to be investigated fully, thereby moving beyond a tradition of discipline-based studies often resulting in severely repressive rangeland policies. The research demonstrates how enclosure by veterinary cordon fences restricts patterns of resource access and mobility within pastoral drylands, with serious implications for both social and environmental sustainability. Enclosure increases the vulnerability of people to risks and natural hazards, while resource access constraints and pastoral adaptations to enclosure have favoured the increasing commercialisation of livestock production, thus obstructing pathways into pastoralism. While widespread environmental change in livestock areas cannot be attributed thus far to enclosure, the curtailment of wild migratory herbivores at the wildlife–livestock interface has caused some large-scale structural vegetation changes and there are indications that fence induced sedentarisation could be accentuating existing degradation trends. Given these changes, future rangeland policies in Africa should be aware of the social and environmental impacts associated with export-led disease management infrastructure and consider alternative, less intrusive, approaches to livestock development and disease control in extensive pastoral drylands.

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List of Acronyms

AHCOF- Ad Hoc Committee on Fences
ALDEP- Arable Lands Development Programme
AU IBAR- African Union/Interafrican Bureau for Animal Resources
BDF- Botswana Defence Force
BLDC- Botswana Livestock Development Corporation
BMC- Botswana Meat Commission
CA- Correspondence Analysis
CCA- Canonical Correspondence Analysis
CBNRM- Community-Based Natural Resource Management
CBPP- Contagious Bovine Pleuropneumonia
CDC- Colonial Development Corporation
CI- Conservation International
CHA- Controlled Hunting Area
CKGR- Central Kalahari Game Reserve
CV- Coefficient of Variability
DAHP- Department of Animal Health and Production
DCA- Detrended Correspondence Analysis
DRP- Drought Relief Programme
DWNP- Department of Wildlife and National Parks
EIA- Environmental Impact Assessment
FMD- Foot-and-Mouth Disease
GCP- Ground Control Point
GPS- Global Positioning System
GIS- Geographic Information Systems
IUCN- World Conservation Union
KCS- Kalahari Conservation Society
LDP- Livestock Development Project
LMH- Large Mammal Herbivore
MAP- Mean Annual Precipitation
NBF- Northern Buffalo Fence

NPAD- National Policy on Agricultural Development
NDVI- Normalized Difference Vegetation Index
PRA- Participatory Rural Appraisal
RAD- Remote Area Dweller
RADP- Remote Area Development Programme
RMS- Root Mean Square Error
OCT- Okavango Community Trust
OIE- Office International des Epizooties (World Organisation for Animal Health)
SAT- Southern African Type
SBF- Southern Buffalo Fence
SGL- Special Game Licence
SLF- Sustainable Livelihoods Framework
TGLP- Tribal Grazing Lands Policy
TOR- Terms of Reference
VDC- Village Development Committee
WENELA- Witwatersrand Native Labour Association

1

Maintaining opportunism and mobility in drylands: The impact of veterinary cordon fences in Botswana

1.1 Introduction

Today, wider debates over global environmental change in developing countries can be structured into two principle perspectives. The first, frequently termed the dominant narrative or ‘conventional wisdom’, is that increasing poverty is caused by ‘environmental degradation’, itself largely attributable to demographic pressure (Leach and Mearns, 1996). The second perspective, emerging from the Rio Summit in 1992, concerns the optimistic view that local initiative and participation could provide the key to reducing poverty and conserving the natural resource base (Woodhouse *et al.*, 2000). The latter perspective has gained progressively more momentum in development theory and practice in the form of participatory, bottom-up and grassroots approaches to research, policy implementation and reform (Chambers, 2003). However, the ‘environmental crisis’ narrative of the former has been increasingly challenged by research exposing European sciences’ misunderstanding of both the rationale of African natural resource use and the dynamics of African ecosystems, principally in drylands.

At the centre of the poverty and development-environment challenge in Africa lie savanna ecosystems. Characterised by the coexistence of trees and grasses, savannas cover 43 per cent of the African continent (Justice *et al.*, 1994). Globally, pastoralist activities represent the main form of natural resource use in savanna ecosystems, which support the majority of the world’s rangeland, livestock and wild herbivore biomass

(Sankaran *et al.*, 2005; Sankaran *et al.*, 2004). This is particularly the case in arid and semi-arid savannas where fluctuating levels of low rainfall limit the widespread occurrence of rain-fed crop production, and the rangelands are predominately used by pastoralists (Hudak, 1999).

Dryland savannas and the pastoral systems they support have been at the centre of arguably one of the most controversial and widespread ‘received wisdoms’: that pastoralists irrationally and deliberately overstock the range, causing widespread desertification or land degradation, for a variety of reasons (cf. Hardin, 1968; Herskovits, 1926). Such beliefs have driven and justified a series of severely repressive pastoral development policies prescribing the destocking, privatisation and fencing of communal lands in almost every pastoral system in Africa (Fratkin and Mearns, 2003; Fratkin, 1997), and some parts of Asia and Central America (Toulmin *et al.*, 2004; Taylor, 2006). In simple terms, rangeland ecologists blamed pastoral mismanagement for the advancing of the Sahara desert, whereas livestock development planners believed that destocking and land privatization would prompt the sustainable use of arid rangelands, thus increasing livestock productivity to feed Africa’s growing population (Lamprey, 1983; Sandford, 1983).

With few exceptions, these sedentarisation policies have been a dismal failure, at best neutral in their impact but frequently disastrous, weakening tenure rights and customary institutions while increasing food insecurity, land degradation, vulnerability, and decreasing livestock productivity. As a result many donors, and development agencies abandoned development in drylands during the 1980s and 90s, opting for a policy of benign neglect (Swift, 1991; Scoones, 1995). To some extent the situation has changed of

late following key developments in our knowledge of pastoralism and the dynamics of dryland environments, culminating in a new paradigm for pastoral development (cf. Scoones, 1995; Warren, 1995).

Pastoral mobility is seen as central to the new pastoral development approach and international development organisations, leading academics and development professionals are currently challenging decision-makers to remove the disincentives and constraints that have hitherto restricted pastoral autonomy and mobility in the drylands (UNDP, 2003; Niamir-Fuller, 1999; Fratkin and Mearns, 2003). At the same time the participatory decentralisation movement has enabled pastoralists to demand their own share of the ‘political space’, with increasing numbers forming local, national and even regional-level organisations to assert their rights (Niamir-Fuller, 1999). For the first time in history, policy makers and donor agencies are now beginning to open a direct dialogue with pastoral groups marking the beginnings of a period of renewed interest in pastoral development in the drylands of Africa.¹

The implications of the new rangeland science and ‘mobility paradigm’ (Niamir-Fuller, 1999) are profound, not least for future policy and development practice. Many are calling for the research community to investigate thoroughly the social and institutional arrangements required for its implementation (Niamir-Fuller, 2000; Leloup, 2006). At the same time the causes, extent, and ecological consequences of communal rangeland fragmentation are being highlighted as an important research challenge (see Boone and Hobbs, 2003; Vetter, 2005). However, while most are quick to catalogue the many causes

¹ In July 2007 pastoralists’ representatives from throughout Africa presented their policy recommendations for the first Pan-African Policy Framework for Pastoralists which is set to be signed by African Union member states in 2008 (AU IBAR, 2007).

of reduced mobility on pastoral rangelands (Fratkin and Mearns, 2003; Fratkin, 1997), few recognise the importance of looking more closely at why these restrictions remain pervasive.

One such persistent constraint to pastoral mobility is disease control, with livestock mobility control achieved using various veterinary instruments such as cordon fences, quarantine camps, movement permits and check points and to some extent the previous drive for, and continued advocacy of, fenced privatized ranching, especially in Botswana. Disease control is facilitated by veterinary cordon fences throughout the pastoral lands of southern Africa in order for livestock products to be classified free of disease for international export (Sutmoller, 2002). By restricting mobility and dividing communal rangelands, disease quarantines and veterinary cordon fences could have potentially detrimental impacts on opportunistic and mobile dryland livelihoods such as pastoralism and foraging (hunting, fishing and gathering), yet the issue remains almost untouched by academic attention (for exceptions, see Chapter 2). Veterinary fence enclosure presents serious environmental, as well as social concerns. Declines in the mobility of people, livestock and wildlife resulting from the increasing fragmentation of rangelands by veterinary fences are likely to increase land degradation and environmental change (Boone and Hobbs, 2003). Thus there is an urgent need for a thorough interdisciplinary investigation into this socio-environmental issue.

1.2 New Directions in Pastoral Development in Africa: The Mobility Paradigm and Livestock Revolution

The new rangeland science and paradigm for pastoral development emerged following the convergence of several decades of research from the natural and social sciences. This has documented pastoralists' ecological adaptation to environmental variability; critiqued development in pastoral areas; and analysed the dynamics of dryland ecosystems in more detail (cf. Scoones, 1995; Behnke *et al.*, 1993). With challenges to what Sandford (1983) termed, '*the mainstream view*', originating from both the social and natural sciences, a major rethinking of the role played by disciplinary divisions within the sciences in establishing such global myths and misconceptions was initiated (Chapter 3) (cf. Warren, 1995; Turner, 1993; Turner, 2003; Little, 2004).

From the social sciences, anthropologists challenged Hardin's (1968) simplistic and negative view of communal rangelands as unmanaged open access systems. Pastoralists' access to their communal rangelands is in fact intricately regulated by a series of customary resource-use rules closely governed and sanctioned by tribal institutions, which guard against mismanagement (McCabe, 1990; Behnke and Scoones, 1992). In arid environments such systems are more effective than private forms of ownership as whole communities can gain access to highly variable resources. However, such traditions have now been severely compromised in many pastoral areas as outside interventions promoting settlement, mechanised boreholes and privatized ownership have created inequality, conflict and overcrowding, increasing clashes between farmers and herders and encouraging the capture of resources by rich elites.

From the natural sciences, rangeland ecologists were puzzled by the long-term sustainability of remaining communal rangelands occupied by pastoralists and their large herds of livestock which often far exceeded the stocking densities ascribed by existing rangeland science (Rowntree *et al.*, 2004; Shackleton, 1993). Driven on by the pitiful performance of pastoral privatization and ranching schemes, they discovered that the conventional carrying capacities used by rangeland ecologists were ascribed using simplistic assumptions regarding the dynamics of arid rangelands, borrowed from more temperate climates. Instead of conforming to the conventional Clementsian linear succession model (Clements, 1916), arid rangelands are dynamic non-equilibrium systems where highly variable inter- and intra- annual rainfall levels and patchy ecosystem resources prevent the attainment of ecosystem stability and equilibrium (cf. Walker *et al.*, 1981; Walker and Noy-Meir, 1982; Ellis and Swift, 1988).

For environments intrinsically at disequilibrium, pastoralists' flexible and opportunistic stocking strategies which closely track ecosystem resources are more efficient and can be more economically profitable than sedentary ranching systems based on conservative stocking rates (Behnke and Scoones, 1992; Behnke *et al.*, 1993; Sandford and Scoones, 2006). Although many of the finer details of the new rangeland ecology continue to be debated (see Cowling, 2000; Illius and O'Connor, 1999), it is now widely accepted that many of the most arid dryland ecosystems are in fact non-equilibrium systems (for an excellent review see Vetter, 2005). Advocates of this new approach have demonstrated that degradation from pastoralists' grazing can be minimal and short-term as livestock numbers are reduced by drought mortality (Sandford, 1983; Ellis and Swift, 1988).

Furthermore, dryland ecosystems are more resilient than once thought (Mace, 1990) with important implications for environmental change studies (see Chapter 8).

With the new pastoral development paradigm's emphasis on opportunism, mobility and flexibility, attention focused on the implications for research, management, policy intervention, and planning (Scoones, 1995). The main focus for pastoral development has been to support, enhance and remove the constraints hitherto restricting pastoralists' mobility and adaptive, opportunistic management practices. The new approach aims wherever possible to build on customary institutions (Behnke *et al.*, 1993; Scoones, 1995) and emphasizes that amongst other things tenure policy, rural infrastructure, service provision, market and credit access facilities, must support pastoral mobility.

At the same time, however, pastoralist populations are facing more pressure on their mobility than ever before with access to pasture increasingly restricted by land privatization and fencing, eviction from conservation areas, alienation of land for agriculture, along with many physical inducements to settle, including the mechanisation of water sources and provision of sedentary services (Fratkin and Mearns, 2003; Fratkin, 2001; Fratkin, 1997). Many changes to pastoral mobility were initiated during the colonial era with the formalization of pastoral territories and settlement programmes causing pastoralists to become administratively 'frozen' in the lands they occupied at the time, driven by the widespread view of the nomadic lifestyle as a cultural anachronism (Niamir-Fuller, 1999).

More recently there are strong socio-political forces at work, with increasingly long distance migration to urban labour markets causing household labour deficits and declines in the quality of herding and herd mobility (Turner, 1999), while economic

differentiation and social stratification are leading to the loss of common property rights and *de facto* privatization of the rangelands (Fratkin, 1997). Such changes have increasingly shifted theoretical understanding of pastoral development to political ecology as the dominant theoretical approach for understanding social and ecological change in the pastoral drylands (ibid: 236).

While elements of the ‘mobility paradigm’ continue to move out of the theoretical realm in the shape of an increasing number of development projects focused on addressing constraints to mobility (Niamir-Fuller, 1999), another dramatic paradigm has prompted renewed interest and investment in livestock development in Africa’s drylands. Research by Steinfeld (2004) and Delgado (1999) predicts a strong growth in the demand for livestock products in developing countries caused by increasing population, urbanisation and disposable incomes. Proponents of the new pastoral development paradigm view this as an opportunity to promote regional and export livestock marketing in the pastoral drylands (UNDP, 2003; Leloup, 2006). However, the so-called ‘livestock revolution’ will also cause increased global concern over disease control, requiring significant reinvestment in hitherto neglected veterinary institutions and their methods of control (vaccination, movement control) (Steinfeld, 2004).

There are alternative livestock development trajectories which may require less rigorous movement control. These include strengthening bilateral trade deals with markets requiring fewer import conditions (Scoones and Wolmer, 2006) and supporting highly lucrative but hitherto poorly quantified regional markets for lower value meats (Hatfield and Davies, 2006). Nevertheless, most countries currently aspire to enter the more lucrative European and American export market. Many African governments are, for

example, currently planning to reinstate or create disease-free export zones as part of ongoing national agricultural development plans, with officials in livestock sections frequently citing Namibia and Botswana as successful export-led livestock systems (Scoones and Wolmer, 2006).

One potential solution to the problem involves improving meat processing for a commodity-based trade (Thomson *et al.*, 2004). However, while the World Organisation for Animal Health (OIE) has recently agreed to pay more attention to this for pro-poor livestock development, strict standards set by influential importers such as the European Union are likely to mean the disease-free export zone model remains pervasive in the short to medium term (Babagana and Leyland, 2008).² Furthermore, economic cost-benefit analyses continue to argue that the export-led livestock systems of southern Africa represent pro-poor development (Perry *et al.*, 2003), despite disease control only directly benefiting the commercial ranching sector and remaining a low priority for the majority population of smallholder communal farmers (Scoones and Wolmer, 2006).

Given the potential for the current pro-poor livestock development movement to involve export-led expansion in the pastoral drylands of Africa, in-depth research must consider the impact of veterinary cordon fences and disease control policies in southern Africa on the mobility of rural livelihoods along with the environmental consequences of increasing enclosure. The urgency of this research agenda is further emphasized given both the continued expansion of veterinary fencing in southern Africa and the continued advocacy, in veterinary journals, of disease-control strategies such as veterinary cordon

² The *Office International des Epizooties* (OIE), the World Animal Health Organisation, is responsible for setting global standards on animal health from the perspective of international trade in livestock and livestock products. The standards are set down in the OIE's Terrestrial Animal Health Code. OIE is a membership organisation of states, each state is represented by its delegate, usually through its Chief Veterinary Officer (CVO).

fencing for areas of dryland Africa where endemic diseases currently limit trade and export (Kivaria, 2003).

1.3 Study Aims and Objectives

The broad aim of this research is to examine thoroughly the social and environmental implications of veterinary cordon fence enclosure in Botswana in order to inform future debates concerning veterinary fencing in southern Africa and pastoral development throughout the drylands of Africa. The focus on Botswana is important as the nation remains steadfast in its commitment to export-led livestock development and is continually expanding its vast network of cordon fences, thus allowing impacts to be investigated in a contemporary context. Furthermore, unlike neighbouring countries such as Namibia, Zimbabwe and South Africa, the nation still retains vast areas of communal rangeland, often with integrated wildlife and livestock, and until recently large sections of permeable unfenced international border which allow the cross-border movement of people, wildlife, livestock and importantly disease. Such conditions are prevalent throughout much of the pastoral drylands further north where transboundary disease control may become the *real* imperative if the export-led model of livestock development is adopted.

To achieve the main study aim a political ecology approach was adopted to consider, in detail, the implications of enclosure on the mobility of rural livelihoods in northern Botswana against a backdrop of declining mobility caused by a variety of factors, some of which were historically embedded. The approach also allowed social and ecological

concerns to be examined in concert which was deemed essential for this socio-environmental issue. This study has four specific objectives:

- (1) to identify the main livelihood strategies involving extensive resource access and mobility, and to investigate contemporary patterns of resource use and asset access,
- (2) to investigate changes to the main livelihood strategies identified above and specifically to:
 - a. establish the direct impacts of enclosure on resource access, tenure, rights and user relationships,
 - b. document all factors causing reduced mobility and access in order to put these impacts into context,
- (3) to examine the nature of fence-induced environmental change
 - a. understand natural variability as a baseline for establishing fence induced change,
 - b. document the extent to which enclosure and associated sedentarisation has impacted on the environment,
 - c. evaluate cross-fence vegetation community changes as an indicator of fence-induced environmental change,
- (4) to consider the longer-term implications of these changes in the context of livestock development in Africa and drylands globally.

1.4 Thesis Map

Very little specific research has considered the social and environmental impact of veterinary cordon fence enclosure in southern Africa. Given this knowledge deficit Chapter 2 begins by tracing the origins of veterinary cordon fencing as a disease control

tool in southern Africa before attempting to draw out some of the possible implications for opportunistic livelihoods and dynamic dryland environments. This forms the basis from which the study's interdisciplinary research questions are drawn.

Chapter 3 then details the theoretical basis and methodological frameworks employed to conduct this interdisciplinary study. The chapter first traces the origins of human-environment research in geography, anthropology and sociology through to the emergence of the interdisciplinary field of political ecology. This approach informed the research as the field supports the tight interweaving and reflexive use of a range of methods from the natural and social sciences, thus emphasizing the causal connection between land managers and environmental change. This allowed acute attention to be given to the historical and political-economic forces governing patterns of mobility, resource access and natural resource use which was deemed essential to understand the socio-environmental impacts of veterinary fence enclosure. The chapter then rationalizes the use of the 'sustainable livelihoods' framework developed by DfID (1999) from the initial work of Scoones (1998). The framework facilitated a thorough analysis of contemporary rural livelihoods, which enabled the research process to focus on specific contemporary livelihoods requiring human and pastoral mobility. The subsequent discussion then outlines the research strategy in detail including the three main phases of fieldwork and exact methods used therein.

The discussion and analysis section of the thesis takes the form of six substantive chapters focused on the direct impacts and long-term implications of enclosure within two sites divided by veterinary cordon fences in northern Botswana. Using inspiration from critical political ecology, in Chapter 4 changing resource relationships in northern

Botswana are explored, providing an overview of historical changes to resource access, use and mobility. Chapter 5 focuses more closely on livelihoods within the two field sites and, drawing upon the sustainable livelihoods framework, provides a grounded analysis of 'what people do' thus elucidating contemporary rural livelihoods that require access to extensive, spatially dispersed resources and therefore both human and livestock mobility. The key livelihood strategies and resource use contexts uncovered in Chapter 5 are then discussed in greater detail through two discursive chapters (6 and 7) which, initially, examine the direct impacts of veterinary fence enclosure for resource access, user relationships and mobility. Following this both chapters discuss some longer term implications of enclosure within a historical context of changing societal vulnerability to natural environmental variability. This discussion highlights some far greater concerns over enclosure for social resilience to future environmental dynamics.

Chapters 8 and 9 focus closely on the environmental impacts of enclosure. Given the process of sedentarisation revealed in the previous two chapters, Chapter 8 provides a scientific assessment of structural vegetation change along disturbance gradients radiating out from cattleposts and villages. Using various multivariate ecological analysis techniques the chapter analyses the results of detailed ground vegetation surveys. The second part of the chapter looks more closely at landscape scale structural vegetation change and analyses data gained from ground vegetation surveys conducted across fencelines, using veterinary cordon fences as natural grazing experiments.

Chapter 9 then develops the scientific appraisal by assessing ecosystem dynamism and long-term structural change using multitemporal remote sensing analysis in order to attempt to determine management-induced change from inherent natural variability.

Finally, Chapter 10 draws together different key findings of the research, including reference to the wider implications for academic debates and policy-making. To conclude the thesis further avenues of research are suggested for what has been, until now, a neglected topic.

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2

Veterinary cordon fences and pastoral development in southern Africa

2.1 Introduction

Fenced infrastructure has been used to exclude or enclose living things for thousands of years, creating marked changes to our landscapes. In Africa, for example, thorny shrubs have long been used to construct fences for pastoralists' kraals or agro-pastoralists' arable land, causing noticeable changes in the landscape through seed dispersal and tree utilisation (Reid and Ellis, 1995). In Europe and America, where much of the land is privatised, field or farm boundaries were often fenced using banks and hedges or wooden posts with wooden rails, dramatically altering the countryside. This type of fencing strategy can be defined as exclusion fencing. In contrast to exclusion fencing, veterinary cordon fencing can be defined as a large-scale barrier fencing strategy (Plate 2.1).

Plate 2.1. A typical veterinary cordon fence in Botswana.



Veterinary cordon fences are constructed within mostly unfenced areas of rangeland to control the spread of livestock diseases. They are frequently found between areas of commercial, often fenced, privatised farmland and areas of largely unfenced communal rangeland, and along international or district boundaries. By far the most infamous proponent of large-scale barrier fencing is the nation of Australia. Large-scale barrier fences have formed a central part of Australian strategies for the control of exotic species and predators for many years, with barrier fences constructed to exclude rabbits (McKnight, 1969); dingos (Allen and Sparkes, 2001); and more recently the poisonous cane toad (Young, 2003) from agricultural land and natural habitats.

According to McKnight (1969) the concept of exclusion fencing is ubiquitous—small plots are fenced against livestock and wildlife globally—whereas the concept of large-scale barrier fencing outside Australia is rare. However, today there are many worldwide examples of large-scale barrier fencing strategies and schemes. For example, large-scale barrier fences are frequently used to secure international and regional borders (e.g. US-Mexico border fence). The intention here is often to control the movement of people rather than wildlife or livestock, often with controversial consequences (e.g. fencing of Palestinians by Israelis, see Ross, 2003). However, in all but a few cases, large-scale barrier fences are used to control the movement of wildlife and livestock within open rangelands for a variety of purposes (e.g. grazing control, pest control, disease control, or exotic species control). In parts of Scandinavia, for example, large-scale fences are used to protect winter pastures from migratory Reindeer during the summer months (see Olofsson and Oksanen, 2002).

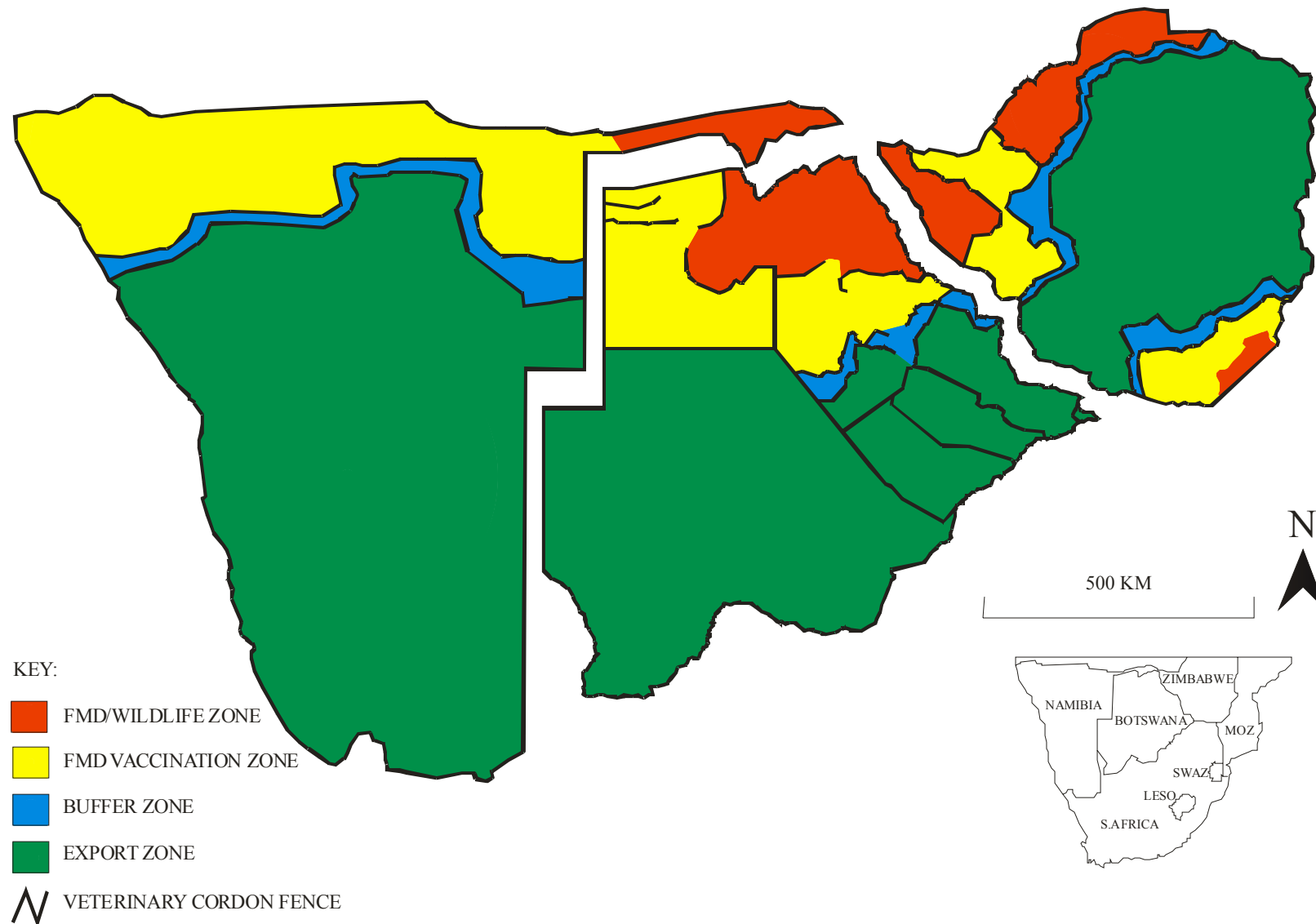
The use of large-scale barrier fences for disease control is a phenomenon largely limited to southern Africa. The southern African region has long been engaged in export-orientated commercial livestock production, facilitated by the use of veterinary cordon fences and vaccination programmes to control the transmission of livestock diseases from rural herds and wildlife populations to the commercial livestock sector (Taylor and Martin, 1987; Kock *et al.*, 2002). However, large-scale barrier fences have been constructed outside of Africa with the rationale of disease control. The US-Mexico border fence, for example, was initially constructed in the 1950s to control the spread of foot-and-mouth disease from Mexico to the US, after US veterinary efforts to control the disease had failed amongst Mexican farmers in the 1940s (see Bahre and Bradbury, 1978).

Today, the majority of livestock in southern Africa's commercial sector are produced within fenced ranches protected from the disease risk of communal rangelands and wildlife areas by veterinary cordon fences. Disease control zones, buffer zones or vaccination areas surrounding ranch areas are delineated by veterinary cordon fences in South Africa, Namibia, Zimbabwe and Botswana (Map 2.1.).¹ Though livestock have been, and are currently, exported from the region's largest communal rangelands (e.g. northern Namibia, and northern Botswana) following periods in fenced quarantine camps adjoining veterinary cordon fences, the success of this trade is hampered by intermittent disease outbreaks and a reluctance to commercialise in some areas. Commercialisation in northern Namibia for example, has been poor as pastoralists have refused to sell cattle due

¹ Though much of the green export zone in Map 2.1 is privatised fenced land where diseases are more easily controlled, there are areas of land under communal tenure within the export zone. Here, there may be livestock marketing schemes with fenced quarantine camps and movement restrictions used to control diseases. In Botswana, for example, large areas of land remain under communal tenure in the export zone and a network of sub-zone veterinary cordon fences and quarantine camps are used to control diseases.

to mistrust over prices paid (see Smith 1992). Large-scale barrier fences have been used as a disease control strategy to restrict the movement of wildlife and livestock elsewhere in Africa, but their use has generally been restricted by funding and resource limitations (Kivaria, 2003).

In the previous chapter the emergence of the mobility paradigm was juxtaposed against the problem of disease control and the phenomenon of veterinary cordon fencing. This chapter explores the origins of veterinary cordon fencing as a disease control strategy and exposes a far deeper conflict of interests between the mobility paradigm and veterinary science.



Map 2.1 Contrasting veterinary cordon fencing strategies across Namibia, Botswana and Zimbabwe for Foot-and-Mouth disease (FMD) control. (Source: Adapted from Taylor and Martin, 1987; Department of Surveys and Mapping, 2004; Meynell and Thomson, 1999) (Note: In recent years land reform and economic collapse in Zimbabwe has seen veterinary fences breached and frequent FMD outbreaks, see Scoones and Wolmer, 2006).

2.2 The Origins of Veterinary Cordon Fencing in Southern Africa

An appreciation for the origin of veterinary cordon fencing as a disease control method is necessary in order to understand the potential social and environmental concerns regarding their use in drylands. Historically, advances in southern Africa's livestock industry have often been accompanied by the parallel development of the veterinary 'paraphernalia' of fences and quarantine camps. The origins of veterinary cordon fencing as a method of disease control can be traced back to southern Africa's early colonial history.²

Early Colonial Period and Global Transmission of Diseases to Southern Africa

The colonisation of southern Africa and the associated increase in the global transport of livestock in the nineteenth century saw the transmission of several highly contagious epizootic diseases to Africa.³ Until this time mainly enzootic, endemic diseases had been prevalent in the native livestock and wildlife of Africa, with populations generally experiencing some form of natural immunity through many years of low mortality and high morbidity rates.

The increased trade in livestock and associated movement of people, animals and goods, along with the widespread use of draught oxen for transport, facilitated the rapid onset of foreign diseases such as contagious bovine pleuropneumonia (CBPP) which entered South Africa with infected livestock shipped from Europe in 1854 (Windsor, 2000). Although CBPP had spread throughout the entire sub-continent by the late nineteenth century and resulted in widespread livestock mortality, it was not

² For a more complete account of the history of livestock development and veterinary science in southern Africa see: Brown, (2005); Beinart, (1997); Milton, (1997); or Gilfoyle, (2003).

³ An epizootic disease is one which appears as a new case in a given animal population and spreads at a rate that substantially exceeds what is expected based on recent experience.

until the highly contagious and virulent disease, rinderpest, threatened the Cape Colony's livestock industry that the first veterinary cordon fences were constructed.

Rinderpest, a highly contagious disease capable of causing between 90 to 95 per cent mortality rates in cattle and wildlife, was known to be more contagious and deadly than CBPP (Molefi, n.d.). By the late nineteenth century rinderpest epizootic, the Cape's cattle industry had become particularly important and oxen remained the key means of transport and traction, thus necessitating veterinary efforts to control the disease (Gilfoyle, 2003). Unlike CBPP, rinderpest spread overland from the north and by March 1886 the disease had spread to the Bechuanaland Protectorate (Botswana) on transport oxen travelling along the Bulawayo-Mafeking road (Falconer, 1971).⁴ Officials battled to control the disease on the open, unfenced communal rangelands of the Protectorate and resorted to constructing an east-to-west bush fence at Palapye and imposing a ban on the southbound movement of oxen (Falconer, 1971; Gilfoyle, 2003). This was Botswana's first recorded veterinary cordon fence.

In southern Africa, the arrival of the rinderpest epizootic highlighted a major conflict of interests between the objectives of disease management and the objectives of opportunistic and mobile pastoralism. Rinderpest was considered a foreign disease entering a hitherto 'clean' region and the disease control policy of the time relied on the British veterinary 'importation theory' involving import bans, slaughter of infected stock and, importantly, the imposition of strict quarantines and movement embargos (Gilfoyle, 2003). Thus, veterinary fences were the most effective and permanent solution to the movement control problem on open unfenced communal land.

⁴ Formerly the British Protectorate of Bechuanaland, the Republic of Botswana gained independence on 30th September 1966.

However, veterinary officials experienced major resistance from both European and African pastoralists who refused, often violently, to forego their traditional practices of pastoral mobility (Beinart, 1997, Gilfoyle, 2003). For example, pastoralists in Bechuanaland refused to submit to the stamping out associated with the veterinary policy of quarantine and slaughter. In 1896 cattle strayed from the quarantined Taungs reserve and were shot by police; a move which is believed to have started the Langeberg rebellion (Saker and Aldridge, 1971). Efforts at disease control upon the open rangelands of the Bechuanaland Protectorate and African communal rangelands were eventually abandoned and a second veterinary cordon fence just south of the Orange River became one of the last lines of defence to protect the Cape Colony's long permeable border (Gilfoyle, 2003).

The origins of several veterinary cordons in southern Africa can be traced to the rinderpest epizootic of the late nineteenth century, most of which were only fenced with wire much later on. There was often a trade-off to be made between the possibly short-term expenditure (i.e. for duration of outbreak) on manned patrols and bush fencing, or potentially longer-term but expensive option of veterinary cordon fencing with poles and wire. Typically, veterinary officials firstly resorted to the short-term expense of police patrols and check points often along natural barriers (e.g. rivers or valleys) or man-made cut-lines delineated with bush/thorn fences in their attempts to control disease outbreaks.

Over subsequent years it became clear that repeated disease outbreaks could be traced to certain regions; often areas of communal land where wildlife were integrated with livestock (native reserves). *Cordon sanitaires* surrounding these areas proved expensive to patrol and were frequently ineffective in controlling livestock movements. As a result, officials were often forced to construct wire veterinary

cordon fences as a more permanent solution because bush fences were frequently collapsing and easily destroyed by veld fires.⁵

The history of Namibia's 'red line' veterinary cordon fence is an excellent example. To protect the former German colony of South West Africa against the advancing rinderpest epizootic, officials established a series of control points along the then unfenced eastern border with Bechuanaland and stretching east-to-west across the entire country (Forrest, 2001). These lines were then patrolled on foot or by horseback to protect the European freehold or leasehold farms from rinderpest in the communal reserves in Bechuanaland to the east and northern South West Africa. The unfenced cordon, however, proved ineffective in curtailing the spread of rinderpest which reached the country in 1897. Largely due to the lack of funding in the country these cordons remained unfenced with wire until the South African administration took over and sections of the 'red line' were constructed between the 1920s and 1950s. Finally, after a foot-and-mouth disease (FMD) outbreak in 1961 a complete wire veterinary cordon fence was constructed along the boundary now called the 'red line'.

The spectacular failure to control rinderpest in the Bechuanaland Protectorate brought to the fore concerns over the need to reform land tenure and agricultural practices such as pastoral mobility (ibid: 137). Rinderpest had been successfully eradicated from Europe due to the subdivision of land into enclosed parcels, which naturally facilitated movement control. Therefore, disease control and the goal of veterinary sanitation is far easier to achieve on privatised fenced land, prompting future efforts at pastoral development throughout Africa to encourage land privatization and fencing as 'progressive' agriculture (Milton 1997; Gilfoyle, 2003; Waller, 2004), a fact often missing or understated in many more recent accounts relating to the expansion of

⁵BNA S535/9.

sedentary pastoralism and land tenure reform (Sandford, 1983; Peters, 1994; Thomas *et al.*, 2000).

2.3 A History of Livestock Development and Disease Control in the Republic of Botswana

Pastoral Development during the Colonial Period

From the 1870s onwards the rapidly expanding South African mining industry created a market for cheap meat and the demand for cattle increased. Thus, when the British Protectorate of Bechuanaland was established in 1885, cattle were immediately commoditized and exported to the South African mine-dominated markets, marking the origins of Botswana's livestock industry (Darkoh and Mbaiwa, 2002). The Protectorate's close proximity to the Witwatersrand mines made it one of the most convenient suppliers of beef which could be easily transported on the hoof. The decline of the regions' earlier exports (hunting products and gold) precipitated the Protectorate's primary role as a labour reserve and supplier of cheap beef to the Union of South Africa (Hubbard, 1986).

For subsequent years Botswana continued to supply the mine-dominated markets as a satellite economy acting within the demands, and often protectionist regulations, of the South African markets. Between 1905 and 1910 Botswana exported in the order of 3000 head of cattle per annum (Hubbard, 1986). However, during the First World War (1914-18) exports increased dramatically due to foreign demand depleting the South African beef supply, and by 1916-17 the number increased to 31,000 p.a. (Darkoh and Mbaiwa, 2002).

During the 1920s and 30s, increased demand from the copperbelt mines of Northern Rhodesia (now Zambia), Southern Rhodesia (Zimbabwe) and the Congo (Democratic Republic of Congo) were met by Botswana's beef, especially from Ngamiland

(Macmillan, 2005). However, Botswana was yet to enter more lucrative international markets owing to various restrictions imposed by a South African monopoly on southern Africa beef marketing (Thomas and Shaw, 1991). The South African government, for example, imposed strict regulations on livestock imported (size and weight) and secured the most lucrative markets for its own producers (Hubbard, 1986). Similarly, Botswana remained heavily reliant on meat processing facilities in Rhodesia or South Africa and the Union frequently used any northern disease outbreak from the communal reserves of Bechuanaland or Rhodesia as convenient reasons to block trade, regardless of whether the region exporting was disease-free (ibid: 94).

Despite continued mineral prospecting, Protectorate officials firmly believed that livestock production represented the only viable land use and identified access to the lucrative export market as the primary factor to develop the sector. As a result, in the late 1920s Protectorate officials consolidated a deal with the Imperial Cold Storage Company (ICS) to establish Botswana's first abattoir at Lobatse and secure a share of the European quota. This was a direct effort to reduce reliance on the South African processing chain and intermittent trade embargoes.⁶ However, livestock were mainly exported live by the ICS and the abattoir only traded for two years (1934-6) after a particularly widespread outbreak of FMD prompted a total trade embargo on Bechuanaland cattle in the 1930s (Falconer, 1971).

⁶ Hubbard (1986) states that the South African government's prolonged trade embargoes after disease outbreaks and restrictions on imports were part of a wider move to illustrate the costs of remaining outside the Union in an effort to force the integration of Botswana. Protectorate officials realised that they must reduce dependence on the South African meat processing chain.

Colonial Veterinary Cordon Fencing and Disease Control

The onset of international trade and the FMD outbreak in the 1930s represented a turning point from which the country began to focus more closely on disease control within its own boundaries, in order to secure lucrative export income. Prior to this, concerns regarding the trans-border movement of diseases and the risk Botswana's intermittent disease outbreaks posed to other countries were the main impetus driving disease control efforts.⁷ The FMD outbreak and collapse of trade also prompted the imperial government to release funds for livestock development which hitherto had not been forthcoming (Steenkamp, 1991). Thus money became available for investment in disease control and developing the livestock export sector.

Alongside market access, the Protectorate administration identified water shortages and livestock quality as areas in need of improvement (ibid: 300). The new investment enabled a network of boreholes to be sunk, allowing cattle to be driven to railheads and commercially-orientated livestock development to spread into remote western regions of the territory. At the same time, the 1930s FMD outbreak and South African trade embargo provoked major efforts to inoculate and restrict the movement of livestock within the territory (Thomas and Shaw, 1991).

During this campaign, veterinarians recognised that diseases such as FMD were frequently spreading from the northwest (Ngamiland District) where the disease appeared often. It was decided to cordon off the entire region with a manned police cordon, establish a 30-100 mile cattle free zone, and begin a widespread inoculation campaign (Falconer, 1971). However, FMD outbreaks continued to restrict trade and

⁷ For example, fear of the spread of disease from the territory to the Transvaal and Cape prompted the Cape government to transfer a leading veterinarian to become the Protectorate's first veterinary officer in 1905 (Falconer, 1971: 74). Similarly, by 1910 parts of the Protectorate's border with Rhodesia (now Zimbabwe) were fenced by the Rhodesian government who feared the transmission of CBPP which remained widespread in the Protectorate until the mid-1920 (BNA S 40/4).

export with outbreaks in 1937, 1944, 1947-9, 1957-8 and throughout the 1960s (Thomas and Shaw, 1991).

Government officials realised that a more “permanent arrangement to isolate livestock in the northwest” was required.⁸ Police cordons proved expensive and continually ineffective because “at night-time people cross cattle or the cattle themselves stray” and veterinarians could frequently “trace outbreaks of FMD to unauthorised movements of stock”.⁹ However, throughout the 1930s and 40s the veterinary department experienced a chronic shortage of staff, especially during World War II, and lack of funds prevented the expansion of staff to the level required to control disease outbreaks in the country effectively (Falconer, 1971). The department fell back on a policy of monitoring and regulating livestock exports, while attempting to control disease outbreaks as and when these occurred (ibid: 76).

The situation changed in the late-1940s when the Inter-territorial FMD Advisory Committee was formed, consisting of the directors of veterinary services from South Africa, South West Africa (now Namibia), Northern and Southern Rhodesia and the Bechuanaland Protectorate. At a meeting in Bulawayo in 1950 the committee proposed a scheme involving the construction of several veterinary cordon fences and fenced quarantine camps designed to prevent the spread of FMD from northern to southern protectorate.¹⁰ This marked the beginning of a period of major investment in veterinary cordon fencing.

Throughout the 1950s and 60s Botswana was divided into a series of quarantine zones demarcated by veterinary cordon fences, with fenced quarantine camps adjoining these at points where cordons crossed regular livestock export trekking routes. The first of these, the 125 mile Dibete Cordon, was constructed between the Zimbabwe

⁸ BNA S542/3

⁹ BNA S535/9 – By 1950 police cordons in Bechuanaland were costing £10,000 per month to maintain

¹⁰ BNA S542/3

border, through Dukwe and Tlalamabele to Mokoba at a cost of £7000.¹¹ Veterinary officials estimated that by fencing the cordon with a permanent post and wire fence, they would be able to half the number of staff and therefore more than half the monthly costs of maintaining a police cordon and bush fence, which was continually collapsing or damaged by veld fires (approx £535 per month in 1950).¹² By independence a further three permanent cordon fences and a series of quarantine and fence maintenance camps were constructed, partly using the annual interest from the export levy fund (Map 2.2).¹³

The colonial expansion of Botswana's veterinary infrastructure highlighted several important points. First, with the establishment of the Inter-territorial FMD Advisory Committee, foreign veterinary organisations had begun to have a greater say on the planning of Botswana's veterinary disease control schemes and fence alignments.¹⁴ This is a trend that, with the increase in global exports that followed, culminated in the greater input of international veterinary regulatory bodies such as the World Organisation for Animal Health (OIE) in Paris, and influential importers such as the European Union (Scoones and Wolmer, 2006).

Second, veterinary cordon fences began to assume a political significance beyond simply a disease control measure. For example, alongside disease control, colonial officials justified the construction of the Dibete cordon on the grounds that the fence would permanently demarcate the frequently disputed boundaries between the Bamangwato, Bakwena and Bakgatla tribes.¹⁵ Several early veterinary cordon fences in southern Africa were constructed on the boundaries of tribal reserves, or between

¹¹ BNA S535/9

¹² BNA S525/9

¹³ BNA S535/9

¹⁴ For example, on 21st May 1948 the resident commissioner wrote a memorandum regarding the proposed fencing off of Ngamiland stating that "the Union Veterinary Authorities have urged upon this government that this step be taken" (BNA S542/3).

¹⁵ BNA S535/9

white owned land and black communal rangeland. Veterinary cordon fences make convenient barriers to control the movement of people and goods rather than just livestock and meat, and today police often use fence crossings to establish road blocks in search of stolen cars or criminals. In some cases, the use of veterinary cordon fences can assume a highly charged political and racist character amongst southern Africans. From the mid-1960s, Namibia's red line cordon fence, for example, was used by South African military forces for political purposes to inspect cars and people during apartheid (Forrest, 2001).

Thirdly, the expansion of veterinary fences, especially in the overcrowded eastern hardveld, could be linked to the older official discourse described earlier concerning the need to reform backward practices such as pastoral mobility, through the rationalisation of land tenure. Communal rangelands and native reserves were seen as diseased, dangerous centres of indiscipline that smothered individual entrepreneurship (Peters, 1994); and practices such as transhumance were believed dangerous to animal health and the environment (Gilfoyle, 2003). In contrast, privatised fenced ranching was seen as sanitary, progressive and sustainable farming; a view that was perpetuated through the success of several European settler schemes in the protectorate (Ghanzi and Tuli), and the Transvaal (Milton, 1997; Gilfoyle, 2003). Though such views drove subsequent efforts by both colonial and post-colonial governments to rationalise land tenure through the establishment of privatised ranch blocks (Peters, 1994), much of the 1950s cordon fencing was justified on the grounds that it would "facilitate the task of the administration of better management of pasture, preservation of herbage and conservation of soil".¹⁶

Finally, fearing that the allocation of tribal land for quarantine camps might become politically challenging, the colonial administration was keen to inform local chiefs

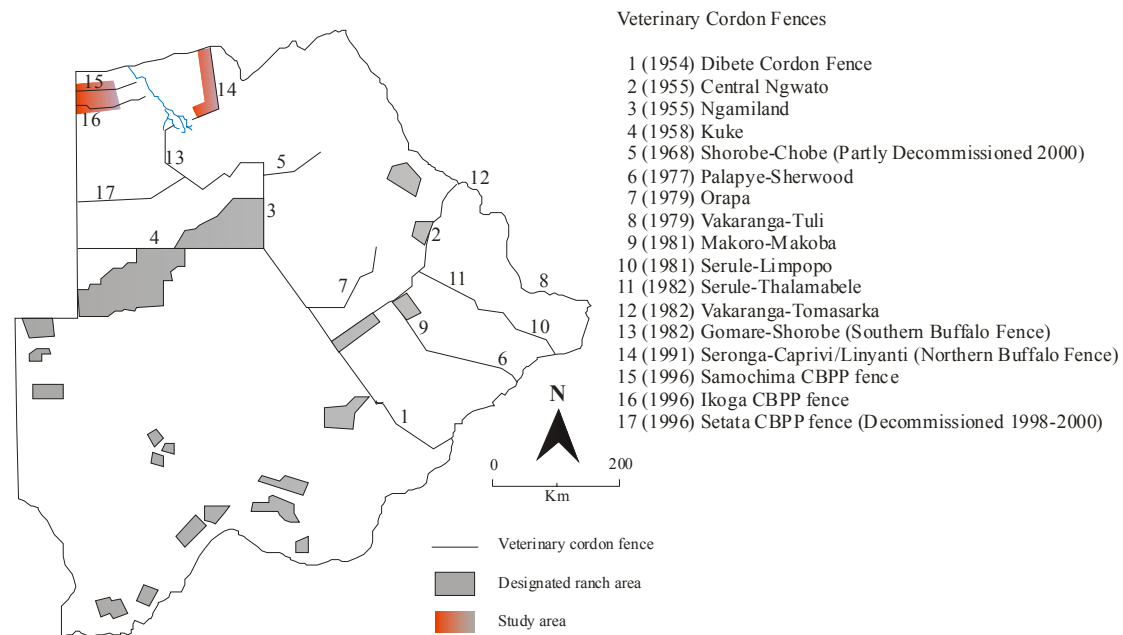
¹⁶ BNA S535/9

about the scheme at an early stage.¹⁷ However, unlike the major conflicts between pastoralists and veterinarians experienced during the pre-colonial use of veterinary disease control measures (section 2.2), there appear to have been few *documented* objections to enclosure or movement restrictions. During the planning stages of the scheme, for example, local chiefs were consulted at a meeting in Mafeking in June 1950 and appeared to favour enclosure.¹⁸ However, they also seemed to have been under the impression that during disease-free periods, “the gates will be open and the cattle will be free to be moved” (BNA S.535/9). In years to come this would not be so simple under the new quarantine–permit system.

The general acceptance of veterinary cordon fences and disease control measures was most likely a result of the greater involvement of pastoralists, especially the tribal elite, within the growing livestock industry. During the 1950s the colonial administration expanded their borehole drilling campaign in an effort to overcome the effects of drought and relieve livestock pressure in the eastern hardveld (Thomas *et al.*, 2000). This enabled the country’s elite to monopolise both range and water resources, thus securing an ever growing share of the commercial livestock sector (Darkoh and Mbaiwa, 2002; Arntzen, 1998).

¹⁷ BNA S535/9

¹⁸ “In considering the matter we feel that a fence would assist in solving this problem [FMD control] and we are glad to know that the Director of Veterinary Services knows the areas in which this disease occurs often. It will be for the veterinary authorities to know where to place the fence, then it would be known definitely on which side the cattle that have the disease are”. (BNA S.535/9)



Map 2.2 Botswana's veterinary cordon fences and fenced ranch blocks today. Areas marked in red represent the field sites used in this project (Source: Adapted from Thomas and Shaw, 1991).

Pastoral Development during Post-colonial Period

Following independence in 1966, the government of Botswana continued what the colonial administration had started but through policy-driven structural land use changes advocating sedentary ranching, rather than piecemeal efforts (Thomas *et al.* 2000). Reconnaissance surveys during the 1940s and 50s portrayed the Kalahari sandveld as a vast untapped grazing resource well suited for livestock rearing, only limited by the absence of surface water (Debenham, 1952). In reality, the area had been subject to seasonal utilisation by opportunistic pastoralists and hunter-gatherers for centuries (Hitchcock, 1980; Thomas *et al.*, 2000; Thomas and Sporton, 2002). In spite of this, post-colonial livestock development policies such as the Livestock Development Project (LDP) of 1972 which transcended into the Tribal Grazing Lands Policy (TGLP) of 1975, sought to alleviate grazing pressure on the eastern hardveld by relocating large herd owners into a series of fenced ranches in the Kalahari sandveld.

At the same time, the beef export industry expanded firstly with the re-opening of the Lobatse abattoir in 1955 under the Colonial Development Corporation (CDC), and latterly with the formation of the Botswana Meat Commission (BMC) in 1965 (Hubbard, 1986). Since independence the BMC consolidated colonial export market relations, securing quotas predominately in the UK and European Union. Lucrative trade agreements such as the EU's Lome Convention (1975), which abolished import tariffs and fixed prices at 50 per cent higher than the global market price, have driven the continued expansion of commercial pastoralism in Botswana, largely following the sedentary ranch-based model (Sporton and Thomas, 2002).

The scale of Botswana's economic growth since independence has been exceptional, largely due to the exploitation of diamond reserves, but also thanks to foreign aid and the lucrative beef export industry (Perkins *et al.*, 2002). The national herd, for example, increased from 1.2 million in 1934 to 3 million in 1998 (White, 1998). The westerly expansion of sedentary pastoralism from the eastern hardveld where 70 per cent of the national herd was located, continued, and by 1984 218 fenced, borehole centred leasehold ranches had been allocated under TGLP (Sporton and Thomas, 2002). The country, however, has come under increasing criticism for pursuing a development trajectory widely regarded as socially and economically damaging, benefiting only a small minority of rich elites at the expense of the environment (Perkins *et al.*, 2002).¹⁹

Post-Colonial Veterinary Cordon Fencing and Disease Control

Historically, by far the most important disease in Botswana has been FMD, with outbreaks capable of provoking embargoes on trade with the EU and major economic

¹⁹ For example, 7 per cent of the population own half the national herd while 45 per cent own no cattle (Sporton and Thomas, 2002)

hardship for livestock owners and the stockless poor alike (Hitchcock, 2002). In order to qualify for EU markets, meat must come from an area which has been free of FMD for more than a year and no vaccinations against FMD may have been administered within the previous 12 months (Agrar-Und Hydrotechnik, 1982).²⁰ Over the last 70 years, the majority of Botswana's FMD outbreaks have occurred in northern Botswana, principally the Okavango, Chobe, Botletle, and Makgadikgadi regions (Table 2.1).

Table 2.1. Livestock Disease Outbreaks in Botswana. Source: Hitchcock (2002).

Year(s)	Livestock Disease	Location	Reference(s)
1896–7	Rinderpest	Entire country	BNA RC.3/2/1
1933	Foot-and-Mouth	Entire country	BNA S.380/3, S.308/4, S.312/9
1934	Foot-and-Mouth	Botletle River, Central and Southern Districts	BNA 2/312/18, S.312/19, S.312/20
1937	Foot-and-Mouth	Palapye, Central Botswana	BNA S471/4; Falconer (1971b: 75)
1944	Foot-and-Mouth	Northern Botswana	BNA S.230/8/1–2
1947–9	Foot-and-Mouth	Northern Botswana	BNA S.230/9/1–4, S.231/1/1–6
1950	Foot-and-Mouth	Chobe	Hedger (1968)
1957	Foot-and-Mouth	Southern Botswana	Falconer (1971a: 154, 1971b: 77, 1972: 358)
1958	Foot-and-Mouth	Ngamiland	Falconer (1971a: 154, 1971b: 77)
1960–61	Foot-and-Mouth	Northern Botswana	Falconer (1971a: 154, 1971b: 77)
1963	Foot-and-Mouth	Motopi, Botletle River area	Falconer (1971a: 154, 1971b: 77–8, 1972: 357)
1964	Foot-and-Mouth	Ngamiland	Falconer (1971a: 155, 1971b: 78, 1972: 357)
1965	Foot-and-Mouth	Central Makgadikgadi	Falconer (1971a: 155, 1972: 350)
1968	Foot-and-Mouth	Chobe	Falconer (1971a: 155, 1972: 354, 358)
1977–8	Foot-and-Mouth	Ngamiland and Central District	Falconer (1980), Hubbard (1986)
1995–6	CBPP (lung sickness)	Ngamiland	Ministry of Agriculture (1996)

Note: BNA stands for Botswana National Archives; the number following (e.g. S.308/3) is the reference file number used in the National Archives filing system.

As mentioned earlier, from the 1930s onwards veterinary officials became increasingly aware of the correlation between wildlife-livestock integration in northern Botswana and FMD outbreaks. From the 1960s, veterinarians also began to

²⁰ Once infected, cattle may show no clinical signs of the disease but remain carriers for some time and can transmit the disease at a later date (Hargreaves *et al.* 1994).

realise that the Southern African Type (SAT) strains of FMD were different from those experienced elsewhere, and began efforts to develop an effective vaccine (Hitchcock, 2002). In subsequent years, studies revealed that buffalo (*Syncerus caffer*) carry three strains of the virus (SAT I, II, III) and vaccines were developed and administered to livestock in close proximity to buffalo populations (Falconer and Child, 1975).

With disease restriction now an essential pre-requisite to the privileged access of Botswana's beef into international markets, and buffalo identified as the principle carriers of the disease, attention focused on effective measures to prevent the spread of FMD from wildlife to livestock in northern Botswana. The urgency of the situation was compounded in 1977 by the country's first widespread FMD outbreak since the 1930s, which prompted a five year suspension on EU exports, costing the industry an estimated 20 million pula (Hobbs, 1981).

As a direct result, expenditure on animal health increased dramatically during the two National Development Plans (III & IV) covering the period, and the Department of Animal Health proposed an ambitious plan involving the construction of seven veterinary cordon fences; the largest single expansion of veterinary fencing in any NDP since independence (Table 2.2). To date, a vast network of 13 veterinary cordon fences has been constructed since independence alongside the TGLP commercial livestock ranches, with the backing of World Bank development loans and the re-investment of EU profits (Yeager, 1989; Darkoh and Mbaiwa, 2002). The country is now divided into four main zones for disease control purposes: red zone (FMD endemic, wild buffalo present), yellow zone (FMD vaccination area), blue zone (surveillance/buffer zone), and finally the green export zone (Map 2.1).

Table 2.2. Development expenditure on livestock and animal health in National Development Plans (NDP) compared to number of veterinary cordon fences constructed during same periods. (Source: Darkoh and Mbaiwa, 2002).

NDP	5 Year Span	Expenditure on Livestock and Animal Health in Thousand Pula ¹	Expenditure on Livestock and Animal Health as % of Total Gov. Spending on Agriculture	No of Veterinary Cordon Fences Constructed (After Thomas and Shaw, 1991)
1	68-73	1,501	59.3	1
2	70-75	4,479	30.7	0
3	73-78	9,224	74.3	0
4	76-81	20,635	68.6	5
5	79-85	61,447	56.6	7
6	85-91	11,606	22.8	1
7	91-97	23,200	18	4
8	97-02	95,751	28.1	0

¹Exchange rate 1.5.2006 1US\$=Pula 5.43

2.4 Social and Environmental Concerns

The rapid expansion of fenced infrastructure, in the form of TGLP ranches and veterinary cordon fences, into the Kalahari sandveld since independence began to raise some searching social and ecological concerns regarding Botswana's export-orientated development trajectory. However, while the social and environmental impacts of TGLP have been thoroughly considered (Thomas *et al.*, 2000; Sporton and Thomas, 2002a), limited attention has been given to those of veterinary cordon fences (exception of Hobbs, 1981; Hitchcock, 1995; Scott Wilson Resource Consultants, 2000; Hitchcock, 2002). Instead, by far the most publicized concern with the network of veterinary cordon fences remains their catastrophic impact on Kalahari wildlife populations, rather than the restriction of mobile or opportunistic pastoralists and foragers.

Depletion of Kalahari Wildlife

The most controversial veterinary cordon fence in this regard was the Kuke fence constructed at the behest of the Ghanzi farming community in the late-1950s.²¹ The construction of the Kuke fence, which runs along the northern boundary of the central Kalahari game reserve (CKGR), was followed by observations of large-scale mortalities of migratory ungulates both shortly after construction, and in the two decades that followed (Parry, 1987).²² Concerned conservationists directly attributed mortalities to the Kuke fence (Owens and Owens, 1980; Williamson and Williamson, 1981). However, those familiar with the region's history sought to put declines into the context of historical drought-induced population dynamics, while attributing the cause to a range of changes (human settlement, livestock expansion, hunting) alongside veterinary fencing (Campbell, 1981). A regional debate ensued.

In fact, migratory wildlife are continually prone to entanglement along most veterinary cordon fences in Botswana, especially in northern wildlife areas, often resulting in death or fence breakage (Mbaiwa and Mbaiwa, 2006). Historically, new fences were often followed by game causing 'breaks very frequently' until 'a very obvious reduction in such breaks' was noticed.²³ Subsequently some veterinarians have maintained that game adapt their movement patterns away from veterinary fences in response to enclosure (Falconer, 1972). Indeed, not all species are fully curtailed by veterinary cordon fences, leading some to question their whole purpose

²¹ The Kuke veterinary fence was originally proposed as part of the colonial scheme in the late-1940s. However, the entire scheme was considered "*far too costly*" and it was decided that the proposed Kuke fence could be sacrificed as a southbound FMD outbreak at Ghanzi would be discovered before it "*infected the remainder of the territory*". Ghanzi farmers objected and used their growing dairy and livestock industry as leverage at a meeting in 1955 to request that the fence be erected (BNA S542/3).

²² The Officer in charge of the Bushman survey at Ghanzi observed large herds of wildlife dying at the fence and wrote to colonial government in 1963 urgently requesting that the fence be dropped in places to allow migratory wildlife to cross and that boreholes be drilled in the CKGR. The request for boreholes was answered but the fence remained due to an ongoing FMD outbreak in Ngamiland (BNA S542/3).

²³ Sgd J.E.R Roe Director of Veterinary Services reported on progress of the Debete Cordon Fence on the 3rd October 1952 stating: "*the fence easily withstands a charging wildebeest as has been seen on frequent occasions*" (BNA S542/3).

(Hobbs, 1981). Eland (*Taurotragus oryx*), for example, are capable of jumping most fences and elephant (*Loxodonta Africana*) can easily flatten non-electrified fences and are even known to break electric fences using uprooted trees (Kalikawe, 1997). On the other hand, species such as giraffe (*Giraffa camelopardalis*) are particularly prone to ongoing entanglement with some veterinary fence patrols along the Ngamiland buffalo fences reporting mortality rates of one giraffe caught in every 100km of fence per annum (ibid: 35; Peke, 2000b).

The key to understanding the impact of veterinary cordon fences on wildlife in the Kalahari lies in an appreciation of the complex ecological adaptations to the heterogeneous landscape (pans, dry river valleys and undulating dunes), and occurrence of periodic drought events. In simple terms, Kalahari wildlife populations are adapted to the arid environment through migration to seasonal water and grazing by water dependant species (Parry, 1987), and utilisation of plant moisture by water independent species (Williamson, 1985). However, the migratory patterns of water dependent species such as the blue wildebeest (*Connochaetes taurinus*), do not fit easily into the classic, annual, fixed route migratory model bestowed upon eastern African populations (Perkins *et al.* 2002).

Instead, in most years, populations follow a pattern of mobility between 'core areas' and dry season refuges. 'Core areas', such as pans or fossil river valleys with mineral rich soils, are utilised by water dependent species for their ephemeral wet season surface water and nutrient rich pasture, before dispersal in small groups during the dry season, often along dry river valleys (Williamson and Williamson, 1985). To survive prolonged droughts, water dependent populations such as wildebeest and zebra must seek access to more reliable sources of water found either near the Orange/Molopo river systems to the south, or the Okavango, Boteti and Lake Xau region in the northeast. Both areas are now enclosed by veterinary cordon and ranch fencing.

More recent population estimates put the drought mortalities of the early-1980s into perspective, silencing many population dynamics critiques of the fencing issue. Over the last 30 years the population of migratory species in the Kalahari has decreased by over 90 per cent (Wheelwright *et al.*, 1996), and, though the populations of some ungulates have recovered, most of the increase is restricted to water independent species (Thouless, 1998). Species dependent on water are now mainly restricted to protected areas of northern Botswana where permanent water can be accessed from the Okavango and Chobe river systems. Furthermore, modelling of population dynamics over an average 20 year drought cycle revealed that the long-term survival of water dependent species in the Kalahari is reliant on immigration from areas with permanent surface water such as northern Botswana, and thus the population of migratory ungulates may never recover (Spinage and Matlhare, 1992). Veterinary cordon fences have, therefore, played a leading role in the destruction of the Kalahari's migratory wildlife populations, and subsequent publications are increasingly recognising this (Environmental Investigation Agency, 2004; Mordi, 1989; Perkins *et al.* 2002; Pearce, 1992).

Socio-environmental Impact of TGLP

One of the main implications of this decline has been a further reduction in livelihood opportunities for people displaced or enclosed by the TGLP ranches (Sporton and Thomas, 2002a). Besides alleviating overgrazing, it was hoped that the TGLP would also reduce inequality by removing the wealthiest pastoralists from the eastern hardveld, thus allowing smaller farmers to improve their livelihoods. However, rather than improve livelihoods and the environment, during the 1980s and '90s the policy was criticized for contributing to rising rural poverty, social polarization and environmental degradation (Cooke, 1985; Hitchcock, 1985; White, 1993; Peters,

1994). It is now widely acknowledged that the policy was founded on several false assumptions.

Firstly, wealthy herd owners who joined ranch syndicates were not willing to relinquish their communal grazing rights and thus retained dual access rights, further marginalising poor farmers in the eastern hardveld (Peters, 1994). Secondly, rather than a vast untapped grazing resource, many of the ranch areas were in fact inhabited by people for whom opportunistic hunting, gathering and pastoralism previously formed the bulk of their livelihoods. In the initial stages of the policy the zoning of ranch areas resulted in the displacement of large numbers of people, either onto remaining communal lands or newly established service centres (Sporton and Thomas, 2002).

One of the secondary objectives of the policy was to achieve social and economic development for displaced Kalahari populations or so-called 'Remote Area Dwellers' (RADs) at service centres. Service centres were settlements established around existing, reliable water sources in remote areas where access to employment opportunities and health and education facilities could be centralised (ibid: 51). It was hoped that these facilities would settle mobile communities and reduce levels of social and economic inequality thought to be inherently associated with traditional pastoralism in the Kalahari (ibid: 113). However, rather than encourage sedentism or reduce inequality, the policy has increased mobility, creating a transient society, utilising localised moves between ranches and service centres, while heavily reliant on foraging, welfare and tenuous social relationships in order to create viable livelihoods (Sporton *et al.* 1999). The resilience of RADs to natural environmental variability has also been further reduced by declines in the availability of veld products due to environmental degradation in some ranch blocks (Thomas *et al.* 2000).

With ranch and veterinary cordon fence enclosure causing declines in Kalahari wildlife and environmental changes reducing opportunities for utilizing rangeland products, RADs have become increasingly reliant on remaining communal rangelands outside ranch blocks. However, could veterinary cordon fence enclosure be causing social and environmental changes in these regions, further reducing livelihood opportunities and environmental sustainability?

Social Implications of Enclosure by Veterinary Fencing

In spite of TGLP's apparent failure, the government of Botswana continued to persevere with the ranch model in the subsequent National Policy on Agricultural Development (NPAD) in 1991; prompting fears that the concentration of rural poor on the country's remaining communal lands may cause further social and environmental problems (Peters, 1994). However, while these issues have been thoroughly considered, the impact of the accompanying veterinary infrastructure and disease control policies remains poorly understood.

To date, the work of the anthropologist Hitchcock (1995; 2002) amongst hunter-gather and pastoral groups in northern Botswana remains one of the few documented considerations within the academic literature, relating to the impact of veterinary cordon fence enclosure and disease management on rural livelihoods in Botswana. Hitchcock (1995) first noted the negative livelihood implications of veterinary fence enclosure and disease management whilst working amongst the Tyua hunter-gatherers of the Nata region, northeastern Botswana. Shortly after the central Ngwato cordon fence was completed to the east of Nata in 1955, an FMD outbreak prompted veterinary officials to restrict the movement of livestock and some goods which prevented people from taking meat and crafts to markets found to the east of the fence (ibid: 184). Households with cattleposts now enclosed by the fence were also unable

to make their seasonal move of cattle to village arable lands, causing a shortage of milk and draft power, and a general movement of people towards cattleposts (ibid: 184).

Hitchcock (2002) noted two important points concerning the societal implications of disease outbreaks and veterinary cordon fences: (i) that outbreaks tend to coincide with drought events when people are at their most vulnerable—likely caused by closer contact between livestock and wildlife at scarce water points and the increased use of mobility as a coping strategy by both livestock and people; and (ii) that the accepted government opinion regarding disease outbreaks and veterinary fencing is that they only impact negatively on the wealthy cattle owning minority. However, Hitchcock (2002) clearly demonstrates that poorer households, especially those without livestock, are in fact most affected by veterinary cordon fence enclosure and disease control. Veterinary disease control along the central Ngwato fence during the 1977-8 FMD outbreak, for example, resulted in the near collapse of the rural economy, as the stockless poor were unable to access livestock to plough their fields and were forced to migrate or forage to survive (ibid: 172).

While some people migrated to urban centres, most moved from villages to cattleposts where milk could be obtained from livestock and natural resources could be hunted and gathered (ibid: 171). However, further constraints were encountered after the ban on animal transport forbade the use of donkeys which were commonly used for transport, hunting and gathering. Unemployment also increased as cattle were quarantined by officials at a government quarantine camp and some RADs employed on cattleposts found themselves out of work. As a result of these measures, several herd owners turned off their boreholes, forcing many to forage for water, meat and wild foods in order to survive. The only advantage of the outbreak was that RADs

were able to consume all the meat of dead cattle, whereas previously they would have been obligated to take the meat to village-based owners (ibid: 171).

Veterinary cordon fences and disease management policies can clearly impact negatively on rural livelihoods, resource use and pastoral mobility during disease outbreaks. However, besides consideration of the *short-term* direct impacts of enclosure and disease management during outbreaks, to date, no research has been specifically focused on the *longer-term* implications of enclosure for rural livelihoods, mobility and natural resource use.

Environmental Implications of Enclosure by Veterinary Fencing

There are further ecological concerns regarding veterinary cordon fences beyond simply their catastrophic impact on Botswana's migratory wildlife, yet few conservationists are cognizant of this. In Botswana, land-use decision making during the late colonial period was seriously flawed in terms of establishing protected wildlife areas, as clearly none are distinct ecological units, with the lack of surface water in the CKGR an extreme example of this (Thomas, 1988; Thomas and Shaw, 1991). The long-term sustainability of most parks in the region is now highly dependent on 'rest-periods' created by the outward migration of wildlife (Hachileka, 2003). However, such out-migration has become severely restricted by further expansions of the veterinary cordon fence network throughout northern Botswana (section 2.5). Such veterinary-fence restricted herbivory by wildlife has created 'severe environmental stress' and long-term changes to the environment in northern Botswana (Thomas, 1988; Thomas and Shaw, 1991).

The problem is that wildlife-restricted herbivory can be far more environmentally damaging than livestock, as wild ungulates feed on a wider diversity of plant species (Taylor and Walker, 1978; Thomas, 1988). Certain species such as elephant can

markedly alter the abundance and composition of mature trees, leading to the extirpation of some species (Wiseman *et al.*, 2004). When combined with the restriction of other large browsers such as giraffe, the impact on savanna woodlands can be considerable, in some cases leading to the replacement of woody canopy vegetation with open grasslands (Pellew, 1983).

The situation in northern Botswana is compounded by an alarming increase in the population of large mammal herbivores (LMH) such as elephant. This is partly caused by natural population growth following the enforcement of anti-poaching laws, but more importantly reduced access to seasonal grazing resulting from the increased enclosure of the region by veterinary cordon fences (Thomas and Shaw, 1991). While concern amongst park managers and ecologists regarding environmental changes within fenced reserves is mounting (Wiseman *et al.*, 2004), to date few studies have considered, in any detail, the impact of herbivory restricted by veterinary fences on savanna vegetation communities in southern Africa. Although those who have considered the extent and possible causes of veterinary fenceline degradation conclude that blocked migratory wildlife are to blame (Ringrose *et al.* 1997), little useful information can be gained from such studies which use a snapshot of the environment at one spatial and temporal scale (McGahey, 2003).

There is therefore a need to investigate fenceline induced changes, especially as adverse environmental changes can result as much from undergrazing by livestock and wildlife as it does from overgrazing (McGahey *et al.*, 2007). Fencelines represent natural grazing experiments whereby the effects of different grazing regimes and management practices can be monitored (Todd and Hoffman, 1999). Chapters 8 and 9 seek to investigate these changes using a combination of detailed ecological surveys on the ground and multitemporal remote sensing.

2.5 Past and Present Impact Assessment and Planning with Veterinary Cordon Fencing in Botswana

Part of the problem, in terms of the social and environmental concerns with veterinary cordon fences in Botswana, relates to the complete lack of *a priori* social or environmental impact assessment and often blatant disregard for current land-use planning and local resource use during fence construction campaigns. To date, no Environmental Impact Assessment (EIA) has been conducted prior to any veterinary cordon fence construction in Botswana.²⁴ Fences are often constructed rapidly during disease outbreaks, driven on by the urgency of the situation.

In recent years, international and national environmental groups have become increasingly concerned about Botswana's veterinary fencing strategies. At the same time the government has begun to recognise that it can no longer continue to expand its network of fences without more detailed veterinary fence planning. Though the situation in terms of fence planning appears to have improved in recent years, the government continue to pursue the export-orientated development trajectory in Ngamiland, seeking to expand veterinary fencing and livestock ranching within the region in northwestern Botswana (Environmental Investigation Agency, 2004). In addition to this, though legislation has been drafted making EIAs a mandatory prerequisite for future fence projects, at present the DAHP retain exclusive powers to construct fences and declare stock-free zones within any part of the country (Driver and Booth, 1997).

Under the Diseases of Animals Act of 1982, for example, the Director of Veterinary Services, after prior authorisation from the Minister of Agriculture, may invoke emergency powers to declare 'stock-free zones' and 'cause fences to be erected on

²⁴ Only retrospective EIAs have been commissioned (See Scott Wilson Resource Consultants, 2000). Although the TOR of this consultancy involved the impact assessment of closing the gap between NBF and SBF, and planning for future Ngamiland fences, to date these changes have yet to be implemented.

any land in Botswana for the purpose of preventing the spread of any disease' (Republic of Botswana, 1982). As a result, the Department of Animal Health and Production (DAHP) often appear to exercise *carte blanche* with regard to fence planning, failing to consult even their own government planners (Hobbs, 1981). Few, if any, veterinary cordon fences in Botswana follow existing land-use plans or boundaries for their entirety. At best fences block communication links, cut cattleposts off from arable lands and villages; and at worst fences even dissect entire villages, despite contravening section 53, point 3 of the 1982 Diseases of Animals Act that states: 'no fence erected under these regulations shall be so constructed as to encroach upon any homestead, garden or village'.

During the early 1980s consultation and planning for fences such as the Makoba cordon (ibid: 16) or southern buffalo fence (Benson pers. comm.) typically involved a flight along the route previously drawn on a map by DAHP officials, with little or no consideration for current land use plans or people's resource relationships. Fence construction campaigns were also rapid, especially if conducted during disease outbreaks. For the Makoba fence, for example, DAHP officials made their proposed plans known in December 1980 yet by March 1981 the fence was almost complete (Hobbs, 1981). The situation appeared to improve slightly during the late-1980s with the northern buffalo fence marking Botswana's first fence involving over five years of prior local consultation and land-use planning, yet even this was problematic with decision-making appearing to amount to a *fait accompli* and the final alignment following land-use zone boundaries for only part of its course (Chapter 7).

By the early-1990s international concern over Botswana's approach to veterinary cordon fence planning had begun to mount (Pearce, 1992; Lomba, 1991). Yet despite increasing criticism from conservationists warning against the "emergency" use of veterinary fencing with little forward planning or local consultation (Taylor and

Martin, 1987), the country's first outbreak of CBPP for nearly 60 years in February 1995 prompted the erection of three emergency cordon fences and the biggest single disease control campaign in the nation's history, costing an estimated 97.5 million US dollars (Mullins *et al.* 2000). Though much of this money was spent compensating farmers for the eventual cull and restocking of Ngamiland's 320,000 head of cattle, by the time the decision to eradicate by "stamping out" was made in April 1996 the DAHP had spent over 45 million pula (15 million US\$), largely on the construction and picketing of veterinary cordon fences (Ministry of Agriculture, 1996).

The CBPP outbreak of 1995/6 occurred after infected livestock entered Botswana from Namibia, probably as a result of a post-independence relaxation of military border patrols and an ongoing process of Herero repatriation (Driver and Booth, 1997; Anon, n.d.). After diagnosing the disease, the DAHP invoked their emergency powers to declare a series of disease control zones surrounding the site and rapidly constructed three emergency CBPP veterinary fences between the Namibian border and Okavango Delta (Samochima, Ikoga and Setata fences, Map 2.2). At the same time a cabinet decision was made to strengthen both CBPP and FMD veterinary cordon fencing throughout the district, resulting in a further two new cordon fences (extension of NBF and Caprivi border fence to Kwando river); a new electrified fence along the northern and western border with Namibia; and an attempt to fence the gap between the southern and northern buffalo fences (Driver and Booth, 1997).

In total, approximately 1130km of new veterinary cordon fencing was constructed during the CBPP campaign without any prior land-use planning, consultation or regard for the social and environmental consequences. This unprecedented expansion of Botswana's veterinary fence network prompted fierce criticism from local, national and international conservation organisations (Hannah *et al.*, 1997; Albertson, 1998). While pressure from local conservation groups meant that sections of the Setata fence

were dropped and wildlife movements monitored (Albertson, 1998), the remaining emergency fences were declared permanent and part of the DAHP's 'national plan' prompting further concern from the conservation lobby (Hannah, *et al.* 1997).

Taylor and Martin (1987) had warned that "under pressure from beef importers, it would be all too easy to adopt a policy that attempted to make the entire country disease free" with wildlife populations "reduced to those in a few heavily cordoned enclosures, grudgingly accepted to satisfy the conservation lobby". Lobbying groups were worried that Botswana's "powerful cattle industry" was intent on establishing "a new beef export zone" surrounding the internationally renowned Okavango Delta ecosystem (Environmental Investigation Agency, 2004). These fears were far from unfounded.

By 1998 Botswana's livestock industry was generating export earnings of 86 million US dollars (Botswana Meat Commission, 1998). However, livestock from the red (FMD) infected zone, yellow vaccination zone and blue surveillance zone, which account for 15 per cent of the BMC's production, are prohibited from the export market, resulting in between 5 to 8 million US dollars in lost earnings per annum (Peke, 2000a) (Map 2.1). The CBPP cull also forced the closure of the Maun BMC abattoir, resulting in the retrenchment of over 200 employees, further highlighting the socioeconomic implications of disease outbreaks to advocates of the livestock industry (Mullins *et al.*, 2000). With the country's largest TGLP ranch block in Ngamiland, government officials were desperate to establish a new export zone in the region by constructing new cordon fences and pushing the surveillance zone further north.

However, in response to the growing negative publicity and arguments over veterinary cordon fences, the government of Botswana was forced to establish an Ad Hoc Committee on Fences (AHCOF) consisting of representatives from key

government departments and local NGO's (Peke, 2000c). In 1997, at the request of the Kalahari Conservation Society (KCS), Conservation International (CI) and the World Conservation Union (IUCN) the AHCOF proposed to commission a retrospective EIA of existing veterinary cordon fencing in Ngamiland, with the study also considering options for further livestock export development in the district. Later that year, a scoping exercise designed to identify the terms of reference (TOR) for the main EIA, recommended the immediate removal of the eastern most section of the Caprivi border fence. It was estimated that this fence could result in an 80 per cent decline in western Caprivi's wildlife populations, costing the country's tourism industry approximately 5 million US dollars and jeopardizing the region's numerous community based natural resource management (CBNRM) projects (Driver and Booth, 1997).

In 1997, two developments were highly influential for the forthcoming EIA, in terms of veterinary regulations and future cordon fence planning and implementation. First, a study of wildlife-friendly fencing techniques was conducted by the Department of Wildlife and National Parks, which included new proposals for more ecologically sound fence designs (Kalikawe, 1997). In particular the study proposed improved targeting of fences for particular species and designing "let down" or "roll back" fences in areas where migratory species historically accumulate or where the disease risk is intermittent (ibid: 37). Though these recommendations were incorporated in the preliminary EIA scoping exercise (Driver and Booth, 1997), they were never adopted or reiterated in the main EIA (Scott Wilson Resource Consultants, 2000).

Second, a large increase in the number of former livestock ranches converting into "wildlife conservancies" in southern Africa, especially southeastern Zimbabwe, caused landowners to challenge strict OIE regulations regarding surveillance or buffer zones (Sutmoller, 2002). Under the OIE recommendations of the time, any territory

with FMD carrying buffalo was considered infected and zones recognised as FMD free for livestock export needed to be separated by a fenced surveillance zone at least 10km deep (ibid: 193; Thompson, 1999). In May 1997 the OIE accepted that FMD infected areas containing buffalo could be separated from the FMD free export zone by a game-proof barrier, typically a double electrified fence with one side high enough to prevent antelope from crossing, and the other strong enough to contain buffalo (Thompson, 1999).

The new OIE recommendations allowed the EIA team greater flexibility to propose four possible options for veterinary cordon fence development in Ngamiland, two of which involve creating a new FMD free export zone in the district (Scott Wilson Resource Consultants, 2000). While the fourth option involves creating a small export zone by enclosing part of the district largely consisting of TGLP ranches with a double electrified game-proof fence, the third option creates a far larger export zone throughout the entire south and west of the district, thus opening up the region for further fenced ranching and export-orientated livestock development.

The report, therefore, recommended that the third option would threaten “wildlife and tourism development in western Ngamiland” and would likely be interpreted by conservationists as “evidence that the Government of Botswana accords a higher priority to livestock development than environmental conservation” (Scott Wilson Resource Consultants, 2000). In spite of this, shortly after the report was published the DAHP recommended the third option to Cabinet, while conservation groups and the DWNP remain in favour of option four (Environmental Investigation Agency, 2004). To date, no new veterinary cordon fences have been constructed in Ngamiland, yet the DAHP remain clearly in favour of expanding commercial livestock development into western Ngamiland, principally following the fenced ranching model. This was evident during a discussion concerning the role of fences and

vegetation change in western Ngamiland with the Deputy Director of DAHP, Dr Pillimon-motsu,

*‘during droughts cattle graze right up to the fences and the [fenceline vegetation] changes are particularly noticeable in some areas. During the drought of 1987 a representative from a farmer group in Ngamiland approached us to ask permission to graze cattle in the delta, as cattle were dying at Gumare. What is needed is better cattle management, fenced ranches, not communal grazing’.*²⁵

To add to this, Botswana’s latest agricultural policy aims to increase productivity in the livestock sector by promoting the intensive use and efficient management of land resources and livestock, partly through the fencing of some communal lands (Sporton and Twyman, 2002). While Botswana’s persistence with fencing and privatised ranching appears on the surface to be based on ecological concerns, there is little doubt that this has strong links to an older colonial discourse once prevalent throughout Africa relating to the need to reform pastoral land tenure and so-called ‘backward’ practices such as livestock mobility, predominantly on veterinary grounds (Waller, 2004; Gilfoyle, 2003).

2.6 Northern Botswana Study Area

In Botswana, over 80 per cent of livestock reared for the commercial sector are grazed on unfenced communal lands protected from disease outbreaks by the network of veterinary cordon fences which divide the country into a series of large zones (Darkoh and Mbaiwa, 2002; Anon, n.d.). The remaining cattle are reared on fenced tribal lands (TGLP) or freehold farms, with the privatised land of the latter covering a meagre six per cent of the country’s total land area (Ndzingi *et al.*, 1984). To date, Botswana remains the only country in southern Africa to use veterinary cordon fencing as a tool

²⁵ Interview DAHP 3, Gaborone June 2006.

to control the movement of livestock and wildlife in unfenced communal lands, outside areas of commercial privatised farmland (Map 2.1).

To some extent this is necessitated by the sheer abundance of unfenced communal tribal land and lack of land appropriation during colonial times. By contrast, in other regional countries engaged in commercial livestock production such as Namibia, approximately 80 per cent of the country is composed of privatised fenced rangeland where almost all the livestock for the commercial sector are sourced (Meynell and Thomson, 1999). In Namibia, land to the north of these farms, and the red line veterinary cordon fence which demarcates their northern border, remain unfenced communal land, where diseases such as FMD and CBPP are endemic. Similarly in Zimbabwe disease control is said to be greatly facilitated by the fact that large areas of the country are fenced farmlands where the movement of wild or domestic animals is restricted (Agrar-Und Hydrotechnik, 1982).

Thus, the veterinary cordon fences of Botswana, particularly in northern areas where most of the land remains under communal tenure, represent an excellent study area to investigate the social and environmental impacts of veterinary fence enclosure. The relevance of the Botswana context is especially enhanced given: (i) the recent drive for livestock marketing within the pro-poor livestock development movement; (ii) the predicted livestock revolution; and finally, (iii) the planned reinstatement of export zones and potential expansion of veterinary cordon fencing as a disease control tool throughout Africa's largely unfenced pastoral drylands (Chapter 1). To add to this, Botswana remains strongly focused on following a commercially orientated livestock development trajectory, resulting in continued investment in developing the sector, particularly with respect to veterinary sanitation. The continued investment in fencing therefore makes this region an ideal study area to investigate the impact of veterinary

fence enclosure on rural livelihoods, resource relationships and mobility in a contemporary context, thereby increasing the value of this research project.

2.7 Conclusion

This chapter has explored the origins of veterinary cordon fencing in southern Africa and exposed the absolute necessity of their use for export-aspiring nations with large areas of unfenced communal rangeland, especially where livestock and disease-carrying wildlife remain integrated. This revealed several important points: (i) that the objectives of disease control under veterinary science directly conflict with those of traditional pastoralism and the new rangeland science; and (ii) that the goal of veterinary sanitation is inordinately more difficult to achieve within unfenced communal rangelands than fenced privatised land, thus necessitating land fencing/privatization and/or veterinary fencing if the commercial export orientated livestock development model is followed.

The discussion also exposed the Republic of Botswana as a nation determined to pursue a contested and controversial export-orientated livestock development trajectory into remote rural areas at the expense of environmental conservation and alternative community-based land-use strategies. Such an approach requires continual investment in veterinary cordon fencing, especially in regions such as northern Botswana where diseases remain endemic in wildlife populations and neighbouring countries. Thus, the veterinary cordon fences of northern Botswana offer a unique opportunity to investigate their social and environmental effects in detail within a contemporary context.

The second part of this chapter sought to draw out some of the key social and environmental implications of veterinary cordon fence enclosure in the drylands of

Botswana. While the short-term implications of enclosure and disease management have been considered, no research has been specifically focused on the longer-term implications. A thorough review of the available literature raises some searching social and environmental research questions hitherto not considered such as: (i) what is the current context of livestock and human mobility within contemporary Kalahari livelihoods and what direct impact does enclosure have upon these resource relationships?; (ii) how do people adapt their livelihoods and resource use to enclosure and what are the long-term social implications of these fence-restricted resource relationships?; and finally, (iii) what are the long-term environmental consequences of these altered land-user resource relationships and what further environmental changes have occurred as a result of the enclosure of people, livestock and wildlife? This thesis aims to address these research questions.

While Botswana's disease control situation presently remains unique within the southern African region, neighbouring countries such as Namibia plan to expand their fences into communal areas in the near future, further enhancing the importance and urgency of this study (Driver and Booth, 1997). To add to this, Botswana is often portrayed as a disease-management success story in the veterinary science literature, with the use of strategies such as veterinary cordon fencing advocated in areas of Africa where wildlife/livestock integration and transhumant pastoralists currently hamper disease control efforts, and resultant endemic diseases limit livestock trade and export (Kivaria, 2003). Botswana, for example, frequently hosts scores of visiting veterinarians and livestock development officials intent on improving their own livestock marketing and disease sanitation within countries with equally long permeable borders and large areas of communal rangelands with livestock/wildlife integration (Scoones and Wolmer, 2006). Though some veterinarians emphasize that enclosure with fences in such regions must be balanced by appropriate land-use

zoning, retaining sufficient areas for the mobility of traditional pastoralists and wildlife, many infer that this has been successfully achieved in Botswana (Kock *et al.*, 2002; Sutmoller, 2002). However, as this chapter makes clear, this is simply not the case.

Given the highly integrated and ingrained nature of the social and environmental concerns over veterinary cordon fence enclosure, the next chapter seeks to establish a theoretical approach and methodological framework to investigate these issues.

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Personal Communication

Bensen, H, Harry Oppenhiemer Okavango Research Centre, University of Botswana, Maun, Botswana.

3

Investigating the impact of enclosure by veterinary cordon fences: Interdisciplinary research for a nature-society concern

3.1 Introduction

One of the most important revelations to emerge from the paradigm shift in pastoral development and the dryland environmental change debate is the recognition that greater interdisciplinarity¹ is required in drylands human-environment research. Too frequently, research attempting to analyse complex environmental issues with social and physical dimensions takes either a human or environmental perspective and is forced to infer or speculate over the other dimension (cf. Turner, 2003). Such positivist, reductionist, and discipline-based investigations can lead to the establishment of global environmental myths (Forsyth, 1998), and it is now becoming widely recognised that interdisciplinary research is required for understanding complex world systems and developing sustainable natural resource management policies (Newell *et al.*, 2005).

This chapter introduces the theoretical and conceptual frameworks used to guide this investigation into the impact of veterinary fence enclosure in northern Botswana. The chapter begins with a review of current theoretical approaches used to investigate the complexity of environmental issues in drylands. The use of political ecology has increased dramatically over the last two decades and the field has come a long way from its roots within the literature on land degradation and now includes diverse topics from the analysis of social movements to environmental discourse (Watts, 2000; Peet and Watts, 1996). However, the field retains a core focus on human-environment

¹ Interdisciplinary research may be conducted across disciplinary divisions both within and between the physical and social sciences. Throughout the discussion, unless otherwise stated, the term is used to refer to human-environment research which crosses the biophysical and social science divide.

relationships, especially concerning dryland pastoralism, resource access and ecological change (Turner, 1993; 2004). Thus, without withdrawing in any way from social theory, the interdisciplinary field of political ecology is critically examined for its usefulness in guiding this research. Next, the ability of several ancillary frameworks to focus the investigation within the burgeoning field of political ecology are critically evaluated. Finally, the mixed-method approach, involving the reflexive and iterative use of a variety of methods from a range of disciplines, is described in detail.

3.2 Studying Nature-Society Issues in Drylands: The Interdisciplinary Imperative

In recent years, the silence on the ‘question of nature’ in geography has been decisively answered and the nature-society identity of the discipline has once again risen to the fore (Fitzsimmons and Goodman, 1998; Turner, 2002). Though there is still much work to be done to ‘heal the rift’ of the subject’s recent dualism (Hanson, 1999), and there may be future identity crises in the restructuring of academy (Turner, 2002), the ingrained counterposition between ‘natural’ and ‘social’ is increasingly being questioned in geography (Massey, 1999; Wasson and Dovers, 2005). At the centre of these ideological developments lies the interdisciplinary quality of geography, providing a bridging role between the natural and social sciences and their divergent realms of understanding. The integrative power of geography has enabled some of its professionals, especially those engaged with environmental issues at the nature-society interface, to challenge divisions within the subject and bring the ‘question of nature’ back to the centre (cf. Whatmore, 2002; Wasson and Dovers, 2005). Some geographers are now calling for the discipline to (re)emphasize, in a variety of arenas, the powerful contribution the subject can make to

understanding complex environmental issues and developing effective environmental management strategies (Castree, 2002). At the same time, calls for cross-disciplinary or ‘hybrid’ research approaches to study complex environmental issues have become increasingly conspicuous, especially in the literature concerning environmental degradation and ‘third world’² development (Sullivan, 2000). This is a field of enquiry where interdisciplinary geographers have made a considerable contribution in recent years (cf. Warren, 1995; Batterbury *et al.*, 1997; Forsyth, 1998; Thomas and Twyman, 2004).

As an interdisciplinary field, political ecology has recently staked its identity on illuminating the “question of nature” and geographers have taken the lead in this endeavour, alongside anthropologists and ecological economists (Escobar, 1999). The field emerged during the 1980s, combining the ‘concerns of ecology with a broadly defined political economy’ primarily from research concerning Third World environmental change (Blaikie and Brookfield, 1987). Thus, political ecology has been a theoretical inspiration to the recent ascendancy of geography’s human-environment identity, with some predicting that the subject’s future will be determined by new directions within the field (Walker, 2005).

Interdisciplinary approaches to research concerning human-environment issues are therefore increasingly becoming the norm, especially in the fields of environmental change and development, and geography as an integrative discipline is well positioned to engage in such debates. Moreover, there are good reasons why an ongoing dialectic between the social and natural sciences is a moral *imperative* for studies concerning

² The term ‘third world’ is used to refer to developing countries in the global south. It is not meant to imply that such countries are detached from the global economic system.

environmental change and the impacts of development policies. The following discussion attempts to trace the origins of the nature-society research tradition within geography and asks why it is now imperative that contemporary research on environmental issues, especially in the drylands of Africa, be conducted in an interdisciplinary fashion.

The history of Geography's nature-society tradition and the origin of political ecology

Geographers have been contesting the identity of their profession since the rise of science and though there have been moments within the discipline's history where one identity prevailed over the other, on the whole geography has been situated in an ill-defined intellectual place (Turner, 2002). The subject's nature-society identity can be traced back to the division of knowledge during the enlightenment of science. According to Turner (2002), newly appointed chairs of geography during the nineteenth century sought to cement their seats within the sciences on the basis of two competing identities: geography as a spatial chorological science (an alternative approach to understanding phenomena and processes) or geography as the human-environment science (a condition or substance of study). These competing identities remain to this day and are largely responsible for the subject's recent dualism and lack of disciplinary unity.

Early geographers, focusing on the human-environment tradition drew heavily on Darwinian concepts of environmental determinism to theorise nature-society interactions. Nature-society geographers of the time believed that the cultural traits of societies could be explained primarily by their physical environment (Johnson, 1954). This identity, particularly championed by early American geographers, however, was soon widely criticised as being conceptually and methodologically flawed or over-simplistic (Sauer,

1924). Sauer, amongst others, subsequently sought to reshape the human-environment tradition and bring the focus back to the landscape scale (Leighly, 1976). According to subscribers of the “landscape morphology” theory in human-environment inquiry, landscapes, especially those man-made or artificial, were an expression of the human-environment relationship and thus the focus shifted to the role of human societies in shaping the natural environment.

In subsequent years, proponents of the “landscape morphology” school of nature-society thought were able to learn a great deal about human-environment relationships through an analysis of ‘man’s’ role in shaping the environment at the landscape scale (cf. Thomas, 1956). However, such enquiries were subsumed by a new school of geographical thought emphasizing human agency and environmental variability in determining nature-society resource relationships. With a research focus on human adjustments to environmental risks or hazards, the new approach which became known as “cultural ecology” to geographers, saw social change, variability and adaptation as evidence that ‘man’s’ relationship with the environment was rarely linear or simple. Instead both the environment and society were constantly changing and cultural change was an expression of human behavioural response to environmental perturbations (Stewart, 1955).

This theoretical approach to the question of human-environment relationships led cultural ecologists to focus on the ecosystem as their spatial unit of analysis. Drawing on Western models of ecology at the time, equilibrium concepts were widely integrated and cultural ecologists or ecological anthropologists sought to find the adaptive functions of societies with regard to their respective ecosystems in order to build a conceptual model of

adaptation applicable to all societies (Watts, 2000). However, during the 1970s theories of cultural adaptation were increasingly challenged, mainly by research from so called peasant studies which found Third World societies not existing in harmony with their physical environment, but rather emphasized the role of the market, social inequalities, conflict and other forms of cultural disintegration associated with an integration into a global capitalist society (ibid: 261).

Subsequent works thus questioned the use of ecological systems theories for exploring human-environment interactions, going so far as to challenge the epistemological foundations of cultural ecology and environmental risk or hazard approaches. The seminal work of Watts', *Silent Violence* (1983), emphasized the need to integrate the concerns of cultural ecology within a broader Marxist political economy (Watts, 1983). Watts demonstrated that the vulnerability of Third World societies to environmental hazards such as drought is understood less in terms of their inability or unwillingness to adapt, but more in terms of the way their pre-capitalist modes of production have been marginalised and disintegrated following their insertion into the global capitalist economy. This period marked the demise of old environmental determinism concepts of human-environment interactions and a new lexicon of marginalisation, resource appropriation and exploitation replaced the old terms of adaptation, self-regulation and system response (Watts, 2000). Moreover, such debates amongst cultural ecologists, ecological anthropologists and risk/hazard researchers paved the way for an entirely new approach termed 'political ecology' (Turner, 2002).

The term 'political ecology' was first coined during the 1970s when several publications used the term to conceptualise the geography and forms of environmental disturbance or

degradation (Watts, 2000). Work by Wolf (1972) and Cockburn and Ridgeway (1979), amongst others used the term to think about the way in which the inherent questions of political economy (i.e. access and control over resources) were central to understanding environmental degradation and developing sustainable alternatives. Thus, much of the early work by political ecologists focused on issues of environmental change and management, particularly in a 'Third World' context. Early proponents of the new approach to human-environment research were able to challenge the previous 'apolitical' (i.e. neo-Malthusian and neo-liberal)³ explanations of ecological change; and, drawing heavily on the principles of political economy, demonstrated that 'Third World' ecological problems were in fact socio-economic or political (Blaikie, 1985).

While the term political ecology may have become more widely used during the 1980s, the field lacked a coherent theoretical position and methodological toolkit. In some respects this problem remains today. However, the work of Piers Blaikie and Harold Brookfield (1987) is widely respected as laying the groundwork for both the method and perspective of political ecology (cf. Watts, 2000), and they emphasized several features for the field's toolkit. Firstly, that land degradation is both a result and cause of social marginalisation (Blaikie and Brookfield, 1987). Secondly, that degradation research should take into account hierarchical "chains of causation" and thus studies should focus on the local, regional and so on when seeking to explain both resource pressure and local decision making. Finally, Blaikie and Brookfield (1987: 27) emphasized temporal considerations and a plural approach to environmental change studies due to the inadequacy of historical environmental data to compare with the "chain of explanation".

³ Collectively the body of work conducted by political ecologists to date has undermined the Malthusian idea that population pressure causes environmental collapse and the neo-liberal assertion that unfree markets and poor local management by land managers results in environmental degradation.

The powerful Marxist-influenced analysis of resource use, Third World development, and environmental change, that characterised early conceptions of political ecology were increasingly reshaped and reworked during the late 1980s and early 1990s. Theoretical shifts in the realms of social development theory, as well as the physical sciences, strongly influenced the rethinking of political ecology. The advances which followed marked the beginning of political ecology as an independent field of enquiry and had important methodological consequences for those attempting to investigate environmental change in the Third World. While to some extent these internal debates may have weakened the field's emphasis on understanding the relationship between social and biophysical change (Vayda and Walters, 1999, Walker, 2005), elements of these new lines of enquiry continue to develop the strong focus on understanding environment and development in the Third World.

The evolution of development theory and advances in ecological thinking have been well documented (Behnke and Scoones, 1992; Slater, 1993; Booth, 1994; Vetter, 2005) and the literature on political ecology has become highly diverse (Little, 2004). For the purpose of brevity and to maintain relevance for this research inquiry the following critique of the new political ecology is focused on advances of concern to studies interested in social and environmental change in the lesser developed "South". It is precisely this line of enquiry and body of political ecology literature which has revealed the often brutally repressive constraints imposed on Third World societies which, in most cases, were initiated and maintained by policies informed by so called "received wisdoms" regarding the environment. Such interventions and "environmental orthodoxies" were more often than not the result of previous disciplined research

enquiries drawing on western theories from more temperate zones. Rather than review all of the internal debates within the physical and social sciences, the following section gives an overview of the most salient developments in the line of political ecology literature concerned with environmental change and development in the Third World.

The new political ecology and emphasis on interdisciplinarity

The emphasis in early political ecology studies on the plurality of perceived environmental problems opened up room for a renewed debate over how nature and environmental issues are represented and perceived in global development policy and practice (Watts, 2000). A subsequent line of enquiry for political ecologists has been concerned with the development and institutionalisation of global environmental change narratives or “environmental orthodoxies” (Stott and Sullivan, 2000). Of particular concern to such debates is the apparent disparity between local knowledge and practice, and global environmental narratives or accepted wisdoms. This is just one of the new directions which attempt to engage political ecologists with wider debates in poststructuralism and discourse theory (Peet and Watts, 1996).

Poststructural theoretical reflections within development studies have proven influential in the progression of political ecology as an independent theoretical and methodological framework. The previous influence of neo-Marxism and the quantitative revolution within the social sciences had proved disappointing in its efforts to advance the ongoing debate over social structure and agency (Simon, 2006). However, poststructural debates within development studies have led to a rediscovery of diversity, complexity and

relativity, which is underpinned by a rejection of the notion of universal truth (Booth, 1994).⁴

Like geography, development studies underwent an identity crisis during the late 1980s when the development geographer Edwards (1989) questioned the relevance of the discipline. Concerns that “academic” approaches to development studies failed to reflect the diversity and complexity of real world development interventions were linked to a partitioning of knowledge between the “expert” researcher and “local” land-user (Edwards, 1989). This caused a renewed interest in the “diversity of the development experience” within development studies (Peet and Watts, 1996: 2), and an increasing recognition that rural people have their own values, priorities and agendas which may not conform to those of development professionals, academics or governments. Two advances in the discipline followed. First the previous failure to incorporate local knowledge led to a proliferation of more “bottom-up” and “participatory” land-user led investigations and techniques in development studies (Chambers, 2003). Next, the Eurocentric character of development studies was challenged, causing critical reflection of knowledge-power, institutions and the notion of universal truth claims.

Within political ecology the poststructural interest in knowledge, power and discourse saw the focus rest on Blaikie’s (1985) idea of the plurality of understandings regarding environmental problems and the notion that one man’s soil erosion is another man’s soil fertility. Blaikie and Brookfield (1987) also called for political ecologists to examine the politics of ecology and seemingly apolitical scientific knowledge. A line of political ecological work followed, particularly from British political ecologists (who

⁴ Enlightenment philosophy considers all human minds to be similar and therefore truths are universal, and knowledge potentially uniform. By rejecting universality in development studies the notion of nuanced and differentiated knowledge within marginalised cultures can be accepted (Slater, 1992).

have a long-standing interest in the deconstruction of science), concerned with critically analysing the science-policy discourse of several global environmental problems (Adger *et al.*, 2001; Forsyth, 2003). Most of these works have analysed the political and historical construction of various widely accepted environmental change narratives often institutionalised via international development organisations.

Early works such as the influential text *Uncertainty on a Himalayan Scale* (Thompson *et al.*, 1986), challenged the Himalayan environmental degradation theory that population increase and the resultant pressure for agricultural intensification was leading to increased soil erosion. Later a whole series of neo-Malthusian environmental orthodoxies were successfully challenged, such as the desertification myth (Thomas and Middleton, 1995) and the so-called deforestation/fuelwood crisis (Leach and Mearns, 1988).

As well as shifting the focus of environmental change explanation from neo-Malthusian concepts to poverty and inequality, two important findings emerged from these critical analyses. First, that such institutionalised myths often led to repressive policies that severely restricted the livelihoods of marginalised peoples and thus often perpetuated the problems; and second, that the simplicity and hegemony of western scientific knowledge was largely responsible for the establishment of such myths (Sullivan, 2000). Although many of these early texts failed to examine scientific sources of evidence and were perhaps aimed at counterbalancing an increasing trend within political ecology to critique deep green ideas of First World environmentalism (Forsyth, 2003; Stott and Sullivan, 2000), they were united in their blame of western positivist natural science for its inability to acknowledge the politics and historical context of environmental change narratives.

As a result, subsequent developments in political ecology have led in several interesting directions. Of particular interest to this research is a line of literature which critically deconstructs environmental science and environmental explanation and calls for a more '*critical*' political ecology based on the concerns of critical realism, critical theory, poststructural discourse analysis and new ecological thinking (Forsyth, 2003; Leach and Mearns, 1996; Stott and Sullivan, 2000).

Though western positivist science initially received most criticism in this project, it soon became clear that the disciplinary division of knowledge within the sciences was largely to blame. While ecologists and environmentalists frequently defend orthodox scientific knowledge as unproblematic universal truths, some social scientists and political ecologists continue to accept environmental degradation narratives uncritically, whilst unaware of ideological developments in the biophysical sciences (Stott and Sullivan, 2000; Forsyth, 2003). The problem, according to critical political ecology, lies in the fundamental epistemological and ontological differences between the natural and social sciences. Forsyth (1998), for example, noted that part of the problem with the Himalayan myth lay in the fact that positivist scientific approaches seek falsification and universally applicable statements regarding environmental change, while cultural theorists seek diverse explanations of environmental change which cannot be applied across wider spatio-temporal scales.

Proponents of the new critical political ecology approach have subsequently asked some searching questions regarding the way environmental problems are socially constructed and environmental research conducted. Forsyth (2003), for example, asks how far it is possible to deconstruct orthodox scientific frameworks yet still achieve a biophysically

grounded, socially relevant and widely applied explanation of environmental change. The concern here is that by deconstructing science and challenging the universality of its claims one might become a relativist and believe that there is no true nonhuman nature out there and thus no validity in scientific knowledge. The answer, according to critical political ecologists, is to adopt an innovative hybrid, mixed-method approach which transcends disciplinary boundaries and fosters communication between the natural and social sciences (Stott and Sullivan, 2000; Batterbury *et al.* 1997). Thus, researchers must seek a pluralist framework that integrates knowledge claims from a variety of sources, whilst acknowledging that the subject of the environment is politically constructed within both the social and physical sciences.

However, while arguments for a more interdisciplinary political ecological framework continue to emerge from research concerned with ecological change, many of the field's internal debates continue to focus on progressing constructivist accounts of the nature-culture debate (Little, 2004). Using the political ecology of Third World social movements as a subject, and developments in discourse theory and poststructuralism as theoretical inspiration, the nature-culture debate has revealed much about the complexity, diversity and material basis of knowledge about the natural world (Escobar, 1996; 1999). However, though these developments have helped maintain the broad appeal of political ecology, they have been criticized for failing to incorporate ecological concerns (Vayda and Walters, 1999; Walker, 2005). This, in part, has prompted subsequent efforts to seek points of convergence between the social and biophysical sciences. For example, Scoones states that:

Despite the emphasis on historical contingency, complexity, and open-ended processes in poststructuralist analysis, the focus has remained almost

exclusively on issues in the social realm. The lack of attention to ecological issues and to the dynamics of environmental change remains a significant gap, resulting in the exclusion of a range of important strands of enquiry. (Scoones, 1999: 488).

More recently, in order to achieve a more socially just explanation of environmental change some political ecologists have focused more closely on two important areas: points of convergence between the social and physical sciences and the role of local knowledge in environmental change studies. One such area of integration is the incorporation of non-equilibrium concepts from the “new ecology.” The new ecological emphasis on multiple spatial and temporal scales of analysis appears to fit well with poststructural social theory (Zimmerer, 1994; Scoones, 1999; Zimmerer and Bassett, 2003). The multi-scalar considerations that emerged from continuations of the structure and agency debate in the social sciences (i.e. local to global influences on human agency) and the complexity of nonlinear global environmental change represent one area where the new ecology and social sciences converge. Secondly, the emphasis in political ecology on historically embedded accounts of social and environmental change fit well with concern over long-term variability and thus multi-temporal analysis within new ecology (Zimmerer, 1994; Scoones, 1999). However, few of these debates have moved beyond the theoretical and addressed the actual nuts-and-bolts of integration.

A second core focus within the new political ecology is on the role of local knowledge. All forms of knowledge are considered socially constructed within poststructural development theory. Therefore, the focus of enquiry should be on the process by which some forms of knowledge (i.e. scientific) become legitimised over others (i.e. local knowledge) (Thomas and Twyman, 2004). However, in the past anthropologists have

tended to portray local knowledge as location-specific, rather than explore its diversity and hybridity (Nygren, 1999).

More recently, political ecologists have attempted to examine the diversity and complexity of local knowledge and practice. Watts (2000) explains that by focussing on so-called indigenous technical knowledge political ecologists were able to identify several important traits regarding local environmental knowledge. First, local environmental knowledge is unevenly distributed throughout marginalised cultures. Second, it is not always most appropriate and is sometimes wrong and unsuitable. And third, that local knowledge is constantly evolving due to experimentation and as such may be considered hybrid.

For researchers concerned with ecological change the focus rested on the integration of local indigenous knowledge with other more powerful knowledge systems, such as that of hegemonic science. Critical political ecologists have argued that as local knowledge is widely regarded as localised and western scientific knowledge as universal and testable, a more constructive view is the concept of 'hybrid' knowledge and research (Forsyth, 1998; 2003). Forsyth (1996), for example, suggests using local knowledge as the starting point in research and western scientific knowledge to extend local concerns to the wider policy arena (Forsyth, 1996). However, the process of integrating local knowledge into environmental change research is far from straightforward. Though hybrid research offers the possibility to extend marginalised knowledge to the wider policy arena, there are concerns that overly neo-populist approaches may uncritically include local voices without evaluating local power structures and the institutionalisation of environmental perceptions (Batterbury *et al.* 1997). It is also common for such efforts to romanticize

local knowledge, labelling it as ‘local’ or ‘indigenous’, which may act to reinforce existing knowledge-power structures (Forsyth, 2003). Furthermore, there are linguistic barriers to the effective communication of local knowledge and thus local concerns are unlikely to be heard from social movements alone. The answer is to attempt to democratize the knowledge of subaltern groups in ways which critically address local power structures and acknowledge that research is not politically neutral (i.e. western expertise is required to communicate local knowledge effectively to policy makers) (Forsyth, 2003).

In spite of criticisms, political ecology remains a powerful framework for research concerning Third World environmental change and development. Though the approach has become somewhat diverse and often appears to lack an ecological basis (Vayda and Walters, 1999), reviews of the field frequently conclude that political ecology is worthy of its biophysical name (Walker, 2005). This is largely due to the ongoing development of critical political ecology and interdisciplinary research concerning natural resource use and ecological change in dryland Africa (cf. Little, 2004; Forsyth, 2003; Zimmerer and Bassett, 2003; Homewood, 2005). Indeed, research concerning natural resource access and ecological change in African savannas is frequently cited as evidence that political ecology retains a strong interdisciplinary focus on biophysical change (cf. Walker, 2005; Little, 2004).

Furthermore, there is now a growing sense that it is a moral imperative to approach research on nature-society issues in an interdisciplinary fashion. At the same time academics are realising that greater communication is needed between the ‘ivory towers’ of academy and the ‘real world’ of policy-making (Sullivan, 2005). Given the likelihood

that often severely repressive policies may arise from environmental narratives informed by the disciplinary divide, both social and natural scientists are now calling for greater integration (cf. Newell *et al.* 2005; Wasson and Dovers, 2005; Sullivan, 2005).⁵ However, despite increasing calls for integration, and an increase in the number of interdisciplinary human-environment programmes fostering communication between natural and social scientists; at present there are some major constraints blocking the progress of such integrated research efforts.

Interdisciplinary approaches have increased dramatically in recent years within a range of subject areas. Scientific understandings are becoming increasingly complex and interdisciplinary perspectives can reveal exciting, socially relevant findings on a whole range of issues (Rhoten and Parker, 2004), not least human-environment relationships. Yet, there are many obstacles challenging such integrative work.

The structure of academia and the discipline bias of most research funding bodies and academic journals represent one constraint (cf. Watt, 1991; Castree, 2002; Anon, 2006). Recent reviews suggest mainly young scientists and established Professors have the academic freedom to explore interdisciplinary avenues (Rhoten and Parker, 2004). There are negative career costs involved with interdisciplinary research and there is a tension between following integrative research paths which show considerable scientific promise and maintaining core discipline interests that offer the prospect of academic tenure track

⁵ While the human geography and social anthropology literature has been largely critical of natural science for its role in establishing such global environmental narratives with little response, several global environmental change projects have recently recognised the moral imperative for integrative work. For example, natural scientists recently working on the global environmental change project entitled Land-Use/Cover Change (LUCC) recognised that parts of the problem are so tightly linked to human action that the natural, social and geospatial sciences need to join forces. For example, Newell *et al.* (2005: 300) urge that “we no longer have the luxury of glossing over this situation. Our efforts to develop effective policies need support from almost all forms of human knowledge. In particular, we urgently need to improve our understanding of the interaction between people and their biophysical environment.”

(ibid: 2046). Most interdisciplinary research is therefore conducted by teams of scientists working in a limited number of interdisciplinary research institutions. However, both interdisciplinary research centres and the few interdisciplinary researchers are often the first to experience cutbacks in funding. Furthermore, integrative university departments (e.g. Geography) tend to retreat into their core areas during funding shortages, with interdisciplinary fringe interests becoming a luxury (cf. Watts, 1991).

There are several problems here. Interdisciplinary projects often reveal complexity and diversity, which lack appeal to policy makers who prefer simple discipline based universal laws and understandings. Thus, during government funding cuts research councils are more likely to award funding to single disciplined projects, rather than messy interdisciplinary studies (Henderson-Sellers, 1992; Wasson and Dovers, 2005). Secondly, the committee members of the research council panels tend to be balanced towards one discipline and the funds themselves compartmentalised into scientific topics on disciplinary grounds (Watt, 1991).

Despite the constraints, researchers are continually emphasizing the imperative for interdisciplinary approaches, especially in the effort to study people's impact on the biophysical environment and develop effective environmental management policies (cf. Newell *et al.*, 2005; Wasson and Dovers, 2005). However, at present such debates are centred on developing "best practice" for effective collaboration and communication between currently disciplined scholars rather than attempting to break some of the barriers restricting the careers of young interdisciplinary scholars. There is also an emerging sense—at least on the issue of fostering communication between disciplines with highly contrasting fundamental beliefs, internal debates and theories such as remote

sensing and social science—that the situation is unlikely to resolve itself unless a new generation of dual-trained, cross-disciplined scientists are supported (Rindfuss and Stern, 1998). As Rindfuss and Stern (1998) emphatically state:

we would suggest, however, that the time has come for funders, both federal and private, to train the upcoming generation of scholars who could bridge the social science and remote sensing fields (Rindfuss and Stern, 1998: 20)

This research closely follows the views of Turner (2003), that by emphasizing the causal connections between local management and environmental change political ecology can act to correct the recent tendency for biophysical assessments of environmental change to infer social changes with little regard for human contexts. As this research project concerns an environmental issue which raises direct concerns regarding local-level resource access and biophysical change, the interdisciplinary quality of critical political ecology was used as an overall theoretical framework to orientate field research. The tight interweaving and reflexive use of methodologies from the social and biophysical sciences is considered essential to gain a more socially relevant, democratized account of veterinary cordon fence impacts.

Applying a political ecology framework in northern Botswana

Having reviewed some of the most salient internal theoretical debates within the divergent field of political ecology, what then are the methodological implications for this study? As described above, the literature concerning environmental change in the ‘Third World’ is replete with calls for greater interdisciplinarity. Yet such integrations are far from straightforward and the process of comparing knowledge across the sciences can be time-consuming and frustrating (Newell *et al.* 2005). Furthermore, despite concerns

for a reflexive approach to research and an awareness of multiple knowledge sources, there is little common consensus as to how these marriages should occur.

The lack of agreement notwithstanding, this study concurs with Turner (2002), that the nature of geographical research should be determined more by the objects of study rather than disciplinary positions of knowledge. In the same vein the approach used roughly follows Newell *et al.*'s (2005: 302) idea that interdisciplinary research should adopt a "head on attack" to "wrestle directly with the focal problem or issue" in order to expose conflicts of knowledge and avenues for research. In Chapter 2 the likely conflict of interest between the natural resource management of dryland pastoralists and the objectives of veterinary cordon fences and disease control policies was described. The enclosure of rangelands which remain under communal tenure raises important questions regarding people's access and control over their natural resources, a central interest shared by political ecology (cf. Turner, 2004; Blaikie, 1989; Berry, 1989). Furthermore, there is a strong case to suggest that the restriction and subdivision of people, livestock and wildlife in a heterogeneous dryland environment could result in permanent environmental changes. Whether approached from the biophysical or social perspective the veterinary cordon fence issue demands an interdisciplinary approach.

Given the emphasis placed on discourse, knowledge and power relations by political ecologists, it seems pertinent for research concerning social and environmental change in the "south" to involve discursive approaches to analysis. This study endorses the integrated and multi-scalar use of methodologies from the biophysical and social sciences that political ecology enables. Political ecology is known for its open-ended nature and commitment to flexibility, allowing the researcher to engage a range of methods from in-

depth ethnographies, complex environmental histories, discourse analysis to detailed ecological studies. Throughout this study a commitment was made to the reflexive use of complementary data sources from both the natural and social sciences in order to provide a complete understanding of the social and physical implications of veterinary fence enclosure. Such flexibility allowed an integration of both an intensive and extensive approach to research design (Sayer, 1984), and a commitment to grounded in-depth local narratives emphasizing the plurality, diversity and internal politics of local knowledge.

Spatial and temporal changes in people's relationships with their land and natural resources was deemed one of the most important concerns for this project. To be able to understand the impact of veterinary cordon fences on the resources people have access to, use of, and control over, required an understanding of how relationships between people and their biophysical resources have evolved over the period leading up to, and after enclosure. Indeed, to understand present patterns of resource access, control and use requires an understanding of how such relationships have evolved over time (Moore, 1996; Peet and Watts, 1996). Resource access, especially in a dryland pastoral context, is considered by some as both in need of (re)emphasis and the root of a more powerful political ecology (Little, 2004).

Given the need to investigate ecological changes that may be attributed to the social and political impacts of enclosure, it was imperative that this research also seriously considered the biophysical as well as the social realms. To this end, a multitemporal and multispatial approach was adopted involving a range of physical science methods from the critical use of geospatial technologies, to the detailed use of vegetation surveys. This

provided vital information regarding natural variability upon which an assessment of fence-induced ecological change could be based.

This approach, therefore, differs from most political ecology studies which tend to rely on either secondary environmental data or mono-spatial/temporal scales of ecological observation (cf. Homewood, 2005). By seriously engaging in both non-equilibrium concepts and critical debates within remote sensing and rangeland ecology this project aims to address many of the shortfalls of the current political ecology. Though we must remain critical of some environmental science, and may never understand the full biophysical implications of human action, by including conceptual influences from the “new ecology” and seriously attending to ecological dynamics, a more accurate account of ecological change can be gained (cf. Sullivan, 2000; Forsyth, 2003). Most would agree that political ecology has not always remained focused on these methodological and conceptual problems. Yet according to Robbins (2004: p.105), the goal of understanding the influence of human action on already complex systems is realizable only with “serious attention to ecological dynamics.”

3.3 Combining other analytical frameworks

The divergent field of political ecology provided the theoretical underpinning for this thesis. However, inspiration and direction was also gained from the ‘sustainable livelihoods’ (SL) framework which was used to guide the research within the burgeoning field of political ecology. The SL concept, derived from the work of Chambers and Conway (1992) and developed into a methodological framework by the Department for International Development (DfID, 1999), amongst others; enabled a baseline

understanding of “what people do” at the local level to maintain a viable livelihood in Chapter 5. This was used as a starting point for the analysis to draw out the livelihood strategies most likely to require access to a spatially-dispersed range of resources.

3.3.1 Sustainable livelihoods framework

People in developing countries are increasingly encountering inhibiting policy environments in their efforts to access and mobilize the resources and assets required to construct sustainable livelihoods and pathways out of poverty (Ellis and Mdoe, 2003; Twyman *et al.*, 2004). Rural livelihoods comprise the capabilities, activities and assets (including both material and social resources) required to make a living. Thus, by focussing on livelihood assets (Chapter 5) and longer-term changes to the activities requiring the capability for dispersed resource use (Chapters 6-7), a more holistic understanding of the impacts of veterinary fence policies and resource enclosure could be gained.

To inform this analysis of fence-induced livelihood change a popular ‘asset-mediating processes-activities’ framework was integrated: the ‘sustainable livelihoods framework’ (Figure 3.1) (Scoones, 1998). The approach originates from various works emphasizing the asset status of the poor as fundamental to understanding their vulnerability to shocks and strategies for survival (cf. Ellis, 2000). The framework was used to guide an assessment of contemporary rural livelihoods analysed in Chapter 5. The approach looks set to move beyond the small-farm first orthodoxy and dovetails appropriately with the modern diversified nature of rural livelihoods (Ellis, 2000). However, as a two-dimensional representation of complex social processes the framework is not intended to

depict reality, rather it is an analytical structure for “coming to grips with the complexity of livelihoods” (Farington *et al.*, 1999: 3).

The starting points of the framework are the various tangible, material and non-tangible assets owned, controlled, claimed or by some means accessed by the household (Ellis, 2000). Capital assets include natural capital (natural resources), social capital (e.g. networks), and human capital (skills and knowledge), along with financial capital (e.g. cash, savings, credit) (Carney, 1998; Scoones, 1998). Livelihood activities are determined by the capability to access these assets, and access is in turn a consequence of transforming structures and processes such as institutional arrangements and historically embedded socio-political structures.

Such transforming structures governing access are frequently divided into endogenous and exogenous factors. Endogenous factors consist of social norms and structures of which rural households are a part (social relations, institutions, organisations), whilst exogenous factors are those external to the household yet which exert control from a distance (Ellis, 2000). The former includes a household’s rules and rights to resources which are determined by social relations and the role of institutions and organisations (Scoones, 1998). The latter includes the external socioeconomic trends (e.g. market prices, migration etc.) and unforeseen shocks (e.g. drought, disease etc.) which have major consequences for livelihood variability (Ellis, 2000).

A key concept within the framework is that livelihoods are rarely static or stable. Transforming structures and processes result in the adoption and adaptation of livelihood ‘portfolios’ or ‘strategies’ (Figure 3.1). A household’s livelihood strategies are dynamic, responding to changing pressures and opportunities that are determined by the changing

asset status of households, or other factors such as health conditions (Scoones, 1998; Ellis, 2000). Thus, people pursue different strategies over different timescales. Livelihood strategies may fluctuate over generations, different seasons or even between domestic cycles, necessitating a temporal and historical approach to research (Scoones, 1998).

These considerations have important implications when one is assessing the sustainability of different options or livelihood outcomes. Scoones (1998) notes the importance of examining the dynamic element of livelihood strategies when considering their sustainability and a historical perspective is vital to achieve this. The livelihood outcomes emerging from different strategies can consist of livelihood security and/or environmental sustainability. Livelihood security (i.e. food or income security) is determined by a household's ability to manage adverse trends and shocks. Most of the sustainable livelihoods literature adopts Chambers and Conway's (1992: 7) concept that a livelihood is sustainable when "it can cope with and recover from stresses and shocks and manage to enhance its capabilities and assets both now and in the future, while not undermining the natural resource base." This represents a conscious effort to merge the concerns of poverty reduction and the environment (Carney, 2002).

For social scientists the idea that livelihoods are multi-sectoral; that each element of people's lives can impact on the choices they make; and that livelihoods are historically embedded in socio-political institutional contexts is nothing new. For development practitioners and policy-makers, however, the processes based approach represents a significant advance from previous rigid reductionist approaches and frameworks (Toner, 2003; Toner and Franks, 2006). Furthermore the framework represents an amalgamation of several important approaches focused on resource access and institutions, such as the

environmental entitlements concept (de Hann and Zoomers, 2005). In spite of this the approach has received several criticisms.

First, by reducing and capitalising people's resources into 'boxes' of assets, some have suggested that we learn little about the trade-offs made between assets, how they change over a lifetime, or whether high levels of one asset compensate for low levels of another (Beall, 2002). Furthermore, Maqueen (2001) suggested that the 'sustainable livelihoods framework' is inoperable unless assets can be compared, and at present defining and measuring assets is problematic. This problem is particularly acute in pastoral areas. Morton and Meadows (2001) found defining pastoralists' livestock within the framework problematic due to the multifaceted role of livestock as an enabling asset. While livestock in pastoral society clearly represent natural capital (a natural resource from which livelihood resource flows are gained, e.g. milk, wool etc.) and financial capital (the financial resources available to people, e.g. savings), livestock also represent social capital, a role which tends to be downplayed in both academic and development circles (Morton and Meadows, 2001). This is partly due to an effort to defend pastoralists from the 'cattle complex' theory and denial of the non-economic reasons for stock accumulation (ibid: 18).

Second, the pro-active and self-help emphasis of the framework tends to over-privilege the agency of the poor while underplaying the role of political economy which results in inflated claims about the possibilities of social action (Wood, 2003). Further concerns have been raised about the framework's approach to individual and household decision-making, along with its tendency to underestimate the explanatory role of power relations (de Hann and Zoomers, 2005). However, the approach is not intended as a 'blueprint for

rural development' but rather an analytical framework to guide development planning and research (Cahn, 1998). Thus, many of these criticisms may, in part, be explained by the differing viewpoints and the experience of its practitioners rather than the framework itself (Carney, 2002). Moreover, in this study these concerns were addressed by integrating the livelihoods approach within the wider critical political ecology framework allowing emphasis to be given to the role of historical change, power relations, local decision making and trade-offs, along with the role of markets.

To amass the wide ranging data required to investigate the sustainability of livelihoods at a given site is beyond the scope of even the largest research projects, and therefore the principle of "optimal ignorance" must always be applied (Scoones, 1998: 13). This study adopted a phased approach which used a focused combination of quantitative and qualitative techniques, drawing out only essential information necessary for an informed assessment of fence impacts (cf. Ellis, 2000). The diversity of livelihood strategies constrained by enclosure was illuminated using the household as the unit of analysis (Chapter 5). Through this approach local-level resource access constraints were examined, and the problems and concerns of certain community sub-groups were investigated in more detail (Chapters 6-7).

A	B	C	D	E	F
Livelihood platform	Access modified by	In context of	Resulting in	Composed of	With effects on
Assets Natural capital Physical capital Human capital Financial capital Social capital	<i>Social Relations</i> Gender Class Age Ethnicity	<i>Trends</i> Population Migration Technological change Relative prices Macro policy National econ trends World econ trends	<i>Livelihood Strategies</i>	<i>NR-based activities</i> Collection Cultivation (food) Cultivation (non-food) Livestock Non-farm NR	<i>Livelihood security</i> Income level Income stability Seasonality Degree of risk
	<i>Institutions</i> Rules and customs Land tenure Markets in practice			<i>Non-NR based</i> Rural trade Other services Rural manufacture Remittances Other transfers	<i>Env. Sustainability</i> Soils & land quality Water Rangeland Forests Biodiversity
	<i>Organisations</i> Associations NGOs Local admin State agencies	<i>Shocks</i> Drought Floods Pests Disease Civil war			

Figure 3.1. A framework for the analysis of rural livelihoods. Source: adapted from Ellis (2000:30)

3.4 Research Strategy

This research adopts an iterative and reflexive multi-method approach to assemble the differing data sources required to address the study aims and objectives (cf. Madsen and Adriansen, 2004). The approach allows the issue of natural resource enclosure to remain at the centre of analysis, while thoroughly investigating the local-level context of natural-resource access and use. To achieve this, a combination of both qualitative and quantitative techniques is used to establish ‘concrete’ social realities through empirical observation and causal connections are investigated using methodological triangulation. This framework proved particularly useful in focussing studies of Sahelian pastoral mobility (Adriansen and Nielsen, 2005).

The mixed methods approach is tailored to the research questions, yet allows the flexibility to explore avenues of research in a reflexive manner. The approach draws on a variety of social research techniques, from participatory methods to in-depth semi-structured interview techniques. At the same time a suite of multi-temporal and multi-spatial scientific research methods were used, from multi-temporal remote sensing to detailed vegetation survey techniques. There were three main phases of fieldwork, allowing the researcher to test and expand emerging themes identified by local knowledge, livelihood changes or environmental alterations (Table 3.1).

Table 3.1. Research strategy.

Fieldwork stage	Research question/Purpose	Methods
Preliminary trip to Botswana	Collection of background papers and reports. Initial contact with government departments and research communities to gain permission to conduct research and obtain details regarding livelihood diversity to design questionnaire. Collection of research permit.	Visits to government departments. University of Botswana Library, National Archives. (Continued throughout research), preliminary field survey
1. Preliminary social survey	Establish the main livelihood strategies requiring extensive resource access. Find out local views of enclosure and identify problems and constraints associated with enclosure. Establish present levels of mobility and resource access (Objective 1).	Questionnaire survey, participant observation, natural resource mapping.
2. Main survey	Establish an understanding of current natural resource management and mobility. Assess livelihood changes and reconstruct past livelihood strategies and farm management (Objective 2).	Semi-structured interviews, group discussions, farm walks/on farm interviews.
3. Scientific assessment	Establish natural multi-scalar environmental variability as a baseline for thoroughly assessing fence induced environmental change (Objective 3)	Multi-temporal remote sensing and detailed ground vegetation surveys.

3.4.1 Research Objectives

To reiterate, the overall aim of this research is to examine the social and environmental changes arising from veterinary cordon fence enclosure and associated quarantine policies in northern Botswana. This aim is to be achieved through the following specific objectives:

- (1) to identify the main livelihood strategies involving extensive resource access and mobility; and to investigate contemporary patterns of resource use and asset access,

(2) to investigate changes to the main livelihood strategies identified above and specifically to:

- a. establish the direct impacts of enclosure on resource access, tenure, rights and user relationships;
- b. document all factors causing reduced mobility and access in order to put these impacts into context,

(3) to examine the nature of fence induced environmental change in northern Botswana, and:

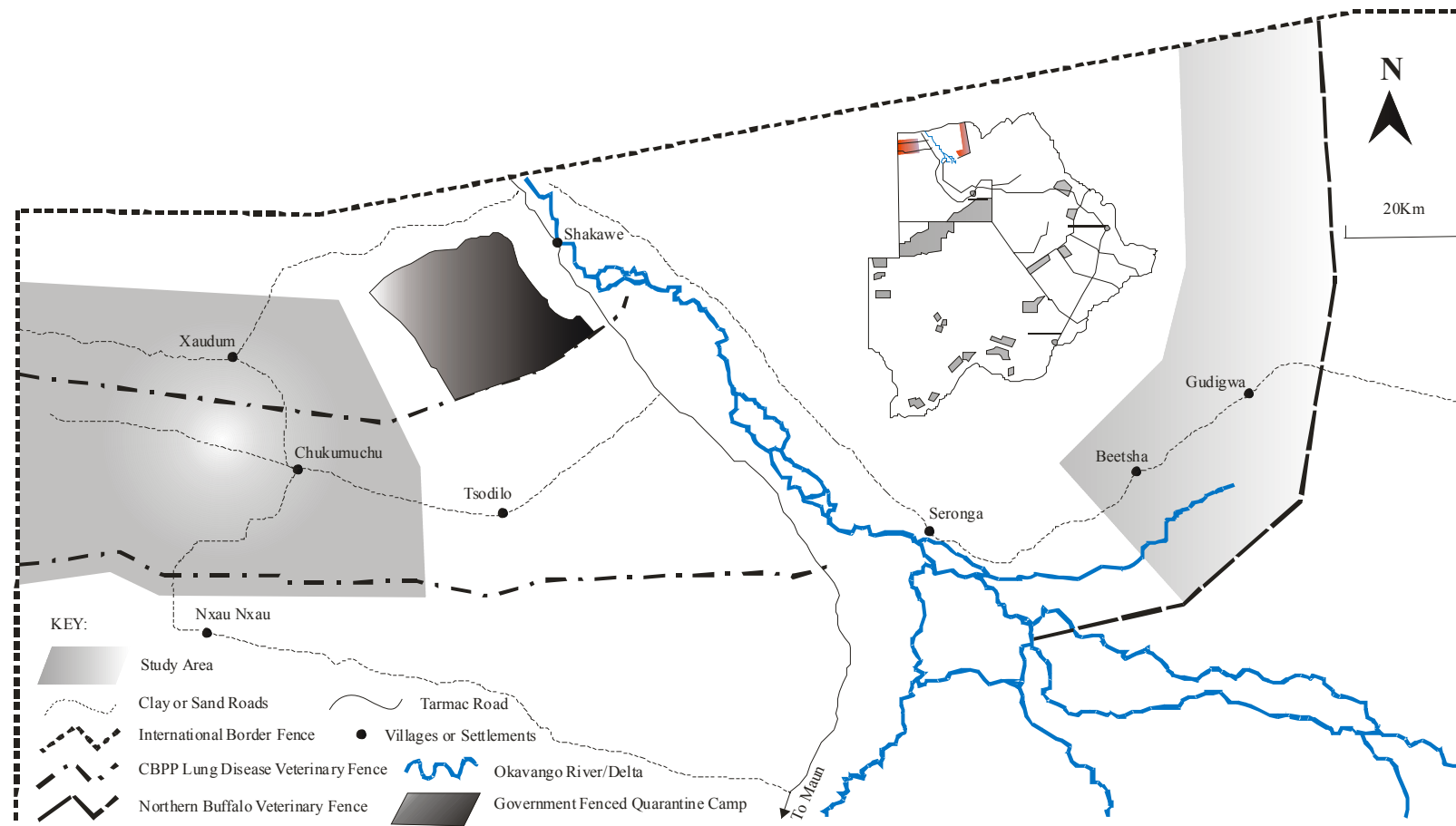
- a. understand natural variability as a baseline for establishing fence induced change;
- b. document the extent to which enclosure and associated sedentarisation has impacted on the environment;
- c. evaluate cross-fence vegetation community changes as an indicator of fence-induced environmental change,

(4) consider the longer-term implications of these changes in the context of livestock development in Africa and drylands globally.

3.4.2 Study area

The previous chapter detailed the various diseases periodically limiting trade in Botswana, along with the main fence construction campaigns and two dominant veterinary fencing strategies used to control disease in the country. Specifically, fences are used to control the movement of livestock in areas of communal rangeland

(e.g. contagious bovine pleuropneumonia and foot-and-mouth disease control fences), while foot-and-mouth disease (FMD) fences are constructed to segregate cattle from buffalo at the wildlife-livestock interface. To investigate the concerns detailed in the last chapter, two study sites dissected by veterinary cordon fences that are representative of the two dominant fencing strategies were selected. In particular, the research focused on the impact of the Ikoga and Samochima contagious bovine pleuropneumonia fences (hereafter CBPP fences) on the village of Chukumuchu and surrounding cattleposts, and the impact of the northern buffalo fence (hereafter NBF) on the communities of Beetsha and Gudigwa (Map 3.1). These sites were also representative of the regional diversity of environmental characteristics (i.e. dry Kalahari, seasonally flooded delta) and dominant social groups and their traditional livelihoods (i.e. pastoralism, agro-pastoralism, or hunting and gathering).



Map 3.1 Northern Botswana study sites and veterinary cordon fences.

3.4.3 The Preliminary Survey- Assessment of contemporary livelihood strategies

The preliminary phase of this research was aimed at addressing the first study objective. It involved establishing the multiple livelihood strategies requiring extensive access to spatially dispersed resources (both natural and non-natural resource based). Drawing on the ‘sustainable livelihoods framework’, an investigation was made to provide what Batterbury (2001) terms a ‘grounded analysis’ of contemporary livelihood strategies or ‘what people do’ within communities and in-particular livelihood diversities involving mobility and spatially dispersed resource access (Batterbury, 2001). The key strategies to emerge from this analysis were used to inform the main survey and provide an understanding of the mobility of current resource relationships. There were three main components of the preliminary phase: the period of community orientation, the social survey and the participatory natural resource mapping exercises.

Period of community orientation

On arrival in each study village the first three to four days were spent becoming familiar with the village and community. Permission to carry out the research had been gained from the headman or *kgosi* during a preliminary trip in March 2005. Similarly several households had been informally interviewed to gain a rough idea of the diversity of livelihoods in order to design a pre-fieldwork draft of the livelihood survey (Table 3.1). In each settlement contact was re-established with the headman and permission sought to camp in the settlement. A convenient time for the research to be briefly announced at the next available *Kgotla* meeting was also arranged. This provided an opportunity to inform the community about the presence of a researcher

and provide a brief summary of the research. For research concerning a potentially sensitive issue such as resource enclosure, ethnic subjugation or exclusion it is sometimes advisable to proceed cautiously, although there are ethical considerations when withholding the true nature of the research (Kitchin and Tate, 2000). Initially it seemed logical to withhold the exact details of the research topic in case there were strong local feelings towards the fences which might have influenced household responses during the livelihood survey. However, it soon became clear that although people held strong positive or negative views towards the fences, most were open, frank and uninhibited with their opinions regarding the fences. The lack of sensitivity notwithstanding, a conscious effort was made throughout the research process to contextualise the emergent data and cross-check certain assertions (section 3.5).

Following this a local representative was asked to act as a guide and to introduce the research team (Translator and Researcher) to village households. This approach is advocated by Ellis (2000) as a good way of building trust between the researcher and the households before conducting a livelihood survey. Several days were then spent interviewing key community figures (Headman, Village Development Committee etc) and several households. During these initial household interviews the questionnaire survey was piloted and, where necessary, tailored to the specific settlement context.

Baseline livelihood survey

In the past, the widespread use of quantitative survey techniques within livelihood studies has been criticised for masking the social and institutional contexts of rural people's lives. However, there is increasing recognition in the development studies literature that a well thought-out combination of qualitative and quantitative research

methodologies can help to solve problems when each method is used alone (Ellis and Mdoe, 2003). Rural livelihood research requires a mixed-method approach combining both case study and broad survey techniques in order to gain a holistic understanding of rural livelihoods (Madsen and Adriansen, 2004). Questionnaire survey techniques represent a critical mixed method tool where geographers require a means of combining qualitative and quantitative data (Sporton, 1999). In light of this, survey methods were used to record the assets, activities, and incomes used within the community to construct viable livelihood strategies, while more detailed qualitative methods were used in order to capture the social and institutional context within which these different actors construct their livelihoods, along with a historical account of how these livelihood strategies have changed over the period of fence enclosure (see Table 3.1). The initial baseline survey also facilitated the stratification of the community into sub-groups for further analysis based on either their opinion of the fence, dominant livelihood strategy or past settlement and mobility.

The questionnaire survey was structured according to the topics listed in Appendix 1. The survey combined mostly open-ended questions allowing the respondent to express their answers fully and providing the flexibility for questions to be rephrased or explanations added. This proved essential in the Chukumuchu study area where people were less familiar with the questionnaire interview format. Closed questions were used to record quantitative data which could facilitate the comparison of data from within settlements and across study areas (Kitchin and Tate, 2000). After recording basic household socio-demographic details and observations regarding the type of housing and physical condition of the compound, questions were asked about present and past mobility, settlement history, livestock, cultivation, natural resource use, commercial activities and livelihood incomes. Further questions were also posed

in order to canvass local opinions regarding the positive or negative impacts of the veterinary cordon fences and their purpose, along with local views regarding the work of the Department of Animal Health and Production (DAHP). This provided interesting insights into the context within which enclosure and veterinary interventions are viewed by different sectors of the community.

Sampling strategy for household survey

Table 3.2 illustrates the total number of interviews conducted during the baseline survey compared to the overall population of each study settlement and approximate number of resident households.

Table 3.2. Survey sample size and settlement population.

	Beetsha	Gudigwa	Chukumuchu	Cattleposts
Total population (CSO, 2001)	760	732	270	240*
Approx No. households*	54	81	28	30
Total No. of interviews	30	32	24	29

*Estimate based on average resident HH size

Though larger-scale samples would have provided more precise data regarding the diversity of population characteristics, it can be time consuming and costly to obtain the vast amounts of quantitative data required in macro-scale livelihood studies (Ellis, 2000). Having said this, it was important to gain a representative sample of the diversity of livelihood strategies and community wealth sub-groups in order to understand local diversity and to identify informants for further in-depth analysis. To this end, formal stratified sampling of the populations was constrained by the lack of a community household inventory. However, formal sampling for the survey was not deemed necessary as the aim was to provide an overview of livelihoods and resource

use rather than to test livelihood hypotheses statistically. Therefore, a sampling strategy was adopted that enabled the researcher to gain a representative understanding of community level diversity in livelihood strategies and wealth income groups quickly and effectively.

In Botswana's settlements people often reside in ethnically distinct areas (Twyman, 1997) and this became evident during this study. Thus, in order to ensure an ethnically diverse range of households and to avoid geographical bias, settlements were divided into several sections and households were sampled from all areas of the village. In this research, more questionnaires were conducted in the larger villages of Beetsha and Gudigwa, than in the Chukumuchu site. Due to the lower population in Chukumuchu nearly all households were sampled (Table 3.2). To select respondents for the household survey the research team (local representative, researcher, translator) walked around the settlement stopping at regular intervals - usually every second or third compound - to ask whether people would like to participate in the survey.

Few people declined to be interviewed and those who did were either too busy at the time (in which case a more convenient time was arranged) or distrustful of researchers. Sampling was largely dependent on whether people happened to be home and therefore at each compound, information was gained as to the whereabouts and daily schedule of absent residents in neighbouring compounds in order to plan a suitable time to solicit their involvement. Often absent households were tending to livestock or arable lands and could be interviewed away from their compound. In these cases a note was made to revisit the compound to make the observations required to position the household within the community. This sampling strategy

enabled an overview of the settlement's income groups and livelihood strategies despite the fact that only a limited number of people were interviewed.

Natural resource mapping and transect walks

The second phase of the preliminary survey involved conducting participatory natural resource mapping exercises with a select number of households. Participatory mapping is a diagramming exercise which allows the researcher to discover the “mental maps” of community members and can be particularly useful for mapping people's spatial mobility and natural resource use (Theis and Grady, 1991). During the exercise informants are asked to draw a map of a specific topic (i.e. social network, natural resource use, mobility etc.) using a suitable medium (i.e. sticks, stones, seeds, on ground/sand or pens on paper etc.) (ibid: 82). Experts are encouraged to step back and allow groups of local actors to draw their own maps until a consensus of opinion is reached and the graphics are then transferred onto paper (Henkel and Stirrat, 2001).

Participatory mapping is just one of a suite of action-research approaches under the umbrella of participatory rural appraisal (PRA) and has proven particularly useful, producing good quality data and ethical research with marginalised groups (Kesby, 2000; Pain and Francis, 2003). The process is designed to be a neutral visual technique, allowing local representations of reality to reach the wider policy environment. Indeed, participatory action-orientated approaches in general are advocated as one way to bridge the scholarly gap between researchers, their landscapes and policy makers (Kitchin and Hubbard, 1999). However, though the approach has been widely applied, until recently participatory techniques have

received little thorough theoretical or critical reflections, partly because they represent a major improvement on previous ‘top down’ methods (Mosse, 1994; Pain and Francis, 2003).

Recent critiques, however, have begun to challenge the widespread belief that ‘participatory development’ represents a new paradigm for development. Mosse (2001), for example, demonstrates how the participation process in PRA development is manipulated by pre-existing community power-relationships, the position of development professionals, and knowledge structures, to the extent that local knowledge in projects is often compatible with that of bureaucratic planning knowledge. PRA exercises are often “public” social events where powerful local actors are able to dominate the subordinate and manipulate the outcomes. This leads to the production of generalised data which underplays diversity and difference (Mosse, 1994).

More recently serious questions have been asked regarding the efficacy of participatory diagramming as a methodology. Often, during the exercise, the relationship between the researcher and the community is short, leading to variable participation and the production of brief and superficial data (Pain and Francis, 2003). In theory the exercise is designed to be a neutral representation of local knowledge led by the participants, yet in practice exercises tend to be guided by the researcher and knowledge categorized into a pre-determined methodological frame (ibid: 50). Henkel and Stirrat (2001) explain that although participatory mapping provides participants with the opportunity to draw and partly own their own maps, it is crucial to recognise that PRA presupposes what visualisations are acceptable, and in reality local ways of understanding and representing the world diverge significantly from the world of the PRA expert.

Given these fundamental criticisms, in this study the concept of participatory mapping was adapted accordingly. Firstly, rather than conducting natural resource mapping at the community level as large “public” social events, exercises were held at the individual household level with a sub-sample of 10 individuals from each settlement. Participants were selected on the basis of their dominant livelihood strategy and asset status identified during the preliminary livelihood survey. Most maps were drawn in the sand using sticks and later transferred to paper by the research team. After marking out dominant physical features (e.g. roads, river channels, dune valleys, veterinary fence, airstrip) individuals were asked to map their natural resources used for fuelwood, gathering, grazing etc.

Whilst preferably participants would be left to produce their own neutral maps using *their* local knowledge, in many cases this proved difficult. Many older participants lacked a formal education and were unfamiliar with the concept of mapping. This is consistent with previous experiences where the style and quality of the maps was found to be largely dependent on educational background (Young and Barrett, 2001). Despite this, male participants were more familiar with the concept of mapping than females and would often voluntarily draw maps of the fence alignment, for example, during the main survey interviews. Some female participants found it hard to position the existing physical features introduced by the researcher and often preferred to point in the direction of resources whilst describing the location and approximate distance. Thus the level of participation in the mapping process varied considerably and records of this were made (after Kesby, 2000).

In practice, interview techniques were drawn upon in many cases to support and facilitate the mapping process. This made meaningful comparisons between the local knowledge displayed within the maps difficult. However as the purpose of the

exercise was to provide a spatial representation of contemporary patterns of resource use and mobility before more in-depth ethnographic interview-based techniques were used to tackle the issue of resource enclosure, this objective was soon satisfied and trends in the maps and responses emerged. Furthermore, any limitations and inconsistencies were complemented by a series of transect walks, field observations and participation on trips (e.g. gathering wild foods) with key informants.

3.4.4 The main survey- assessment of changing mobility, resource access and livelihoods

One of the main aims of the preliminary survey was to guide the main survey whilst at the same time addressing the first study objective. By identifying the dominant livelihood strategies involving extensive resource access and mobility, the main survey questions could be focused and the remaining research objectives could be conclusively addressed (Objectives 2,3 and 4). Much of the information in Chapter 5 is taken from the preliminary survey and sets the scene for further more discursive chapters.

The main survey was conducted over a period of seven months and involved a series of in-depth interviews, focus group discussions and detailed case studies. The survey focused on the individual and their constraints and opportunities in gaining access to the necessary resources required when forging a sustainable livelihood, along with the role of enclosure in facilitating or hindering this. By concentrating on the individual, the main survey allowed a holistic understanding of the diversity of resource access and use. However, emerging issues were also cross-checked at the community level at several group discussions.

Though some additional informants were gained through “snowball” sampling from established contacts (Kitchin and Tate, 2000), most of the respondents interviewed from the study settlements and areas were identified from the preliminary survey group. Table 3.3 shows the total number of interviews, focus groups and case studies conducted in the settlements and study areas. Respondents were selected on the basis of their household’s wealth and asset access rights, their pre-enclosure settlement and resource use, their ethnicity, their age group or their opinion regarding the fences. Most informants satisfied a number of these criteria and were grouped accordingly. At the cattleposts surrounding Chukumuchu, a subset group of three pastoralists were selected for more detailed case study analysis of livestock management practices.

Table 3.3. Interviews conducted by study area.

Village/Area	Total No. of interviews	Total No. of case studies	Group meetings/focus groups
Beetsha	19	-	2
Gudigwa	16	-	3
Chukumuchu	10	-	2
Cattleposts	20	3	0

Respondents were interviewed alone or with close family in a variety of settings, from their field, to their cattlepost or compounds. Questions were open-ended, allowing for intended and unintended themes to be explored and interviews to unfold in a reflexive manner (Miles and Huberman, 1994). Interviews lasted from 30 minutes to several hours and individuals were often interviewed several times, allowing the researcher the flexibility to explore avenues of interest and to close logical gaps in the data (Kitchin and Tate, 2000).

Interviews were not taped as recording equipment would have created unnecessary local attention to the interview process and might have made respondents

uncomfortable. Instead all responses were documented using handwritten notes emphasizing the main concepts, phrases and sentences. However, all interviews were transcribed into typed transcripts during fieldwork at which point additional memos, thoughts and notes were added regarding the context within which discussions occurred. This formed the first of three stages of qualitative data interpretation and analysis following the approach described by Kitchin and Tate (2000) and Dey (1993). At this point any further gaps in the data were exposed and follow up discussions were conducted. More details regarding the consequent stages of the qualitative data analysis are given in section 3.4.6.

Appendix 3 provides a list of the main topics used to guide the main survey interviews. Rather than a definitive set of questions, these topics were used only to guide the discussion and were tailored to the specific context of each field site and group of respondents.

The final part of the main survey involved a series of interviews with local and national government officials from the relevant departments (Table 3.4). The aim of these discussions was to gain an understanding of the veterinary fence issue from the policy and institutional perspective. Once again interviews followed a pre-defined schedule of core questions and in most cases additional questions relevant to specific departments were also asked (see Appendix 4).

Table 3.4. Interviews conducted with government officials.

Key figure	Dept	Position	Office	Total No. of interviews
Dr Jason Mpofu	DAHP	Senior Veterinary Officer	Shakawe	1
Mr Mokgethe	DAHP	Superintendent	Maun	1
Dr T.K. Phillemon-Motsu	DAHP	Deputy Director	Gaborone	1
Mrs F. Motlalepula	DWNP	Wildlife Officer	Maun	1

3.4.5 Scientific assessment of environmental change

The final stage of the study sought to address the third research objective and involved both computer laboratory and field based analysis. The objective was to provide a detailed assessment of environmental changes resulting from veterinary fence enclosure. Environmental changes caused by declining mobility are recurring themes in the study of pastoralism resulting from a variety of driving forces and therefore critiques of pastoral development interventions should investigate biophysical as well as societal changes (Fratkin and Mearns, 2003). This is especially important for a policy directly aimed at controlling the movement of livestock and wildlife through the construction of large-scale barrier fences.

The results of the preliminary and main survey detailed the role of veterinary fence enclosure on the sedentarisation of natural resource-based livelihoods in northern Botswana. In order to investigate the environmental consequences of this sedentarisation and enclosure, a scientific assessment of fence induced vegetation change was conducted using a series of physical science approaches, operating at a range of spatial and temporal scales and drawing on theories of non-equilibrium from the 'new ecology' (Wu and Loucks, 1995; Ellis and Swift, 1988).

The environmental change assessment was divided into two parts: (i) an assessment of sedentary resource use pressure around villages and cattleposts, and (ii) an assessment of fenceline changes in vegetation communities. The investigation could be further divided between scientific techniques using ground based one-time observations and those using multi-temporal geospatial technologies such as remote sensing.

On the ground, contemporary fine-scaled vegetation surveys were conducted both across fencelines and along disturbance or grazing gradients radiating out from

settlements and cattleposts in order to investigate the relationship between local level sedentarisation and the current state of the environment. A series of 30 metre line intercept transects and tree density quadrates (30 x 30m) were conducted at set distances across fencelines and along disturbance gradients in order to record species and vegetation community structure. Data generated from these activities were then analysed using various uni- and multivariate statistical techniques.

Many have noted the problems associated with distinguishing longer term directional change (e.g. management induced bush encroachment) from shorter term readily reversible fluctuations (e.g. fire or rainfall induced bush variability) in non-equilibrium dryland environments (Lambin *et al.*, 2001; Dougill *et al.*, 1999). As a result, a multi-temporal assessment of vegetation change was also conducted using multi-temporal remote sensing over the 16 year period of veterinary fence enclosure in the northern Botswana study area. This approach was aimed at being sympathetic to the currently contested non-equilibrium nature of dryland ecological functioning and apparent non-permanence of many observed environmental changes in drylands (cf. Vetter, 2005). The technique also attempted to address many of the current limitations with multitemporal remote sensing.

Using an innovative post-classification change detection technique, the remote sensing part of this study involved several sections of work. Firstly, image enhancement techniques were used on coarse resolution imagery to provide an assessment of seasonal vegetation spectral response to rainfall inputs. This enabled a baseline understanding of seasonal and inter-annual variability upon which a more confident multi-temporal change detection could be made. The second element involved accurately classifying the main structural rangeland scale components of the landscape on high resolution satellite data and tracing their changes over time. This

was achieved using a hybrid post-classification change detection technique which combined “ground-truth” data from field based vegetation surveys in order to map changes to spectrally distinct vegetation communities over time.

3.4.6 Qualitative data analysis and interpretation

After all interviews were transcribed and annotated in the field the next stage of qualitative data analysis involved the classification of data into several master categories immediately after return from fieldwork (after Kitchen and Tate, 2000). Most interviewees had already been selected and grouped on the basis of their opinion of enclosure, past mobility or settlement history and the interview topics were divided into several logical sections. This made categorising the data into master categories relatively simple and the information was grouped into issues such as details of past mobility, forces causing sedentarisation, issues restricting resource access, adaptations to risks, present localised natural resource use.

Following this the data was disaggregated by further refining the information into sub-categories using a process called coding. These sub-categories were then sorted, refined and reassigned into new categories using a splitting and splicing procedure (Kitchen and Tate, 2000). This procedure acted to refine and refocus analysis, allowing several key findings to be cross-checked and more commonalities in the data exposed. Cross checking and reorganisation also enabled larger sub-categories to be refined and reduced to include only the most pertinent data.

3.5 The research experience: positionality and reflexivity

Today social scientists are increasingly recognising that the research experience is not “objective” and “value free”. Rather local knowledge is often situated, constructed and packaged by the respondent, leading to widespread recognition that reflection on the positionality of the researcher is central to understanding the context-laden fieldwork process (England, 1994; Mosse, 1994). Thus, contextualising the research process requires a shift from the concept of the researcher as observer, to the researcher as observed (Frenk, 1995).

Throughout the research process attention was given to how I projected myself and how this influenced my interactions with respondents (Batterbury, 1994). During fieldwork I consciously attempted to distance myself from the government, tourism operators or expert consultants and I presented myself as an independent research student from Oxford University. I also made every effort to reassure people that they had the choice not to participate, and that their knowledge would be treated confidentially.

A total of nine months were spent in the field during which time I became a recognised figure amongst the participating communities. This facilitated a more grounded, in-depth approach, compared with more short-term studies designed to merely extract information. In spite of this, at first some people were sceptical and suspicious of a white, British, foreign ‘outsider’ living amongst the community. This only applied to a handful of people who were weary of researchers and the utility of participation in the project. Most wanted to know whether their participation would initiate changes at the policy or institutional level, even after explanations that the results would be passed to the government but that there was no guarantee that they

would be read or acted upon. However, by easing into the research during a period of orientation and employing a local guide most people were welcoming and keen to participate.

There is a suggestion that participation in research is often agreed to out of intimidation and knowledge packaged to “please” the researcher or use the research process for local gain (Mosse, 1994). Such considerations were especially important given the likely local sensitivity of the veterinary fence issue, with potential “winners” and “losers” following resource enclosure. Thus, the research findings may have been biased by people who thought their responses might lead to changes in fence alignments or veterinary policy. To guard against this, emerging findings were continually cross-checked against data from different methods and sources. Also, repeat visits helped to build a close relationship between researcher and respondent, while enabling their views regarding enclosure to be fully contextualised.

Research ethics

This research was conducted in an ethical manner, seeking the appropriate permissions and permits, while fully informing participants about the nature of the research and respecting people’s rights and customs (cf. Kidder, 1981; Kitchen and Tate, 2000). Before each interview or survey the nature of the research and background of the researcher was fully explained to participants who were given the right not to participate. Participants were encouraged to ask questions about the research and its purpose. Finally, efforts were made to treat participants fairly and confidentially while fully respecting their privacy.

3.6 Conclusion

This chapter outlined the theoretical approaches underpinning this interdisciplinary human-environment study. By tracing the origins and progression of geography's human-environment tradition it detailed the emergence of critical political ecology and evaluated the efficacy of the approach in providing theoretical inspiration to this study. The chapter then detailed, and justified the use of, the 'sustainable livelihoods framework' in providing a grounded analysis of the different ways in which people make a living in the two study areas (cf. Scoones, 1998; DfID, 1999). The chapter then presented the mixed method approach and three main stages of fieldwork: the preliminary survey, the main survey, and the scientific assessment of environmental change, which correspond broadly to the study objectives. The principle methods used were both quantitative (questionnaire survey, participatory resource mapping ecological field survey, remote sensing) and qualitative (semi-structured and repeat interviews, group discussions, field walks). Finally, the approach used to maintain rigor in the analysis of qualitative data, along with ethical and self-reflexive contextualised research was explored.

One of the most important considerations emerging from this review of political ecology's internal debates is the need for a temporal approach in the quest to understand present resource relationships (Moore, 1996; Peet and Watts, 1996). At the same time changing resource access and thus mobility is considered in need of (re) emphasis in political ecology, especially in pastoral areas (Little, 2004). The following chapter traces the changing resource relationships of the main ethnic groups in northern Botswana from the early 18th century, until the period immediately prior to enclosure in the 1990s. This provides an account of the many historical factors

causing declining mobility and resource access in the region before the exact impacts of enclosure can be analysed.

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4

Declining Mobility and Sedentarisation in Northern Botswana

4.1 Introduction

Understanding how declining resource access and mobility shapes people's livelihoods is one of the primary objectives of this study and a suitable starting point from which to examine the impacts of veterinary cordon fence enclosure in northern Botswana. However, to understand contemporary livelihoods and patterns of resource access and use fully requires a historical investigation of how such relationships evolved over time (Twyman, 2001). This is especially important given that historical patterns of access to, control of and exclusion from resources stem from and mould competing meanings and cultural understandings of rights, property relations and entitlements (Moore, 1993). Furthermore, understanding the various factors that structure resource access by land managers is considered essential to determining patterns of degradation and the root cause of environmental change (Blaikie, 1989; Batterbury and Bebbington, 1999).

In Chapter 2 the origins of veterinary cordon fencing as a disease control tool in southern Africa was explored. Northern Botswana was highlighted as an area of continued fence construction and thus an ideal study site to investigate enclosure in a contemporary livelihood context. This chapter focuses more closely on northwestern Botswana, especially northern parts of Ngamiland district where two contrasting study sites were located (section 3.4.2). The chapter traces, through time, the displacement, sedentarisation and settlement of the key ethnic groups resident in northern Botswana. Using a mixture of published material and qualitative data from the various interviews and informal discussions held at the community level, and drawing theoretical inspiration from elements of political ecology, the chapter illustrates how resource

relationships were dramatically altered by political, economic and social changes over the last century up to the point when the region became enclosed by cordon fences. A complete list of respondents referred to in this, and following chapters, is provided in appendix 5.

4.2 Ethnic groups and resource use in northern Ngamiland

Ngamiland district is one of the most remote and inaccessible regions of Botswana and has a large diversity of ethnic groups which has contributed to a range of rural livelihoods and land-use systems (Bishop and Scoones, 1991; Sterkenburg, 1990). Historically, the region's economy has been predominantly livestock- and wildlife-based (Macmillan, 2005; Bolaane, 2004). The main form of rural resource use is agro-pastoralism, which is supplemented by the gathering of veld products (for craft production, housing, brewing etc.), fishing, and hunting (Bishop and Scoones, 1991). Of the ethnic groups living in Ngamiland today, the Hambukushu, Bayei, Basarwa, Herero and Bakgalagadi predominantly occupy the northern part of the district. The Basarwa are considered the undisputed 'first people' of Ngamiland, yet they have always been the most politically under-represented group in the region (Taylor, 2000).¹ The Bayei migrated into the area from the early 18th century and their settlements encircled the Okavango Delta by the 19th century, while the Hambukushu have continuously migrated down the Okavango river since the mid 19th century (Larson, 1970; 1992). For the Herero of Ngamiland, Lake Ngami to the south represented the easternmost point of their territory (Werner, 2000). However, the

¹ There are several groups of Basarwa in northern Ngamiland. To the west of the Okavango !Kung San are found amongst dry Kalahari savanna. To the east of the Okavango two groups of Khwe speaking Basarwa are found, the //Anikhwe and the Bugakhwe. The Bugakhwe speaking Basarwa are most associated with the dryland forest and riverine resources to the north and east of Gudigwa village. All Basarwa interviewed in Gudigwa and Beetsha considered themselves Bugakhwe, and Gudigwa village consisted almost entirely of Basarwa.

Ngamiland population increased dramatically following the German-Herero war from 1904 to 1907 when 80 per cent of the Herero population were exterminated and many escaped to Ngamiland (Werner, 2000). From the 1930s onwards they have expanded north as far as Shakawe (Pennington, 1992).²

The pre-colonial history of northern Ngamiland reflects a region which until the middle of the nineteenth century lacked a unitary state, and which became a distant hunting area for the ruling Batawana. During this period, the people of the Okavango Delta lived in dispersed settlements under the administrative control of the Batawana living on the southern edge of the Delta (Tlou, 1985).

For much of the 19th and early 20th century the Basarwa, Bayei and Hambukushu groups in the northern Ngamiland enjoyed considerable autonomy from the ruling Batawana who were unable to send enough people to the remote areas of their territory in order to maintain an effective rule (Larson, 1965). At first the Batawana chieftaincy had divided Ngamiland into districts and appointed district heads through *kgamelo* to extract tribute from the people and carry out the chief's orders in each area.³ However, district heads were expected to reside in the regions' capital Maun, to provide counsel to the paramount Tawana chief, as well as regularly visit their district to conduct courts, and collect taxes and tributes. As a result Okavango communities retained much of their social organisation, traditional customs, and dispersed patterns of natural resource use. Local chiefs maintained power through social relations, and provided the intercessory role between the ancestral spirits and the community,

² Given that Herero pastoralists only migrated to the area during the mid 20th century this section predominantly focuses on Basarwa, Bayei and Hambukushu groups. Changes occurring within Herero society both before and after their arrival to the area are reviewed in following sections.

³ *Kgamelo* is the system by which Setswana-speaking tribes often incorporate subordinate tribes and maintain political domination. Under the system, the chief divides his kingdom into districts and appoints representatives, usually not of royal blood, to become district heads and to whom he lends some cattle. When the Batawana expanded into Ngamiland where other tribal groups were the majority, the Batawana chieftaincy appointed prominent cattle owners from the subordinate tribes as district heads and thus integrated followers.

illustrated by the Hambukushu chief's position as the '*great rainmaker*' under Mbukushu '*rain-medicine*' (ibid: 165). Communities lived largely from hunting, gathering and fishing, to supplement their small-scale agro-pastoral livelihoods. Although the ruling Batawana later asserted their claim to wildlife resources, under customary law Mbukushu chiefs owned all wild game and hunters would pay tribute to their local leaders.

The absenteeism of district heads resulted in the weak administration of many of the most remote districts, until the Batawana chieftaincy decided to adapt the system and appoint representatives to reside in their respective districts (ibid: 174). The decision to appoint resident representatives of the Batawana chieftaincy marked the beginning of a period in which the tribe began to subjugate other groups in Ngamiland, appropriating their labour and resources (Tlou, 1985). As owners of significant numbers of livestock the Bakgalagadi occupied a privileged position in the Batawana chieftaincy and were probably the first non-Setswana speaking people to become incorporated as district representatives or *balebeleedi* (overseers) under the Batawana *kgamelo* system (Taylor, 2000). Several Bakgalagadi wards were created in the region's capital Maun and Bakgalagadi representatives were sent to oversee a number of territories including the northern sandveld (area north and east of Seronga, Map 4.1), which was claimed by Chief Moremi II (1876-1890) as a hunting ground.⁴

The arrival of the Bakgalagadi in northern Ngamiland marked a period of increased inequality in the region, as relationships between different groups changed. Until this time the main groups coexisted with relative ease, with little domination or dependency by either group. This was certainly true for relations between the Basarwa and Bayei; the latter were described as 'the most peaceful of any of the Bechuanaland

⁴ In the 1950s, there were Bakgalagadi representatives of the Batswana chieftaincy living in Seronga, the largest of the northern sandveld villages (Larson, 1970)

peoples' by Larson (1965). The Hambukushu on the other hand were known to have sold their own people to Portuguese slave traders in Caprivi before many fled to the safety of the northern sandveld (ibid: 165). However, such atrocities were never practiced by the Ngamiland Hambukushu and although some Basarwa interviewed in Gudigwa spoke of mistrust for the Hambukushu and may have temporarily been forced into servitude during times of stress, on the whole, most Basarwa only described equitable exchanges with the Hambukushu.⁵

The Bakgalagadi on the other hand were known for the particularly brutal way in which they coerced subordinate groups, especially Basarwa, into enforced serfdom (Bolaane, 2004). As the Bakgalagadi representatives brought their large herds of cattle with them so livestock numbers began to increase in the region, especially after the rinderpest epizootic of the late 1890s forced the tsetse fly into riverine areas. Although the Bakgalagadi population was, and still is, relatively small their presence created new demands for labour which were met by the subordinate Hambukushu, Bayei and Basarwa. While labour exchanges between the Bantu-speaking Bayei and Hambukushu generally involved equitable payment and freedom to leave employment, many Basarwa families became effectively owned by Bakgalagadi households, as they worked on their arable land and herded their livestock for payment in kind. However, Bakgalagadi subjugation was never as strong as in other areas of Ngamiland, partly because many Basarwa resisted servitude by migrating deeper into the sandveld and partly due to the re-infestation of tsetse throughout much of the region by the 1940s which prevented widespread settlement by pastoralists.⁶

⁵ However, during times of stress, such as when rinderpest decimated the wildlife Basarwa may have been temporarily forced into servitude with the Hambukushu in order to survive. During interviews many Basarwa households described surviving droughts by migrating out of the sandveld to Hambukushu settlements and 'begging or working for food' from the Hambukushu.

⁶ Bolaane (2004) noted that there were several Basarwa families in Kwai who moved from the Gudigwa area during the 19th century after being maltreated by the Bakgalagadi.

Livelihoods, settlement, mobility, and natural resource use before enclosure

By the beginning of the 20th century settlement patterns in the northern sandveld remained dispersed, with few resource-based conflicts. Though Basarwa had begun to be dispossessed of their land by Bantu-speaking groups (especially along the Delta fringe), they managed to maintain control over much of the drier parts of the region largely due to their resistance to servitude and the intermittent tsetse fly infestation. As a result, Basarwa households were split between those who lived amongst and were effectively owned by Bakgalagadi agro-pastoralists at cattleposts dotted along the Delta fringe; and independent bands living in the dry sandveld. The Hambukushu and Bayei were mainly dispersed in small settlements lining the edge of the permanent swamps and Okavango river.

Opportunistic livelihoods based on the abundant natural resource base were most reliable, due to periodic livestock diseases and drought. While all groups practiced small-scale agriculture, often keeping some livestock and growing crops of maize, sorghum and pumpkins; households spent much of their time hunting, gathering and fishing.⁷ Of the resident groups, the sandveld Basarwa exercised the most mobility, often congregating in large settlements near permanent water sources during the dry season and dispersing in family groups during the wet season (Bolaane, 2004; Taylor, 2000; Lee, 1984). Although the Bayei, Hambukushu and Bakgalagadi lived in permanent settlements, these were often transient as people were forced to move after tsetse infestations. The 20th century saw a period in which settlements became more permanent and economic development widespread which altered people's relationships with the land and natural resources. This emerged first through the arrival of British colonial rule (Bechuanaland protectorate established in 1885), and

⁷ Larson (1970), for example, noted that Hambukushu spend 'considerable time' hunting for both game and honey, along with collecting wild fruits and fishing.

then the independent state of Botswana (independence granted 1966). Though northern Ngamiland remained on the periphery of the districts' development, the area felt the influence of changes which were occurring in more accessible areas.

Arrival of cash economy from 1940s

Major economic changes occurred in the region in the 1930s and 40s. Until this time formal employment opportunities have been limited within the northern Ngamiland region. Since the 1930s, however, men from the region have been engaged in paid employment mainly involving long-distanced labour migration (Taylor, 2002). Firstly, most men from Beetscha, Gudigwa and Chukumuchu worked in the South African mines at some point between the 1940s and early 1970s. After this both men and women migrated to other employment opportunities both within Ngamiland district and further afield. Some people gained employment clearing farmland in Namibia, while others worked on road construction projects in Caprivi.⁸ For many Basarwa men from Gudigwa and the Chukumuchu region there were also opportunities to earn unusually high salaries from 1974 until 1989 when the South African Defence Force established 'Bushman Battalions' at Omega in Caprivi (Taylor, 2000).

The emergence of migrant employment opportunities in the region marked the arrival of a cash economy. The major significance people of northern Ngamiland attach to their cash incomes within contemporary livelihoods has been well documented (Taylor, 2002; Hoon, 2004). Money brought development and an economy to an area which, until the 1940s, had been marginal to trade routes and lacked infrastructure. Money provided a means to invest in commodities that would begin to define future resource use in the region and labour migration to the South African mines

⁸ Interview with LN from Beetscha (B5 7.05)

represented the beginning of this new era. Old men spoke with enthusiasm about their days in the mines, often quoting their mining numbers during discussions, and elderly women described in detail what the arrival of a cash economy meant for the household economy. *'Working in the mines changed our lives'* said TJ, a male Mbukushu elder from Beetsha.⁹ *'I could send money and clothes back to my family when a friend I trusted travelled home and when men returned they could buy spring-loaded traps, guns for hunting, and cattle in Shakawe (B2 7.05)'* he added.¹⁰ Interviews with elderly female informants confirmed that the mining era marked the arrival of consumer goods in the region. *'It was when the men came back from the mines that we started to get sugar, soap and clothes; they would buy them in Shakawe (B1 7.05)'* said MS from Beetsha.

At first economic changes were slow and development remained focussed on more accessible areas to the west of the Okavango River. However, by the 1960s developments had spread to both sides of the Okavango and northern Ngamiland was a major catchment area for mine labour recruitment. By this time Shakawe had grown into a busy recruiting centre for the Witwatersrand Native Labour Association (WENELA) and at the peak of labour migration during the 1960s the organisation made considerable improvements to the regions' infrastructure, constructing several roads, an airstrip (at Shakawe), and a recruitment sub-office within the northern sandveld at Seronga (Larson, 1970; Taylor, 1990).¹¹ As the region became more accessible, so opportunities to purchase consumer goods became more widespread

⁹ To protect the anonymity of informants only initials are used in this and the following chapters. This was especially important given the potential sensitivity of the fencing issue and discussions regarding illegal activities such as hunting.

¹⁰ Lee (1993) notes that though there were no formal systems for remitting mine wages back to families, people from northern Ngamiland operated elaborate exchange systems whereby returning labourers would be wearing items of clothing belonging to others.

¹¹ WENELA operated one of the most developed systems for recruiting, transporting, and repatriating labour in Africa. The company operated a ferry service across the Okavango and a weekly flight from Shakawe to Francistown where mine labourers would board trains bound for the mines in South Africa (Taylor, 1990).

and the need for cash increased. At first Shakawe became the trade-centre for the whole of northern Ngamiland (ibid: 37), but later trading stores began to expand to villages in the northern sandveld such as Seronga.

The arrival of a cash economy and rural trading stores dramatically altered the household economy. While many people abandoned their traditional dress in favour of European clothing and footwear, the abundance of new commodities such as sugar began to open up new livelihood opportunities (Larson, 1970; Lee, 1984). First, sugar could be used to make beer which could then be sold to villagers, especially returning mine labourers. This would become a major informal income earning opportunity for female household members and informal bars can be seen throughout the region today. Second, schools, healthcare and welfare began to emerge in the area and the colonial administration began to tax people for these services. The arrival of a cash economy and the necessity of cash for paying school fees and taxes resulted in people engaging in a variety of informal income earning activities such as craft production, carving, carpentry and ironmongery.

The increase in trading stores, particularly to the west of the Okavango, also marked the beginning of export-led livestock marketing in the area. Livestock had in-fact been exported from Ngamiland to the copperbelt mining regions to the north since the 1920s and 30s, and trading stores were established at Gomare and Tsau to purchase cattle and supply commodities as the abundance of cash increased (Macmillan, 2005). However, cattle from the Shakawe region had to be trekked to Gomare until trading stores began to emerge in the area in the 1950s and 60s. Larson (1970), for example, notes that Shakawe tripled in size with several trading stores established between 1950 to 1969 to purchase cattle and sell commodities. The increase in livestock sales is most likely the result of a northerly expansion of Herero pastoralists, who by the 1950s had begun to settle in Shakawe (ibid: 36). To add to this the ongoing

investment of migrant labour earnings in livestock by Hambukushu and Bayei may have created more commercially-orientated agropastoralists in the region. The next section of this chapter explores changes occurring in Herero pastoral society both before and after their arrival to the area.

Arrival of the Herero circa 1950s

Herero pastoralists have been expanding their territory to the north of Lake Ngami since the 1930s predominantly along the western margins of the Okavango Delta (Pennington, 1992). Their numbers remained low in the dry Kalahari sandveld to the west of the Delta fringe, however, until the 1950s after which Herero settlement increased (Lee, 1984). Oral testimonies of pastoralists interviewed in the Chukumuchu area confirm that Herero and Hambukushu households moved into the region from the 1950s onwards. Most cited stock losses to crocodiles along the Okavango River as reasons for moving inland and described expanding first along the Xaudum valley where water could be easily accessed through shallow wells. By the 1960s there were wells throughout the valley and cattleposts had begun to be established at large waterholes between Xaudum and Nxau Nxau (see Chapter 3, Map 3.1). One of these was established at Chukumuchu, a large waterhole retaining water long after the wet season. Chukumuchu remained a large Herero cattlepost until 1991 when a government settlement was formed at the site.

Before the arrival of pastoralists, the region remained the territory of the !Kung San or Ju/'hoansi, as they refer to themselves. Lee (1984) noted that the expansion of Herero in the Dobe region to the south began to alter Ju/'hoansi resource relationships and livelihoods. While there is convincing evidence which suggests that Kalahari Basarwa groups have been in intermittent contact with pastoral groups for some time, and may

have emerged from an undifferentiated group of hunter-herders (Wilmsen, 1978; 1989); before the permanent settlement of pastoral groups in the area, the Ju/'hoansi remained largely reliant on hunter-gathering. Following the arrival of pastoralists in the region, however, increasing numbers of Ju/'hoansi made permanent settlements and their seasonal mobility decreased and temporary camps were gradually replaced. Since the 1950s Ju/'hoansi have become increasingly reliant on agriculture, relief programmes and permanent water sources (Gould and Yellen, 1987).

Some Ju/'hoansi also became employed as herdsmen by Herero pastoralists. Though subordinate, Lee (1984) noted that the Ju/'hoansi were not simply servants but were paid a calf per year for their service and their immediate family were clothed, fed and housed at the cattlepost. Working for the Herero also accrued the benefit of being able to strengthen social networks by offering hospitality and food to friends and relatives at the cattlepost. Although some Ju/'hoansi worked for the Herero on a short-term basis, several entered into lifelong clientship relationships which fostered intermarriage and a loss of the hunter-gatherer culture. Few, however, managed to establish themselves as autonomous farmer-herders, largely due to the pressures of kinship relations within Ju/'hoansi society (Lee, 1984).

Unlike the Ju/'hoansi, there is little documented information regarding social changes occurring within Herero society before their arrival in the Chukumuchu/Xaudum region. Prior to fleeing to Botswana as stockless refugees at the beginning of the 20th century, the group was described by early missionaries as 'inveterate nomads' moving from place to place with their herds, depending on the conditions of the pastures (Werner, 2000). Indeed, anthropological research amongst the group during the 1980s found cooperative cattle management systems similar to mobile pastoral groups from East Africa (Smith, 1992). Other authors, however, suggest that Herero settlement patterns are more permanent than neighbouring Himba pastoralists and in comparison

to the temporary camps and mobile arrangements of East African Turkana or West African Fulbe, the group's social organisation is much more tied to one place (Bollig and Gewald, 2000).

Bollig and Gewald (2000) also note that the Herero use far less intensive herd management practices than East African pastoralists, usually herding livestock in the direction of intended pastures in the morning and relying on cattle returning at dusk for water. This is in fact the traditional cattlepost system employed throughout the Kalahari, used to avoid working through the extreme heat of the day and generally based on the minimum expenditure of energy (Perkins *et al.*, 2002). What differentiates the Herero from other Kalahari pastoral groups like the Batswana is their social organisation, which is clearly linked to their systems of settlement, land tenure, opportunistic management and mobility. Central in this regard is their main homestead or *onganda* where several patrilineal-related households reside together (Silitshena, 1982). Each social group also own another homestead or temporary cattle-camp at a waterhole where some of the men and their wives move with the cooperatively-managed herd during the wet season (Almagor, 1980). Several social groups owning larger herds may also own an additional dry season cattlepost, in order to reduce the pressure on dry season resources.

The Herero can, therefore, be described as semi-sedentary pastoralists utilising opportunistic management and mobility in order to cope with the highly variable resource base (Almagor, 1980). While the Herero may have been more mobile in the past, the main *onganda* has remained sedentary since at least the late 1970s in Botswana (Vivelo, 1977) and for over 58 years in Namibia (Bollig and Gewald, 2000). However, the Herero still use mobility as a principle drought coping strategy and herd management technique. Since the late 1970s in Namibia, Herero pastoralists have been known to truck or trek cattle from one native reserve to another during

prolonged droughts (ibid: 28). In Botswana the Herero objected virulently to proposed tribal grazing lands policy (TGLP) ranching near Lake Ngami, largely on the grounds of the reduced mobility enclosure would bring (Almagor, 1980). Herero may also rely on other forms of opportunistic livelihood, especially following the collapse of the pastoral economy. In northwestern Botswana, for example, Lee (1984) noted that newly settled pastoral groups hunted with Ju men and Herero women would gather wild foods side by side with Ju/'hoansi women during times of drought.

Though the Herero may have retained some form of pastoral mobility, like most pastoral societies (Chapter 1) there are further social and economic changes that have occurred within Herero society since their (re)pastoralization and expansion in northwestern Botswana which could challenge their present mobility and herd management practices. Firstly, Herero social organisation has been changing as studies observed cases of compromised households that appeared to be more female-headed than male, which some attribute to high levels of divorce (cf. Pennington and Harpending, 1993). Given that Herero herd mobility is linked to their patrilineal homesteads, this is likely to have implications on the ability of households to maintain mobility.

Secondly, while cattle have traditionally remained the central focus of the Herero economy, economic diversification has historically been the norm, rather than the exception (Bollig and Gewald, 2000). For example, Herero have been known to engage in horticulture, growing and selling vegetables and tobacco within small irrigated gardens, and Herero men have used labour migration as a coping strategy since the Rinderpest epidemic of the late 19th century (ibid: 19). More recently, Pennington and Harpending (1993) found that many Herero households in Botswana now plant crops following their close contact with agropastoral groups.

The Herero pastoral economy has also changed. In the early 1980s Almagor (1980: 39) described the Ngamiland Herero as ‘a prosperous community of wealthy cattle owners who take part in, and are aware of, the advantages of cattle export’. Since the 1930s, many Herero have integrated cross breeds to improve yields of meat and milk for commercial purposes (Bollig and Gewald, 2000). However, the group still give preference to establishing extensive herds, only selling cattle during droughts or to satisfy specific economic needs such as to purchase food, pay school fees or various social obligations (Hinderink and Sterkenberg, 1987).

Given the historical and recent significance of mobility within Herero society and the likely diversification of the Herero economy, it is essential that this study thoroughly investigates the current nature of pastoralism in the Chukumuchu region, as well as the diversity of livelihoods involving extensive resource use (i.e. hunting and gathering). The contemporary nature of livelihood opportunities and pastoralism in the Chukumuchu CBPP fence region is described in more detail in the next chapter. The following sections of this chapter describe the implications of the emerging cash economy for people who invested their new wealth in cattle or weapons for hunting in the northern sandveld NBF region to the east of the Okavango River.

Investing in cattle in the northern sandveld

Though much of the income earned from the new livelihood opportunities which emerged during the 1940s was absorbed by expenditure on everyday household commodities, several men from Beetsha and Gudigwa were able to invest in assets such as cattle or guns. These investments would begin to shape future relationships with the environment in a region where livelihoods have traditionally been balanced between agriculture (agropastoralism) and the abundant natural-resource base

(hunting, fishing and gathering). As the ensuing commentary will show, investing in cattle or wildlife would have important implications for the regions' people. For many this marked a turning point after which both of these livelihood trajectories led to resource-based conflicts. This discussion will also illustrate the major tension between livelihoods based on livestock and those based on wildlife which appears particularly acute at the wildlife/livestock interface.

In agro-pastoral societies cattle provide a social and moral significance far beyond their economic value (Hoon, 2004). 'Livestock keeping is our Tswana culture, with cattle we can plough and drink milk' was a common response when asking local informants to explain why livestock remain important in a region where people have often lost large numbers of stock to predators and disease. As this response illustrates, most people in the region identify themselves as part of a wider agro-pastoral Botswana society. Today, throughout Botswana cattle are used to pay bride price or slaughtered to raise money for funeral expenses or schooling costs. Historically, however, livestock production has been a highly variable and precarious source of livelihood for the inhabitants of the northern sandveld. While investing in livestock can have real benefits in terms of livelihood security, farmers who invested their migrant labour earnings in livestock faced major constraints in their attempts to establish a significant herd.

The tsetse fly and associated trypanosomiasis disease was the primary factor that restricted the expansion of pastoralism in the region despite the abundance of water and grazing (Smith, 1992). Historically, the tsetse fly belt has expanded and contracted, leading to a parallel pattern of movement for livestock. This has been one of the main determinants of the regions' settlement patterns, and shifts in the importance of livelihoods based on either wildlife or agriculture. Though the tsetse fly infestation in the northern sandveld receded to riverine areas after the rinderpest

epizootic in the late 19th century, it expanded to cover much of the region by the 1940s (Davies, 1980). Both colonial and post-colonial governments have since attempted to control the infestation in the northern sandveld, causing further fluctuations of tsetse populations (ibid: 39-135). However, many of the early attempts at control were largely unsuccessful, and it was not until the large-scale aerial spraying campaigns of the late 1970s and early 80s that any widespread eradication was achieved.

Until recently the distribution of cattle in northern Ngamiland has therefore been dependent on a highly fluctuating tsetse fly belt. Further constraints are presented by variable water availability due to fluctuating Delta flood levels, and also by a high risk of stock loss to predators. As a result cattle ownership has historically been restricted to a select few wealthy Bakgalagadi pastoralists or local Hambukushu or Bayei elites. Wealthy owners such as SB, the headman (*Kgosi*) of Beetsha, have been able to maintain consistent livestock numbers by moving their herd between a cattlepost owned outside of the tsetse fly belt on the Okavango River, and a cattlepost near Beetsha village. However, the capital and resources required to secure access to a second borehole or well outside the tsetse fly zone was beyond many Hambukushu or Basarwa in the Beetsha and Gudigwa area.

According to local sources, the Beetsha and Gudigwa region was free of tsetse for much of the 1950s and 60s, and only re-infested the region in the 1970s. Those who invested their mine earnings in livestock therefore had three options after the fly increased in the 1970s: move outside the tsetse fly zone and adjust livelihoods accordingly; lend livestock through *mafisa* to a trusted friend or relative; or pay

someone to herd them.¹² Most people were unprepared to move and lacked the resources to employ contract herdsman. As a result many were forced to use their social networks to retain their livestock. KS a Mbukushu man from Beetsa who worked for the Bakgalagadi described the nature of cattle production in the early 1950s and his own efforts to accumulate livestock:

During the 1950s I worked for the Bakgalagadi's near where Gudigwa is today. In those days the tsetse fly was not present in our area and there were large herds of livestock all along the Delta at cattleposts from //Gam /wi to Seronga. Tsetse came from the south later on in the 1970s and forced the Bakgalagadi and Hambukushu to move their cattle. I worked for two years before leaving for the mines. They paid me a calf per year but when I returned from the mines the calves had been killed by predators. I bought more cattle from Shakawe after I returned from the mines in the 1960s but when the tsetse fly increased in the 1970s I was forced to take the cattle to a relative near Mohembo until they sprayed the village in the 1980s (B12 7.05).

KS's strategy of moving his cattle to a relative who lived along the tsetse free Okavango panhandle was common among most farmers who invested in livestock in the post-mine era. One farmer interviewed sent his elderly grandfather to live with the livestock indicating that those with the human capital would prefer to move with their cattle. Despite the risks and difficulties of obtaining and managing cattle, the livelihood benefits from cattle ownership were high. Investing in cattle provided a means to increase yields from arable farming and the importance of farming changed after livestock ownership became more widespread. KN an elderly Mbukushu woman explained what the arrival of livestock after the period of mine labouring meant for arable farmers in the region.

Farming changed after the men came back from the mines. Many men spent their money on cattle which meant we could make bigger fields and plough later in the season, usually in January. Before this we made small fields and

¹² Mafisa is Setswana for a Tswana system whereby cattle are lent to another person to herd. The herder generally has access to products such as milk and benefits such as animal traction. The livestock remain the property of the owner except for a calf per year which is often given as payment.

ploughed by hand which meant we had to start work after the independence day celebrations [30th Sept]. Although my husband couldn't afford to buy cattle until 1990 he would help other farmers to herd their cattle and they would plough our fields in return. Farming changed in those days, as we ploughed later in the season there were less weeds and the crops yielded well. We sometimes had two years supply of food. We could make our fields further away from the home as we had oxen and sledges to transport the harvest. We spent the extra months between September and December repairing the fences and clearing the fields (B9 7.05).

The significance of livestock within agropastoral societies could therefore be more pragmatic than symbolic. Livestock provided a means for people living along the northern fringes of the Okavango to obtain a degree of food security and allowed more time to be invested in maintaining and expanding arable lands. However, although the period of migrant labour to the South African mines provided the means for some households to invest in livestock, cattle did not become common within the community until the tsetse eradication campaigns of the 1980s. Having said this, the benefits of livestock would often trickle down to stockless households, as is illustrated by KN's account.

What is also interesting from KN's testimony is that the reduced labour demands and thus spare three months, which access to livestock afforded, was not spent hunting, gathering and fishing. For people in the northern sandveld labour has historically been divided between agropastoral activities and livelihoods based on wildlife and natural resources (Larson, 1970). However, it was the increased food security obtained through access to livestock during the post-mine era, rather than reduced labour demands which began to affect relationships with the natural resource base. As a result some households experienced declines in the distance and diversity of their hunting, gathering and fishing activities. LN a male Mbukushu elder from Beetsha invested in livestock after returning from the mines and described the effect this made to his desire to travel long distances to hunt, fish and gather.

Before we went to the mines the whole family would go to the south and make a camp where we would gather and hunt. We would take spears and dogs and hunt while the women gathered wild fruits and water lilies. After the mines I bought cattle and goats in Shakawe and brought them to the village. During this time people would harvest a lot of millet and there was a surplus. People made beer from the extra millet and used this as payment to attract people to help on their land. The distance I travelled to hunt and gather depended on how much I wanted or needed, some people still went long distances on donkeys and stayed away for up to five days. I would generally gather close to the village and would leave at 5am and be back by 7pm (B5 7.05).

LN's account illustrates the entwined nature of livelihoods based on agropastoralism and wildlife in the northern sandveld, and the sedentarisation that began to occur after livestock ownership became more widespread. His emphasis on the distance travelled depending on 'how much I wanted or needed' also illustrates that wildlife and natural resource gathering livelihoods are used to fill any shortfalls in household subsistence requirements. Wildlife and veld products represent a dependable resource which has always been there for northern sandveld dwellers. However, as arable production increased so the need to engage in long distant hunting and gathering decreased and wildlife and natural resources became a strategy to fall back on in times of need. This role was evident in a discussion about the future of livelihoods based on agriculture or wildlife (tourism) in the northern sandveld with SM a young Mbukushu man at a cattlepost near Beetsha.

You can plough and get milk from cattle. Even if I worked in the lodges I would still keep some cattle. The only time we may depend on wildlife is if they kill our cattle like they did in 1996, then we will have nothing to do but to rely on wildlife. In 1996 when the cattle were killed I stayed on the cattlepost and hunted everyday. If I didn't catch anything one day I would go again the next (B36 7.06).

Today, livestock therefore remain as unpredictable as in the past. Wildlife resources are seen as an insurance against the likely collapse of agriculture. However as the following section will illustrate, investing in wildlife resources came at a price for

those who remained focussed on this dependable resource. While the arrival of a cash economy and vibrant migrant labour market allowed some men to invest in guns, traps and ammunition to facilitate their subsistence hunting activities, the gradual commoditisation of wildlife resources and increase in cash hunting began to lead to major conflicts between hunters and both colonial and post-colonial hunting legislation.

Investing in wildlife in the northern sandveld

Hunting in the northern sandveld has been restricted for many years. Under tribal law all wildlife belonged to the chief and hunters would primarily pay tribute to their local tribal leader by surrendering the best meat from any animal killed (Larson, 1970). Once the Batawana chieftaincy claimed the northern sandveld area as their hunting ground in the nineteenth century they began to set limits on the numbers and types of animals that could be hunted (Spinage, 1991). However, as was the case with the weak subjugation of Basarwa described above, in remote areas such as the northern sandveld the authority of the chieftaincy was not strong and local people continued to hunt relatively freely (Hitchcock, 1996). This remained the case even after the Fauna and Conservation Proclamation Act of 1961 which initially made hunting without a permit illegal, but was later amended with a clause allowing subsistence hunting (Twyman, 1997; Taylor, 2000). However, by the late 1960s subsistence hunters in the northern sandveld began to experience spatial restrictions on where they could hunt, along with legislation restricting what they could hunt.

Restrictions on people's access to wildlife resources in northern Botswana came after the Fauna and Conservation Proclamation Act was revised and legislation transferred into the Unified Hunting Regulations of 1979. Under the new unified system, people

of the northern sandveld were either eligible for a free Special Game Licence (SGL) if they were classed as remote area dwellers, or they were able to apply, and pay a nominal fee for a citizen licence. Most Basarwa from the northern sandveld were classified as remote area dwellers and were, therefore, eligible for SGLs, whereas for many Hambukushu from Beetsha where the demand for citizen licences exceeded the quota allocated, a raffle system was introduced.¹³ Most Hamukushu continued to hunt without a licence during the 1980s, especially during droughts and until the tsetse eradication facilitated widespread livestock ownership.

At this time there were Basarwa households living in small communities throughout the Kwando/Linyanti region to the north of Gudigwa. By now most were settled around permanent hand-dug wells in areas where the groundwater was close to the surface. During the 1960s many northern sandveld Basarwa living in the Kwando-Linyanti region began to experience limitations on where they were able to hunt. Spatial limitations to wildlife utilisation by subsistence hunters came first from the demarcation of several game reserves and national parks to the east (Chobe National Park 1967; Moremi Game Reserve 1963) and secondly when the Tswana Land Board was established following the Tribal Land Act of 1968. Ngamiland district was then divided into concession areas for commercial and citizen hunting. This period also marked the beginning of Botswana's tourism industry as safari hunting companies were able to obtain exclusive access to hunting concessions. Subsistence hunters with SGLs were now restricted to hunting certain species in areas allocated for citizen hunting.

After the land-use zoning exercise of the late 1960s Basarwa subsistence hunters in the Kwando region found their traditional hunting territory designated as a

¹³ The unified hunting regulations of 1979 made critical changes to people's access to wildlife resources and in areas such as Beetsha in northern Botswana where demand for citizen licences were high residents were forced to apply for a licence through a raffle system.

commercial hunting concession and leased to a safari hunting company who established a hunting lodge on the Kwando River. At first this improved livelihoods as the arrival of the tourism industry marked the beginning of employment opportunities within the northern sandveld and several households gained employment as trackers, skinners, and gun-bearers. Using the money earned from this employment men such as SP from the small settlement of Movembe were able to invest in a gun.

Gun ownership has historically been limited among the northern sandveld Basarwa; partly because guns were often taken by the Bakgalagadi, and partly due to the lack of opportunities to raise the necessary cash (Taylor, 2002). Though several Basarwa were able to obtain weapons during the 19th century, gun ownership remained rare until the widespread availability of labour markets and a cash economy (ibid). This explained why gun ownership came much later for the residents of Movembe. For people in Movembe, investing in a weapon provided an opportunity to profit from the sale of wildlife products obtained under their SGLs. JM, a Basarwa elder from Movembe, described what this meant to the community.

No one had a gun in Movembe until SP, my brother, bought one with money he earned from guiding the hunters in the 1960s. I didn't guide the hunters but after SP bought his gun I hunted and the community made money by selling dried meat from the animals I killed. The villagers would come and make dried meat which we sold in Namibia. We made 50 Nambian dollars each trip. We also took the skins of animals and sold them in Beetsha or exchanged them for tobacco. In those days we were given Special Game Licences and would sometimes hunt four animals a month (G2 6.05).

Profiting from the sale of game meat has been a means for Basarwa from the northern sandveld to obtain income for nearly fifty years (Taylor, 2000).¹⁴ This was evident in

¹⁴ Taylor (2000) suggests that Basarwa from the Mababe area have traded dried meat in Maun since the 1960s and continue to do so today.

Silberbauer's *Bushman Survey Report* of 1965, as Basarwa from northern Botswana were separated from other hunter-gatherer groups in Botswana and described as living in 'independent villages with cash hunting and wage labour'. Hambukushu from Beetscha also participated in the sale of game meat before the area was enclosed by the NBF. During the livelihood survey of households from both Beetscha and Gudigwa the survey group were asked whether they hunted and/or made income from the sale of natural resources in the two decades prior to enclosure in 1991. Although the results were almost definitely influenced by a reluctance of many households to admit to hunting for reasons which will be explained later (see below), the data revealed that at least 20 per cent of households from both villages generated income from cash hunting.¹⁵ Most described selling meat in Seronga which by now had become the largest village in the region with schools, vending shops, police station and hardware store.

Though illegal under the new unified conservation laws, profiting from the sale of wildlife products was initially tolerated by the Department of Wildlife and National Parks (DWNP). According to Hitchcock (1996: 55) the DWNP's initial intention was for SGLs to 'enable people to obtain wildlife products which they would then sell' and generate an income so that they would 'no longer have to be dependent on the hunting and gathering lifestyle'. It was hoped that through selling wildlife resources Basarwa would become 'civilised' and integrated into national society. As the survey data and hunter accounts revealed, profiting from cash hunting required travelling to settlements where a significant population created a demand for meat and for people in the northern sandveld the closest markets were either Seronga or Namibia. While

¹⁵ The number of households owning a hunting licence or hunting before 1991 was high and though some people were reluctant to discuss their hunting practices 81 per cent of those questioned (n=62) hunted in the years before enclosure. 22 per cent of households questioned in Gudigwa (n=32) and 20 per cent of those questioned in Beetscha (n=20) also gained income from cash hunting.

commercial hunting may have been initially tolerated by government officials, concerns over the future of large mammals in northern Botswana and mounting political instability in the region during the 1980s prompted a government crack-down on both border security and illegal hunting.

The 1980s were an intense period for southern African politics and for inter-region relations. Botswana faced a variety of threats from neighbouring countries as anti-apartheid movements and armed conflicts intensified in Namibia, Angola and South Africa. Armed groups frequently permeated Botswana's long and sparsely populated borders seeking refuge or targeting opponents.¹⁶ This instability created a boom in the market for ivory. For some people in the northern sandveld this created an opportunity to earn more lucrative incomes. Basarwa from the northern sandveld became involved in the ivory trade, often guiding both Botswana citizens and criminal syndicates. Several Basarwa and Hambukushu also hunted elephants themselves; especially after powerful weapons became widely available from armed conflicts to the north.¹⁷ Hambukushu, Bayei and Bakgalagadi were likely to have been involved in the trade as middlemen who loaned weapons to Basarwa hunters or purchased tusks from the Basarwa and sold them to white dealers for export (Taylor, 2000).

Ivory obtained from the northern sandveld has in fact been traded for many years and people in the northern sandveld have long facilitated the trade, acting as guides to hunters or hunting on behalf of weapon owners.¹⁸ At first, during the latest boom, many of the elephants shot were killed illegally by Botswana citizens exceeding the quota allocated legally under the citizen licence system (Taylor, 2002). Twyman

¹⁶ For example, in May 1985 South African Defence Force soldiers entered Botswana and attacked the homes of people allegedly associated with anti-apartheid activists killing twelve people (Hitchcock, 2002).

¹⁷ Elephants require high calibre weapons to kill effectively. Informants described how relatives working for the South African Defence Force would steal military weapons and that these were excellent for hunting large game such as buffalo or elephant.

¹⁸ For example, Basarwa guided hunters to elephants and hunted elephants on behalf of the Batawana during the late nineteenth century (Bolaane, 2004).

(1997) noted that the raffle system was essentially unequitable, as each person in the country then had an equal chance of obtaining a licence. Licences were transferable between districts and between hunters and thus many entered the raffle with no intention of hunting, but intent on selling licences. This allowed abuse of the licence system as citizens who won the right to buy licences cheaply were able to sell them to recreational hunters at a profit, leading to concerns that some regions were being over hunted. MK, for example, a Basarwa man who lived at Letshaobe near present day Gudigwa recalled a period during the early 1980s when ‘*black hunters with permits from as far as Francistown and Gaborone (G10 7.05)*’ would come and employ him to help them hunt elephant.

By the late 1980s the difficulty experienced by government officials to control both border security and illegal hunting was highly apparent. Until this time both SGLs and citizen licences were poorly regulated and offered little control on the numbers or species of game utilized. Hunting regulations were enforced by the poorly resourced DWNP and a few Botswana Local Police officers stationed at villages along the Delta fringe. However, the ivory trade from northern Botswana continued unabated even after the removal of elephant from citizen licences in 1983 made it easier to determine illegal poaching activities from subsistence hunting. Mounting environmental concerns over dwindling populations of some large mammals and ineffective DWNP anti-poaching operations prompted government efforts to control poaching in the northern sandveld during the late 1980s.¹⁹ As a result the Botswana Defence Force (BDF) were re-deployed from border security duties and assumed anti-poaching operations in 1987 (Henk, 2005).

¹⁹ Rhino horn was also traded and by the late 1970s there were few rhino were left in northern Botswana, and by the 1990s they were considered extinct. Elephant were also targeted for ivory. Widespread environmental concern over dwindling rhino and elephant populations during the 1980s and fears for national security prompted a response from the government. It was clear that the DWNP lacked the resources to control the burgeoning ivory and horn trade and in 1987 the Botswana Defence Force commenced anti-poaching operations in the northern sandveld.

After 1987 northern sandveld people who continued to hunt in the areas north and east of Gudigwa came under increasing scrutiny from both BDF and DWNP anti-poaching operations. While commercial hunting by SGL holders may have been initially tolerated, any form of hunting activity not immediately obvious as for subsistence needs was now challenged by government officials. This period marked a turning point from which investing in wildlife as a livelihood option now became increasingly restricted. Using a unit of special forces trained commandos guided ironically by several dozen Basarwa trackers of Botswana origin recruited from the disbanded South African Defence Force bushmen battalions, the BDF began to tackle illegal hunting in the northern sandveld (Henk, 2005). At first the BDF focussed on challenging only armed groups or gangs of hunters. However, after curtailing the ivory trade their attention focussed on the illegal activities of Basarwa from the various small settlements to the north of Gudigwa.

Since this period government officials from the police, DWNP and BDF have controlled illegal hunting in the northern sandveld using a suite of techniques all aimed at deterring would-be commercial hunters. Firstly, the BDF keep a visible presence in northern sandveld villages and engage in random long-range foot patrols in the hunting concession areas to the east of the NBF.²⁰ Henk (2005) described the tactics used by the BDF to regulate hunting the northern sandveld after they had succeeded in controlling the criminal syndicates.

Once committed to environmental security, the BDF was confronted with various different categories of poaching besides the armed gangs. Some local citizens that lived near the conservation areas poached for meat, typically snaring or shooting smaller antelope. The meat hunters, whether from Botswana, Namibia or Zimbabwe, were clearly engaged in illegal activity that required some response, but did not pose the same kind of threat as the well disciplined, armed groups of commercial poachers. Since that time, the

²⁰ The BDF frequently drive to and from their Kwando camp using the Mohembo-Gudigwa road and during fieldwork the BDF were seen parked in Gudigwa and Beetsha on several occasions.

conventional forces [i.e. BDF regulars not commando unit] have maintained a very visible presence in northern game areas, deliberately intended to deter all forms of poaching and reassure citizens and tourists that they are secure (Henk, 2005: 182)

Secondly, undercover police officers have attempted to infiltrate communities posing as potential ivory traders or in one instance as a potential herdsman, while local village police often search for people eating game meat without a licence or using unlicensed firearms. Finally DWNP officials have nominated local game guards to report community members violating hunting laws using the CBNRM idea.²¹ These techniques have created a great deal of mistrust in the northern sandveld communities and, as a result, few people admitted to hunting.

SGLs were withdrawn in the mid-1990s in favour of a community quota system. Those who continue to hunt these days do so in secrecy and the direct impact of enclosure on these activities was hard to determine and is discussed in Chapter 7. The enforcement of restrictions on hunting and land-use in the northern sandveld altered people's relationships with the land and natural resources. After the crack-down on poaching and withdrawal of SGLs, Basarwa were no longer able to move freely throughout the Kwando-Linyanti region. However, a period of sedentarisation during the 1980s also began to alter natural resource use in the region.

4.3 Villagisation and (re)settlement in northern Botswana

Today, people in the northern Ngamiland live in a series of large villages each with their own state-provided services including schools, boreholes and clinics (Chapter 3, Map 3.1). In both study areas, villagisation occurred before the region became

²¹ The concept of community based natural resource management (CBNRM) emerged during the 1990s following theoretical advances within common property resource management theory (Jones, 1999). In Namibia a community game guard system played an important role in reducing poaching activities and the idea has spread to other regions of Africa, including Botswana.

enclosed by veterinary cordon fences in the 1990s. This sedentarisation caused further dramatic changes to resource use and mobility in the region. Settlement in the CBPP fence area occurred only five years before enclosure and, therefore, the resource use changes that ensued are best explained together with the direct impact of enclosure in Chapter 6. The following section describes dramatic changes that occurred in the NBF area during the 1980s when village development occurred and people were encouraged to settle in one place.

By the time hunting restrictions began to be enforced in the late 1970s the Hambukushu and Basarwa in the area surrounding present day Beetsa and Gudigwa still lived in a series of small settlements dispersed along both the Delta fringe and sandveld. Open access resources were owned communally, and although claims to resources were not tightly fixed, each community, household and person had shared claims to a certain area or piece of land. Resource access was negotiated through social relations at the community level (Taylor, 2000).

For the Basarwa the issue of land rights is highly contentious in Botswana. Basarwa have been denied rights to land ownership under common law largely due to widespread perceptions of Basarwa as nomadic, stemming from early anthropological studies, which emphasized the mobility of Basarwa resource use and thus lack of permanent attachment to certain resources or areas. However, ideas of territoriality have been particularly stressed in recent anthropological work, especially amongst the Basarwa of the northern sandveld (Bolaane, 2004; Taylor, 2000). Recent studies indicate that much like Basarwa throughout Botswana, ideas of territoriality are inextricably linked to social organisation.

In the past, Basarwa in the northern sandveld lived in small bands consisting of several extended families each identifying themselves with a certain territory. Taylor (2000) spent a considerable amount of time mapping the historical land tenure of

northern sandveld Basarwa and noted that people now living in Gudigwa once identified themselves with one of ten family territories spread throughout the northern sandveld. He also found that family territories became increasingly amalgamated during the mid-to-late twentieth century as families spent increasing amounts of time in some of the larger Basarwa settlements (ibid). Data collected during fieldwork affirm that Basarwa groups in the northern sandveld began to move together in some of the larger settlements during the 1960s and 70s as livelihoods became more orientated towards the cash opportunities available along the Delta fringe.

During the fieldwork interviews, fieldwalks and surveys, data were recorded regarding changes to social organisation and regional demographic patterns over the period before enclosure. Informants were asked to name some of the most important resource areas utilised in the past, and now enclosed by the NBF. Further details were also obtained with regard to household's previous places of residence prior to their present location. These enquiries were aimed at establishing changing patterns of social organisation in the years leading up to enclosure in 1991 and therefore focused on changes within living memory. Although it was not possible to accurately establish and map individual band territories, some of the main settlements of importance to people in both Beetsha and Gudigwa were recorded and, where possible, mapped in the field (Table 4.1). Most settlements were inaccessible by vehicle and would have taken several weeks to map on foot. Informants were, therefore, asked to describe the approximate distance and location of places they lived in, or hunted, gathered and fished in, during the 1970s and 80s.

Table 4.1. Some of main settlements occupied by households in Beetsha and Gudigwa before moving to government villages during 1980s and 90s. * = Place visited during fieldwork.

Gudigwa	Beetsha
Dishokora* (<i>Bien/wa</i>)	Bomoi
//Gam/udi	De Kenya
//Gam/wi*	Dikakaharue
Ghoi	Gombo*
GwaGwaGwa	Jungwe
Kaexhava	Katata
Movembe	Katjeketa
Mowana	Kaxumai
Tsaabe	Matendendora
Tshizi	Matswii*
Letshaobe*	Nxgaranga
N/am N/am	Nxharnga
	Phuphudli
	Shamhuho
	Setjope
	Tanejo
	Thicjope
	Thitjeketa
	Xhomoha
	Yotsa
	Zambia 1
	Zambia 2

Source: Fieldwork

Though the precise dates when sedentarisation began to occur were difficult to establish, both Basarwa and Hambukushu settlement patterns began to change during the 1960s, 70s and 80s. Basarwa, previously living in small bands consisting of extended families, began to congregate in a number of the larger Basarwa settlements near present day Gudigwa (e.g. Letshaobe and //Gam/wi). Most Basarwa cited the below average rainfall, crop failures and water shortages as reasons for moving to larger Basarwa settlements. There were several waves of resettlement over the three decades prior to enclosure in 1991, and some households migrated back and forth between settlements in the sandveld and larger settlements closer to the Delta.

Several described ‘falling out’ with other family groups after gathering in one settlement and thus a period of demographic reorganisation ensued, as many were

forced to move on to other settlements before establishing new patterns of resource use. A typical example is that of SW, a Basarwa man now living with his family at Beetsha. SW was one of the earliest who described migrating from Ghoi shortly after independence. After several years of poor rainfall and crop failure at Ghoi, he settled at Letshaobe, relying heavily on Basarwa there for support. During the 1970s he returned several times to Ghoi and attempted to resume his past patterns of natural resource use. However, SW finally decided to move to Beetsha from Letshaobe after falling out with the other Basarwa there.

While the Basarwa's social organisation began to change, the Hambukushu on the other hand largely remained in distinct family groups. Households lived in small extended family villages each with a different name (Table 4.1). Several households had adopted the regional countries as settlement names after they became aware of their wider geography following the increase in long-distance labour migration. However, after the tsetse re-infestation of the late 1970s many were asked by a local councillor to move their settlements closer to the main Kwando-Seronga road, in order for a regular ambulance truck to take the sick to Maun for treatment.

The 1980s saw a period in which rural development policies created more permanent settlements in the region, principally under the auspices of the Remote Area Development Programme (RADP). The RADP emerged in 1982 from the 1978 bushman development programme. These initiatives were initially aimed at providing services principally for Basarwa groups but later remodelled to include all Remote Area Dwellers (RADs) outside the traditional village structure in a geographic or socioeconomic sense (Twyman, 2001). The RADP aimed to provide social services (health, education, food), access to land and water, self reliance and income earning opportunities (Osaki, 1990). Part of the RADP's policy was to provide these services

through various service centres in rural areas and thus promote the aggregation of scattered settlements.

Having already settled close to the main access road, the Hambukushu were the first to be encouraged to converge in a single settlement. In 1980 a primary school was constructed in Beetsha village and Hambukushu living in scattered settlements in the area were encouraged to settle closer to the village. Gudigwa village was created eight years later, and was made up mostly of Basarwa from the region to the northeast, who by now were mainly settled at nearby //Gam/wi and Letshaobe. There were, however, several households still living in dispersed settlements to the north that remained even after the settlement was established in 1988. These households lived at settlements such as Movembe, Dishokora and Tshizi. Although not forced to move to Gudigwa, several households cited the increased insecurity as reasons for moving and some even alleged that they were harassed by the BDF anti-poaching unit.

It seems that households that invested in wildlife after the arrival of the cash economy found themselves forced to forego their hunting and gathering lifestyles after hunting restrictions became more rigorously enforced by the BDF in the late 1980s. Households such as those at Movembe who continued to hunt even after their land and traditional territories were designated as a controlled hunting area (CHA) and leased to a tourism operator, found themselves increasingly in conflict with the BDF. According to Movembe residents they continued to hunt in the CHA as they: *'knew it wasn't wrong, god gave us these animals to use, it's our Basarwa culture to hunt'*.²² However, although no one was forced to move, continued harassment by BDF patrols left them with little choice. JM, from Movembe, described how he ended up moving from Movembe to Gudigwa in 1989:

²² Informant KB a male elder from Movembe (G1 6.05)

The BDF made a camp at Kwando to protect the remaining rhinos in that area. They started to come to the village around 1989 and said, 'why do you want to live with wild animals go to Gudigwa', and 'If you don't go we will bury you here'. They told us to leave the village and fired shots into the air. The crops yielded well that year and we had to leave it all in the fields and walk to Gudigwa (G2 6.05).

Like the Basarwa in the Kwando region, many of the Hambukushu and Basarwa in Beetsa and Gudigwa have shared claims to certain areas or territories where they have hunted and gathered in the past. However, unlike the Basarwa family territories to the north, Hambukushu areas were open access resources held by the community as a whole. In times of environmental stress, during droughts for example, or when the Delta floods were poor, households would travel large distances to certain well defined areas to hunt, gather and fish. The late 1980s marked a period when it was no longer acceptable to hunt and gather in many of the areas previously utilised by both Hambukushu and Basarwa. By this time most were settled into government service centres or villages and many were busy increasing their returns from agriculture. Nevertheless, while past patterns of resource use had changed dramatically over the previous three decades, local claims over these resources were still highly evident and in recent memory. This was the local context within which enclosure by veterinary cordon fencing inserted itself in the early 1990s.

4.4 Conclusion

The various pastoral, agropastoral and foraging groups occupying northern Ngamiland have undergone considerable changes in terms of their economic activities, settlement patterns, resource relationships and mobility over the last hundred years. Certain livelihoods which have historically been limited and highly risky in the region, such as pastoralism, have expanded and attained a degree of

stability, especially after the successful eradication of Tsetse from some parts of the district. Other forms of resource use such as wildlife utilisation, historically the mainstay of the region's economy and once open to all, are now restricted (albeit pending the collapse of livestock farming).

Settlement patterns have also changed dramatically. Conflicts with anti-poaching and security forces, along with rural development schemes have encouraged the sedentarisation of people around services centres or villages. Meanwhile, to the west of the Okavango River, pastoralists historically known for their opportunistic and mobile management have expanded into the dry Kalahari sandveld. Given this history of extensive resource use and mobility based livelihoods, especially in times of need, it is imperative that the long-term implications of veterinary fence enclosure are investigated thoroughly. However, it was considered logical and essential to establish the contemporary nature of livelihoods before these issues are explored in more detail in Chapters 6 and 7. Thus, the next chapter explores the contemporary context of livelihoods and natural resource use in the two study areas.

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5

Contemporary Livelihoods, Resource Availability and Mobility

5.1 Introduction

It can be difficult to understand fully the use of mobility within rural pastoral communities without a clear knowledge of how it is used within the context of livelihood strategies (Madsen and Adriansen, 2004). Contemporary rural livelihoods throughout Africa are increasingly characterised by high levels of diversification, typically towards long-distance labour migration, following the compounding influences of structural adjustment, market liberalisation and globalisation (Bebbington and Batterbury, 2001). Though drylands are to some extent marginal to the globalisation process, recent research suggests that here too farmers are utilising economic diversification ‘at large’ (Batterbury, 2001). While some suggest that a widespread process of deagrarianisation could be occurring (Bryceson, 2002), such theories have been criticized in the Kalahari context for masking the complexity and diversity of rural resource use (Twyman *et al.* 2004). Having explored many of the historical factors that underlie contemporary livelihoods and mobility, this short chapter specifically focuses on providing a ‘grounded analysis’ (Batterbury, 2001) of the ‘different ways in which people try to make a living’ (Francis, 2001) in northern Botswana.

Access to the necessary capital assets (both tangible and non-tangible) is the key issue in the conceptualization of rural livelihoods (Batterbury and Bebbington, 1999, de Hann, 2000, de Hann and Zoomers, 2005). Using a baseline livelihood survey inspired by the sustainable livelihoods framework outlined in section 3.3.1, this chapter specifically

focuses on the household level and seeks to establish the diversity and complexity of contemporary rural livelihoods in the two study sites. This chapter is especially interested in understanding the context of mobility within contemporary livelihoods based on spatially dispersed assets. Livelihoods are therefore also explored in relation to resource availability. The present spatial distribution of key resources for some of most dispersed livelihood activities is exposed using data gained from various participatory diagramming exercises and supported by direct observations during field walks and information recorded during various in-depth interviews. The chapter is divided into two sections: section 5.2 investigates the present livelihood context within the CBPP fence community at Chukumuchu and in section 5.3 livelihoods of the NBF communities of Beetsha and Gudigwa are explored (Maps 5.1 and 5.2).

5.2 The CBPP fence Community: Chukumuchu

Section 2.5 described the contagious bovine pleuropneumonia (CBPP) outbreak of 1995, subsequent emergency fencing campaign, international outcry, eventual decommissioning of the Setata fence, and finally the permanent inclusion of the remaining CBPP fences in the Department of Animal Health and Production's (DAHP) national plan. The Samochima and Ikoga veterinary cordon fences that remained dissect the communal rangelands to the north and south of Chukumuchu village (Map 5.1). The village and its surrounding rangeland between the Xaudum valley (just north of the Samochima fence) and Jobo cattlepost (just north of the Ikoga fence) formed the focus of investigations in the region. The village was created in 1991 as a regional service centre and is located approximately 50km southwest of Shakawe and 30km due west of the

Tsodilo Hills in northern Ngamiland (Map 5.1). Movement of livestock from south to north through each fenced disease restriction zone is only allowed on application for a permit, which is available either in the village, when veterinary officials are present (usually during vaccination campaigns) or from the DAHP office at Shakawe. Any livestock moved south from the northerly zone at Shakawe are required to spend 21 days in quarantine within the Kgomokwane quarantine camp (Map 5.1). Livestock for national beef markets are collected by truck from the same camp and transported to the Botswana Meat Commission (BMC) abattoir at Francistown.

In 2001, the village had a population of 270 (140 male, 130 female) living in approximately 55 dwellings (CSO, 2001). In addition, there are c.30 dwellings at dispersed cattleposts and settlements aligned along inter-dune valleys to the north, south and west (ibid). Although a small number of inter-ethnic households were present in the region, households in Chukumuchu village were either Herero or Hambukushu. There were also several Ju/'hoansi households in the region. However, most Ju households lived and worked on Herero cattleposts having entered into lifelong clientship relationships (cf. Lee, 1984). Those who remained independent lived at the Xabacha 1 cattlepost having refused to settle in the village partly for fear of running into conflicts over smallstock damage to property. One Bayei household was also resident on a dispersed cattlepost surrounding the village (Table 5.1). During the questionnaire survey a total of 24 households were surveyed in Chukumuchu village and a further 29 households were surveyed at cattleposts in the surrounding rangelands.

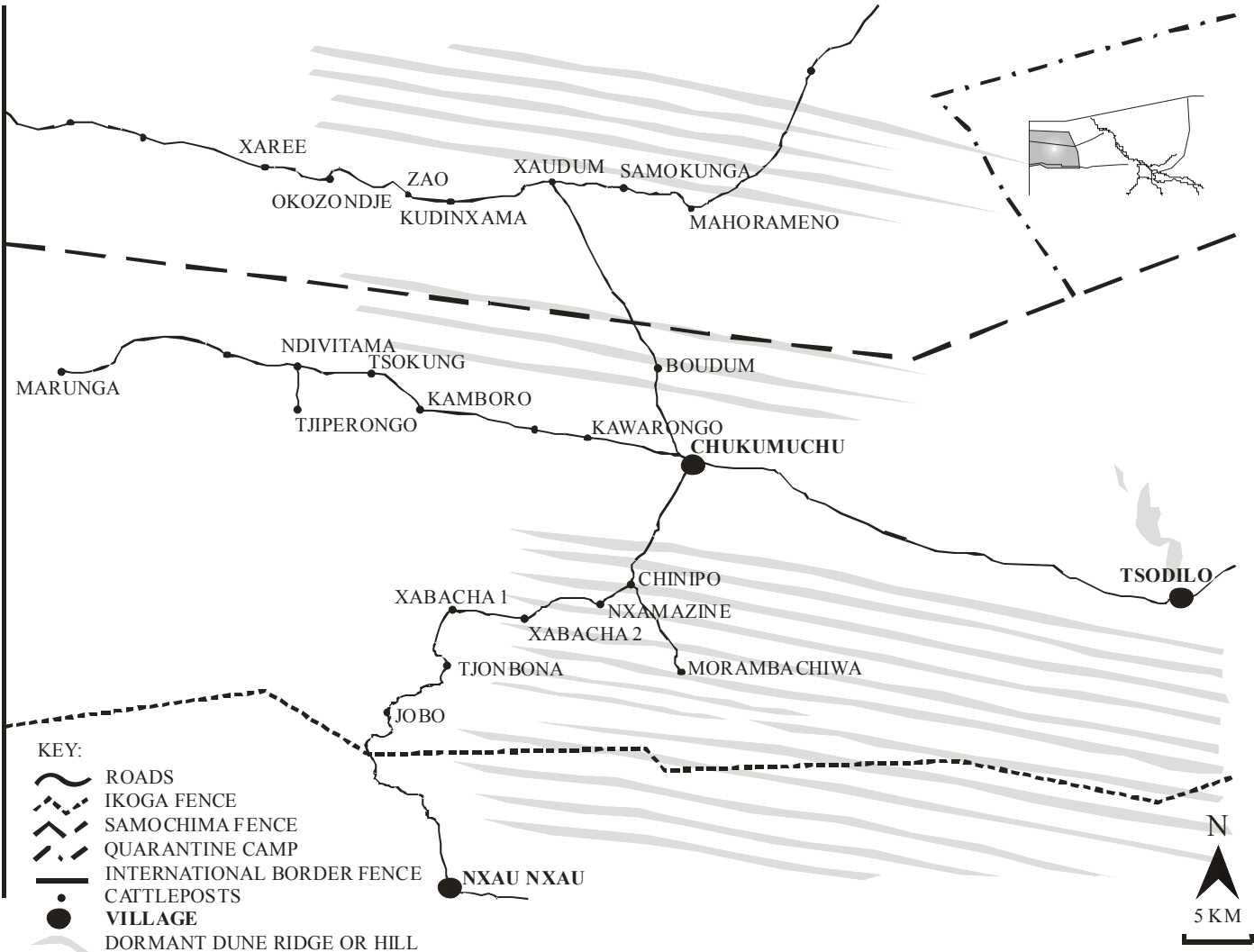
During the survey, questions were asked regarding household livelihood asset holdings, along with household livelihood activities and incomes from both on-farm and off-farm

sources. The following sections detail the results of this survey including, where possible, quantitative measures of incomes gained from each activity.

Table 5.1. Total number of households surveyed from each ethnic group in Chukumuchu village and surrounding cattleposts

Ethnic Group	Chukumuchu	Cattleposts
Herero	13	13
Hambukushu	11	12
Basarwa	0	3
Bayei	0	1
Total	24	29

Source: Fieldwork survey of 53 households



Map 5.1. Chukumuchu village and surrounding cattleposts

Household and community demography

The 'resident household size' was defined as the number of individuals determined by the respondent to be living at the homestead at the time of the survey. In Chukumuchu village, resident household size ranged from one or two parents, their pre-primary and primary school aged children and one or two grandparents, to an extended family consisting of over 15 members. The mean household size was ten individuals. The mean number of resident household members at households living at cattleposts in the surrounding rangelands was slightly less than in the village with an average size of eight members. This could be explained by the presence of several cattleposts occupied by either a few contract herdsman and their immediate family or only the male members of a household whose main homestead was in the village. This dispersed household structure and livestock management system has important implications for how the impacts of veterinary cordon fences are perceived and therefore these households were included in the survey. However, care was taken to accurately establish the non-resident component of such households and check that the households with two homesteads were not included twice in the survey.

Non-permanent residents of the household were those members considered to be part of the household by the respondent, but who were not resident at the homestead at the time of the survey. These members were generally children attending regional secondary schools or family members engaged in, or seeking, seasonal or permanent employment in nearby service centres or towns.¹ The non-resident component of households in Chukumuchu varied in size from no members to four, with an average of one member per household. In the surrounding cattleposts the non-resident

¹ Non-resident family members generally utilise social networks and reside with relatives or friends with homesteads in larger regional villages or towns. Many households had children attending secondary school in Gumare and close family members living and working in the formal urban employment sector in Shakawe, Gumare or Maun.

component varied from no members to six, with an average of two members per household. The slightly higher non-resident component was caused by the connection between the village and cattleposts with young children attending primary school in the village during the week and residing at the cattleposts during the weekend.

5.2.1 Off-farm income in Chukumuchu

Though some households have family members working or seeking employment in the regional towns (principally Maun or Gumare), few admitted receiving regular remittance payments. Most were therefore solely reliant on income opportunities from within the area. Access to non-farm employment opportunities in the study area was limited for households whose only homestead was located on a cattlepost in the Chukumuchu rangelands. Most of the non-farm income opportunities could be found in the village with the exception of temporary drought relief road clearance work and temporary employment constructing facilities at the DAHP Ikoga fence camp south of Jobo cattlepost (Map 5.1). Table 5.2 below compares the percentage of households from the village and cattleposts whose primary non-farm income source comes from formal employment, temporary labour, pensions or other income-generating activities such as brick-making or thatching. The data illustrate the greater number of village-based households engaged in both formal waged employment and other non-farm waged activities, whereas remote cattlepost households are solely reliant on either temporary labour intensive public work programmes (such as the drought relief programme, hereafter DRP) or pensions.

Table 5.2. Comparison of percentage households from village and cattleposts gaining primary income from selected non-farm sources.

Income Source	Study Location	
	Chukumuchu <i>n=24</i>	Cattleposts <i>n=29</i>
Permanent waged employment	54.2	0
Temporary drought relief programme work	29.2	62.1
Other non-farm income generating activities (brick making etc.)	16.7	0
Pensions	0	10.3
No waged income	0	27.6
Total	100	100

Source: Fieldwork survey

Table 5.3 illustrates the diversity of waged non-farm income sources available in Chukumuchu village, together with the average income associated with each source. Both formal and informal non-farm income sources were available in the village and households not engaged in full-time employment are able to gain informal incomes from temporary jobs such as house building, cooking at the school or brick-making. As a result cattlepost household members occasionally visit the village seeking informal temporary employment when in need of cash to satisfy immediate household needs.

Table 5.3. The main waged non-farm income sources available in Chukumuchu region. (Exchange rate 1.5.2006 1US\$=Pula 5.43)

Employer	Waged Employment	Average Income per Month (Pula)	Location
Government	Village borehole maintenance (water affairs)	1700	Village
	Night watchman (clinic or school)	1700	Village
	Clinic cleaner	1600	Village
	School cook	350-400	Village
	Drought relief work	150-300	Village + Cattlepost
Private Sector	Shop assistant	500-900	Village
	Brick making	300-500	Village
	Private house building	200	Village

Source: Fieldwork survey

5.2.2 Farm based income opportunities

Livestock management and ownership in the Chukumuchu rangelands

By far the most important natural resource-based livelihood activity in the region was livestock production. Of the 53 households surveyed, four households in Chukumuchu and three households from the surrounding rangelands owned no cattle and almost all households surveyed kept some smallstock, with only one household owning no cattle or smallstock. However, the distribution of livestock throughout the region and between different households varied considerably depending on either household location or ethnicity. Table 5.4 shows the percentage ownership of selected livestock between households residing in either the village or cattleposts. The data show the higher percentage of small herd owning households residing in the village with less than five head of cattle and the higher percentage of large stock owning households at the cattleposts with over 30 head. The results also highlight the higher

percentage of households owning large numbers of smallstock and poultry on cattleposts surrounding the village.

Table 5.4. Percentage ownership distribution by households of selected livestock in Chukumuchu and surrounding rangelands

Ownership Range		Study Location	
		Chukumuchu <i>n</i> =24	Cattleposts <i>n</i> =29
Cattle	0	16.7	13.8
	1-5	29.2	17.2
	6-10	12.5	17.2
	11-30	20.8	17.2
	More than 30	20.8	34.5
	Total	100	100
Goats	0	29.2	13.8
	1-5	20.8	10.3
	6-10	16.7	17.2
	More than 10	33.3	58.6
	Total	100	100
Chickens	0	29.2	17.2
	1-5	25.0	24.1
	6-10	33.3	24.1
	More than 10	12.5	34.5
	Total	100	100

Source: Fieldwork survey

Contemporary livestock production in the region often appeared to be mechanised and sedentary requiring very little labour at the cattlepost. The majority of livestock were raised at a series of permanent hand-dug wells situated along inter-dune valleys where ground water resources were within 10-15 metres of the surface. At almost every cattlepost encountered, at least one owner possessed a 2000 litre plastic water tank, petrol or diesel generator and electric water pump (Plate 5.1). All of this equipment can be purchased at hardware stores in Shakawe or Maun. For the remaining pastoralists water could be accessed either for free at a government borehole near the village; through formal payment to a principal well owner; through informal herding arrangements where access formed part of payment in kind; and finally at private wells operated by hand, using buckets lowered and raised on a winch system (for

those fortunate enough to be granted a permit by the Tswana land board and wealthy enough to afford the construction costs).

The mechanisation of hand-dug wells allowed many pastoralists owning larger herds the freedom to employ only one or two contract herders, thereby providing the herd patriarch the flexibility to migrate between the cattlepost and village or regional towns often in search of employment or other livelihood opportunities. As a result of this social organisation, Chukumuchu often had the impression of being dominated by female-headed households. Indeed, many of the households in Chukumuchu were *de jure* female-headed due to high divorce rates and those male-headed households operated bilateral household structures with members of the family (usually the eldest male member or herd patriarch) dividing their time between the village homestead and a second homestead near the family well and kraal. For example, out of 24 households questioned at the village, 13 were *de jure* female-headed and 11 were *de jure* male-headed. However, out of the 24 households questioned during the survey, 19 households were *de facto* female headed, as only 5 of the 11 male household heads were present at village homestead.



Plate 5.1. The mechanisation of cattlepost wells in the Chukumuchu rangelands typically consisting of a small electric water pump powered by a petrol or diesel generator which supplies water to a 2000 litre plastic storage tank

These findings, together with the higher level of non-resident household members on the cattleposts presented above, illustrate the cattlepost-centred livestock management system used in the study area. However, while pastoralism is an important component of regional livelihoods and almost all households are engaged in livestock production, the ownership of livestock was not equally distributed throughout the community.

Skewed distributions of livestock ownership are common within most pastoral societies and in Botswana inequality was normal even in pre-colonial times (Hinderink and Sterkenberg, 1987). Chapter 2 described how increased commercialisation and land privatisation exacerbated existing inequalities in Botswana's pastoral society. Observations from Chukumuchu illustrated the primary resources required to establish and manage a reasonable herd. Although households

living in the village benefited from additional employment opportunities and propinquity to services such as education and healthcare, village-based herders without access to cattleposts are limited in the amount of stock they can accumulate for a variety of reasons.

Maintaining access to extensive rangelands is of greater interest to middle and better-off herders, rather than poor households with low stock numbers who are more reliant on forage found around the settlement (Toulmin *et al.* 2004). This was the case in the Chukumuchu region as village-based herders with large herds (>30 head) must manage their livestock at cattleposts in order to access adequate grazing and water supplies. While smallstock can be kept in rangeland with little grazing, the cattle of village-based herders with over five head were generally in poor condition. In addition, many respondents cited the damage that cattle can cause to houses and fields as the main reason for needing to keep larger herds at cattleposts away from the village.

During the household livelihood survey additional questions were asked about livestock management and, in particular, the location of each household's watering point and kraal. Fifty per cent of those owning cattle in the village watered their stock at a government well on the edge of the village. These owners kept on average 4.4 head of cattle each and 66.7 per cent were Hambukushu households. In contrast, 46 per cent of village-based herders kept and watered their cattle at cattleposts in the rangelands surrounding the village; 81.8 per cent of these were Herero households with an average of 41.5 head of cattle. Livestock ownership was therefore strongly influenced by ethnicity with the larger herd owners predominantly of Herero origin. Table 5.5 below further illustrates the contrast in the livestock ownership for the different ethnic groups. Fifty per cent of the Herero households surveyed owned over 30 head of cattle and 61.5 per cent owned over ten head of goats. In contrast only 4.3

per cent of Hambukushu households owned over 30 head of cattle. This contrast was not surprising given that Herero are traditionally pastoralists, as opposed to the more agro-pastoral background of the Hambukushu.

Table 5.5. Percentage ownership distribution by households of selected livestock by ethnic group

	Ownership Range	Ethnic Group		
		BaHerero <i>n=26</i>	BaHambukushu <i>n=23</i>	Basarwa/Bayei <i>n=4</i>
Cattle	0	3.8	21.7	50.0
	1-5	19.2	30.4	25.0
	6-10	3.8	17.4	25.0
	11-30	23.1	26.1	0
	More than 30	50.0	4.3	0
	Total	100	100	100
Goats	0	11.5	26.1	25.0
	1-5	11.5	21.7	0
	6-10	15.4	17.4	25.0
	More than 10	61.5	34.8	50.0
	Total	100	100	100
Chickens	0	19.2	30.4	0
	1-5	15.4	30.4	50.0
	6-10	38.5	13.0	25.0
	More than 10	26.9	26.1	25.0
	Total	100	100	100

Source: Fieldwork survey

Livestock sales

Livestock are an important store of wealth and buffer against difficult times for rural households throughout sub-Saharan Africa (Ellis, 2000). Although livestock represent a less liquid form of savings when compared with cash, it can be traded for cash and converted into other forms of capital or into consumption (ibid: 34). In the Chukumuchu rangelands livestock trading is mainly an activity for the large stock owner with over 30 head of cattle (Table 5.6). In addition, of the 41.5 per cent of households who gained income from livestock sales only one household kept stock in

the village, with the majority owning and keeping livestock on cattleposts in the surrounding rangeland.

Table 5.6. Percentage of households gaining income from livestock sales within selected herd size ranges

Size of Herd	% of Households
0-5	13.6
6-10	4.5
11-30	27.3
More than 30	54.5
Total	100

Source: Fieldwork survey

Livestock have been exported on the hoof and by road from northwestern Ngamiland to countries in central Africa and Europe for nearly 100 years (Macmillian, 2005). Many of the older male pastoralists in the region described sales of livestock to the Ngamiland trading stores at Nxamasere and Shakawe during the 1950s, 60s and 70s. After this time the traders stopped buying livestock and cattle were trekked by farmers on horseback to the Makalamabedi quarantine camp where they were sold to the BMC. For a short period during the late 1970s cattle were trekked twice a year (January and June) to the Botswana Livestock Development Corporation (BLDC) ranch at Nokaneng. Following the CBPP cull in 1996 a quarantine camp was constructed adjoining the Samochima fence (Figure 4.1). As a result, livestock can now be sold at certain times of the year to the BMC through the Kgomokwane quarantine camp. Pastoralists also slaughter and market beef informally at community butchers run by the village development committees (VDCs) around central kraals in many of the larger villages and towns. In addition to this, livestock are continually slaughtered at a large butchery in the centre of Shakawe.

The price obtained for livestock varies considerably depending on the market chosen and the quality or size of animal sold. Most cattle fetch between 1000 and 3000 pula at the BMC although farmers must pay the costs incurred (i.e. trucking, quarantine, water, grazing fees) and livestock are only accepted at certain times of the year.² Most farmers questioned during both the household survey and interviews stated the BMC as their preferred market due to the larger quantities of stock which can be sold at one time and higher prices earned. However, many farmers complained about livestock loss from stress during transportation and high costs incurred, along with loss of livestock quality during quarantine.

Farmers who slaughter cattle themselves and sell the meat in villages or towns after gaining the relevant movement and slaughter permits make between 800 and 1800 pula per head (147 to 331 US\$). Although village slaughter earns pastoralists lower prices, these informal markets are available at any time which provides farmers with the flexibility to sell cattle one at a time to meet emergency household income needs. However, there are risks associated with village slaughter as only the largest villages can provide enough demand for meat to sell a whole animal and often meat is wasted. As one pastoralist stated, *'I don't slaughter at Chukumushu as the meat may not be sold as there are not enough people here to buy, I mainly sell to the BMC and at the community butchers in Shakawe, but even in Shakawe more than one person may slaughter in one day and then some of the meat will be wasted'*.³ All farmers surveyed stated that the lowest prices paid for livestock were at the butchery in Shakawe where cattle made between 500 and 1000 pula per head (92 to 184 US\$).

² Exchange rate 1.5.2006 1US\$=Pula 5.43

³ Interview with MS a male Mbukushu elder (Ch38 7.06)

Other livestock related products

Several households with access to livestock in close proximity to villages reported gaining additional income from the sale of dairy products. Milk could be taken to villages by female household members and sold for approximately five pula per litre (0.92 US\$). On average households could gain 200 pula per month from milk sales (37 US\$). Cooking oil can also be made from milk and sold to villagers. However, according to respondents income gained from these activities were occasional or seasonal depending on household subsistence needs and milk yields.

Arable production

According to Ellis and Mdoe (2003) remoteness to services and markets tends to be associated with high reliance on self-provisioning even at higher income levels. Arable production formed a significant livelihood activity for many households in the study area, with 60.4 per cent of the households surveyed owning arable land. However, household reliance on arable production was clearly higher for cattlepost households as 65.5 per cent of those surveyed owned fields as opposed to the 41.7 per cent level of field ownership for village-based households. Cattlepost fields were generally well fenced and weeded, while many fallow, poorly fenced fields could be observed in the village. All farmers surveyed practiced rain-fed cultivation of sorghum, millet and maize with many farmers (87.5%) also cultivating groundnuts, pumpkins, melons, beans and sugarcane. Fields were generally fenced with thorns and ploughed using oxen. Those without cattle plough with donkeys or cultivate small gardens by hand. In both study areas (NBF and CBPP) arable land is allocated to individual families and can be inherited, although no land can be bought or sold. Most

land in the region is classified as communal ‘tribal’ land and prior to the Tribal Land Act of 1968 all land was administered by local chiefs. Since 1970, however, district land boards allocate new land and register pre-existing land claims. Although remaining rangeland is communal, the land board effectively control access by governing the allocation of well permits. The ownership of land differed considerably between ethnic groups with far fewer of the traditionally purely pastoral Herero households owning land and cultivating (Table 5.7).

Table 5.7. Percentage ownership of arable land by households of differing ethnicity

Ownership of Arable Land	Ethnic Group		
	BaHerero <i>n</i> =26	BaHambukushu <i>n</i> =23	Basarwa/Bayei <i>n</i> =4
Yes	34.6	83.6	100
No	65.4	17.4	0
Total	100	100	100

Source: Fieldwork survey

According to local informants, in the past, the amount of Herero households owning and cultivating land was even lower and many exchanged livestock and dairy products for cereals and vegetables. These findings support other relevant sources concerning changes to the Herero livelihoods in Ngamiland (section 4.3).

Crop and beer sales

Only one household gained income from the sale of crops, although several households (5.7%) exchanged surplus crops for livestock and other goods. However, a larger number of households (17%) from both the cattleposts and village brewed beer from surplus crops. All brewing households residing in the village gained cash income from beer sales to drought relief workers, selling cups of beer in 50 thebe, one pula

and two pula sizes and making between 100 and 200 pula per month (18 to 36 US\$ per month). In contrast, households who brewed beer on the cattleposts generally brewed for their own consumption or to attract labour.

5.2.3 Livelihoods based on natural resource use

Natural resource gathering and hunting

Veld product gathering forms part of the natural resource based livelihoods of most households, with 94 per cent surveyed gathering for food and building materials. Gathering was generally conducted for fuelwood, building material, craft and tool making, beer production and partly for subsistence food. Table 5.8 lists some of the most commonly cited species gathered or harvested, along with their primary use (i.e. food or material). Most gathering is conducted by females who often gather in groups. Men primarily gather wood for fuel, construction or tool making.

Today, natural resources are mostly gathered for commercial purposes. Gathered natural resources can be used to make baskets, mats and jewellery which can be sold within the booming tourist industry in Ngamiland. Thatching grass can also be gathered and sold in the village and the berries of *Grewia bicolor* can be gathered and used to make *Kgadi* beer which is often sold in the village.

Table 5.8. Some of most frequently cited plants and trees gathered and utilised by households surveyed in Chukumuchu and at surrounding cattleposts. The main use of the resource, division of labour in gathering, frequency and seasonality of gathering are included in the table. (Note: medicinal plants are not included)

Species	Tswana name	English name	Part of plant utilised	Purpose	Frequency of gathering	Seasonality	Division of labour
<i>Guibourtia coleosperma</i>	Tsoadi	Large false mopane	Seed	Food	Frequent	May-Jul	F
<i>Grewia bicolor</i>	Mogwana	Bastard brandy bush	Fruit	Food/beer	Frequent	Jan-Apr	F
<i>Grewia flavescens</i>	Mogkomphatha	Sandpaper Rasin	Fruit	Food	Occasional	Jan-Apr	F
<i>Grewia flava</i>	Moretlwa	Brandy bush	Fruit	Food	Occasional	Jan-Apr	F
<i>Dialium englerianum</i>	Muhamana	Kalahari podberry	Seed	Food	Occasional	Jul-Oct	F
<i>Annona senegalensis</i>	Mokamanowa	Custard apple	Seed	Food	Occasional	Dec-Mar	F
<i>Ricinodendron rantanenii</i>	Mongongo	Manketti tree	Seed	Food	Frequent	Perennial	F
<i>Strychnos sp.</i>	Mogorogoro	Monkey orange	Fruit	Food	Occasional	Jun-Aug	F
<i>Berchemia discolor</i>	Motsintsela	Bird plum	Fruit	Food	Occasional	Jan-Jul	F
<i>Bauhinia petersiana</i>	Mojope/Mokoshi	Kalahari bauhinia	Root	Food	Occasional	Jan-Apr	F
<i>Cymbopogon sp.</i>	Mokamakama	Turpentine grass	Grass	Thatching	Frequent	Perennial	F
<i>Hyphaene petersiana</i>	Mokola	Silver Real fan palm	Leaves	Baskets	Occasional	Perennial	F
<i>Terminalia sericea</i>	Mogonono	Silver terminalia	Wood	Carving	Frequent	Perennial	M
<i>Pterocarpus angolensis</i>	Mokwa	Kiaat	Wood	Carving	Frequent	Perennial	M

Datasource: Fieldwork questionnaire, interviews and relevant published sources (e.g. Palgrave, 1981; Setshogo and Venter, 2003).

Traditionally, women have always made baskets in the Okavango region for agricultural and household uses (Mbaiwa, 2004). The Ngamiland trade in baskets was developed during the early 1970s in Gumare and Etsha (Botswanacraft est. 1973) as an income earning activity for Hambukushu refugees (Bishop and Scoones, 1991, Perkins, 1999). Commercial basket making is a relatively recent livelihood activity for households in the Chukumuchu region, however, and a group of female basket weavers were established in 2004 with the assistance of the local Rural Area Development Programme (RADP) officer. The opportunities for marketing such rural crafts locally were recently significantly improved following the construction of a calcrete road between Nxamasere and Tsodilo village. Nowadays the site attracts approximately 3-4000 visitors per year, and, although numbers are highly seasonal, during peak periods women can often be seen selling locally made crafts to tourists at the entrance gate to the Tsodilo Hills (Plate 5.2).



Plate 5.2. Ju/'hoansi woman selling handmade necklaces to tourists at the Tsodilo Hills gate.
(Source: Fieldwork)

In total 28.3 per cent of the households surveyed made and sold either baskets, mats or jewellery. Table 5.9 below presents the percentage number of households from each ethnic group who gain income from selected natural resource-based crafts or products. Hambukushu households weaved mats and baskets while the Ju/'hoansi generally make jewellery from ostrich shells and dried seeds. Craft products were sold to government workers or primary school teachers, or directly to passing tourists at the Tsodilo site (Plate 5.2). Additional household income was also gained by village-based Herero and Hambukushu women who collect bundles of thatching grass and sell them to villagers for 5 pula per bundle (0.92 US\$).

Table 5.9. Percentage of households of different ethnicity gaining income from selected products derived from gathered natural resources.

Rural NR-based Craft Made and Sold:	Ethnic Group		
	Herero <i>n</i>=26	Hambukushu <i>n</i>=23	Basarwa/Baye <i>n</i>=4
Baskets/Mat	0	52.1	0
Necklace	0	0	75.0
Other Natural Resource Sold:			
Grass Bundles	11.5	26.1	0

Source: Fieldwork survey

It is likely that the subsistence use of natural resources for many households declined long before people settled around the village of Chukumuchu in 1991. SS, a Mbukushu woman from Chukumuchu in her fifties coped with food shortages during the early 1980s drought at Xaudum by using income gained from thatching grass sales to buy maize meal from Shakawe. During an interview discussing changes to regional gathering she added, *“Now that we can buy rice, macaroni and mayonnaise at the village shop we don’t gather for food as there is enough to eat (Ch9 10.05)”*.

Since the early 1980s people in the region have received food handouts from the government, causing further declines in the need to conduct subsistence gathering

(Lee, 1984). Monthly food rations are delivered to the elderly and orphaned children, and drought relief rations are widely available after drought conditions are declared. Lee (1984) noted that in 1964 subsistence hunting and gathering by Ju/'hoansi groups in the region accounted for 85 per cent of their calories, yet by the early 1990s this had decreased to 30 per cent. Although gathering for subsistence food may have declined, cattlepost households appeared more reliant on this form of gathering than village based households who had access to potential income earning opportunities in the village. MR an elderly Mbukushu man living with his elderly wife and daughter's family at the Nxamazine cattlepost explained that he was reliant on government food rations but complained that these were often late in arriving and not enough to meet his family's subsistence food requirements. As a result, MR's wife and daughter regularly conduct gathering trips, particularly collecting and valuing the nutritious, drought resistant nut of the *Mongongo* tree (*Ricinodendron rantanenii*).⁴

While village-based households may have greater access to markets for their gathered produce and shops to supplement their food requirements, there were certain advantages to life at the cattlepost. In general, cattlepost households were closer to their natural resources with many able to gather edible fruits and nuts within a few hundred meters of their homesteads. Figure 5.1 compares a typical natural resource map for a female gatherer from Chukumuchu, with that of a female from a cattlepost household, including approximate returns times on foot or donkey from the main resources gathered. Cattlepost households were often able to access *Grewia sp.* and *Strychnos sp.* within 30 minutes return walk of their homesteads. Many also lived close to *Ricinodendron rantanenii* trees. However, often the best groves were found within one hours return walk of the main homestead. Village-based households, on the other hand, travel up to two hours walk to find viable gathering sites for most

⁴ Interview with MR and his family (Ch12 10.05).

species. The closest species available to villagers were *Grewia sp.* which could be found within an hours return walk of the settlement. One advantage of being a village based gatherer was access to the *Mokola* palm for basket making which was facilitated by the RADP officer who organised transport to collect the palm from Marunga cattlepost.

The diversity of species gathered was greater than those listed in Table 5.8 for several independent Ju/'hoansi households living at Xabacha 1. Lee (1984) noted that in the past the Ju/'hoansi gathered a large diversity of 105 species of edible plants (14 fruits and nuts, 15 berries, 18 species of edible gum, 41 edible roots and bulbs, 17 leafy greens, beans or melons). Like most households the Ju/'hoansi regularly gathered the nuts of the superabundant, drought resistant and highly nutritious *Ricinodendron rantanenii*. Similarly they also gather the seasonally available fruit and nuts of *Guibortia coleosperma*, *Strychnos sp.*, *Dialium englerianum*, *Bauhinia petersiana*, *Grewia sp.*, *Annona senegalensis*, *Berchemia discolor*. However, they also continue to gather various gums (principally *Acacia* species), along with several different melons, roots and tubers.

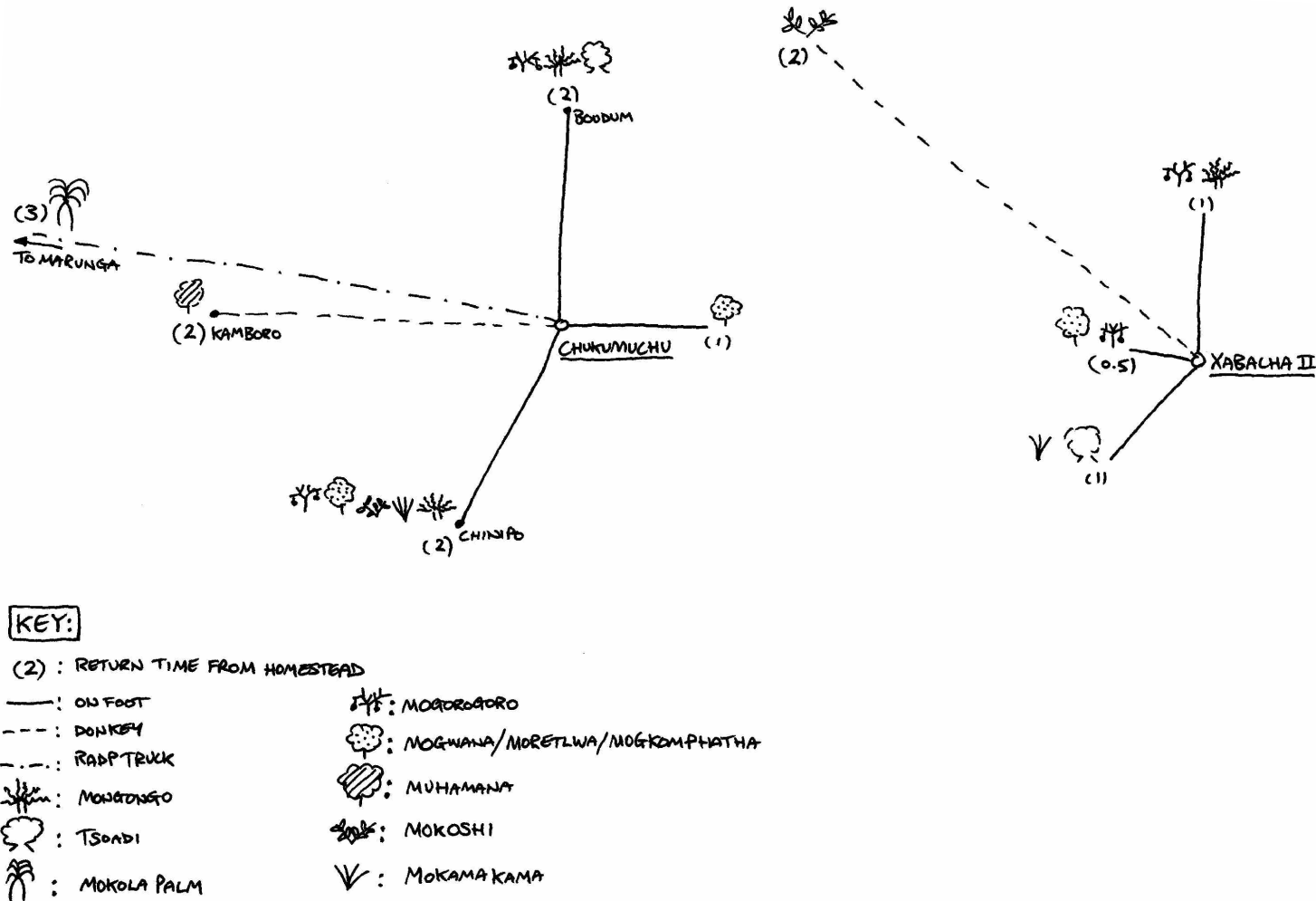


Figure 5.1. Typical natural resource map of female gatherer from Chukumuchu compared with a female gatherer from the Xabacha 2 cattlepost.

Ju/'hoansi hunting

While most households gathered some natural resources for commercial and subsistence purposes, a further nine per cent of households engage in hunting small game such as spring hares, guineafowl and ostrich, either on foot or horseback. These were mainly Ju/'hoansi men living as permanently employed herdsman or as independent farmer/foraging households at the Xabacha 1 cattlepost. Men also gather honey while on such trips. Additional questions were asked during the main survey regarding the distances travelled on hunting and gathering trips. The region does not have the same historical background of hunting restriction experienced by NBF communities which meant hunters were not afraid to discuss their activities. Few hunters questioned travel more than 10-15km from their homestead to gather and hunt, indicating that, on the whole, hunting is localised to areas within the veterinary fences. However, several men hunt further afield using horses or donkeys and the impact of enclosure on these activities and the wildlife populations on which they depend are presented alongside the hunting issues raised in the NBF site (Chapter 7).

5.3 The NBF Communities: Beetsha and Gudigwa

The second fieldsite focussed on the NBF (c. 1991) and villages of Beetsha and Gudigwa in the northern sandveld region (Map 5.2). The villages are two of the most remote in Botswana, located 150km southeast of Shakawe. Access by the rough Mohembo-Seronga-Gudigwa calcrete road is gained after crossing the Okavango River near Shakawe on a government ferry service. A sand road used principally by the Botswana Defence Force (BDF) and Department of Wildlife and National Parks (DWNP) also extends to the east of Gudigwa to Kwai. However, most land to the east

of the NBF is leased to consumptive and non-consumptive tourism operators and therefore access is treated with suspicion. The preliminary survey mostly focussed on the villages as few households remain permanently at cattleposts. However, two households were surveyed at the Dishokora cattlepost 70km to the north of Gudigwa. Interviews and environmental surveys were conducted at most cattleposts during the main part of the study (Chapters 7 and 8).

In 2001 the study villages of Beetsha and Gudigwa had populations of 760 and 732 respectively (CSO, 2001). The villages have distinctively different household and community demographics with the majority of households living in Beetsha of Hambukushu origin, while the residents of Gudigwa are predominantly of Basarwa⁵ origin. In the largest village Beetsha there were a small number of Basarwa and Bakalagadi⁶ households, and there were one or two intermarried households in both villages. The distinct ethnic division between the two settlements could be explained by the reluctance of many Basarwa in the past to live amongst the Hambukushu for fear of subjugation. For example, one Basarwa man explained why his family had moved from near Beetsha to deeper into the dry sandveld north of Gudigwa in the 1950s, *'we moved because we didn't want to mix with the Hambukushu, they were trying to make slaves of us'*.⁷ During the livelihood survey a total of 30 and 32 households were questioned from Beetsha and Gudigwa respectively (Table 5.10).

⁵ Two sub-groups of Khwe speaking Basarwa are present in the northern sandveld: Bugakhwe and AniiKhwe

⁶ A sub-group of the Batswana originating from western Botswana

⁷ Interview with MK (G10 7.05)

Table 5.10. Total number of households surveyed from each ethnic group in northern Okavango study villages.

Ethnic Group	Beetsha	Gudigwa
Hambukushu	25	0
Basarwa	3	32
Bakalagadi	2	0
Total	30	32

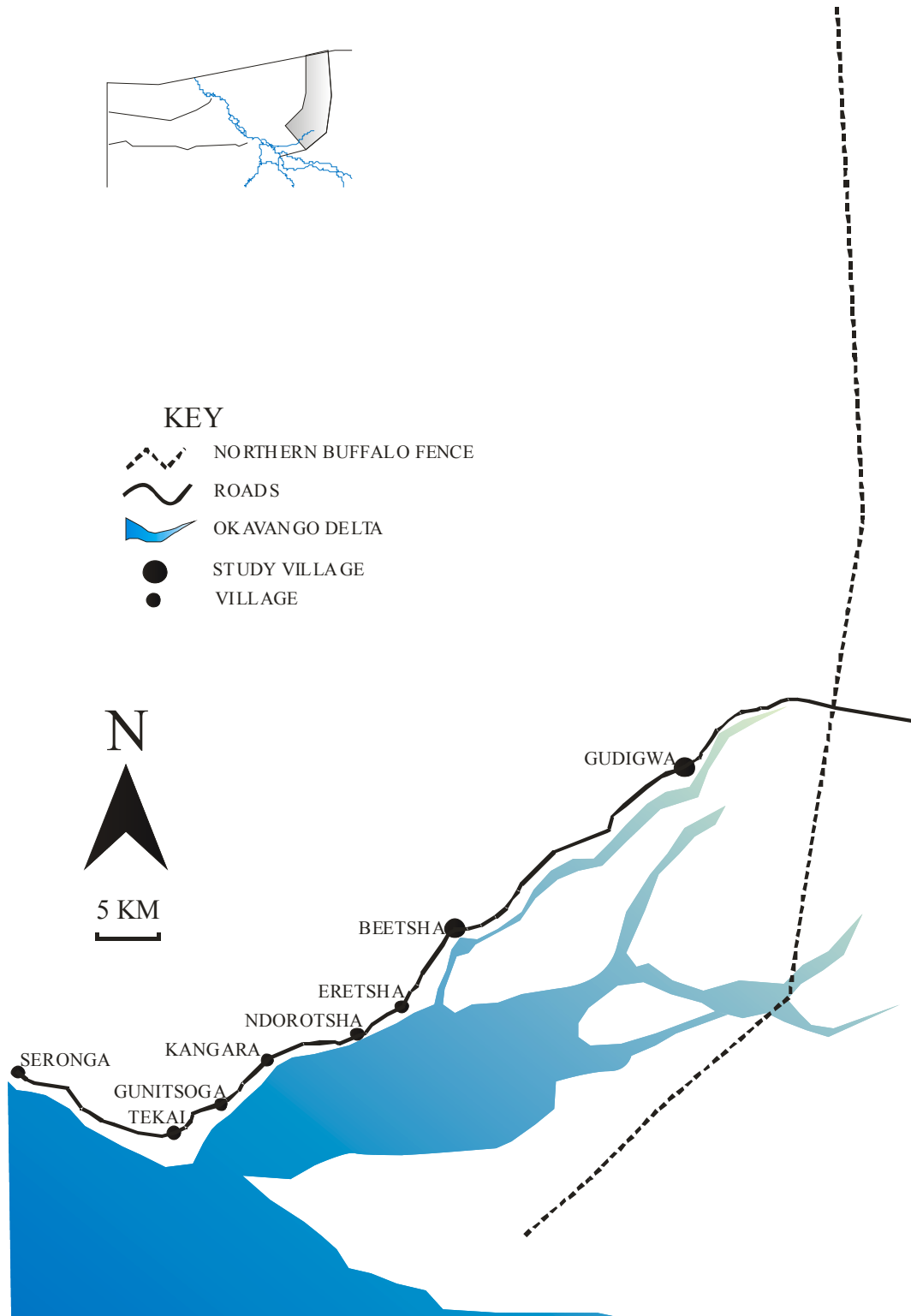
Source: Fieldwork survey

Present settlement and community demography

The mean resident household size for Beetsha was higher than Gudigwa with on average fourteen resident members per household in Beetsha and nine resident household members in Gudigwa. Beetsha households ranged in size from a female headed household and her four primary school aged children to a large household of over 20 members including extended family. The higher resident household sizes in Beetsha could be explained by the agro-pastoral origins of the Hambukushu requiring large amounts of labour for herding and arable production. In contrast, Gudigwa households ranged from a female headed household and her children to an extended family household with over 15 members.

The non-resident component of Beetsha's Hambukushu households was slightly higher with an average of three members per household. In Gudigwa, this figure was an average of two persons per household and this could be explained by the higher educational attainment of Hambukushu households in Beetsha. The most lucrative permanent employment in the northern Okavango Delta's tourism industry require high levels of education and fluency in English, and only recently have a few Basarwa been able to overcome these obstacles (Taylor, 2002). The higher level of non-resident household members in Beetsha could be explained by the higher number of

Hambukushu attending regional secondary schools or working in the tourism industry (section 5.3).



Map 5.2. Northern Buffalo Fence study area and villages.

5.3.1 Off Farm Income in Beetsha and Gudigwa

Formal and informal cash income sources

Though most households, particularly in Beetsha, have family members engaged in formal employment (primarily the tourism industry), few can rely on regular remittance payments due to the remoteness of the region and lack of regular transport. Most people are therefore heavily reliant on income generating opportunities from within the area. Opportunities for formal employment within Beetsha and Gudigwa are limited to several positions offered within the various government facilities, such as night watchmen or cleaners at the clinic or school. Sporadic unskilled employment can also be gained within the government sponsored Labour-Based Drought Relief Programme (DRP).⁸ Members from most households surveyed (73%) in both villages had gained income from DRP labour at regular intervals. Other than this, the main formal employer is the tourism sector through the various community-tourism joint ventures and associated lodges and camps in the region. Most of these lodges and camps are situated within community concession areas in the permanently flooded swamps to the southeast of the NBF (see areas NG22 and NG23 on Map 7.2, page 281). As described in section 5.3 above, access to permanent employment within the tourism sector is closely governed by educational attainment. During the survey far more Hambukushu households (20%) in Beetsha had family members employed in the lodges in NG22 and NG23 than those in Gudigwa (9%). According to Taylor (2000) in 1999 twenty Gudigwa residents were employed in the lodges in NG22 and

⁸ The Labour-Based Drought Relief Programme is often one of the main forms of waged work for unskilled people in rural areas and is available only when central government declares drought conditions. As such it may not run year round, nor on consecutive years.

NG23 (Taylor, 2000). Many of the poorest households in both Gudigwa and Beetsha are, therefore, sceptical of tourism and claim that the employment process is bias towards wealthier households.

However, opportunities for community-based natural resource management (CBNRM) to benefit the wider community were improved with the development of both formal and informal employment within several community lodges and cultural camps in the community concession area of NG12, between the NBF and Beetsha and Gudigwa. For example, in March 2003, the Gudigwa cultural camp was established offering employment for eighteen full-time members of staff along with twenty-nine part-time positions such as tribal dancers and craft makers (Mbaiwa and Rantsundu, 2004). Both temporary and full-time employment opportunities are also available within the Okavango Conservation Trust (OCT), which was established to represent the interests of northern Okavango Delta communities within the various CBNRM activities. Board members of the OCT are paid on a regular basis to attend meetings and courses, while both full and part-time employment can be gained as shop attendants or truck loaders at OCT run stores in both Beetsha and Gudigwa. A limited number of people also gain full-time employment as shop attendants in several village tuck shops established either by local entrepreneurs or by government employees such as teachers or veterinary officers.

An estimated 22 per cent of households from Gudigwa and 23 per cent of households in Beetsha gain income from family members working in formal employment. The majority of households are therefore reliant on income generated from informal earning opportunities. These involved a large range of activities including: beer sales, house building, brick making, tool making, carpentry, craft sales and hired labour. Most households engage in a diverse portfolio of informal income activities with male household members engaging in carpentry, tool making, house building and brick

making, while females tend to brew beer, make crafts and clear land or harvest crops for payment in cash or in-kind. Table 5.11 below compares the incomes generated from both formal and informal sources. As the figures show, formal employment incomes are far higher than those from informal sources, illustrating the need for poorer households to diversify activities in order to meet their income requirements.

Table 5.11. Details of incomes gained from main formal and informal income sources other than tourism in Beetsa and Gudigwa. (Exchange rate 1.5.2006 1US\$=Pula 5.43)

Income source		Wage per month (Pula)
Formal	Night watchman	700
	Driver	700
	DAHP Fence Repair	700
	Cleaner	600
	DRP	200/300
	Shop assistant	500
Informal	Farm labour	100/200
	Beer sales	250
	Craft sales	120/30
	Carpentry	150/200
	Tool making	150/200
	House building	150/200
	Brick making	150/200

Source: Fieldwork survey

Livestock production

Today, livestock are important assets for the people of Beetsa and Gudigwa. Section 4.3 described how livestock ownership became more widespread amongst the Hambukushu after the tsetse fly eradication. For Basarwa at Gudigwa livestock ownership remained limited until the settlement was established under the RADP and a council livestock scheme was initiated in the 1990s. To qualify for livestock, households have to be classed as stockless remote area dwellers and Botswana citizens. In Gudigwa, several households who migrated to Namibia to find work or

avoid hunting restrictions have since returned to live in the village. These families complained about not having a citizen's identification card or *Omang* which is needed to register for the livestock scheme. That said most households with *Omang* were eligible for the scheme.

Table 5.12 below shows the percentage ownership of selected livestock by households surveyed in both villages. The data show that more than half of the Basarwa households surveyed owned between six to thirty head of cattle. In contrast the data from Beetsha indicated that fewer households own a small herd of six to 30 cattle, with over 60 per cent owning less than five head of cattle. Smallstock ownership is generally low amongst the people of Gudigwa with over 60 per cent owning no smallstock. These figures are the result of the livestock development scheme in Gudigwa favouring the acculturation of Basarwa into mixed agropastoral livelihoods.

Table 5.12. Percentage ownership of selected livestock by households resident in either Beetsha or Gudigwa.

	Ownership Range	Study Village	
		Beetsha <i>n</i> =30	Gudigwa <i>n</i> =32
Cattle	0	30.0	34.4
	1-5	37.7	6.3
	6-30	30.0	56.3
	More than 30	3.3	3.1
	Total	100	100
Goats	0	20.0	66.6
	1-5	30.0	13.5
	6-10	13.3	6.3
	More than 10	37.7	16.6
	Total	100	100
Chickens	0	13.3	41.6
	1-5	10.0	6.3
	6-10	40.0	22.9
	More than 10	37.7	31.3
	Total	100	100

Source: Fieldwork survey

Arable farming

Arable farming is an important livelihood strategy for many households living along the northern fringes of the Okavango Delta. However, arable farming appeared to be of greater significance to the livelihoods of households in the predominantly Hambukushu village of Beetsha, as opposed to the Basarwa households of Gudigwa. This is partly reflected in the land ownership statistics with all of the households questioned in Beetsha owning and ploughing fields, while only eighty-one per cent of those surveyed in Gudigwa own arable land. Taylor (2002) noted that, although many Basarwa of the northern sandveld own fields, only a small portion are generally planted and the yields are generally low, which he attributes to the quality of food handouts, erratic rainfall and wildlife damage. However, while 37.5 per cent of households surveyed in Gudigwa received food rations from the government, half of all households in the Beetsha survey received food handouts indicating that there could be other reasons for the lower participation in arable agriculture.

Closer observations of the nature of arable production and in particular the division of household farm labour in the two villages revealed the cause of the apparent lower level of arable production in Gudigwa. Households division of labour for arable production was such that men and young boys tend to plough while women generally harvest and thresh the crop. The Hambukushu of Ngamiland are known primarily as an agricultural group who also raise cattle and participate in hunting, gathering and fishing (Larson, 1970). As a result Hambukushu social organisation is centred on providing labour for their arable production with extended families cooperating to clear, till, sow and harvest their shared land which is reflected in the far higher

household sizes in Beetsha.⁹ In contrast, the Basarwa households in Gudigwa tended to be far smaller and therefore many lacked the high levels of labour required to participate in arable production. This said, arable production in Gudigwa was generally conducted by land owners cooperatively sharing labour during harvesting. At this time, households without land or the required labour were able to help with the harvest on a number of large arable fields in return for a share of the yield. Fields in both areas are generally fenced with thorns and ploughed using oxen or donkeys. Most farmers plant crops of maize, sorghum, millet, groundnuts, beans, melons and pumpkins, although several also plant small crops of sugarcane. In addition to this, several households grow a variety of vegetables in small hand irrigated gardens on the banks of seasonally flooded channels.

5.3.2 Livelihoods based on natural resource use

Natural resource gathering

The household survey results indicated that participation in natural resource gathering among the study communities is high with only one household from either village claiming not to gather for subsistence or housing materials. Gathering of veld products is generally conducted for firewood, building materials, craft and tool making materials and for subsistence food to supplement food handouts or arable produce. People also gather from plants and trees for medicinal purposes and for trading. Household divisions of labour over gathering resources are generally clearly defined with men collecting firewood, tool and woodworking material and poles for building and fencing either on foot or using donkey carts or oxen sledges. Women also collect firewood along with thatching grass, palm leaves and wild fruits or seeds

⁹ Source: fieldwork personal observations and interviews with Beetsha Mbukushu households.

for household consumption, beer and basket making. Men often assist the women by providing draught power (oxen and sledge) to bring heavy loads of gathered produce to the homestead (i.e. firewood/thatching grass). During interviews men spoke of opportunistically gathering a variety of wild foods while herding, hunting or fishing but this was generally for immediate consumption.

Table 5.13 below lists some of the most frequently cited natural resources gathered by households for beer brewing, thatching, subsistence food, and craft or tool making. The table also shows the part of plant utilised, frequency of use, seasonality of gathering, division of labour and dominant habitat where each resource is found. Most resources gathered are within the dry sandveld to the north of Gudigwa and Beetsha. All of the seasonally and permanently flooded Delta channels and dry island habitats were located to the south of both villages and the channels south of Gudigwa may only flood in good years.

Table 5.13. Some most frequently cited plants and trees gathered and utilised by households surveyed in Beetsha and Gudigwa. The main use of the resource, drought response, division of labour in gathering, dominant habitat, frequency and seasonality of gathering are included in the table. (Note: medicinal plants are not included)

Species	Tswana name	English name	Part of plant utilised	Purpose	Frequency of gathering	Seasonality	Division of labour	Dominant habitat
<i>Guibourtia coleosperma</i>	Tsoadi	Large false mopane	Seed	Food	Frequent	May-Jul	F	Sandveld
<i>Grewia bicolor</i>	Mogwana	Bastard brandy bush	Fruit	Food/beer	Frequent	Jan-Apr	F	Sandveld/Delta
<i>Grewia flavescens</i>	Mogkomphatha	Sandpaper Rasin	Fruit	Food	Occasional	Jan-Apr	F	Sandveld/Delta
<i>Grewia flava</i>	Moretlwa	Brandy bush Kalahari	Fruit	Food	Occasional	Jan-Apr	F	Sandveld/Delta
<i>Dialium englerianum</i>	Muhamana	podberry	Seed	Food	Occasional	Jul-Oct	F	Sandveld
<i>Annona senegalensis</i>	Mokamanowa	Custard apple	Seed	Food	Occasional	Dec-Mar	F	Sandveld
<i>Ricinodendron rontanenii</i>	Mongongo	Manketti tree	Seed Fruit/	Food	Occasional	Perennial	F	Sandveld
<i>Sclerocarya birrea</i>	Morula	Marula	Seed	Food	Occasional	Feb-Jun	F	Delta
<i>Diospyros mespiliformis</i>	Mokutshumo	Jackal berry Monkey	Fruit	Food	Occasional	Apr-Sep	F	Delta
<i>Strychnos sp.</i>	Mogorogoro	orange	Fruit	Food	Occasional	Jun-Aug	F	Sandveld
<i>Berchemia discolor</i>	Motsintela	Bird plum Kalahari	Fruit	Food	Occasional	Jan-Jul	F	Sandveld
<i>Bauhinia petersiana</i>	Mojope/Mokoshi	baubinia Turpentine	Root	Food	Occasional	Jan-Apr	F	Sandveld
<i>Cymbopogon sp.</i>	Mokamakama	grass	Grass	Thatching	Frequent	Perennial	F	Delta
<i>Hyphaene petersiana</i>	Mokola	Real fan palm Silver	Leaves	Baskets	Occasional	Perennial	F	Delta
<i>Terminalia sericea</i>	Mogonono	terminalia	Wood	Carving	Frequent	Perennial	M	Sandveld/Delta
<i>Baikiaea plurijuga</i>	Mukusi	Zambezi teak	Wood	Carving	Occasional	Perennial	M	Sandveld
<i>Pterocarpus angolensis</i>	Mokwa	Kiaat	Wood	Carving	Frequent	Perennial	M	Sandveld

Datasource: Fieldwork questionnaire, interviews and relevant published sources (e.g. Palgrave, 1981; Setshogo and Venter, 2003).

For men, the main resource gathered is wood for carving and tool making. Larson (1970: 36) noted that Hambukushu men were ‘skilled craftsmen’ and ‘proficient blacksmiths’ producing a variety of different carved objects, from dug out *Mokoro* canoes to sledges and tool handles, while forging metal into spear heads, knives and axes. This is evident today as men from both Gudigwa and Beetsha engage in tool making and carving. Few men leave home to herd cattle without an axe, the blade of which is made from an old vehicle spring and the handle from a young *Terminalia sericea* bush. During herding men search for suitable trees and bushes to make new axe or hoe handles and occasionally new canoes, oxen sledges or ploughing yolks.¹⁰ While almost all men are able to carve tool handles, canoes and sledges for their own use; a few carpenters or blacksmiths are specialised in producing a variety of products for sale at an average price of P175 for doors, P50 for chairs, P100 for hoes, P50 to P100 for axes and P30 for knives and spears. For carpenters the wood of the *Mokwa* tree (*Pterocarpus angolensis*) is most important and men travel for several hours into the dry sandveld to the north of Beetsha or Gudigwa to find a mature specimen.

For women most gathering in Beetsha and Gudigwa is commercially motivated. First, *Grewia bicolor* is seasonally gathered (Jan-April) to produce *Kgadi* beer for sale in the village. At all other times Sorghum beer is produced. Second, most Mbukushu, Bakgalagadi and Bayei women make baskets and mats to sell in the local lodges and concession areas. For Basarwa this activity is a relatively new livelihood strategy, as a basket making group was only recently established by an International NGO to supply

¹⁰ A V-shaped trunk can be carved into a sledge which is dragged by oxen to haul wood and crops along many of the sandy tracks in the northern sandveld. Old canoes could be used in similar way or as water troughs for cattle. See appendix for example.

the village cultural camp. In Gudigwa, gathering of the *Mokola* palm is often facilitated by the NGO who organise transport to collect the palm leaves.

Another potentially lucrative natural resource is the thatching grass *Mokamakama* (*Cymbopogon sp.*). Thatching grass can be sold to local lodges and to other households in the village. Most people suggested that there has been a widespread decline of the grass in areas close to the villages. Whether this was caused by increased disturbance by livestock or over-utilisation it is unclear. However, the decline could instead be linked to a lack of utilisation or disturbance. Some women, for example, suggest fire suppression as the likely cause, due to the need for burning to remove dead and senescent material. Gathering and transporting thatching grass is notoriously hard work as grass must be cleaned, bundled and then transported by the bundle on foot (Perkins, 1999). Some women gather grass near cattleposts and access roads and hire the OCT truck, passing government vehicles, local vehicle owners or livestock farmers with oxen and sledges to transport grass back to the settlements.

In the northern sandveld, the quantity and diversity of gathered food has declined following increases in the volume of food handouts from the government (Taylor, 2002). As described in Chapter 4, increases in arable production following widespread access to oxen for ploughing may have also reduced the need for subsistence gathering. Natural resource mapping and interviews with both male and female household members confirmed that gathering for subsistence food was low (Figure 5.6).

Today, the most commonly gathered wild food is the seeds of the *Tsaodi* tree (*Guibourtia coleosperma*) (Plate 5.3). *Tsaodi* trees are numerous in Beetsha and many Hambukushu households deliberately construct their homesteads around mature specimens to benefit

from the shade and seeds produced. In Gudigwa informants refer to the food produced by boiling the seeds as ‘bushman tomato sauce’ and, although the trees were less obvious in the village, the species is present within a short distance from the village in the surrounding dry sandveld. While this resource can be accessed in close proximity to the villages, these trees are quickly exhausted and local women make special trips to *Tsoadi* trees found within the sandy veld to the north of both settlements (Figure 5.2).

The only other natural resource still gathered for subsistence food are the fruits of the *Mokutshumo* (*Diospyros mespiliformis*) or *Morula* (*Sclerocarya birrea*) trees. The fruits of these trees have been utilised by the Hambukushu for many years and females still seasonally travel to mature specimens found near perennial Delta channels to the south of Beetsha. Gudigwa households rarely gather *Mokutshumo* (*Diospyros mespiliformis*) or *Morula* (*Sclerocarya birrea*) as they lack access to the perennial channels found to the south of Beetsha.

All other resource gathering is commercially orientated. The furthest resource collected for commercial purposes is the *Mokola* palm (*Hyphaene petersiana*) which can be found within clay-rich termitaria delta islands to the south of the villages. Women in Gudigwa have to travel further to find the palms, through these trips are often made with a vehicle.

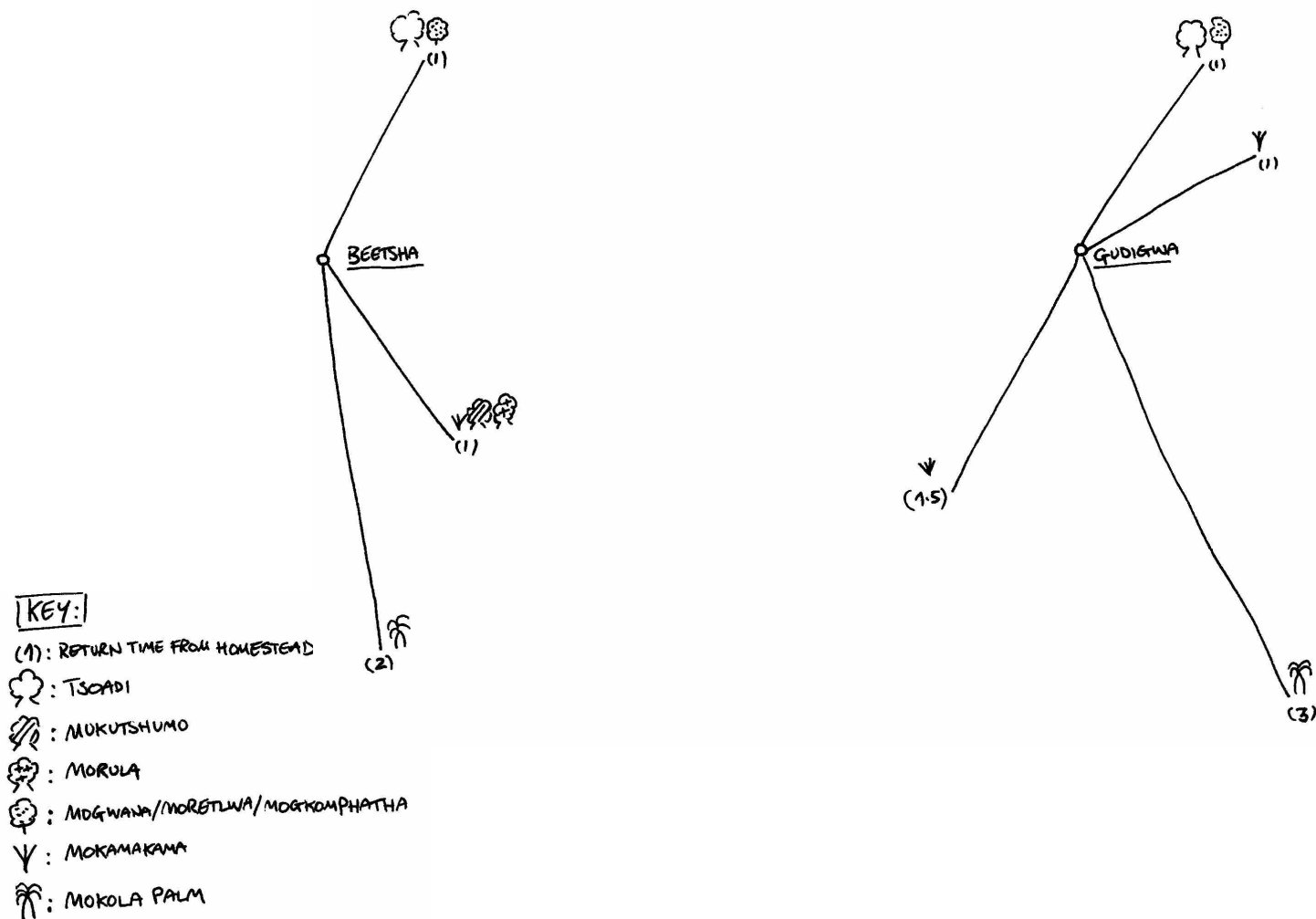


Figure 5.2. Typical natural resource map of female gatherer from Beetsa and Gudigwa.



Plate 5.3. The seeds of the False Mopane tree (*Guibourtia coleosperma*).

Contemporary natural resource gathering therefore appears to be localised to resources within a few hours walk of the settlements. While men travel further to locate suitable wood for carving, most trips are three to four hours to the north of the settlements. In Chapter 4 the longer-term stability of livelihoods based on wildlife and natural resource gathering and fishing emerged given the intermittent collapse of agriculture in the region. During discussions concerning changes natural resource gathering, both male and female gatherers were asked to recount their gathering response after the last shock (drought, disease outbreak) caused poor crop yields and the household faced a subsistence food shortage. Many households recounted their experiences after the CBPP cull in 1996. While most relied on government food rations and income from intensive labour

programmes to buy food, many also gathered wild fruits such as *Tsaodi*, indicating that the diversity of gathered resources for subsistence use may increase during times of need. However, most also supplemented their diets with food purchased using earnings from commercial gathering practices (thatching grass sales, basket making etc.).

Hunting and fishing

These days hunting for subsistence or commercial purposes is illegal and severely restricted in the northern sandveld. Chapter 4 detailed the rigorous enforcement of hunting restrictions experienced in the northern sandveld resulting in legacy of mistrust in the community. Although both subsistence and commercial hunting continue to be conducted by men in the region (Taylor, 2000), these activities are conducted in secrecy. Some men, however, were not afraid to speak about contemporary hunting activities and the impact of enclosure on these activities is explored in Chapter 7.

Another dispersed natural resource use conducted by both men and women is fishing. Women generally collect fish using simple fish traps in shallow drying delta channels, often within a few hours walk of the settlements. Men, on the other hand, travel further afield and fish using nets and *Mokoro* dug outs. According to local fishermen the perennial channels three hours walk to the south of Beetscha are the best places to fish. During the annual delta flood these areas can be accessed using canoe. Gudigwa households are restricted in that they lack perennial channels close to the village. Fishing is regulated by a permit system.

5.4 Conclusion

In summary, the households of Chukumuchu village and surrounding cattleposts rely on access to range of resources in order to make a living. The availability of non-farm income generating opportunities within the region is limited, with access restricted to village-based households or those cattlepost households willing to visit the village to gain informal temporary employment. Pastoralism is clearly the mainstay of the region's economy, with a long history of commercialisation recently further enhanced by the construction of a local quarantine camp adjacent to the Samochima fence. Livestock production appeared sedentary with low labour demands facilitated by investment in well mechanisation. Access to rangeland water and grazing is essential for establishing a significant herd of cattle, and village based households were clearly disadvantaged in this regard. The impact of enclosure on these livelihood activities is examined in detail in Chapter 6.

Though principally for commercial purposes natural resource gathering appeared widespread, if localised to within several hours walk of homesteads in most cases. While village-based gatherers have to travel further to gather veld products, cattlepost households appeared more reliant on these resources for subsistence needs. A small population of Ju/'hoansi households are also reliant on small scale hunting and gathering which may require more spatially dispersed resources. These issues are incorporated into the discussion in Chapter 7.

In contrast, households in Beetsha and Gudigwa rely on a diverse range of income generating activities and natural resources to make a living in the northern sandveld. While wildlife and natural resource based livelihoods have historically been the most

reliable in the region (Chapter 4), these resources are now heavily restricted. Formal employment opportunities can now be gained in the local tourism sector. However, this is dependant on educational background with Gudigwa households disadvantaged in the job market. Although there are formal employment opportunities in the villages, most are reliant on income from DRP or a diverse range of informal income activities from beer brewing to thatching grass sales.

Farming is facilitated by widespread livestock ownership and though ownership levels of arable land are lower in Gudigwa, access is maintained through social relations. Increased arable produce and government food rations have decreased local reliance on gathered natural resources. Today, most gathering is conducted for commercial purposes and is restricted to resources within a few hours return walk of settlements for most women. Gudigwa residents are disadvantaged in terms of their distance from perennial delta channels which are found to the south of Beetsha. Men conduct the most dispersed gathering patterns and may hunt and fish several hours walk from the settlements.

Several issues emerge from this analysis of contemporary livelihood opportunities in the northern Ngamiland region of Botswana. This chapter aimed to examine the present diversity and complexity of the different ways in which people make a living in the study communities, with particular emphasis on the nature of livelihoods based on spatially dispersed resources or mobility. In general, the area is characterised by its remote and inaccessible location, educational constraints to employment in formal sectors (tourism, civil service) and thus high reliance on a diverse range of informal income sources, self provisioning and welfare. Natural resource based livelihoods traditionally used for subsistence and utilising spatially dispersed resources and mobility, are now largely

sedentary and orientated towards settlements and cattleposts. Households may, however, be more reliant on spatially dispersed natural resources during times of need (i.e. droughts or disease outbreaks).

The following chapters, 6 and 7, will examine the dynamics of livelihoods in more detail, particularly examining the direct impacts of enclosure on livelihoods and natural resource use at the time of fence construction. The analysis in these chapters shifts from the household level to the individual, exposing the direct short-term impacts, adaptations and longer-term implications of enclosure for people in northern Botswana.

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6

Direct Impacts, Adaptations and Longer-term Implications for Pastoralists

6.1 Introduction

In the previous chapter, contemporary livelihoods and the nature of livestock production in the Chukumuchu area was investigated, illustrating the commercial and sedentary character of pastoralism which exists today. This chapter examines exactly how enclosure by veterinary cordon fences in northwestern Botswana directly impacted on the livelihoods and natural resource use of pastoralists.

Given that Herero pastoralists are known to have practiced seasonal mobility as recently as the early 1980s, it was essential to establish the past nature of mobility in the region, along with the timing and cause of its demise. Within this narrative of declining mobility, the direct impact of veterinary cordon fence enclosure on pastoral livelihoods can be illuminated. This chapter explores these issues at the individual level, using qualitative data gained from various semi-structured interviews, in-depth case studies and group discussions with pastoralists from the Chukumuchu region (Chapter 3). The discussion attempts to answer some of the key questions set out in Chapter 2, such as:

- what factors have historically caused reduced mobility in the region and what was the nature of livestock and human mobility at the time of enclosure?;
- what positive and negative impact did enclosure have upon these resource relationships?;
- how did pastoralists adapt their livelihoods and resource use to enclosure?;
- and finally, what are the long-term social implications of these fence-restricted resource relationships?

As Herero pastoralists objected to rangeland enclosure under the tribal grazing lands policy (TGLP) (Almagor, 1981), it appeared pertinent to canvass local opinions regarding the veterinary cordon fences before conducting more in-depth discussions. Thus the chapter begins by investigating local views regarding enclosure. This highlights several direct impacts of enclosure through the divergent opinions of three disparate groups of pastoralists, whose views are further explored via case studies. The second part of the chapter examines the pre-enclosure demise of mobility and illustrates the role played by the contagious bovine pleuropneumonia (CBPP) cull and construction of fences in encouraging sedentarisation in the region. This exposed a period of agricultural restructuring whereby pastoralists used various strategies to adapt to enclosure and labour shortages. The chapter finally concludes with a discussion of the implications of these changes for the long-term sustainability of pastoralism in the region.

6.2 Fence views: Local opinions of the CBPP fences

During the preliminary questionnaire survey additional questions were asked regarding the general opinion of the veterinary work conducted by the Department of Animal Health and Production (DAHP); local understanding of the purpose of the veterinary fences; and local perceptions of the positive or negative impacts of veterinary fence enclosure. For the latter question the survey group was asked to provide their overall opinion of enclosure (i.e. positive or negative), as well as the main reasons for their stance on the fences. The resulting data revealed an interesting contrast in opinions between village and cattlepost households. Based on the data collected from the village of

Chukumuchu (as opposed to the surrounding cattleposts), the veterinary work and services provided by the DAHP are well received and perceived as positive to local livelihoods. Ninety-six per cent of informants in the village consider the work of the DAHP as providing positive benefits to livelihoods, enjoying the free vaccinations and veterinary disease control (Table 6.1). Complaints over the frequency of the vaccinations and lack of community members employed by the DAHP concern the four per cent who see the veterinary work as negative, with informants suggesting that vaccinations could be done less often to avoid disruption to local lives.

Table 6.1. Contrasting opinions of DAHP work and CBPP fences from village and cattlepost based households.

Region of Survey	Opinion of DAHP work + CBPP fences	(%) +ive	(%) -ive	Neutral
Chukumuchu (<i>n</i> =24)	DAHP	96	4	0
Cattleposts (<i>n</i> =29)	DAHP	79	14	7
Chukumuchu (<i>n</i> =24)	CBPP fences	83	13	4
Cattleposts (<i>n</i> =29)	CBPP fences	21	59	20

Source: survey of 53 households in the Chukumuchu region

With regard to the CBPP fences, 83 per cent of the villagers questioned think the fences provide positive benefits to livelihoods, when given the option between positive, negative or no change. From the remaining pastoralists, 13 per cent see the fences as having a negative impact on livelihoods, often stating that the fences reduce livestock grazing, prevent the movement of meat, and cut off short cuts to regional villages and cattleposts. When the 83 per cent of informants who see the fences as positive were questioned about their reasoning, 54 per cent replied that the fences stop disease spreading from the north

and forty-two per cent stated that the fences stop cattle from straying and reduce stock theft (4% saw no positive impact).

It would, therefore, appear that the fences are generally well received in the region and only cause a minor inconvenience to local livelihoods. However, the survey data from herders at cattleposts in the region surrounding Chukumuchu reveal highly contrasting results. Whilst there are similar opinions regarding the work of the DAHP (79% see the veterinary work as beneficial), there is a mixture of opinion regarding the impact of veterinary fences as 59 per cent of informants regard the fences as negative. Furthermore, while 21 per cent of informants from the cattleposts see the fences as positive, 20 per cent see no positive or negative impacts. Those who see the fences as negative cite blocked short cuts (7%), restrictions on the movement of meat (7%), and reduced livestock mobility (38%) as reasons. The remaining complaints are largely against the lack of maintenance following wet season elephant damage (7%), rather than conflicts over resources and movement (Figure 6.1).

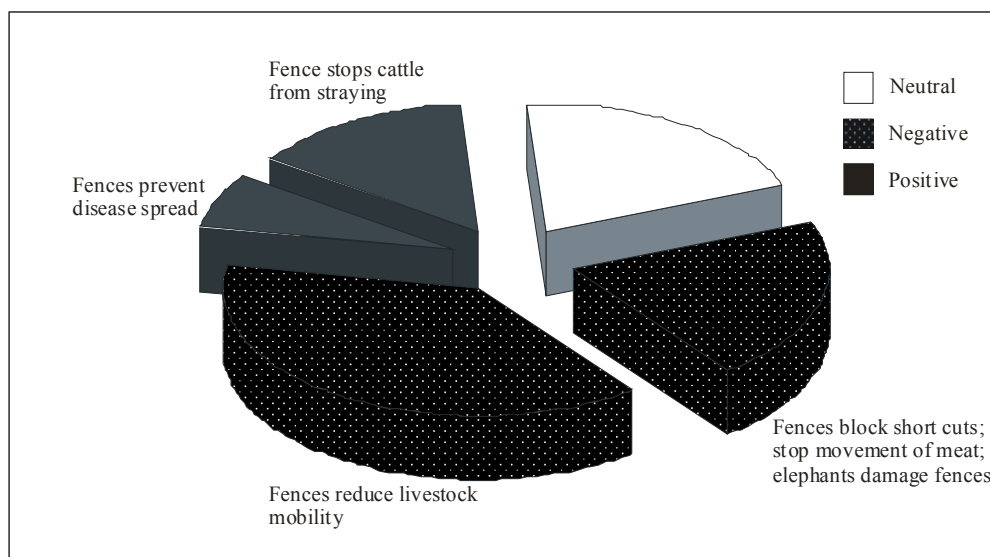


Figure 6.1. Contrasting fence opinions of cattlepost households. Source: survey of 29 cattlepost households

The results of this survey illustrate that there is a clear divide between the views of those living within Chukumuchu and those residing at cattleposts within the surrounding rangelands. Given that maintaining access to cattlepost resources is of greatest interest to middle and better-off herders, and that these pastoralists were often looking after the interests of their village-based family (Chapter 5), this contrast was significant and represented the views of those most likely to be experiencing the opportunities and constraints of enclosure. Further analysis of views revealed that concerns can be divided between the 14 per cent of cattlepost dwellers who complain about what, initially, appeared to be minor difficulties caused by enclosure and those who cite longer-term issues such as reduced mobility. The views of the former group were similar to the short-term impacts reported by Hitchcock (1995; 2002) in section 2.4.

Most people in the region have ties to land or resources found to the north or south of the CBPP fences and enclosure has caused difficulties for people attempting to conduct their usual livelihood activities. Take, for example, the case of DS. DS is 65 year old Mbukushu woman from Chukumuchu and her husband manages their family herd at the Morambachiwa cattlepost 9km to the south of the village. DS also owns cattle at another well in the Xaudum valley to the north of the Samochima fence. DS complains that the fence has made it harder for her to herd cattle between Xaudum and Morambachiwa which she occasionally needs to do, especially after water or grazing become scarce.

'Before the fence I could go alone and just herd the cattle back, now I need a permit and have to employ a herd boy as we have to stop at the fence gate and fill out forms (Ch10 10.05)'.

She also complained about the problem of moving meat across the fence, *'if one of my cows die at Xaudum I can no longer bring the meat to my house in Chukumuchu (Ch10 10.05)'*, she explained.

While those who retained access to wells and grazing to the north resent not being able to take meat over the fence or freely move livestock, there are other people who have links to the village of Nxau Nxau to the south of the Ikoga fence. A 58 year old Herero man from Jobo cattlepost called KK, for example, explained his problems attempting to provide milk and meat for his wife and daughters who live in Nxau Nxau:

'before the cull I planned to dig a well close to Nxau Nxau so that I could split off some cows and a few goats for my wife and daughters so that they can have some milk and meat. The land board granted a permit before the cull but now they have taken the permit away as they don't allow wells within 3km of the fence. Now if I want to take a goat to slaughter at Nxau Nxau the vets have to come and inspect the stock and it takes a long time (Ch19 10.05)'.

Some people complained about the Ikoga fence blocking direct donkey tracks used to travel between cattleposts and Nxau Nxau village. Most of these complaints were from people at the Xabacha or Nxamazine cattleposts and concerned the added distance required to travel through the Jobo veterinary gate. One old man from Nxamazine explained, *'it's as if my direction is now towards Namibia (Ch12 10.05)'* due to the need to travel west before heading south to the village. KM a 35 year old Mbukushu man from the Xabacha II cattlepost explained what happened after the cull when he found that the Ikoga fence now blocked his track:

'before 1995 we used to go straight to Nxau Nxau on donkey and it would take us from sunrise to about 1pm to reach the village. After they killed our cattle we went one day on our old track and found the fence blocking our track. We were

very angry and it took all day to get to the village. Why didn't they put a small gate for us to use? They must have noticed our track? (Ch15 10.05)'

When pressed to provide a negative implication of enclosure most pastoralists could offer one of the above problems. There were, however, some deeper rooted reasons for certain groups to either welcome or resent enclosure in the region. Closer analysis of the qualitative data, characteristics of the key respondent, and the household structure of families questioned revealed several distinct groups of pastoralists with opposing views regarding the CBPP fences. The majority of pastoralists concerned about reduced mobility, for example, were either Herero herd patriarchs >50 yrs (28%) or young herding households with male household heads <40 yrs (10%). Furthermore, of the 21 per cent who claimed that the fences were positive, the majority welcomed the added enclosure on the grounds that the fences reduced stock loss through cattle straying, and these pastoralists were mainly recently established Hambukushu herders. Pastoralists in the Chukumuchu rangelands could therefore be divided into three distinct groups based on their perceptions of the impact of the CBPP fences: (i) recently established Hambukushu herders; (ii) Herero male household heads >50yrs and (iii) young male household heads <40 yrs. In the discussion below the views of case study households from each of these groups regarding the impact of the CBPP fences on livestock management are presented. These enquiries revealed considerable insights into the context of contemporary pastoralism in the Chukumuchu region, along with the key positive and negative impacts of the CBPP fences.

6.3 Characterizing pastoralists in the Chukumuchu rangelands

Case study 1- recently established Hambukushu herder

The group of pastoralists who viewed the CBPP fence enclosure as positive were generally recently established Hambukushu or Bayei herders aged between 40 and 50 years old. The case of KB, a Hambukushu man from the Tjiperonga cattlepost was representative of this group (Box 6.1).

Box 6.1. The case of KB, a recently established Hambukushu pastoralist. Source: fieldwork interviews.

KB is a 45 year old Hambukushu man who spends most of time at his cattlepost, Tjiperonga, with his eldest son. KB's wife and extended family live at a second homestead in Chukumuchu. He bought the cattlepost from a Herero friend with whom he worked in the South African mines during the 1970s. He described his own struggles to gain access to adequate water and grazing in region and the opportunities which arose during the early 1990s after Namibian independence facilitated a period of organised Herero repatriation. *'My Herero friend decided to repatriate to Namibia just before the cull in 1995'*, he explained. The number of vacant wells in the region increased dramatically after the Herero repatriation. Though some Herero families maintained ownership of their wells by leaving them in the hands of extended family members, many decided to sell or abandon their wells. This created opportunities for Hambukushu, Tswana and Bayei herders relying on tenuous agreements with well owners to access water, as KB explained. *'Shortly before moving here I had been given permission to share a well with some Hereros at Xaudum, but they soon changed their minds and asked me to move on. My Herero friend could see that I was tired of moving around and offered to sell his cattlepost to me'*. Unlike many in the region, the well at Tjiperonga is reliable and rarely dries up or needs re-digging. At present there is an abundance of grazing in the area due to the repatriation of many of the wealthiest pastoralists. *'Since the cull and Herero repatriation there are fewer cows around and there is plenty of grazing'*, he explained. *'My Herero friend owned 400 head of cattle and these had multiplied from only 3 cows, and I only had 10 cows when I arrived and now have over 50, so there is a lot of grazing here'*.

KB divides his time between his cattlepost and village-based homestead where he sometimes gains temporary drought relief programme (DRP) work. Like many pastoralists in the region, KB owns a petrol generator and electric water pump, along with a plastic water tank. Whenever he or his son are alone at the cattlepost they use the

generator and pump to water the livestock, as the bucket and winch system requires at least two people to operate. The household regularly sell cattle to the Botswana Meat Commission (BMC) through the Kgomokwane quarantine camp.

Much of the reasoning for this welcoming of enclosure is the current difficulty of obtaining adequate labour at the cattlepost. Most pastoralists in the region rely on family members, particularly young males as KB explained:

'as you can see I cannot afford to pay a herd boy and rely on my eldest son to help me at the cattlepost while my other children attend school in the village. The fence is good and it stops our cattle straying very far, I can now easily find them as I know they can only go as far as the fence (Ch20 10.05)'.

In the dry Kalahari, livestock are physiologically constrained to graze within several kilometres of drinking water, especially in the dry season (Moleele and Perkins, 1998). Under the traditional cattlepost system, the borehole or well has been described as effectively *'the herder'* due to the reduced need for herding during the dry season (Jerve, 1982). Like much of the Kalahari, in the Chukumuchu region there are many ephemeral waterholes or pans often situated along inter-dune or fossil river valleys. As a result livestock often walk considerably large distances in search of fresh pasture in the wet season as they access these seasonal water sources. Perkins (1996) notes that straying, especially after the first rains, results in much time and effort spent by herders retrieving cattle from distances of up to 40km away. Many pastoralists are, therefore, aware that the new CBPP fences and veterinary zones now present a barrier to livestock who can now only stray as far as the Samochima fence to the north, the Ikoga fence to the south, or the Namibian border fence to the east.

Thus, the CBPP fences have benefited herders with limited human capital and this is reflected in the twenty-one per cent of herders from the cattleposts and eighty-three per cent of herders from the village who recognize the positive outcomes of enclosure.¹ Veterinary cordon fences and their associated maintenance roads, sporadic gate camps, along with regular maintenance patrols and permanent gate keepers also represent infrastructure and personnel that can be utilised by pastoralists. When cattle fail to return home after release in the wet season, pastoralists begin looking for livestock often relying on the knowledge of other herders who may have seen their cattle in the rangeland. Cattle often stray as far as the veterinary fences where they can be easily seen or tracked. Pastoralists use fence roads to search for livestock, often stopping to ask permanent DAHP gatekeepers if their cattle have been seen along the fence. On one occasion during fieldwork DAHP officials visited a cattlepost to inform a herder about the location of his lost herd.

Pastoralists also report that enclosure by the cordon fences has improved the security situation in the region. MS a male Hambukushu herder in a similar situation to KB explained why he welcomes enclosure:

'The fences are good, especially the Samochima fence to the north. Before the fences were made there used to be a lot of cattle stolen to the north and now it has decreased. In the past people would steal your cattle during the night and take them to Namibia.(Ch38 10.06)'

Before the CBPP fences and additional electrified international border fence were constructed in 1995/6 there was a period after Namibian independence in 1990 when

¹ Human capital refers to the labour available to the household and changes constantly due to internal demographic reasons (e.g. births, deaths etc.) and to deliberate restructuring to meet unexpected events (e.g. divorce) or external pressure (Ellis, 2000).

military border security was relaxed and cattle thefts increased in the Xaudum area, probably precipitating the CBPP outbreak. Pastoralists are aware that the new CBPP fences and electrified border fence have decreased the likelihood of cattle being stolen.

Case study 2- Herero herd patriarchs

The first group of pastoralists who claimed to be affected negatively by the increased enclosure were predominantly Herero herd patriarchs. Herero males represented 74 per cent of all informants ($n=11$) who cited reduced livestock mobility as their primary reason for resenting enclosure by the CBPP fences. Illustrative of this group was the case of KB (Box 6.2).

Box 6.2. The case of KB, a long established Herero pastoralist. Source: fieldwork interviews.

KB is a 60 year old Herero herd patriarch who divides his time between the family cattlepost at Boudum and the village homestead at Chukumuchu. His family were one of the first to pioneer livestock production in the region and he remembers moving to the Xaudum valley to dig a new well with his father in the late 1950s after losing cattle to trypanosomiasis and crocodiles at Nxamasere. In 1984 the family decided to move their permanent *onganda* to their wet season waterhole, Boudum, as grazing had been depleted at Xaudum due to the ongoing drought. The family kept their cattle permanently at Boudum until 1995 when poor rains and lack of grazing forced KB to move the herd to his brother's well at Xaudum where they remained until the cull. Since their cattle were restocked in the Chukumuchu region, like many households they have remained in the area since 1997/8 and established a village based homestead. When asked his views about the CBPP fences KB replied, '*it seems as if I'm in a ranch, I can't breath, I can't move anymore*'. Although the households' children were all of primary school age and would occasionally help out at the cattlepost during the weekends KB would often herd the cattle alone. '*The young don't like coming to the cattlepost, they don't like rearing cattle and are always spending time in the villages and towns, they like entertainment*', he complained. The household collectively own over 100 head of cattle along with a horse and four donkeys and sell cattle each year to the BMC. The household also own the usual well pumping equipment.

During discussions with KB and others like him, it was clear that this group were more concerned about the lack of mobility in times of emergency rather than the enclosure of seasonal resources. KB explained why he resented the CBPP fences,

'before the fences were made you could take your cattle anywhere you wanted. If there was good rainfall at Xaudum you would go there. Before if my well dried up or there was a drought I would be able to go to Nxau Nxau or Xaudum and ask a friend or relative to keep them there. Now, since the fences were made if my well dries up I will have to stay here and my cattle will die here (Ch26 11.05)'.

KB's response to enclosure highlights some of the contemporary risks and vulnerabilities facing sedentary pastoralists in the region. The strategy he used to cope with risk in the 1995 drought also illustrates the contemporary context of mobility used before enclosure to mitigate these problems (Box 6.2). According to KB, during droughts his well often runs dry and he is forced to try and dig deeper. Before enclosure he could utilise his social network to access water sources elsewhere in the region. Today, with movement restrictions and the permit system, livestock cannot be easily moved across the fences.²

These mobility issues are similar to those faced by sedentary pastoralists enclosed within TGLP ranch areas. Perkins (1996) notes that breakdowns are a frequent occurrence with mechanised boreholes in the Kalahari. Borehole owners often have a network of boreholes and/or contacts and use herd movements, often over large distances, to alleviate breakdowns, droughts and spatial variations in grazing (ibid: 505). Although many herders in the Chukumuchu area owned water pumping and storage equipment,

² Cattle can be moved in a northerly direction across the fences but only after applying for a movement permit. This can take some time as veterinary officials only occupy their village based office during vaccination campaigns and pastoralists must often travel to Shakawe and visit the district office. Few animals have been moved south over the fences as this would require either a veterinarian to visit the cattlepost and inspect stock or livestock to spend 21 days in quarantine which would incur fees.

most wells in the region were hand dug and thus equipment failure was just one aspect of the risk faced by pastoralists. Lee (1993) noted that Herero occupation of wells in the Dobe area caused the water table to be lowered dramatically. High utilisation, particularly in the dry season when the water table is at its lowest, can cause wells to dry out and the only solution is to try and dig deeper or move to alternative water sources. Another serious risk is that wells dug in areas with sandy substrata are prone to collapse. The life span and cost of a well depends heavily on whether it is dug through hard calcrete or soft sand. The cases of two pastoralists attempting to construct new wells over the course of fieldwork during 2005 illustrate the risks and rewards of well construction (Box 6.3).

Box 6.3. The risks and rewards of well construction. Source: fieldwork interviews: KH- (*Ch14 10.05*) MB- (*Ch57 7.06*).

KH is a 40 year old Herero man who took over his father's cattlepost at Xaudum in 1991 after he returned to Namibia. He recently moved to Nxamazine cattlepost with his 200+ cows as the grazing was poor at Xaudum, and in October 2005 was in the process of digging a new well in the hard calcrete of the valley floor. He slaughtered four cattle at the BMC to pay for his new cattlepost and well. He says he choose the site by looking at where the big trees are growing as he knows the water will be closest to the surface there. He employed four young Hambukushu men to dig the well. Three men are paid a calf each for clearing the rock and earth from the surface, while one man was paid 3000 pula to dig the well shaft. The well took three months to complete and successfully found water. Similar wells in the region have lasted over 50 years.

MB is a 45 year old Herero man who lives with his wife at the Kamboro cattlepost. The cattlepost is situated in an interdune valley with sandy substrata. In November 2005 MB was busy constructing a new well near his kraal as his existing well was beginning to subside. He slaughtered several cows at the BMC to pay for construction and paid two men 1500 pula each to clear the sand from the top and one man 4000 pula to dig inside. The higher rate was considered fair given the added danger of digging in sand. To support the well the men had prepared wooden poles to line part of the shaft. The well took six weeks to construct. The well collapsed towards the end of the project, as the men sat having lunch (Plate 6.1). Luckily no one was hurt in the incident and MB had to clear out his original well. He now plans to find another site to try again.



Plate 6.1. A well at the Kwarongo cattlepost: (i) under construction, photo taken in October 2005 (left); and (ii) six months after it collapsed, photo taken in June 2006 (right). Source: fieldwork.

Another major risk facing people in the region is fire. Enclosure by veterinary cordon fences in the region has increased the vulnerability of pastoralists to grazing shortages following periodic fire events. WK a 32 year old Herero man from Kwaronga cattlepost explained why he resented the CBPP fences:

'look at the veld now, it's all burnt up. Before the CBPP cull I could have gone in search of grass for my cattle where the fire hasn't burnt and look for water and then returned when the rains arrived and my area was green. We don't need this fence, before we could trek cattle easily to Shakawe to the community butchers, now we need permits. The fence even kills wild animals (Ch25 11.05)'

Historically, pastoralists use fire as a management tool to encourage the growth of grasses and control woody plants and pests (McGahey *et al.* 2007). In the Kalahari, hunter-gatherer groups have traditionally burnt the veld to remove dead vegetation and to facilitate hunting and gathering (Perkins *et al.* 2002). The veld fire problem even concerned pastoralists who were in favour of enclosure due to the improved security situation. MS, the Mbukushu headman of Chukumuchu explained,

'When the fire burns and then there are poor rains, there is little grazing left for cattle between the fences, but there may be grazing to the north or south in these circumstances (Ch38 7.06)'

The issue is compounded by a dramatic increase in the spatial distribution and temporal frequency of burn mosaics throughout the Kalahari since the droughts of the 1980s (Perkins *et al.* 2002). Most people have noticed a similar trend in the Chukumuchu area. MK, a 52 year old Mbukushu man explained:

'These days fires are a problem, they burn all over our area. During the 1980s you couldn't see fires that often, they would burn only here or there. Even in the early 1990s when Chukumuchu School was built fires were not this bad. It's only since the cull that fires have become this bad. The problem is this conservation of the environment idea (Ch6 10.05)'.

According to Perkins *et al.* (2002) there are two possible reasons why fires in the Kalahari have become more severe and widespread. First, the almost unprecedented decline in large wild herbivore numbers has increased the volume of dead biomass. Almost every person interviewed from the area stated that there has been a decline in wild herbivores, particularly since the CBPP fences were constructed. This is unsurprising given that veterinary cordon fences represent impermeable barriers for most species and are associated with large-scale declines in water dependent species in the Kalahari (Chapter 2).

The second reason is what MK refers to as the 'conservation of the environment' idea. This concerns the widespread ban on traditional burning practices in the Kalahari which, coupled with the sedentarisation and shift from hunter gathering to livestock-dominated modes of production, has caused a reduction in the diversity of spatial and temporal burn mosaics. This, in turn, has increased the frequency of intense and widespread fires (Perkins *et al.* 2002). The incidence of fires originating from close to fences is also reported to have risen following increased human activity along fence roads (Scott Wilson, 2000). Finally, while veterinary fences can also act as fire breaks, they often trap wildlife attempting to escape bush fires (*ibid.* 10), thus increasing the fuel load problem.

It is likely that the reduced stocking rates following the CBPP cull and Herero repatriation have caused a further increase in the volume of dead plant biomass and fire intensity. This was confirmed by local observations of recent environmental changes in

the region. According to local people there was an increase of unpalatable shrubs around the cattleposts before the cull. After the livestock were culled, however, the encroachment became even worse as cattle trampling had kept these areas relatively contained.

While shrub encroachment may have increased close to kraals and wells, these areas are found in valley floors where veld fires often burn out due to the lack of grass. On the dune top savanna, however, intense veld fires have caused a reduction in mature trees and shrubs. According to natural resource gatherers, veld fires now regularly destroy crops of wild berries and thatching grass, while the reduction in mature trees has reduced the bee population making honey hunting more difficult.

Case Study 3- Young pastoral households under 40 yrs old

The second group of pastoralists who resented enclosure were predominantly young pastoral households, several of whom were attempting to establish themselves as independent herders. Although many young people still plan to farm for cultural reasons, these days most young people prioritise formal and informal employment opportunities as their preferred livelihood activity. During a meeting with a group of young teenagers in Chukumuchu they discussed the pros and cons of farming and the role it may play in their future livelihoods:

SJ (Male 27yrs): It's difficult to keep cattle these days. Veld fires burn all the grass and you may need to buy feed for the cattle. Raising buckets all day to water your cows is hard work so you have to buy a water tank and generator. These things are expensive but its easy to solve these problems if you have a job you can buy fuel and pumps. Without these things you are in trouble. I want to

continue making bricks and working as a builder. Maybe one day I will farm, its Tswana culture (Ch11a 10.05).

KG (Female 19yrs): I don't want to keep fields, its hard work ploughing and harvesting. Then you have to pound the crop and fix the fences. I want to go to technical college and learn textiles (Ch11b 10.05).

While there may be an abundance of young people seeking formal and informal cash income opportunities in villages and towns there were several young households, mainly in their 30s, attempting to establish themselves as independent pastoralists. For the Herero it is traditional for sons, especially the youngest, to 'break with their father' upon reaching adulthood and seek to establish their own cattlepost (Twyman *et al.* 2001). In the Chukumuchu region there were several young Hambukushu households attempting to become autonomous as well, though this may be more out of necessity than tradition. These households were often resource poor, with no village-based homestead or well permit. The problems faced by this group in their efforts to gain access to the resources required to construct a pastoral livelihood are demonstrated by the case of MJ and his family (Box 6.4).

Box 6.4. The case of MJ a young Mbukushu man. Source: fieldwork interviews (Ch52 7.06).

Representative of this group was MJ, a young herder with a small herd of 25 cows. MJ was 39 years old and was born at Nxau Nxau a village just south of the Ikoga fence where most of his relatives still live. Before the CBPP cull in 1996 MJ herded his cows together with his father's cattle, but like many the family decided to opt for 100 per cent cash compensation amid speculation that cattle would not be replaced by the government. Since this time MJ's father has passed away and he has been busy building his own herd, primarily by working for the Herero. For several years now the family have been trying to establish their own cattlepost. At the time of the fieldwork MJ lived temporarily with his wife and four children at Jobo, a well just north of the Ikoga fence established by a Herero family in 1957. In return for access to water for his herd, MJ provided labour to the Herero herd patriarch while the man's sons gained temporary employment improving facilities at the nearby DAHP veterinary camp.

Households such as MJ's often lack the financial capital to invest in the expensive and risky process of well construction. As a result they find it hard to secure access to permanent water sources that are reliable, free and close to sufficient grazing resources. These issues were central to the negative fence opinion of this group of pastoralists as MJ explained,

'before the fence I could have taken my cattle to Nxau Nxau where there are lots of wells that I can use for free, now I cannot go through the fence and have to either pay to use a well or work for the well owner (Ch52 7.06)'.

For households such as MJ's there are few options open to access both adequate water and grazing. The only free water available in the Chukumuchu veterinary zone is a government borehole within the heavily grazed communal rangelands surrounding the village of Chukumuchu (Map 6.1). However, in addition to the limited availability of grazing, keeping large herds of livestock close to villages is likely to end in conflict as livestock damage crops and other property.

While constructing a deep well may be beyond most pastoralists in this group, there are areas where water can be accessed within a short distance from the surface. Most of these, however, are found along the Xaudum valley to the north or near Nxau Nxau village to the south. The only place where shallow wells can be dug in the Chukumuchu region is at Tsokung, a cattlepost already occupied by several households (Map 6.1).

There are other key factors besides access to adequate water which such households must consider when attempting to become independent pastoral households. For young herding households such as MJ, who sought access to wells near Nxau Nxau, proximity to

villages is also a major concern, as these groups are more reliant on income generated from trading natural resource-based goods to village dwellers,

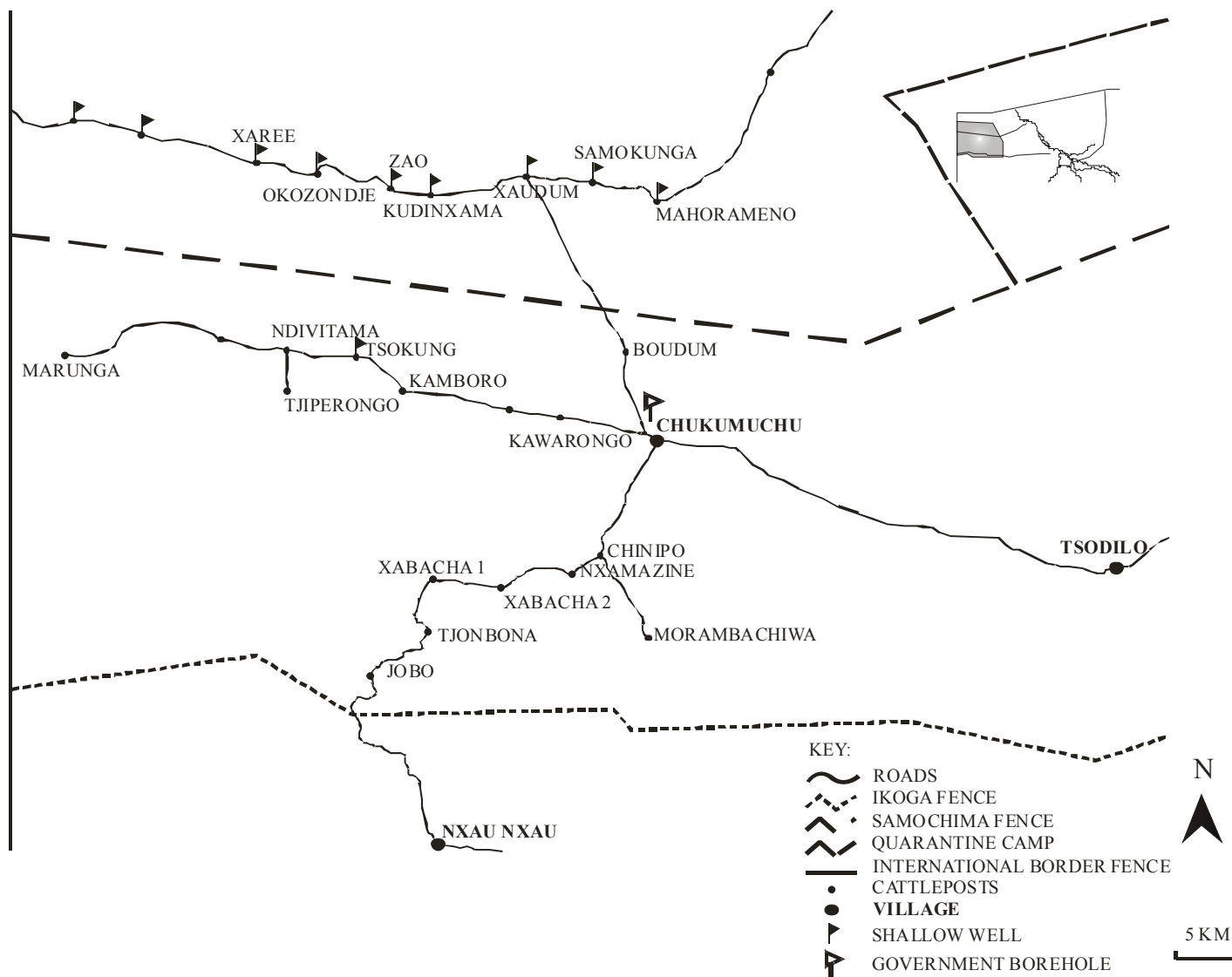
'I want the Ikoga fence to be removed because there is not enough grazing or water this side for us. If the fence was not there now I would be able to go to Nxau Nxau and find water as there are plenty of waterholes and wells I can use there. Now I have to come up here and beg these hereros to use their well. I would rather be closer to Nxau Nxau as my wife can sell milk and oil in the village and buy maize meal for the family (Ch52 7.06).'

Young families such as MJ's are finding it increasingly difficult to establish themselves as independent herding households. Constrained between the need to access adequate grazing and water on the one hand, and settle within easy distance of settlements in order to participate in local markets on the other, they have been further disadvantaged by the CBPP fences. Such households are often forced to move from one cattlepost to another in search of adequate water and grazing. During the course of fieldwork, for example, the sons of the Herero patriarch at the Jobo cattlepost returned from their temporary employment and their father no longer needed MJ's help. MJ and his wife were forced to move their cattle and homestead from Jobo to Nxamazine cattlepost where they were required to pay 1000 pula per year to the Herero owner.³

Livestock are important assets from which the rural poor can construct routes out of poverty, and while poorer households may be more reliant on small stock and forage close to settlements, there are examples where some households have managed to accumulate stock and access to extensive rangelands are critical for this to occur (Toulmin *et al.* 2004; Ellis and Mdoe, 2003). It appears, therefore, that enclosure in the

³ Exchange rate 1.5.2006 1US\$=Pula 5.43

context of the CBPP fences could further enhance existing social differentiation within the region's pastoral society.



Map 6.1. Shallow wells and government boreholes in the Chukumuchu region (NB: water sources south of Ikoga fence not included in survey). Source: fieldwork

Summary of the major direct positive and negative CBPP impacts

Previous studies not specifically aimed at investigating veterinary cordon fence enclosure have described various negative livelihood impacts associated with fencing and disease control policies during outbreaks (cf. Hitchcock 1995; 2002). This study explored the implications of fencing and disease control for people attempting to conduct livelihoods across veterinary fences during disease-free periods, indicating the longevity of these restrictions in some areas, especially at the interface between different veterinary zones. Initially it appeared that the fences and movement restrictions present only minor inconveniences for people whose livelihoods once involved access to resources now enclosed by the CBPP fences. People resent the permit system, are unable to move meat across the fences, or split their herds easily between village and cattlepost wells. Short-cuts have also been blocked increasing travel times between the cattleposts and villages. Many of these impacts are similar to those documented by Hitchcock (1995; 2002) and reviewed in Chapter 2. However, detailed analysis of pastoralists' views revealed some of the deeper rooted issues and concerns behind an individual's reasons for welcoming or resenting enclosure by the CBPP fences.

While newly established herders with labour shortages welcomed enclosure on the grounds of improved security and reduced stock loss, older herders, perhaps with more experience of the risks and vulnerabilities of the sedentary management of a large herd, resented the reduced mobility and flexibility caused by enclosure. Well failure and veld fires represent the most important risks and vulnerabilities facing contemporary pastoral society in the region, and the CBPP fences and movement control policies have restricted pastoralists' ability to access shallow wells and support networks in times of emergency.

For young pastoral households attempting to establish themselves as independent herders, this restriction is particularly important, making it harder to conduct the diversified livelihoods required to accrue the wealth needed to invest in well construction. Thus veterinary fence enclosure could be increasing social differentiation in the region by obstructing the pathways into pastoralism.

In pastoral societies, livestock mobility is primarily maintained through investments in herding labour. Low labour availability results in a greater reliance on younger more inexperienced herders or contract herders, often leading to constricted patterns of livestock grazing (Turner, 1999). Although contemporary livestock production in the Chukumuchu region was characterised by low levels of human capital at the cattlepost, this was not always the case. The following sections of this chapter provide a historical account of the changes to livestock management and mobility over the pre-fence to present-day period. These findings show that in the past pastoralism involved far more mobility in the region and documents how various socioeconomic changes caused declines in mobility before the 1990s. The discussion also illustrates how pastoralism entered a period of major restructuring during the 1990s following several dramatic events (i.e. Herero repatriation, CBPP fencing, CBPP cull and eventual restocking). This historical perspective raises some searching questions as to the longer-term environmental sustainability of sedentary pastoralism in the Chukumuchu rangelands.

6.4 Pastoral mobility pre-1996

Mobility is historically one of the principal means by which pastoralists manage uncertainty and risk in drylands (Scoones, 1995). There are many types and degrees of

pastoral mobility, which may vary according to environmental conditions, or the given stage of a household's life cycle (Naimir-Fuller, 1999). Pastoralism is dynamic, flexible and opportunistic such that attempts to categorize pastoralists into mutually exclusive groups based on livestock movements alone have proved to be an intellectually sterile exercise (Dyson-Hudson and Dyson-Hudson, 1980). The distance, timing and rationale of mobility may be determined by a variety of factors such as disease outbreaks, conflicts, water or grazing availability, drought, availability of harvest residue or markets, ceremonies or seasonal gatherings (Naimir-Fuller, 1999). The mobility of livestock may not necessarily be related to the mobility of households, and movement is not always undertaken for ecological reasons (it may be for trade, conflict or political reasons) (McGahey *et al.* 2007).

The new mobility paradigm for pastoral development (cf. Niamir-Fuller, 1999) has sparked a renewed interest in studies concerned with mapping and characterising the mobility of pastoralists and their livestock (Adriansen and Nielsen, 2005; Adriansen and Nielsen, 2002; Turner and Hiernaux, 2002; Coppolillo, 2000). Indeed, geographers and anthropologists have a long tradition of describing the inter-regional and inter-camp mobility of livestock as this could provide considerable insight into the spatial distribution of resource conflicts (Coppolillo, 2000), along with the heterogeneity of grazing impacts and factors shaping long-term environmental change (Turner, 1998).

Until recently, however, most studies were of course spatio-temporal resolution with range assessments relying on spatially broad livestock census data or temporally narrow aerial surveys (Turner and Hiernaux, 2002). Nowadays, detailed studies generally use a combination of GPS measurements, GIS mapping and herder interviews to investigate

present-day patterns of mobility, with variable degrees of accuracy (cf. Adriansen and Nielsen, 2005; Turner and Hiernaux, 2002). Adriansen and Nielsen (2002; 2005), for example, used a hand held GPS to record weekly measurements of the herds location. They note that more detailed sampling could have been achieved using a GPS collar for cattle, but regret that this was beyond the reach of their fieldwork budget. Turner and Hiernaux (2002) used interviews, direct herd tracking and GIS derived field maps to accurately estimate the spatiotemporal distribution of livestock. While they appear to have successfully mapped the various forms of livestock mobility present, they failed to complete itineraries for 26 per cent of their interviews as some herders use free-range or herd-release management and are therefore often unaware of the location of their herd.

It is well established that herbivore use intensity (combined grazing, excretion, and trampling) decreases exponentially from water sources in sedentary Kalahari livestock systems, and that the limit of major grazing effects is 2km regardless of spatiotemporal changes in livestock distribution (cf. Perkins and Thomas, 1993; Dougill *et al.* 1999). Chapter 4 described the low intensity 'herd release' method of management traditionally used throughout the Kalahari and section 6.3 described how livestock mobility increases during the wet season as cattle access surface water available in numerous pans and waterholes throughout the region. The section also explained why some pastoralists, particularly households with labour shortages, welcome enclosure as they are aware that the fences act as a barrier reducing stock loss. Given that the Boudum and Jobo cattleposts are within 3km of the fences, and that livestock mobility studies show the average daily return distance cattle travel under 'herd release' grazing to be 7km (Adriansen and Nielsen, 2002), the CBPP fences clearly curtail livestock mobility. This

raises some important questions regarding the long-term environmental consequences of this reduced mobility which will be addressed in Chapters 8 and 9.

The detailed spatio-temporal mapping of contemporary livestock movements was beyond the scope of this study and considered unnecessary, as it was clear that livestock are curtailed by the cordon fences in certain places. Of greater interest was the need to determine whether herd management involved greater mobility in the past, and to investigate whether enclosure played a role in its demise. Detailed discussions with many of the region's long established pastoral households, mostly of Herero origin, revealed that pastoralism did involve more mobility in the past. In particular, both Herero and Hambukushu pastoralists would make temporary wet season camps at waterholes and pans distributed throughout the region.

Given the difficulty experienced in mapping contemporary livestock mobility accurately, it would be extremely difficult to reconstruct past spatio-temporal livestock movements or herding itineraries with any degree of precision. Likewise, attempting to visit and map all the seasonal waterholes and pans mentioned during interviews would have been time-consuming and logistically challenging in this remote and inaccessible region. Nevertheless, during the interviews descriptive details of the different rationales and types of mobility practiced in the past, along with the local names, distances and approximate locations of most seasonal waterholes used by pastoralists were recorded. This information provided sufficient detail to map approximately some of the most frequently used pans and waterholes (Map 6.2), while at the same time characterise the different types of mobility practiced. Mapping was also aided by an enlarged Landsat TM

scene and several aerial photos covering the study area, upon which the location of most pans and depressions could be directly visualised.

Discussions about past mobility revealed that herders could be divided into three groups according to the type of livestock management practiced from when the area was first occupied by pastoralists in the 1950s, to the early 1980s. First, some people with small herds of cattle, mostly of Hambukushu origin, have never practiced seasonal mobility and preferred to fence fields against livestock damage and practice 'herd-release' or 'free-range' management (cf. Turner and Hiernaux, 2002). Second, pastoralists engaged in arable agriculture with larger herds practiced regular seasonal moves to a particular waterhole during the growing season partly to relieve grazing pressure and partly to avoid crop damage. Finally, pastoralists with large herds, and primarily of Herero origin, would make seasonal camps at waterholes located within a certain pasture area, sometimes utilising more than one waterhole per wet season and sometimes visiting different pasture areas in different years.

There are, therefore, two groups of pastoralists who conducted seasonal herd movements in the past. For those with arable fields mobility was primarily conducted to protect arable lands from livestock damage and reduce the need to rigorously maintain labour intensive thorn fencing. *'We moved the cattle to our camp at Chaveha just after the rains to stop the cattle destroying the crops (Ch1 11.05)'*, said MT an elderly Mbukushu man from Chukumuchu. According to MT, he would herd the cattle with his sons and make a temporary camp at the waterhole each year, remaining until the water dried up, sometimes as late as June or July. Meanwhile the women and remaining children would look after the fields (bird scaring, harvesting, threshing) and attend to small stock. A

similar pattern was practiced by KM a Mbukushu man from Xababach II. KM used to camp at the Romkaro waterhole, now dissected by the Ikoga fence, which he says held water for up to three months after the rains had stopped (Map 6.2).⁴

The second form of seasonal mobility practiced in the past was that of large herd owning Herero pastoralists. For Herero herd patriarchs the primary motivation was to alleviate the resource pressure on grazing surrounding permanent cattleposts. Another reason to move was the ease of watering livestock at waterholes as this requires far less labour than permanent hand operated water sources. In an annual cycle, Herero herd patriarchs would trek cattle to temporary camps near one or more large waterhole, from which livestock would be managed using the usual 'herd release' method. Pastoralists would generally move with their livestock after the first major rainfall event of the wet season (usually between October to December), remaining until the water sources dried out (usually May or June). Typically, male household members or contract herders would move to cattle camps while wives and extended family would remain behind at the main cattlepost to look after smallstock and a small milking herd. Some Herero women would visit the camps to make butter and oil from milk, as they report that there was often a surplus during the wet season. Most households would therefore utilise waterholes no further than a day's walk of the main dry season homestead. These arrangements are similar to those noted by Almagor (1981) for Lake Ngami Herero.

Although herders could provide the name and approximate location of at least four or five waterholes regularly used within 5-10km of their dry season cattlepost, most would spend the entire wet season camped at a single waterhole. For example, KK, a Herero herd patriarch and owner of Jobo cattlepost described moving his herd over different years to

⁴ Interview with KM (*Ch15 11.05*)

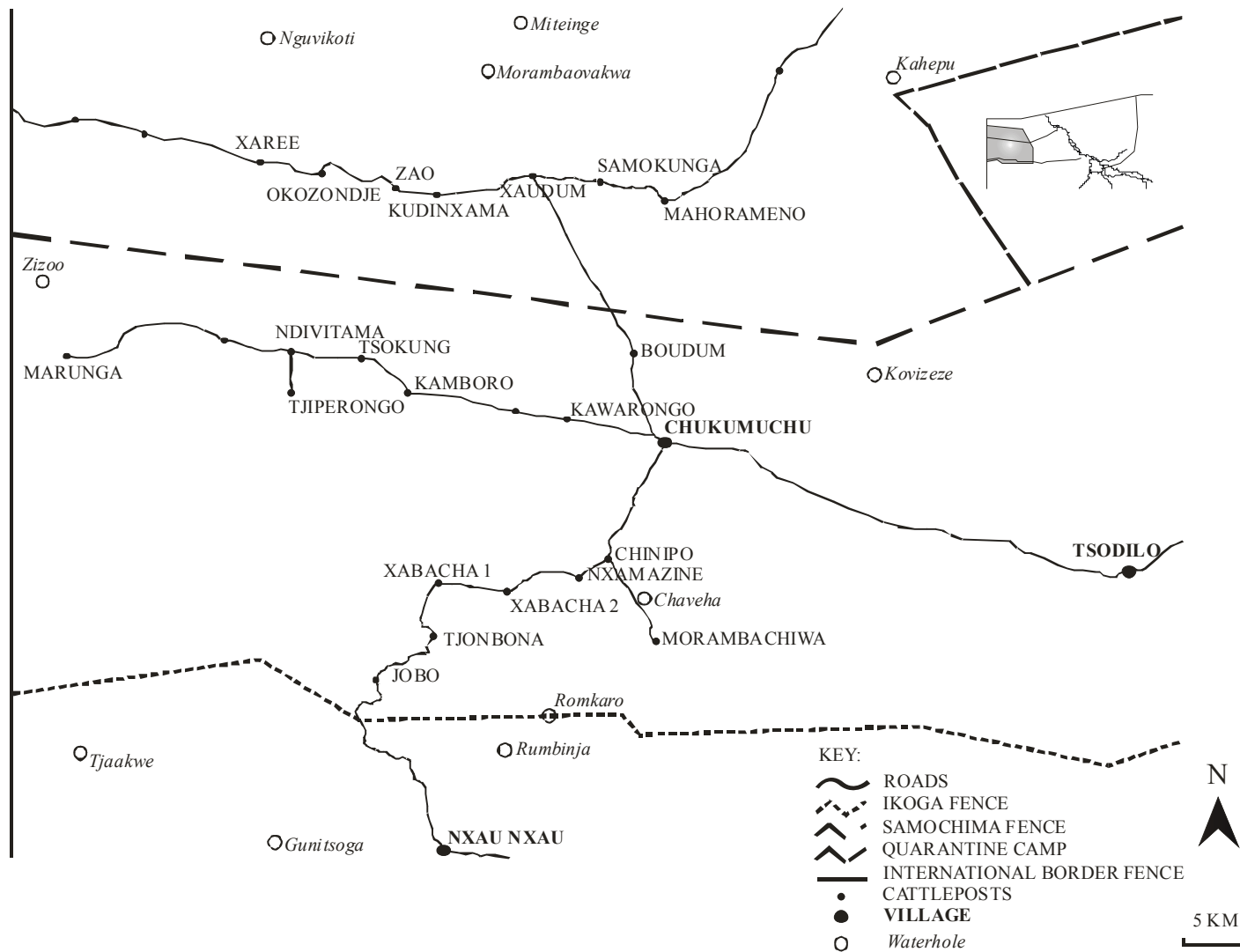
Ramkaro, Rumbinja, Gunisoga and Tjaakwee waterholes (Map 6.2). All of these are now partly or fully enclosed by the Ikoga fence. Herders such as KK would vary the waterhole visited mainly on the basis of where the rains were heaviest.⁵ This is a similar pattern of mobility to the 'meeting the rain' management described by Adriansen and Nielsen (2002) for Fulani pastoralists in West Africa.

Although the precise years when mobility declined were difficult to establish, most herders cited the early 1980s as the time when they became fully sedentary. For pastoralists with large herds the transition to sedentary management often involved constructing a second permanent well at their favoured wet season waterhole. This allowed greater flexibility enabling the owner to split the family herd, use mobility in emergencies, or continue to make regular seasonal moves to one specific area. This restructuring of pastoralism was evident in the case presented in Box 6.2 above, and is considered in more detail in section 6.5.

Once the nature of past mobility was established, questioning centred on the main factors driving sedentarisation. These enquires revealed several main forces causing sedentarisation. First, an out migration of households and farm labour to regional towns and large villages caused by regional socioeconomic developments. Second, a gradual erosion of the traditional Herero household structure and co-operative herd management system. And finally, a period of Herero repatriation to Namibia from 1993-6, in an attempt to regain some Herero political autonomy. All of these changes caused a reduction in the availability of labour at the region's cattleposts and herd mobility. In the following sections, each of these forces are briefly described, in turn, before examining the situation regarding pastoral mobility and opportunistic management which existed at

⁵ Interview with KK (*Ch19 10.05*)

the time of the CBPP outbreak and the subsequent impact of the fences on pastoral management.



Map 6.2. Waterholes and pans available to pastoralists in the past. Source: Fieldwork interviews (note: the location of all waterholes except *Romkaro* are approximate, based on map-supported interviews).

6.5 Pastoral sedentarisation pre-1996

Out-migration and settlement in villages or towns c.1970s-80s

One of the main factors causing pastoral mobility to decline during the 70s and 80s was labour shortages at the cattleposts. In response to the question, *'Why do you no longer move your cattle seasonally?'* one Herero herder replied, *'I can't take the cattle away to waterholes as I don't have enough herd boys to help and my wife is usually in the village so there would be no one to look after the smallstock'* (Ch30 11.05). The reduction in labour availability has been driven by an ongoing process involving the settlement of household members in nearby villages or towns. This followed improvements in the quality of public services and various physical capital assets in the region, as roads and villages have developed through government investment in rural development. The expansion was accompanied by improved social welfare and livelihood opportunities in larger villages through increases in waged labour, education, health care and trade. In Ngamiland district as a whole, these trends can be seen in the disproportionate increase in the population of the district's main town Maun, whose population has increased more than three times the rate of the district as a whole (Bensen and Meyer, 2002). In the Chukumuchu region, household members started to reside in large villages such as Shakawe and Nxamasere from the late 1970s until 1991 when the village of Chukumuchu was established by the Botswana government. Since this time Chukumuchu has steadily expanded with the construction of a school and clinic which attracted further out-migrations of rural households and resulted in the bilateral social organisation observed in the study area today (Chapter 5).

Chapter 4 described traditional Herero social organisation which centres on the main homestead or *onganda*, where several patrilineal related households reside. For Herero pastoralists, the socio-economic changes documented above represented an erosion of their social organisation, which had major implications for herd management and mobility. According to local patriarchs, elements of the patrilineal homestead or *onganda* remained intact in the region until the early 1980s, which is in agreement with anthropological research of the time (e.g. Almagor, 1981). However, the Herero household structure had already started to become increasingly compromised as more generations of the Herero sought outside employment and education. As a result, many Herero families began to establish their main homesteads in regional towns and large villages and started to manage their cattle from a distance, leaving mainly older males and unemployed young men at the cattlepost. KE, the Herero owner of Zao well described the changes that occurred within Herero society:

‘during the 1970s many of the Herero family members became educated and found work in the towns. By the late 1970s most of the mothers and children had left the cattleposts and moved to Shakawe or Nxamasere and in the early 1980s many families stopped making seasonal movements to waterholes (Ch33 11.05)’.

Most households stopped going on seasonal livestock movements due to the lack of extended family members able to remain at the main cattlepost and tend to calves and smallstock. While cattle can often be left to roam freely in an area they know, small ruminants require daily herding because they can easily get lost, stolen or taken by predators (Adriansen and Nielsen, 2002). In most pastoral societies cattle are usually the responsibility of the household head, while small ruminant herding is the responsibility of

children or women. The change in Herero household structure caused many to reduce the number of smallstock kept at the cattlepost as they could no longer be looked after by children and female members of the household. Once again, this trend is supported by anthropological observations amongst Ngamiland Herero in the late 1970s (Almagor, 1981). During the 1970s and 80s, therefore, pastoralism for the Herero in the Chukumuchu rangelands was characterised by declines in labour availability and reduced pastoral mobility. However, a further decline in the number of pastoralists likely to practice seasonal mobility occurred after Namibian independence in 1990.

Herero Repatriation c.1993-1996

The Herero of Botswana have often been described as a proudly independent ethnic group with aspirations to return to their homeland in Namibia (Pennington and Harpending, 1991, Almagor, 1981). These aspirations came into fruition following Namibian independence when the governments of Botswana and Namibia agreed on an organised repatriation of Herero pastoralists to Gam in Namibia (Kruger, 1998). While official data regarding the scale of the Herero repatriation from the Chukumuchu region are lacking, the decline in Herero households was evident from the number of newly established Hambukushu and Bayei herders in the region and several abandoned and vacant Herero wells (see case study 1 in section 6.3).

Almagor (1981: 49) noted that the Herero were closely monitoring political developments in Namibia as early as the late 1970s and were reluctant to invest in borehole technology or deepen their economic involvement at the time as a result of 'encouraging signs of an approaching independence.' Today, most Herero engaged in livestock production in the

study area have invested in water pumping technology or village-based homes and many have become more involved in the local village institutions and regional politics. SM, a Herero man in his fifties, for example, is the local councillor for the region and a prominent figure in the community. According to SM before the cull he owned over 100 cows and used to practice seasonal mobility. After the cull he decided to keep fewer cattle and invest in water pumping and storage equipment,

‘a large herd need a lot of water, its hard work watering by hand, so you must move to search for waterholes in the wet season. I wanted to stop having to move around so much so I invested my compensation in a water tank and pump, you can’t move these things easily (Ch2 10.05).’

It would appear, therefore, that the Herero repatriation resulted in the loss of households less integrated into regional society, less likely to have invested in borehole technology or sedentary infrastructure, and more likely to use mobility. For these households mobility was an important part of management as they preferred to ‘continue to rely on the natural resources’ and not invest in ‘expense and activity which would deepen their economic involvement in a country which they see as their temporary host’ (ibid: 49).

Social changes in the region from the early 1980s until the early 1990s therefore caused some fundamental alterations to pastoral management and herd mobility. Pastoralists faced with an out-migration of household members to large villages and labour shortages, were forced to decrease their herd mobility. The Herero repatriation may have also resulted in the loss of many of the most mobile pastoralists. Although some herders may have begun to adapt to these changes before the outbreak of CBPP in 1995, the CBPP

cull caused an enormous disruption to the pastoral economy which resulted in a major restructuring of pastoralism in the Chukumuchu region.

6.6 The CBPP cull: adapting to sedentarisation

The depopulation of livestock in the Chukumuchu region, and throughout Ngamiland, caused the migration of many households and the majority of rural farm labourers to village service centres or regional towns. This migration, and the provision of compensation and relief work which followed, forced the rapid acceleration and consolidation of many longer term tensions which had hitherto been driving changes within the pastoral management systems of the Chukumuchu region. Firstly, many households took the opportunity to establish a second homestead in the village, especially as there were widespread rumours that the Chukumuchu veterinary zone would be restocked first. For example, 12 out of 24 households questioned in the village migrated to Chukumuchu and established homesteads in 1995 and 1996. Many of these households migrated from the infected red zone to the north of the Samochima fence, with 7 of these 12 migrating from the Xaudum valley.

Incentives to attract labour

The CBPP cull and subsequent migration of households to large villages caused an awakening of young herdsmen who became firmly entrenched within village life. According to one focus group of young men,

‘after the cull there were so many young people just sitting around in big groups enjoying themselves. The herd boys realised what they were missing and many decided not to go back (Ch11 10.05)’.

The CBPP cull, therefore, prompted a further out-migration of potential herders who soon became engaged in alternative income opportunities within large villages and towns. The decline in pastoral labour has been widespread in Ngamiland which can be seen in the official statistics for formal employment in the region. In 1991 the agricultural sector was the largest employer with forty per cent of the district’s labour force, whereas only fourteen per cent were employed in 2001 (Bensen and Meyer, 2002). The majority of households became reliant on emergency food rations and labour intensive public works programmes for income (ibid, p.17).

For pastoralists, the CBPP cull and subsequent compensation payments provided a huge increase in the availability of cash for the household economy. After the cull, the government offered several compensation options, from all cash compensation (compulsory for small farmers with up to 10 head of cattle) to 70 per cent cash and 30 per cent restocking, or 30 per cent cash and 70 per cent restocking. Regionally, most farmers opted to receive high rates of cash compensation (Fidzani *et al.*, 1999).⁶ In the Chukumuchu region 43.4 per cent of households surveyed opted for 100 per cent cash compensation and the remaining households opted for compensation involving either 30 per cent or 70 per cent restocking and the rest cash.⁷ Most households spent the money on immediate or routine household expenditure, especially households with small herds of cattle. However, several households choose to invest their money on major purchases such as vehicles and water pumping technology. These purchases were a direct adaptation

⁶ 54% choose 100% cash compensation and 23% choose 70% cash compensation (Fidzani *et al.* 1999).

⁷ Source: Fieldwork survey (n=53)

to the pressures forcing sedentarisation (i.e. labour shortages) and represented the beginning of a period of agricultural restructuring in the Chukumuchu rangelands.

Ngamiland's pastoral lands were restocked between April 1997 and March 1998 with 70,000 cattle (Mullins *et al.*, 2000). As discussed earlier, once they received their livestock, pastoralists in the Chukumuchu veterinary zone could only move livestock up through the zones with the requisite permits from the DAHP. As a result many abandoned shallow wells previously used in the Xaudum valley to the north, in favour of wells located along the inter-dune and fossil river valleys of the Chukumuchu region. A period of pastoral restructuring ensued as households reorganised their livestock management arrangements within the new veterinary disease control zone. Pastoralists with the financial capital to employ a contract herder now had to compete with government labour intensive work programmes. While households with cattleposts within close proximity to the village could rely on young family members to provide herding labour after school and at weekends, owners of remote cattleposts struggle to find contract herders willing to work in the rangelands. Several herd patriarchs spoke of matching the minimum DRP wage and providing extra incentives such as food and other daily consumables, in order to attract labour. The increased investment in water pumping technology was also a direct adaptation to the lack of labour availability and designed to make the herding work easier and more attractive to contract herders.

Herd splitting

In section 6.3 the vulnerability and risks involved with relying on deep hand-dug wells was exposed, particularly for owners with large herds. The section also illustrated how

most of the areas where water can be easily accessed are now enclosed by the fences. To reiterate, veterinary cordon fence enclosure in this context has disadvantaged poorer households attempting to become independent herders and increased the risks involved in the sedentary management of a large herd.

Since receiving their new livestock, many pastoralists with large herds have adapted to the increased risk through dual well ownership and herd splitting. A number of these households acquired second wells when several became vacant during the Herero repatriation. Most of those who remain reliant on one well spoke of plans or pending applications for a second well permit from the Land Board. These strategies were a direct adaptation to the increased risks involved as a result of enclosure.

One household fortunate enough to secure a second well was SM's family. Two brothers, MM and SM, cooperatively manage their large herd of cattle between two wells Marunga and Ndivitama. The family's main homestead (*onganda*) was originally located at Xaudum from where they would occasionally make a seasonal cattle camp at the Marunga waterhole. During the 1980s the family dug a permanent well at Marunga after the water table dropped at Xaudum and the area became overgrazed. They continued to move seasonally between the two wells until the cull. After being restocked at Chukumuchu, however, they were told by DAHP officials to remain within the veterinary zone.

According to MM the well at Marunga is one of the deepest in the area and requires a Lister engine to operate. These are more expensive to purchase and maintain. To mitigate the risk of Marunga's well failing the family purchased the Ndivitama well from its

Herero owners when they repatriated in 1994. MM explained how the brothers cooperatively manage their herd between the two wells:

'We split our herd between Ndivitama and Marunga because of water. We keep more cows at Marunga as there is more water in that well and it doesn't dry out easily like Ndivitama. There are many waterholes near Marunga also. In the wet season we even take cattle from Ndivitama to Marunga. We then herd them towards the waterholes and fetch them again in the evening.'(Ch21 10.05)

The way SM's family adapted their herd management system illustrates both the gradual process of sedentarisation that has occurred in the region and the role played by veterinary cordon fence enclosure. It also shows that mobility and flexibility remain important strategies through which pastoralists manage enclosure and sedentarisation. Whereas in the past the family managed their livestock between the grasslands of the Xaudum valley and Marunga, they now maintain mobility between Marunga and Ndivitama. Dual well ownership and herd splitting represent important strategies by which pastoralists manage the risks and vulnerability of enclosure.

6.7 Lessons for pastoral communal lands

This study of rangeland enclosure in the case of Botswana's veterinary cordon fences is unique for two reasons. First, it investigates enclosure driven not by resource scarcity, resource conflicts, or state-led land tenure reform policies as is often the case (cf. Turner, 2004; Taylor, 2006; Peters, 1994), but rather by government veterinary disease control legislation. This means that instead of operating at the micro-scale creating privatized fenced parcels of land within already restricted areas, enclosure is occurring at the

rangeland scale in hitherto unrestricted areas, creating limits on people's macro-level mobility and ability to access distant resources.

While veterinary cordon fence use currently remains limited outside southern Africa, there may be a strong case to suggest that in the absence of understanding regarding their direct impacts on pastoralists and the environment, their use for disease control may increase in the future. For example much of the veterinary literature concerning disease control in Africa infers that veterinary fencing in southern Africa has little impact on pastoralists and rural livelihoods. This is probably caused by the lack of research into these issues and could mean that the use of fencing may increase in the absence of understanding and awareness. Kock *et al.* (2002), for example, suggest:

In order for Africa to fully benefit and share in world trade, the zoosanitary situation must show improvement. To do this without destroying the natural resource base and traditional pastoral systems, will require a careful future orientated land-use policy along ecologically sound criteria. Export livestock will have to be maintained in areas, probably free of ruminant wildlife, with strict veterinary controls. This to some extent has been the policy of countries which are exporting products to lucrative markets (Botswana/South Africa/Zimbabwe). If this can be balanced with sufficient areas retained for traditional pastoralism including protected areas for wildlife, the benefits will be considerable. (Kock *et al.* (2002: 24)

Similarly, Bengis *et al.* (2002) states:

When dealing with the threat of certain endemic African diseases such as FMD, African swine fever and theileriosis, the containment option has frequently given best results. This option is usually effected by means of control zones/areas, game proof fences, cordons and movement control, which separate wildlife from domestic livestock, thus effectively blocking the interface. This option is generally used in countries with an advanced land use policy and where nomadic pastoralism does not occur [emphasis added] (Bengis *et al.*, 2002: 60).

This analysis, therefore, provides an understanding of the impacts of enclosure on pastoral mobility within a context which could come to typify macro-level enclosure in the future.

Secondly, rather than strictly denying access through the individualisation of previously communal lands, as is the case with most examples of enclosure, veterinary cordon fence enclosure represents a type of quasi-restricted access, whereby movement is controlled by the quarantine and permit system. In pastoral areas where access to resources is principally governed by livestock ownership (Little, 2004), this increased level of bureaucracy appears to represent the *de facto* exclusion from, and loss of control over, resources north and south of the fences. This was seen in the CBPP case as some herders relinquished their rights to resources to the north of the Samochima fence, and restructured their herd management within the Chukumuchu veterinary zone.

So what are the key lessons to be learnt from this type of enclosure? The analysis above indicates that enclosure in this context can have similar positive and negative impacts as the micro-level enclosure of communal pastoral lands. One of the only positive implications of veterinary cordon fence enclosure was the improved security situation regarding stock-theft and reduced labour requirements for the time-consuming process of retrieving lost stock. In Namibia, large tracts of communal grazing have been fenced illegally by individuals and small groups of farmers (cf. Werner, 2000; Stahl, 2000). Stahl (2000) found that reduced stock theft was one of main benefits of illegal fencing and indeed the main determinant of management decisions and impetus to fence. Small scale enclosures in this context could be used to protect valuable assets such as young male calves from theft (ibid: 332). Elsewhere in Africa, ongoing conflicts in pastoral areas are

often precipitated by livestock theft (cf. Swift and Kratli, 1999) and thus well placed large-scale barrier fences could serve to improve security.

A second common theme in the literature on pastoral enclosure is that in almost every case the fencing and privatizing of communal pastures results in negative implications for poor marginalised groups.⁸ In this case young pastoral households attempting to establish themselves as independent herders are finding that enclosure by veterinary fences restricts their ability to construct diversified livelihoods involving the marketing of dairy products in villages, while also gaining access to adequate grazing and water. Once again these findings are comparable to the case of enclosure in Namibia's communal rangeland. Twyman *et al.* (2001), for example, found that community fencing in Namibia disadvantaged marginalised groups (e.g. emergency borehole residents, landless, Bushmen) making it harder for young households to 'break with the father', potentially creating a growing number of 'landless' households forced to move in search of permanent residency rights. The same conclusions can be drawn from the case study presented in section 6.3 (case study 3).

Further parallels can be drawn from the enclosure literature concerning the impact of fencing on pastoral risk management. It has been well documented that under traditional cattlepost management people of the Kalahari use flexible strategies, principally using mobility to cope with environmental variability (Perkins, 1996: 505). Enclosure under the TGLP dramatically lowered societal resilience to the risks and vulnerability of life in the Kalahari with those able to exercise flexible management best placed to cope with shocks

⁸ There are too many examples to list all here but enclosure in Africa (e.g. Namibia's community fencing-Twyman *et al.* 2001; Botswana's TGLP- Sporton *et al.*, 1999), and Inner Mongolia (e.g. Taylor, 2006) has caused further social stratification in pastoral society by obstructing pathways into pastoralism, and displacing or disadvantaging marginalised groups.

such as drought (cf. Thomas *et al.* 2000; Sporton and Thomas, 2002). Similar issues were raised with CBPP fence enclosure as pastoralists are aware that the fences limit their ability to adapt to the risks of well failure, drought or aggressive veld fires.

From the wider policy perspective regarding the latest pro-poor livestock development movement and emerging mobility paradigm (Chapter 1), the CBPP fence case demonstrates that while there may be opportunities for veterinary fencing to provide positive impacts (i.e. improved security), on the whole enclosure must be viewed negatively. Although Scoones and Wolmer (2006) suggest that the export-led development trajectory (involving strict veterinary control and fencing) will become increasingly less attractive in the face of free market competition, they appear to underestimate the potentially strong influence of the veterinary lobby in driving the latest pro-poor movement and the frequent portrayal of Botswana as a disease management success story in the veterinary literature (cf. Kivaria, 2003; Kock, 2002). The findings for policy-makers are, therefore, clear: veterinary cordon fences and disease management policies restrict the ability of dryland pastoralists to exercise risk management strategies and limit their ability to adapt to environmental variability. Furthermore, fencing also impacts most on more vulnerable marginalised groups for whom the ability to access both village and rangeland based resources is crucial for establishing a diversified livelihood. Any future veterinary fence developments must, therefore, take into account both the spatial distribution of resources used within pastoralists' risk management strategies (i.e. social and physical resources) and the requirements of marginalised groups (i.e. access to free water in proximity to villages).

6.8 Conclusion

This chapter initially set out to explore the direct impacts of the CBPP veterinary cordon fences on pastoral livelihoods before examining the more detailed implications of enclosure on pastoral mobility and management. A community level survey regarding local opinions of enclosure appeared at first to support existing understandings of veterinary fence livelihood impacts reviewed in Chapter 2. People complained about difficulties moving livestock and meat between the village and cattleposts, along with blocked short cuts. Closer analysis of the survey results, however, illustrated a stark contrast between the views of cattlepost and village-based herders, with the former group further divided between those welcoming or resenting enclosure. The views of three disparate sections of pastoral society were then explored using detailed case study material. Several important issues regarding the positive and negative implications of veterinary cordon fence enclosure have emerged from this chapter:

- The enclosure of communal rangelands with large-scale veterinary cordon fences and their accompanying movement restrictions represents a new type of macro-scale enclosure whereby rural herders indirectly lose control and access to distant resources.
- Enclosure in this context is perceived as positive for some herders faced with labour shortages at the cattlepost as the fences reduce stock loss through theft and straying. This could present opportunities for improving security and resolving conflict in other pastoral areas, although fence alignment and movement restrictions would need to be carefully considered.
- The CBPP fences have, by restricting pastoral mobility, increased pastoral vulnerability to risks and shocks (e.g. veld fire, well failure and drought).
- The fences have further marginalised vulnerable groups such as young herding households attempting to establish themselves as independent herders and could

therefore be creating a growing number of transient households opportunistically seeking equitable watering arrangements.

A historical account of pre-enclosure pastoral management provided a narrative upon which to consider the exact implications of CBPP fencing in 1996 for pastoral mobility. This analysis revealed two types of pastoral mobility practiced in the past: (i) that of agropastoral households involving seasonal mobility to regular cattle camps at ephemeral waterholes; and (ii) that of purely pastoral households involving the option of mobility to a number of different areas under a 'meeting the rain' style of management. Both forms of mobility declined before enclosure, although some retained the option of mobility between two permanent wells.

Mobility declined principally due to labour shortages at the cattleposts as sedentarisation, villagisation and the increased economic opportunities that followed caused an out-migration of family members to major settlements. The number of households likely to have practiced mobility also reduced dramatically following an organised repatriation of former Herero refugees to Namibia in the early 1990s. This is the context in which the cull and enclosure occurred and pastoralists adapted their management to the labour shortages and new disease control zones. The cull caused a further out-migration of family members and herders who relinquished their rights to enclosed resources and became firmly entrenched in village life. Most pastoralists have since restructured their management to enclosure by investing in borehole technology in a direct attempt to reduce labour demands and attract contract herders back to the cattleposts. Some of the more wealthy owners adapted to enclosure by securing dual well ownership within the Chukumuchu veterinary zone, splitting their herd, and practicing seasonal mobility

between permanent wells. In short, pastoralism has become increasingly commercialised, partly as an adaptation to enclosure.

Today, therefore, some pastoralists continue to practice flexible systems of management involving some form of pastoral mobility, while most practice sedentary 'herd release' management. Pastoralists have reorganised their management within the Chukumuchu zone and pastoralism has become commercial and sedentary causing increased social stratification and the marginalisation of the poor. Given that this restructuring is clearly an adaptation to the risks involved with sedentary management and enclosure this raises some questions as to the longer term environmental implications of these changes. These issues are explored using a multi-temporal assessment of environmental change in Chapters 8 and 9.

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7

Development, Conservation and Enclosure at the Wildlife/Livestock Interface

7.1. Introduction

Africa is presently a net importer of livestock products, spending annually three times what is earned from livestock exports (Kock *et al.* 2002). In terms of global trade, by far the most inhibiting pathogen is foot-and-mouth disease (FMD) because in developed countries intensive livestock production is highly vulnerable to infection (Vosloo *et al.* 2002).¹ In Africa, most FMD viruses are maintained in African buffalo (*Syncerus caffer*) populations, such that widespread eradication of the disease is impossible without the destruction of large numbers of wildlife; a move that would be morally unacceptable (Thompson *et al.* 2003). Therefore, one of the greatest challenges facing disease control efforts in Africa involves controlling the transmission of pathogens at the wildlife/livestock interface (Bengis *et al.* 2002; Thomson, 1999).

Typically, areas with free-ranging wildlife populations in close proximity to livestock are marginal regions where people depend on a variety of livelihood strategies based on both agriculture and natural resource-based activities. While disease management at the wildlife/livestock interface may become increasingly more important in order for Africa to fully benefit from the export trade in livestock products (Kock *et al.* 2002), in many countries it has become increasingly apparent that ecotourism based on wildlife could be potentially more profitable than livestock raising (Bengis *et al.* 2002). In enclosed

¹ In most parts of Africa FMD is endemic in pastoralists' livestock which often show only minor decreases in productivity (reduced milk yield or poor draught capacity). The exception is southern Africa where commercial cross-bred cattle are widespread and more susceptible to FMD. In the developed world huge sums of money have been spent eradicating FMD from privatized, fenced farmland where cattle have no natural immunity and are highly susceptible to infection (Vosloo *et al.* 2002).

rangelands this has intensified and expanded the interface between wildlife and livestock as former livestock owners diversify into game ranching, causing increased concern over disease control, requiring innovative new approaches to disease management and legislation.²

In areas remaining under communal tenure a combined approach linking community development and wildlife conservation through the guise of community-based natural resource management (CBNRM) has become widespread (Ghimire and Pimbert, 1997). Historically, people residing in such areas have endured a complex history of changing resource use and land dispossession often driven by a combination of preservationist conservation policy, structural land-use change and ethnic subjugation. Since 1975, a series of global conferences and international agreements facilitated a worldwide rethinking of the management of protected areas, towards approaches recognising the needs of local populations (Twyman, 2001). However, the success of CBNRM has been highly variable with failures attributed to number of reasons, including the poor recognition of local knowledge and an over reliance expatriate expertise (Leach *et al.* 1999), and a poor understanding of natural resource relationships (Twyman 2001).

Trends towards community involvement in conservation follow a growing recognition within development studies that understanding people's resource relationships and including this local knowledge into decision making and planning is essential for the effective decentralisation of resource control (Leach *et al.* 1999). It is also becoming

² For example, throughout the privatized fenced ranch areas of Zimbabwe, South Africa, Namibia and Botswana livestock farmers are increasingly converting to wildlife ranching causing a rise in the translocation of wild animals and thus disease. By keeping FMD infected wildlife in a hitherto FMD free ranch, many ranchers put their neighbours' land into a surveillance zone by implication (Thomson, 1999). The OIE regulations have now been challenged and FMD present wildlife zones can be separated from commercial livestock areas using a double electrified cordon fence. These alterations allowed greater flexibility during the EIA of Ngamiland fencing, but are yet to be implemented within Botswana's communal areas.

increasingly apparent that co-management strategies can only be effective if accompanied by paralleled efforts to understand and address historically embedded issues of land tenure and resource conflict (Forrest, 1999). In northern Botswana rural populations have faced a complex history of resource alienation and sedentarisation driven by preservationist conservation policy, rural development schemes and market integration (Chapter 4). However, such developments have also been accompanied by expansions of veterinary infrastructure (fences, quarantine camps, maintenance camps etc.) aimed at separating livestock from wildlife, yet few have considered how such developments impact upon peoples' access to, and effective control of, the natural resource base.

This chapter seeks to examine how enclosure at the wildlife/livestock interface by veterinary cordon fences has altered resource relationships in northern Botswana. Since the early 1980s officials have attempted to fence the nation's wildlife/livestock interface using several 'buffalo proof' fences after repeated outbreaks of the disease were traced to the region (Chapter 2). The chapter focuses on the northern buffalo fence (c.1991-7) and initially explores how the history of negotiations during a community consultation exercise conducted during the late-1980s impacted upon local understandings of rights and entitlements to land. These findings emphasize the importance of historical perspectives when analysing the myriad of forces causing tenure insecurity and resource conflicts before decentralising resource management (Twyman, 2001). The analysis then focuses on the direct impacts of enclosure upon community access to wildlife and natural resources, particularly with reference to societal risk and vulnerability coping mechanisms and the poor performance of community-based resource management in the region. Finally, the chapter concludes by discussing the implications of emerging fence-

related resource conflicts for the future sustainability of enclosed livelihoods and resource management in the region.

7.2 The Northern Buffalo Fence

In 1991, construction was completed on the southern section of the northern buffalo fence (NBF), a 1.5 metre high and 140 kilometre long fence with a steel cable capable of withstanding a lateral impact of 25 tonnes, and thus impervious to FMD carrying buffalo in the Okavango Delta.³ It had taken six years for the southern section of the fence to be completed. During this time the Department of Animal Health and Production (DAHP) had commenced construction at least once, and the proposed fence alignment had changed four times.⁴ The NBF was Botswana's first veterinary cordon fence to involve prior local consultation (Chapter 2) and the cause of this delay was conflict between the interests of the Delta communities and the various agencies of the state. Six years later, in 1997, amongst a great deal of criticism from conservationists, the NBF was extended northwards to meet the Namibian border fence with no prior community consultation. This effectively isolated wildlife populations within the region to the west of Beetsha and Gudigwa.⁵

Like the southern buffalo fence (SBF) the alignment of which was decided by an aerial survey of livestock distributions and human settlement in the early 1980s (H.Benson,

³ Although designed to prevent buffalo migrating out of the delta grasslands the fence could not be joined to the southern buffalo fence for logistical reasons (i.e. permanent swamps). The fence is also damaged by elephant on a regular basis and thus buffalo are regularly shot or herded back using helicopters.

⁴ Brief to the President regarding the northern buffalo fence, 15.6.88, prepared by Mr N Hunter on behalf of the Permanent Secretary of the Minister for Local Government and Lands (Lomba, 1991).

⁵ The NBF extension received a great deal of criticism from local conservationists, as unlike the southern section of the NBF which evolved around a land-use plan, the extension dissects the Kwando wildlife management area of NG 13 (Driver and Booth, 1997).

pers. comm. May 2005), planning for the northern buffalo fence began in May 1985 with a flight over the DAHP proposed route by representatives from the Tawana land board (Lomba, 1991). Unlike the SBF which was constructed before any thorough land-use planning or community consultation, much of the southern sections of the NBF eventually followed the boundary between communal land and land gazetted as a wildlife management area (WMA) during a land-use planning exercise conducted in the mid-1980s (GOB, 1991). However, the decision to opt for this route was politically motivated and came after the communities had been consulted at least three times to discuss alternative alignments, the last of which agreement was made on a different course for the fence.

Table 7.1 outlines the sequence of events which took place between January 1985, when the DAHP submitted their proposal to the Tawana Land Board, and April 1988 when the various agencies of the state finally reached a decision on the NBF alignment. Map 7.1 shows the approximate locations of the various proposed alignments. Following the NBF aerial survey, a series of village-based *Kgotla* (public) meetings were conducted with the northern delta communities in January 1986. After these discussions government officials from several departments took representatives from the communities to review the proposed fenceline, which, by now, had been demarcated by a cut line through the bush. DM a Mbukushu man from Matswii cattlepost explained what happened:

In 1986 they [the DAHP] came and made a cut line in the bush and put beacons along the proposed route. We were consulted at Kgotla meetings about the proposed route. People complained that the fence would cut off our gathering areas and water sources for cattle. The government [land board, DAHP, Department of Land Use and Planning Unit] took several representatives from the village to the bush and asked them to decide which water sources should be left

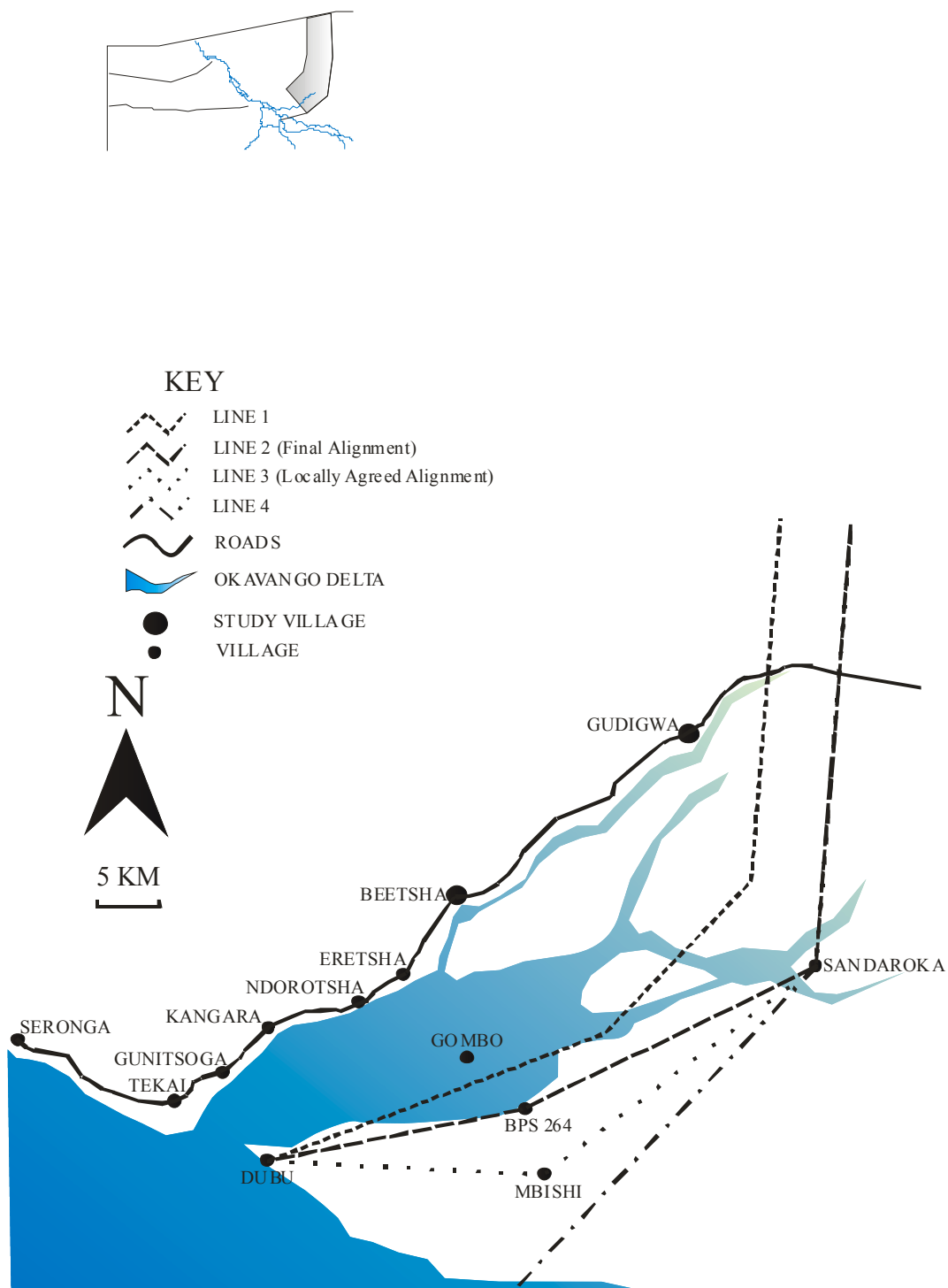
for wildlife and which for livestock as they told us they couldn't leave it all for livestock owners. The government wanted the fence to be near Gombo and Xarakae, and we wanted the fence to include all our areas: Gombo, Xarakae, Mbishi and Sandaroka.(B11 7.05)

The result of these consultations was that an alternative route was proposed south of that originally suggested by the DAHP in their application to the Land Board in 1985 (Line 2-Map 7.1). This alignment was agreed upon by the various government departments and work commenced clearing the fenceline for a year. During this time the district council, probably under the influence of several wealthy cattle owning councillors from the northern sandveld region, managed to persuade the Land Board that livestock grazing had been inadequately provided for.⁶ This pressure prompted the Land Board to return to the region and consider the most southerly proposed alignment suggested by the district council in May 1987 (Line 4-Map 7.1). However, after it emerged that this route would be extremely difficult to construct and would leave a considerable population of buffalo on the community side, an alternative 'compromise' route was proposed (Line 3-Map 7.1). This was the last route which was discussed with the northern sandveld communities on a *Kgotla* tour which commenced in October 1987.

⁶ The northern sandveld refers to the entire dry rangeland region to the northeast of the Okavango Delta shown in figure 7.2.

Table 7.1. Sequence of events leading up to construction finally starting in earnest on the NBF from 1989-1991. Source: (Lomba, 1991)

Date	Event
Jan 1985	DAHP submit a proposal to Tawana Land Board to construct the NBF according to their own alignment (Line 1)
May 1985	Land Board conduct aerial survey of the proposed line and Kgotla meeting in Maun
Jan 1986	Land Board, DAHP, Department of Land Use and Planning Unit (DLUPU), conduct <i>Kgotla</i> tour of northern sandveld communities
Apr/May 1986	Land Board and DLUPU take representatives from northern sandveld communities to inspect the proposed alignment
-	As a result of community consultation alignment changed in favour of line slightly to the south (Line 2)
Nov 1986	District council accuse DAHP of starting construction before properly consulting communities
Jan/Feb 1987	Meeting held with relevant government departments and council which concludes that consultation was properly conducted- construction continues
Apr/May 1987	At a meeting in Maun council persuade Land Board to consider more land for grazing and realign fence further south (Line 4)
May 1987	Land Board go back to region and discuss new alignment with community
Oct 1987	Various government departments meet and decide that line 4 would be impossible to construct due to areas of perennial swamp and propose a compromise route (Line 3)
Oct/Nov 1987	Government departments and district commissioner conduct another Kgotla tour (incl. Beetsha) to discuss line 3
Apr 1988	Various government departments meet and decide that any alignment not closely following previous land use plan would be politically dangerous and therefore decide to go for Line 2. No further community consultations appear to have been conducted.



Map 7.1. Approximate locations of four proposed alignments for the northern buffalo fence.
(Adapted from Lomba 1991)

After various local government departments reached a final decision with the community and district council on the Dubu-Mbishi-Sandaroka compromised alignment (Line 3), several joint meetings were conducted with relevant national-level government ministries to discuss the northern buffalo fences' alignment. At these meetings, government officials expressed concerns over the latest proposed alignment and suggested that amongst other issues, any route that deviated further south of a line which did not closely follow the boundaries set out under the Okavango-Kwando land-use plan would be politically dangerous. Government officials believed that the two most southern alignments left the country open to criticism from environmental groups who may lobby international donors funding the livestock industry in Botswana. Pressure had already mounted during the mid-1980s on both the government of Botswana and World Bank after growing criticism from academics and international environmental groups concerning the social and environmental impacts of the various livestock ranching projects (section 2.4).

As a result of these concerns government officials decided against the last alignment which local government had agreed with the northern sandveld communities. Instead the government were in favour of line two which runs along the northern boundary of NG22 and 23. Though northern sandveld communities had in fact been informed about this route after the first round of consultations, no further Kgotla meetings were conducted to inform local communities of the change in decision from the Dubu-Mbishi-Sandaroka line (Line 3). The consultation process had taken too long and according to one government minister who addressed the communities on the last Kgotla tour in 1987, '*the matter was now long overdue*' (Lomba, 1991: 33.). Officials were clearly concerned that

the successful Tsetse fly eradication campaigns would lead to livestock expansions into the Delta.

Although the NBF represented Botswana's first fence to involve prior land use planning and local consultation the final decision was motivated more by state politics than local resource requirements. This has created a great deal of resentment towards the fence and enclosure has forced some major livelihood changes. A thorough understanding of current resource access and use, along with who has effective control over these resources and how conflicts are or are not resolved, requires an understanding of how such resource relationships evolved over time (Twyman, 2001).

The following sections analyse how the final fence alignment impacted upon local resource access and how the *failed* consultation exercise influenced local understandings regarding rights, property relations and entitlements to land and natural resources. These findings have significant implications for contemporary debates concerning resource management and conflicts in the region, yet as the discussion illustrates, few are cognizant of this.

7.3 Lost land and resources: The failed consultation process

Community views of the NBF

A short survey of opinions regarding the NBF provided a starting point from which to interrogate its direct impacts on livelihoods and resource access. Table 7.2 below shows the results of the survey which included 44 households from the initial questionnaire

group of 62.⁷ Respondents were asked to give their overall opinion of the NBF, along with the main reason for this. Over 60 per cent of households from both Beetsha and Gudigwa resented enclosure, while 27 per cent of households from both villages saw enclosure by the NBF as positive. People who regard the fence as beneficial claimed that the fence stops livestock disease, reduces stock loss from straying and decreases conflicts between farmers and wildlife. A small number of newly established farmers from Gudigwa (16.7%) welcomed enclosure due to reduced stock loss through straying and predation due to the close proximity of the fence to the settlement. Of those who welcomed enclosure due to reduced conflicts between farming and wildlife, a significant number were female headed households. These households generally lacked the labour required to rigorously maintain bush fences around arable land and protect crops during the growing season. Finally, less than 10 per cent from each village had no positive or negative view of the fence. These respondents were usually female household heads who stated that they had *'only heard from other people that there was a fence'* and *'had never needed to go that far gathering'* which further supports the view that resource use for some became more localised before 1991 (Chapter 4).

Those who view the fence on balance to be negative, do so for various reasons. Some people from Gudigwa (27.8%), particularly younger men involved in the local community tourism venture, saw enclosure and the subsequent reduction in wildlife as negative for community based natural resource management (CBNRM) in the area. A small group of wealthy livestock owners from Beetsha (3.8%) also viewed enclosure

⁷ Due to the strong local resentment regarding the NBF these questions were omitted from the initial livelihood survey. Thus a subset of the original survey group were selected to canvass local opinion regarding enclosure. This group included a diversity of households (young, old, female headed, poor, wealthy, livestock owners, stockless etc.)

negatively due to conflicts with community tourism over grazing resources. However, by far the greatest concern regarding enclosure related to the loss of access to land and natural resources now enclosed within the Okavango Delta.

Table. 7.2 Comparing local opinions of NBF between Beetsha and Gudigwa villages. Source: fieldwork survey with subset sample of 44 households

	Positive			Total +ive	Negative				Total -ive	Neutral
+ive/-ive view of fence	Stops disease spread	Reduces stock straying/loss	Reduces wildlife/farmer conflict		Causes wildlife decline/conflict with CBNRM	Lost Land/NR	Elephants damage/repair slow	Reduces livestock mobility		
Beetsha <i>n=26</i>	15.4	0.0	11.5	26.9	0.0	57.7	0.0	3.8	61.5	11.5
Gudigwa <i>n=18</i>	5.6	16.7	5.6	27.8	27.8	38.9	0.0	0.0	66.7	5.6

7.3.1 Local understandings of resource rights

Throughout the interviews and informal discussions with the residents of Beetsha, people complained about the alignment of the NBF. Several men like MB, a Mbukushu man from Beetsha, felt particularly aggrieved and accused the government of betraying the people by failing to position the fence along the line agreed by the community.

I don't want to talk about the NBF. I have spoken enough about this issue at the Kgotla. We agreed with the government to put the fence from Dubu to Mbishi then Sandoruka but they then put it from Dubu to beacon 264 then Sandoruka. The fence is too close we have lost many of our old gathering areas. (B3 7.05)

Feelings of betrayal were echoed at a regional workshop on fences in July 1998 organised and hosted by Conservation International in Maun (Conservation International, n.d). At the workshop a representative from the Okavango Community Trust (OCT), a community organisation established to represent the interests of northern sandveld villages in the region's various CBNRM projects, claimed that the DAHP had pressurised the people into reaching a compromise on the NBF alignment, yet the agreed alignment was not followed (ibid).

During discussions at Beetsha there were mixed memories regarding the consultation process and confusion over why the government had adopted a different final alignment for the NBF. Some felt that the government had lost patience with the community *and* the DAHP and aligned the fence where *they* wanted it, whereas others thought that the community's indecisiveness was solely to blame and led the government to 'just do their own thing' after the community had 'failed to reach a decision'. All felt powerless to challenge the alignment as one man put it, *'the government decided to put the fence where it is, and we wanted it further away, but there is nothing that we can do'*.⁸ However, while the residents of Beetsha were aware of the consultation process, including the village *Kgotla* meetings and field visit by village representatives, few people from Gudigwa were involved in decision making for the NBF. This was because Gudigwa village was only established in 1987 well after the first round of consultation and field visits had taken place. At this time most of Gudigwa's residents were still living in dispersed settlements throughout the sandveld (Chapter 4).

Accounts from people in Gudigwa confirm that there was little consultation regarding the NBF. MW lived at Kaodube near present day Gudigwa and claimed that the DAHP *'just*

⁸Interview with ST (B26 7.06)

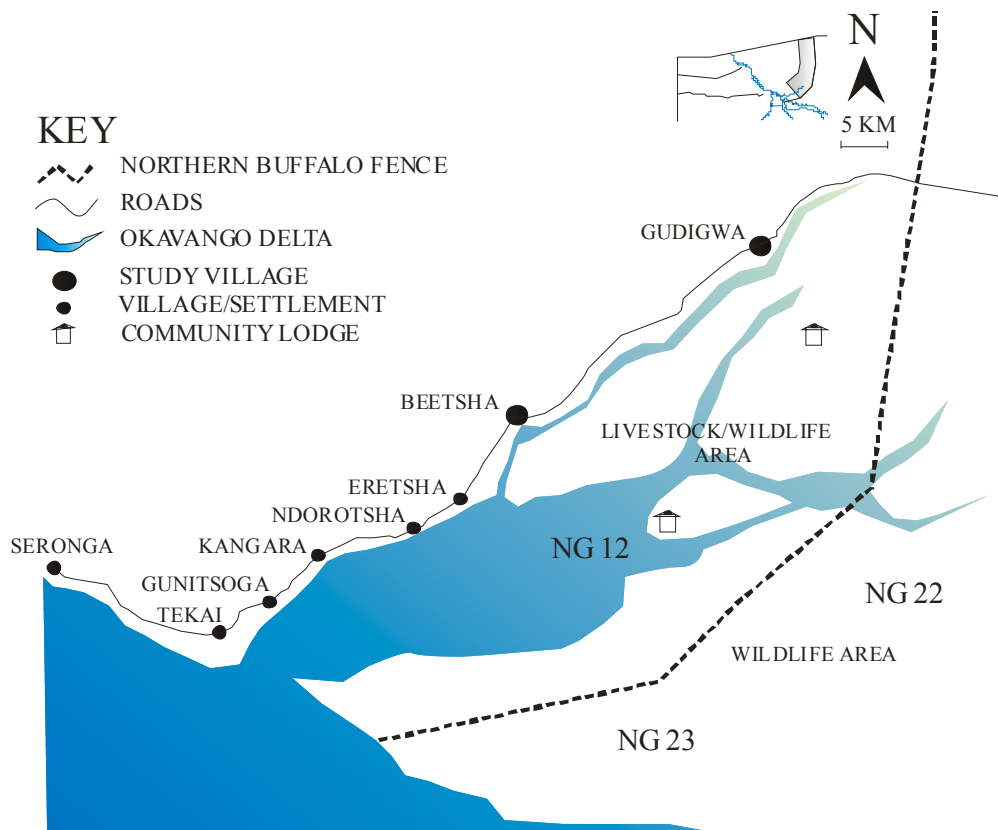
*came and told us that they are going to put a fence there'. 'We asked them to put it far away because we gather honey and fish in those areas, but they refused to realign it', he added.*⁹ To this day Gudigwa residents complain that they are often marginalised by the government and the last of the northern sandveld villages to receive developments. In 1996, for example, the government upgraded the main Seronga-Mohembo sand road to calcrete in order to improve access during the CBPP cull. However, according to the headman of Gudigwa officials initially improved the road as far as Beetsha, and only continued the work after the people of Gudigwa protested to the government.

Moore's (1993) statement that historical patterns of access to, control of, and exclusion from resources emerge from and mould competing meanings and cultural understandings regarding entitlements, rights and property relations has particular relevance to the NBF consultation exercise. The divergent local views regarding rights and property relations after the failed consultation illustrate this point clearly. On the whole, people from Beetsha are much more aware of their lost rights to land than those from Gudigwa, having participated in the consultation exercise.¹⁰ Although in total over 60 per cent of people from both villages resented enclosure, only 38.9 per cent of people from Gudigwa complained about lost land, the remaining 27.8 per cent complained about the impact of wildlife declines on the village's community tourism venture (Table 7.2). While this is undoubtedly caused by the cultural significance of wildlife resources to the Basarwa and local importance of benefiting more directly from community based tourism for reasons explained below, for most people in Beetsha the incorrect fence alignment was a particularly raw issue despite securing a better alignment than Gudigwa.

⁹ Interview with MW (G11 7.05)

¹⁰ Beetsha residents are more likely to cite lost land and natural resources as their reason for resenting the NBF (57.7%) than those from Gudigwa (38.9%) (Table 7.2).

The extent of Gudigwa's marginalisation in the consultation process can be seen by the final alignment of the NBF. The fence passes closer to Gudigwa than any other village in the northern sandveld and unlike the southern part of the fence which follows a land-use boundary, the 1997 extension to the Namibian border cuts straight through the Kwando Wildlife Management Area (NG13).¹¹ Furthermore, the southern section of the NBF passes within six kilometres of Gudigwa and the northern section of the fence passes within less than a kilometre of Dishokora, a remote Basarwa settlement to the north of Gudigwa (Map 7.2).



Map 7.2 Northern sandveld showing OCT community concession areas (NG22, NG23 & NG12).

¹¹ While the NBF runs approximately 10km south of Gunitsoga and Eretsha it passes just 6km to the east of Gudigwa (Map 7.2)

Several authors have also stressed the importance of a range of formal and informal institutions in governing the relationship between land use and resource access (cf. Batterbury and Bebbington, 1999; Berry, 1989; Scoones, 1998). The NBF case illustrates the importance of access to formal state initiated village institutions in order to attempt to negotiate an appropriate alignment that least disrupts local land use. Marginalised communities still settled outside these formal village institutions lost out during the consultation exercise and failed to negotiate access to their resources. As a result the fence impacted most on these people's resource use and enclosed some important natural resources. Furthermore, by coinciding with a period of rigorous enforcement of hunting legislation in northern Botswana, the fence appears to have assumed a preservationist conservation role demarcating what was now the barrier between open access communal land, and protected land leased to private safari operators.

7.3.2 Impact on wildlife utilisation and natural resource use

A small number of Basarwa households managed to remain living at Dishokora after the enforcement of hunting regulations in the late-1980s largely due to the presence of a wealthy Bakgalagadi cattle owner who obtained a permit from the Tawana Land Board. AW moved from Dishokora to Gudigwa in the late-1990s and pointed out what happened in 1997 when the DAHP extended the NBF past Dishokora.

There was no consultation when they built the fence. They just arrived with trucks and said there was going to be a fence here and that we should stop going the other side [east] as we would be breaking the molao [law]. (G8 7.05)

For many people in the northern sandveld, particularly the Basarwa, the fence is also linked to the government's hunting legislation and period of intense anti-poaching activity in the northern sandveld during the late 1980s (Chapter 4). AW was not alone in claiming that government officials had told the people to 'stop going the other side' as they would be 'breaking the *molao*'. There was general local consensus throughout both Beetscha and Gudigwa that areas now enclosed by the NBF were now out of bounds or protected, supporting the notion that the fence may have had a conservation agenda. During the planning stages of the NBF the DAHP solicited the full support of the Department of Wildlife and National Parks (DWNP), unlike the current impasse over fence planning in Ngamiland whereby the DWNP are against DAHP proposed plans (Environmental Investigation Agency, 2004). The NBF was clearly motivated by conservation concerns over the expansion of livestock into the Delta, but DWNP support the NBF may have been further prompted by problems controlling poaching in the region.¹² People from Beetscha described how they were afraid to continue using areas, close to, or enclosed by, the NBF. For example, MS, a Mbukushu man from Beetscha described why he is afraid to go near the fence to the south of Beetscha.

We used to go to Gombo and Mbishi hunting and gathering during the droughts. Now the fence blocks our way and we are told not to go there as we would disturb the lodge and could be poaching. (B1 7.05)

¹² During interviews with various DWNP officials in Maun, a wildlife officer was asked whether DWNP support for the NBF was motivated by the challenges faced controlling ongoing poaching activities in the Kwando-Linyanti region: 'Yes the fence helped us to say this is for wildlife and this is for cattle, however, the border fence helped to stop those Namibians from coming over and taking our game. The border fence helped us to say this is Botswana and this is Namibia.' (Interview DWNP 1, Maun, November 2005).

Although many Basarwa were in the process of shifting towards mixed agro-pastoral livelihoods, most possessed SGLs until the mid-1990s and all retained a strong cultural attachment to wildlife. The NBF now represented a physical barrier demarcating 'legitimate' cattle-based livelihoods and 'illegal' wildlife-based activities. The fence further limited the potential for livelihoods based on wildlife (both subsistence hunting and tourism) by reducing the diversity and density of game to the west of the NBF (Taylor, 2000).

While many people's relationship with the natural resource base had become more localised and were thus less affected by the fence, the alignment of the NBF through remote areas such as Dishokora had a large impact on current patterns of natural resource use. People from Dishokora lost access to their natural resource gathering areas to the east of the fence. There were several important waterholes to the east of the fence, for example, where people would gather water lilies.¹³ Basarwa also lost access to the Mobola Plum (*Parinari curatellifolia*). According to gatherers the Mobola Plum is only found in northern areas of the sandveld to the east of the NBF. When the NBF was extended past Dishokora it enclosed many of the areas where Mobola trees were most numerous.

There were other remote settlements that had remained dispersed amongst the seasonally flooded channels to the south of Beetsha after the period of resettlement in the 1980s. For example, people remained at Gombo, a predominantly Bayei settlement directly south of Beetsha, until the government asked them to resettle along the main road in 2002 (Map 7.1). Like the Basarwa from Dishokora, people from Gombo referred to losing areas

¹³ To signify the importance of these waterholes, Bien/wa, the Basarwa name for the area, refers to a particularly large waterhole now fenced in.

where they would gather, fish and hunt after the government notified them about the fence construction. Many had to adjust their natural resource use after losing resources to the fence.

Before the fence we would gather to the south of Gombo, there were big rivers where the men caught large fish. There were also areas where we gathered thatching grass and Muchochomo. The government informed us they were making the fence, we said we wanted it further away but they put it near us where they wanted it. After they made the fence we just had to say, "let's leave those trees now and concentrate on these trees around here". (B19 7.05)

LK's account illustrates how a similar situation to that which occurred in Dishokora was faced by the people from Gombo. The fence represented a barrier between what was now legal and illegal land use and people were forced to rely on resources the community side of the fence. However, while the fence directly impacted upon people's access to natural resources required for gathering and fishing, the NBF also caused some longer-term changes to the region's ecology with serious implications for people's access to wildlife.

7.3.3 Impact on hunting practices

Section 4.2 discussed the enforcement of hunting restrictions which occurred during the late 1980s and the various overt and covert tactics used by government officials to control subsistence and commercial hunting in the region. These activities have resulted in a legacy of mistrust within the community and most hunting activities today are conducted in secrecy (Taylor, 2000). As a result it was difficult to gain a proper perspective on the direct impact of enclosure on hunting activities. However, occasionally people were

unafraid to speak about their hunting activities and the impact of enclosure on these.¹⁴ The following section examines the impact of enclosure on those who remained reliant on wildlife resources as part of their livelihoods.

Interviews with Basarwa from Gudigwa affirm that many continued to hunt even after hunting restrictions were imposed in the late-1980s and the area was enclosed by the NBF. JB, a Basarwa man from Gudigwa, recounted how he was caught hunting during the early 1990s using a military weapon obtained from relatives who worked in the bushman battalions:

After they made the fence in 1991 we continued to hunt from //Gam /wi to Dishokora. There are places where the bush is open there and it's easy to track and hunt wildlife. Most people continued to hunt as god gave us these animals to use. We used Namibian guns from the army. I was arrested and taken to Maun and then Francistown prison. These days it is hard for them [Botswana Defence Force (BDF) or DWNP] to catch us as we know the bush well. They pass right by and we know how to go around them if we hear them coming [gestured and mimicked hiding]. Most were caught back in Gudigwa. (G27 7.06)

With the southern border between NG22/23 and NG12 now enclosed by the fence, hunters began to focus on the unfenced northern region within NG13 (Figure 7.2). Taylor (2000) noted that most men older than forty in Gudigwa have been in court at least once for offences related to illegal hunting, and about one third of them have spent time in prison as a result. Records from Ngamiland's Anti-Poaching Unit support JB's claim that hunting continued during the 1990s in the region north of Gudigwa. The statistics also confirm that hunters were largely able to avoid detection and few were caught whilst hunting. Of the 52 cases of illegal hunting which the DWNP's unit handled between 1993

¹⁴ One of the following accounts from Basarwa hunters was gained from informal discussions with Kung! hunters living within the CBPP fences to the west where hunting restrictions are rarely enforced.

and 1997 only two cases involved residents from Beetsha and Gudigwa, and these were cases involving the illegal possession of a firearm rather than hunting.¹⁵

Nowadays, most large animals are hunted using guns. In the past, those without access to a gun would chase down prey using a spear. As a result hunting has usually been the occupation of the fit and able. Older men tended to remain around areas close to the settlement setting traps or hunting springhares. Today, many Basarwa in Gudigwa still possess a *gondo*, a long stick with a hook at one end used to hunt springhares. These are difficult to conceal and therefore hunting springhares and some small game is generally tolerated by DWNP officials and more openly conducted by Basarwa.¹⁶ However, while being seen with a *gondo* may be tolerated by officials, people seen with guns in wildlife areas are targets for arrest.

Due to hunting restrictions, hunting of large animals must be conducted at a distance from the village to avoid being caught. Taylor (2000) found that some residents of Gudigwa hunted on horseback, a trend often linked to sedentism among Basarwa communities (Osaki, 1990). According to Basarwa from Movembe the use of horses or donkeys for hunting is a practice that began after their arrival in Gudigwa.

In Movembe we never had donkeys we just walked everywhere. In 1987 when we moved to Gudigwa some people had donkeys and horses here. With donkeys we could visit our relatives at Kwai easily. We hunted and gathered on the way. We made biltong and waited for it to dry before bringing it back to Gudigwa on the donkeys. Since the government stopped the free game licence and made the fence

¹⁵ Poaching records indicate that one man from Gudigwa and one Beetsha resident were arrested with illegal military weapons (probably Kalashnikov or AK47) on 14.3.94 and were fined and sentenced to five years in jail (Boltothomile, 1999).

¹⁶ There may be some informal leniency exercised by the DWNP towards subsistence hunters. This was confirmed during an interview with a DWNP official in Maun who claimed, 'we accept that local people hunt for subsistence and we allow them to do so' (Interview DWNP 1, Maun, November 2005). However, such leniency is generally restricted to small game hunting (Taylor, 2000).

we stopped going that side. There are only safaris that side now, we can't go there anymore. (G21 7.06)

The extension of the NBF in 1997 coincided with the termination of SGLs, which were converted into a community quota system under the CBNRM concept. People now wishing to continue gathering, fishing and hunting for honey in areas enclosed by the NBF required a permit from the DWNP. As discussed above, those still living outside the village structure and close to the fence adjusted their natural resource use accordingly and while their access to resources was restricted, they were forced to focus on the resources around them. However, for the Basarwa, hunting is more than a strategy used to support agro-pastoralism in times of need. For Basarwa hunting is tied to notions of identity and enclosure forced a major cultural shift.

I was from Dishokora, I moved to Gudigwa permanently in 1997. We gathered in Gudigwa because the government asked us to be in one place so that they could build schools. In Dishokora I wasn't a farmer, I was as my parents had left me, a Bushman. I hunted animals freely and gathered honey. The government then came and asked us to move to Gudigwa. We got a lift on the veterinary truck as they were building the fence. I don't think the fence had a role to play in our move, we were just asked by the government to come to Gudigwa. I left a life in Dishokora and I can't find many of these things in Gudigwa because of the fence and hunting restrictions. We cannot go to the bush and collect things here without permits. If we are caught with meat we will be jailed. (G32 7.06)

Though the NBF restricted access to wildlife resources and formed a barrier to hunters, there are still animals on the community side of the fence. Interviews with the few Basarwa who admitted hunting confirmed that people are still able to hunt game to the west of the fence. However, the construction of the NBF caused some long-term changes to the regions' ecology. The extension of the NBF in 1997 effectively isolated most

wildlife species to the west of the fence and almost continuous settlement along the Delta fringe leaves few migration corridors to permanent water. Since this period there have been declines in the diversity of wildlife found on the communities' side of the fence.

People from the northern sandveld were acutely aware of the impact of the NBF on wildlife populations to the west of the fence. Almost all informants have noticed a decline in animal populations and diversity in the community areas to the north and west of the NBF. KB a Mbukushu man in his 40s said, *'when we were young there were animals just here, but now they are all gone, I don't know if it is because of poaching or what but they have been finished'*.¹⁷ However, while people such as KB did not know why the animals have decreased, most attributed the reduction to the fence. For example, one Mbukushu man from Beetsha claimed, *'the only animals this side of the fence are zebras and elephants, this shows that the fence has caused a big decrease in animals'*.¹⁸

While the Hambukushu from Beetsha were aware of the general declines, Basarwa hunters noted specific species that have decreased. OP, a Basarwa man from Gudigwa, commented, *'the numbers of tsessebe, wildebeest, impala, kudu, red lechwe, wild dogs, lions, giraffe and buffalo have all decreased this side'*.

The Basarwa's increased awareness concerning the impact of the fence on wildlife further supports the notion that they continued to rely on hunting as a source of livelihood after enclosure. According to OP giraffe often become entangled in the fence and elephant are able to break through it, kudu can jump it, and predators such as lion can dig

¹⁷ Interview with KB (B23 7.06)

¹⁸ Interview with DI (B27 7.06)

underneath.¹⁹ These local observations regarding species interaction with Botswana's fences match those of scientists reviewed in Chapter 2.

Local observations of widespread wildlife declines to the west of the fence are also supported by aerial census population data from the DWNP. In Botswana, there are major limitations with aerial survey data, including a lack of consistent methodologies and ground-truthing (Wheelwright *et al.* 1996). However, from 1996 to 2004 surveys were based on standardized methods, thus enabling population trends to be estimated for some important species (cf. Junker *et al.* 2008). Estimating the population dynamics of key species either side of the NBF is beyond the scope of this study given the long runs of data required to accurately assess changing levels and trends. Mean population data for two zones roughly relating to areas directly east and west of the NBF, however, provides an estimate of the diversity of species found either side of the fence. Table 7.3 shows mean dry season population estimates for the main wildlife species found to the east and west of the NBF between 1996 and 2004.²⁰

¹⁹ Interview with OP (G21 7.06)

²⁰ The populations of two zones are used to gain these estimates. Zone 25 and 26. It is unclear from the census map whether the boundary between the zones was the fence or the road running along the northern delta but these estimates represent rough estimates of the diversity and abundance of species found to the east and west of the fence.

Table 7.3. Mean population estimates based on dry season wildlife aerial census data for areas east and west of NBF from surveys conducted between 1996 and 2004.

Species	West	East
Elephant	7439	32949
Zebra	5027	3557
Hippo	10	4764
Warthog	193	255
Giraffe	0	641
Eland	0	818
Kudu	0	87
Sitatunga	0	357
Gemsbok	342	28
Roan	0	17
Sable	0	223
Waterbuck	180	661
Lechwe	0	141
Tsessebe	0	701
Duiker	92	0
Klipspring	5	0
Wildebeest	0	950
Impala	0	3201
Steenbok	155	69
Buffalo	0	10030
Baboon	0	496
Hyena	0	11
Lion	0	62
Ostrich	26	226
Crocodile	81	53

(Source: DWNP 1996, 1999, 2001, 2002, 2003, 2004)

The data illustrate that the diversity of species found to the west of the fence is considerably less than that to the east. Of the 23 species to the east, only 10 are found to the west. The populations of all species apart from crocodile, gemsbok, steenbok and zebra are higher to the east of the fence. Furthermore the absence of primarily water dependent species previously observed by Basarwa hunters before enclosure (tsessebe, wildebeest, impala, kudu, red lechwe, lions, giraffe and buffalo), supports the theory that these have declined since the region was fully enclosed in 1997. The higher populations of water independent species such as gemsbok and steenbok to the west of the fence

could be indicative of fence induced trends similar to those which have occurred in the central Kalahari (Thouless, 1998).

For subsistence hunters, therefore, most large antelope are now found to the east of the NBF. This presents difficulties for Basarwa continuing to hunt in secrecy, on foot, or on horseback. In an area where livestock are often lost to predators and restrictions on hunting are strongly enforced, livestock ownership provides the only legitimate reason to carry a gun and men are frequently seen herding with a weapon. This means that people walking with a weapon in wildlife areas beyond those grazed by livestock risk being caught by anti-poaching patrols or reported by DAHP fence maintenance crews. Residents of the northern sandveld were well aware of this. Donkeys and horses are not allowed through the veterinary gate as the Animal Disease Control Act of 1997 declared the Okavango and Kwando wildlife management areas to be stock-free zones. Those who cross the fence on foot risk being tracked by DWNP or BDF anti-poaching patrols. As a result anyone who continues to hunt, gather and fish in areas close to, or across the fence must appear to be conducting legitimate activities such as fishing, gathering or hunting for honey. Natural resource use is also closely governed by a system of permits issued at the village Kgotla.

Both Hambukushu and Basarwa described how they were afraid to visit areas previously used for hunting, gathering and fishing for fear of being suspected of poaching. Those who continue to use resources near the NBF are cautious not to be seen with a weapon or in groups which may resemble hunting syndicates. For example, BB, a Mbukushu man from Beetsha, continues to conduct long distance trips to catch fish in areas of perennial swamp near the NBF. He pointed out that, in the past, several families would make

camps and hunt and gather freely for several weeks. However, he now prefers to go alone and is reluctant to carry a gun for fear of being beaten by the DWNP officials.²¹

Few Hambukushu or Basarwa were willing to describe their current hunting practices and admit whether they continue to hunt in the concession areas to the east of the fence. There were rumours that some hunters bury weapons in the bush to avoid being caught by the DWNP and BDF. Whether these are buried to the east of the NBF and used to access the abundant wildlife resources is hard to say. Discussions with Basarwa hunters from the CBPP study site, where hunting restrictions are rarely enforced, revealed interesting insights into how Basarwa hunters cope after being excluded from wildlife resources. Once again most people noticed a decline in the diversity of wildlife present in the area since the erection of the fences in 1996. According to Basarwa most animals are now found to the south of the Ikoga fence.

We used to hunt near here by Tjakwe cattlepost now we have to go far past Nxau Nxau to find game. We take donkeys and put the meat on the donkeys to bring it back. We are afraid of getting reported by the veterinary officials so we wait until sunset before passing through the fence gate. We take blankets and cover the meat so they think we have been visiting relatives to the south. We used to hunt with bows and arrows in the past but these days we borrow a gun from the Herero and give them meat in return. (Ch51 7.06)

Several studies have documented the impact of sedentism on hunting and social relations within Basarwa societies in Botswana (Osaki, 1984; Kent, 1996) and the changes described above match these observations. Today, hunting requires access to the requisite resources required to enable long-distance trips (horses, donkeys, guns etc), itself determined by investments in relationships with the owners of such resources (in this

²¹ Interview with BB (B7 7.05)

case the Herero). By enclosing wildlife the fence has increased reliance on these relationships which encourages the individualisation of hunting as people seek to invest in these networks over kinship ties. Taylor (2002) found that hunting legislation in northern Botswana has encouraged the individualization of hunting, though he fails to expose the role of enclosure in facilitating the enforcement of preservationist conservation policies, nor the impact of the fenced exclusion of wildlife from some community areas on hunting practices. He also noted that hunting has become less efficient as hunters often leave some of the meat after taking only what a lone hunter can carry on foot (Taylor, 2002). Thus, it is possible that by enclosing wildlife and denying access to donkeys and horses veterinary fence enclosure has contributed to factors encouraging wasteful hunting practices amongst hunters in northern Botswana.

By effectively 'fencing out' most wildlife species, the fence closed the door on a period of diverse natural resource use based on spatially dispersed resources (wildlife, fish, veld food, honey). People lost access to some locally valued plant and animal species as well as some unique dependable resource areas. Although many of these resources can still be found on the community side of the fence, the NBF enclosed some key hunting and gathering areas well known to local residents for important reasons. The next section of this chapter turns to analyse how this loss of access to wildlife and natural resources has some major implications for the ability of people to exercise traditional strategies to cope with environmental variability and natural hazards in the region.

7.4 Impact on societal vulnerability to risks in northern Botswana

Drylands are inherently risky environments. However, people of the Okavango Delta have to cope with a myriad of water-related risks in addition to recurrent drought, fire, disease and civil unrest (Kgathi *et al.* 2006).²² The Delta is subject to an annual flood event which takes place during the dry season (August-September) and is largely dependent on rainfall in the Angolan highlands. The area inundated changes annually and interannually with long term variability ultimately determined by external climate changes and El Niño/Southern Oscillation (ENSO) effects (McCarthy *et al.* 2003). As a result, the flooded area can vary from an annual minimum of between 4000-6000 km² to an annual maximum of between 6000-12000km² (Wolski and Murray-Hudson, 2006). Flooding is also spatially dynamic with floodplain morphology naturally changing due to sedimentation, channel blockage and avulsion (McCarthy and Ellery, 1998).

Flood regimes therefore change annually and interannually, and are subject to longer-term trends. Discussions with people who lamented the loss of land and resources revealed that longer-term concerns regarding societal risk and vulnerability caused most people from Beetsha (57.7%) and many from Gudigwa (38.9%) to resent enclosure (Table 7.3). People were well aware of their contemporary vulnerability to risks and that enclosure has restricted their ability to exercise traditional coping strategies. The following discussion with MN and his wife RN illustrates what troubled this group of

²² In 1999-2000, for example, Namibian troops assisted Angolan forces to combat an increase in banditry in western Caprivi (Kgathi *et al.* 2006). Such problems can have an adverse effect on tourism upon which may depend for income. In 1999-2001 ongoing political problems in Zimbabwe reduced the volume of tourists in Moremi Game Reserve by 35 per cent (ibid: 13).

people, and why they fought hard to retain access to distant resources during the consultation process.

*MN: The fence has disturbed us. During droughts we would travel to Sandaroka or Mbishi and make camps and gather Mokutshumo [*Diospyros mespiliformis*] and fish. We would then dry them and bring them back to the village. (B8a 7.05)*

RN: Many years back we would gather, hunt and fish in some areas near where the fence is, but for some years now we have had our fields and we haven't needed to go to these areas anymore, we only used these areas during droughts when the crops failed or when the floods were poor. (B8b 7.05)

While her husband resents the loss of traditional hunting, fishing and gathering areas at Sandaroka and Mbishi, RN acknowledges that these were resource areas used in the past, especially in times of need. In doing so she recognises that her current resource use is localised, yet is aware of the need to use mobility as a coping strategy in times of need, often in response to natural hazards.

In section 4.3, the connection between livestock and natural resource relationships was explored and investing in livestock during the post-mine era was found to have caused a reduction in the distance and diversity of hunting, gathering and fishing in the northern sandveld. Natural resource use had become largely localised in nature and commercialised after successful tsetse campaigns enabled more widespread livestock ownership during the early 1980s. Further changes in people's relationships with the environment occurred after resettlement and provision of drought relief (section 4.4). However, water-related risk remains a primary concern, not least for livestock owners (see above). PM owns a small herd of cattle and, therefore, did not migrate or experience

resource conflicts during the 1990s, yet he laments the loss of access to areas further south.

The fence is too close to us. The areas where we used to hunt, gather and fish during droughts or poor floods have been cut off by the fence. For several years during the 70s there was poor flooding in the Delta. The water didn't reach the rivers near Beetsha and we had to travel to the deeper channels further south. These are now the other side of the fence. I'm now asking myself, "what are we going to do next time there is a drought or the river doesn't come". (B38 7.06)

Table 7.4 below lists the main shocks that affected the community over the period of enclosure from the late 1970s until the present day. Intermittent droughts and poor delta floods are recurrent risks to which the community have been exposed, both directly before and after enclosure. Droughts, poor floods and disease epidemics can coincide, as was seen in 1995-1996. These risks were confirmed by the rainfall record from Seronga police station (Figure 7.1) and flood distribution data from McCarthy *et al.* (2003) (Figure 7.2). In the latter study AVHRR data clearly show the poor floods south of Beetsha from 1993-1999. So how did enclosure affect the ability of people to cope with these shocks?

Table 7.4. Summary of main shocks to affect community before and after fence (1978-present). Source: fieldwork interviews or referenced literature.

Date/Duration	Main Risk or Natural Hazard	Reference Material
1978-1979	High flood	Bendson and Meyer (2003)
1982-1988	Drought	Bendson and Meyer (2003)
1991	Southern section of NBF completed	
1993-1999	Poor floods	McCarthy <i>et al.</i> (2003)
1995-1996	Drought	Bendson and Meyer (2003)
1995-1996	CBPP disease outbreak	Bendson and Meyer (2003)
1997	Northern section of NBF completed	
1999-2001	Civil unrest and unemployment from tourism industry	Kgathi <i>et al.</i> (2006)
2002-2004	Poor floods	Interviews
2002-2003	Drought	Interviews

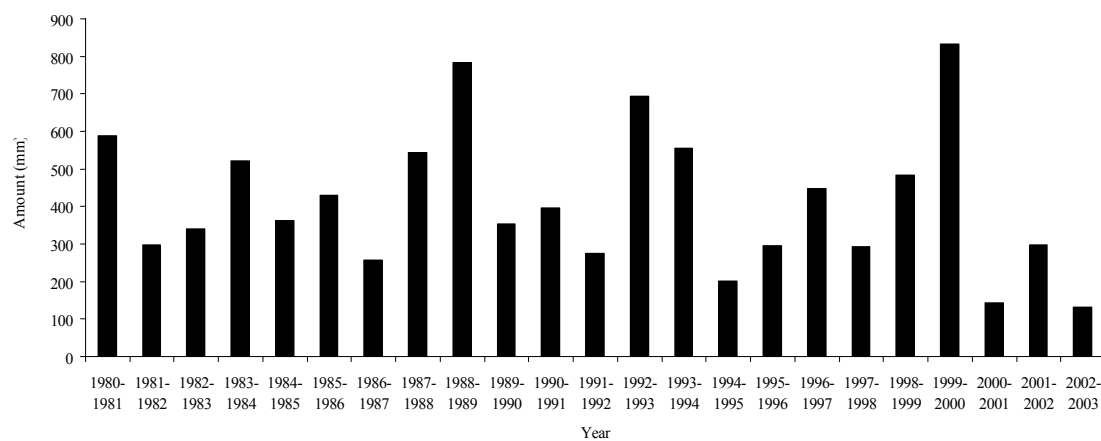
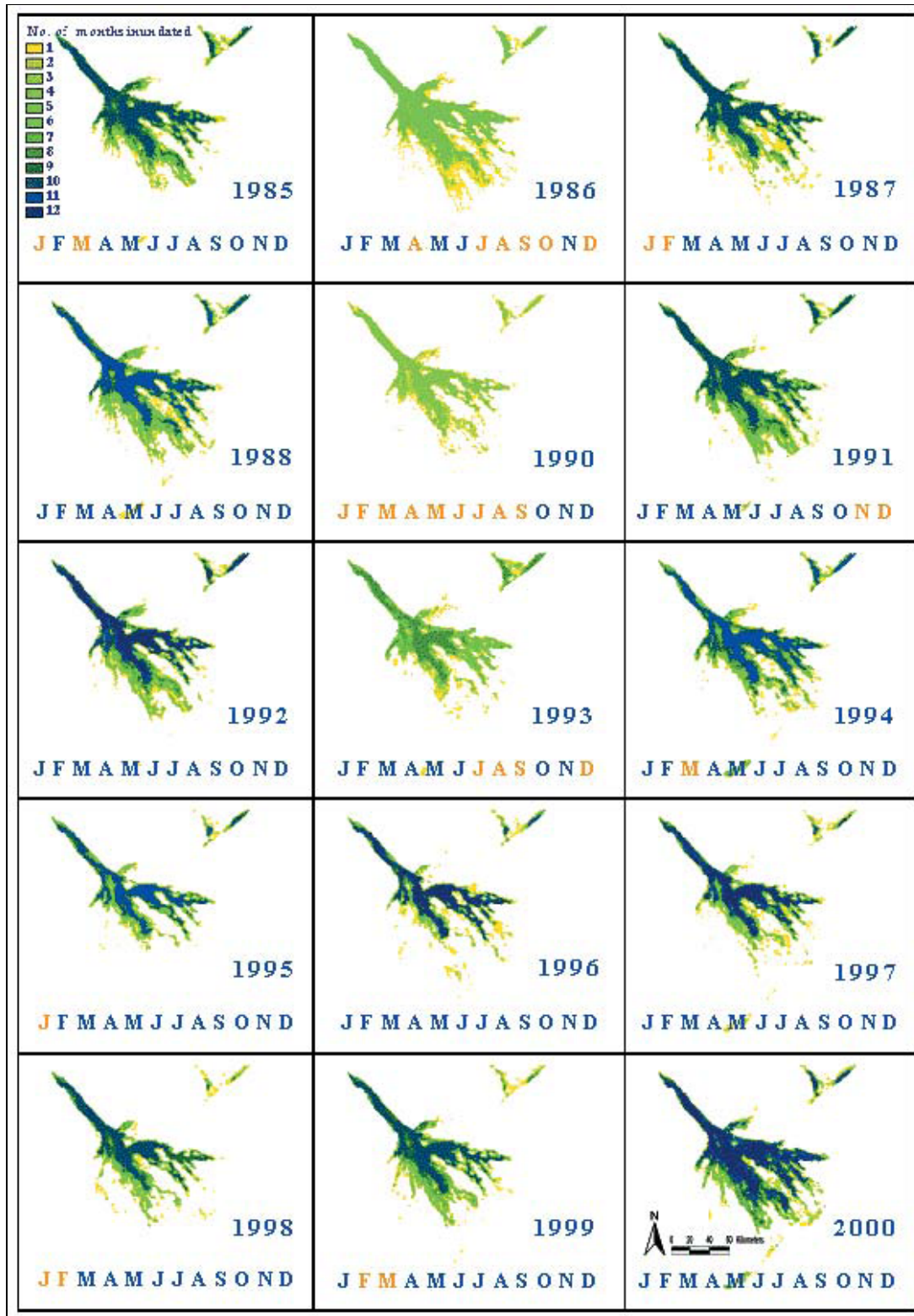


Figure 7.1. Average annual precipitation from Seronga police station for the period 1980 – 2002. Source: Appendix 6.

Figure 7.2. Yearly area of Okavango Delta inundated with water 1985-2000 (1989 missing). Legend refers to number of months inundated and letters in yellow below the maps refer to months when data is missing. (Source: McCarthy *et al.* 2003)



Pre-fence coping strategies

During discussions in Gudigwa and Beetsha it emerged that coping strategies have changed considerably over the last 25 years. In order to determine the impact of enclosure on local vulnerability to risk, discussions centred on how the community coped with droughts and poor flood events before and after the construction of the NBF. The last time the community were forced to migrate due to poor delta floods was before the 1980s. Thus drought is the main perturbation to affect the community both directly before and after enclosure (Table 7.4). The succession of drought years from 1982-1988 were particularly bad causing considerably poor crop yields and Ngamiland's cattle population to decline by 24 per cent (Bendsen and Meyer, 2003).

Section 7.3.2 demonstrated how the NBF directly impacted most upon marginalised households that were the last to settle in villages established during the 1980s. Discussions concerning the impact of enclosure on coping strategies revealed that those who remained outside the new settlements exercised most mobility during the 1980s droughts, surviving using migration and social support networks. Two cases, from a Basarwa household already settled near present-day Gudigwa and a household still living at Dishokora illustrate the differing coping strategies used to survive the droughts of the 1980s (Box 7.1).

Box 7.1. Drought coping strategies of two households used to cope with 1980s droughts. Source: fieldwork interviews: DT (G15 7.05), PB (G6 7.05).

During the 1980s DT and his family lived at //Gam /wi near present-day Gudigwa. They grew crops on a large field previously owned by a Kgalagadi household who left the region after Tsetse re-infested the area. During the early 1980s the children started to attend school in Beetsha and household members could access government relief and labour programmes. DT recounts several years in the 1980s when the family faced a food shortage. *'In 1985 there was poor rainfall and the crops failed. The VDC talked to the government and they sent drought relief food. We still gathered wild food in the bush.'* According to DT the seeds of the Tsoadi tree (*Guibourtia coleosperma*) and fruits of the Mokutshumo tree (*Diospyros mespiliformis*) were the most important foods as they are drought resistant and freely available close to the settlement. Mongongo (*Ricinodendron rantanenii*) is also drought resistant, while Muhamana (*Dialium englerianum*) and Mokomphata (*Grewia flavescens*) only produce good fruit every few years. *'We collected all these fruits during that drought. We went after the harvest. We also made fish traps to collect fish from channels that were drying out near Kapiri,'* he added. To fill any short-term shortages the household bought food from local shops using income earned from drought relief work.

PB lived at Dishokora during the 1980s and cultivated a small field by hand. He often worked for a Kgalagadi livestock owner who gave him milk and meat if an animal died. When the crops failed he survived the drought by collecting wild fruits and hunting, or receiving milk and meat from the livestock owner. *'We depended mainly on the Mujope plant (Bauhinia petersiana). We would roast the roots on the fire. If the rains were poor we sometimes went towards the river where there is honey and lots of food to eat. We were given meat from Dubu when he lost cattle to lions or the drought. If we helped him make biltong we were given meat in return. He would also give us milk whenever we liked. We also went to Movembe to visit our relatives there. We hunted and gathered there.'* After surviving for several months the family decided to migrate further afield and used their social support network to access food. *'We decided to go to //Gam /wi where our friends had been given food by the government. They shared food with us.'*

The differing strategies illustrate how households already settled at Gudigwa and Beetsha still relied on the natural resource base, but tended to gather, hunt and fish in areas close to the settlements. On the other hand, those living furthest from Gudigwa and Beetsha lacked access to social welfare and were heavily reliant on their dispersed social support network and resources. Other households who moved to Gudigwa from Dishokora also recount migrating to Caprivi, Seronga or Beetsha to survive the drought. For these households the fence has made it harder and more expensive to travel to visit relatives in Namibia. AW, who lived at Dishokora until the mid-1990s, has sons who live and work in Namibia:

During the drought we left the fields as the crops were poor and we hunted and gathered to the north of Dishokora. We then travelled to visit my sons in Namibia and they gave us sugar, soap, tobacco and maizemeal as they were working there. We also travelled to Beetsa and Seronga and begged for food and tobacco from the Hambukushu. Now with the fence we cannot travel to Namibia easily, we have to go via Mohembo and it takes a long time and is expensive. (G8 7.05)

Some people claimed to continue crossing the border fence even after it was extended and electrified in 1997. There were several households without a national identity card (*Omang*) in Gudigwa and some of these continue to migrate on foot to Namibia. However, most people were now afraid to cross the fence for fear of being arrested by soldiers. OP from Gudigwa explained why he no longer crosses the fence to visit relatives:

I was young when I used to go to Namibia and I thought it was just one country. Now I realise that it is another country when I saw the fence there in 1997. Now I use the border crossing at Mohembo because if I cross the fence the soldiers will shoot me. I sometimes see people who have crossed from Namibia and the government catch them in the village and take them to Dukwi refugee camp. (G21 7.06)

The decreased accessibility of trans-fence support networks has economic implications for some people. Many households from Gudigwa have relatives living at Kwai, a settlement on the edge of Moremi game reserve. Before the NBF was constructed people could walk to Kwai freely without restriction and were able to visit relatives and sell crafts such as baskets or knives to tourists. They would also be able to visit during emergencies or ceremonies such as funerals or weddings. Now the only way to visit Kwai is by bus via Maun, or on a VDC vehicle which sometimes passes through the fence.

Again, some people continue to cross the NBF and walk to Kwai but run the risk of being accused of poaching by government officials or concession holders.

Post-fence coping strategies

Since the completion of the southern section of the NBF in 1991 there were several years of poor delta flooding which culminated in the drought of 1995 and CBPP cull in 1996 (Table 7.4). Section 7.6 describes how livestock owners used mobility to cope with the poor floods during the 1990s and illustrates how resource conflicts have increased after the allocation of community concession areas. The enclosure of land and resources previously used for hunting and gathering has been locally linked to recent losses of land to the CBNRM movement. By association the NBF has clearly impacted negatively on livestock management coping strategies. However, how did people without livestock cope with the shock of the CBPP epidemic, droughts and poor floods of the mid-1990s and did the NBF impact on these strategies?

Many stockless households were reliant on informal exchanges and the *mafisa* system to access livestock before the cull. The shortage of oxen dramatically reduced the cultivated area as people struggled to find adequate draught power to plough land. According to one farmer,

After the cull many people abandoned their fields, especially people with distant land as they lacked oxen for transport and ploughing. If you go there now you can't believe people ploughed there as bushes are everywhere. (B38 7.06)

Government tried to assist farmers by providing access to donkeys for draught power through the Arable Lands Development Programme (ALDEP) subsidy scheme (Bendson and Meyer, 2003). Although the area under arable production declined most people still cultivated using the traditional hoe technique or with donkeys. District level socio-economic studies reveal the impact of the cull on arable farmers. Surveys conducted before the outbreak revealed that 25 per cent of the population perceived arable farming as their primary livelihood income, whereas after the cull the activity was ranked by 37 per cent as their main source of income (Fidzani *et al.* 1999).

The state also increased access to labour intensive public works programmes (Arntzen, 2005). Many people, particularly men, earned exceptionally high wages working for the DAHP to assist the cull effort. Another relief measure was a government programme providing subsidies for ploughing, clearing and weeding land (Bendsen and Meyer, 2003). As a result, MN a Mbukushu blacksmith from Beetsha experienced an increase in the sales of hand made tools.

Just as I prepared to travel to Seronga and sell some axes people would come and buy them from me to use on the land. Many people were clearing land and they wanted big axes. I decided to clear land also and made axes during the evenings. We used the money to buy food in the village. (B8a 7.05)

Most people coped by relying heavily on income from labour intensive public works programmes and remaining arable production. Those who owned cattle opted for 100 per cent cash compensation which resulted in a cash boom as many spent their money on consumer goods. The period saw a dramatic increase in the number of small village shops in the region (Hoon, 2004).

Chapter 6 described how the CBPP cull caused the migration of herders to villages in the Chukumuchu region and retrenchment into labour intensive public works programmes. In the northern sandveld a similar pattern occurred after the cull caused the collapse of livestock farming in the region. Herders returned to the villages to seek alternative work and soon became entrenched into temporary employment. The increased population of young herdsman in villages and increase in cash prompted a rise in beer brewing as some women diversified their livelihoods to cope with the drought and CBPP cull.

The period also saw an increase in people resettling in the main Delta villages. These were households who remained at distant settlements and were most likely to have relied on the natural resource base, mobility and social support networks to cope with previous pre-fence shocks. One particular community were the people of Gombo, a small settlement several hours walk to the south of Beetsha (Map 7.1). The cull marked the beginning of a period whereby the people of Gombo gradually resettled near Eretsha on the main Seronga road. Those who migrated after the cull moved to find employment following the increase in government subsidies and village based informal income opportunities. As a result many became fully integrated into village life. Young men became engaged in temporary employment and were reluctant to return to Gombo after the restocking exercise. According to one man,

The young men don't want to return to Gombo as there is always beer here. Before in Gombo we would make beer after the harvest and it would soon be finished. Now in Eretsha we can find beer anytime we want if one person's beer runs out another will be brewing and the young men are happy here. (B20 7.05)

Economic diversification into a variety of informal income activities, therefore, forms the principal means by which most people cope with contemporary risk and vulnerability in the northern sandveld. As well as brewing beer and making tools, people reported using sales of thatching grass and baskets to generate income during the mid-1990s. Government labour based public works programmes and arable farming also provided many with both grain to make beer, and money to buy sugar for brewing and food. These days diversification has become a longer-term adaptive strategy used to cope with risk. Davies (1996) classifies coping strategies as short-term responses to unplanned crises; while he argues that adaptive strategies are the ways people respond over the long-term to adverse events, cycles and trends. Faced with resource conflicts for grazing lands and instability in the tourism sector in the late 1990s (Table 7.4), people are cautious not to rely too heavily on one source of income. This was evident during a discussion with one man who owns cattle but at the same time is looking for work in the lodges:

You never know what will happen, the cattle may die of disease. Its better to find some work somewhere like tourism. I am looking for work now and if I find some I will send other youngsters to look after the cattle here. I won't give up farming if I get a job in the tourism. If you make a mistake where will you go, my heart will always be with the cattle on the cattlepost. (B15 7.05)

While most people coped with the droughts and CBPP cull using economic diversification and migration to government-initiated employment programmes, some people were still reliant on the natural resource base to some extent. Several households from Beetsha and Gudigwa claimed to have relied on short distant gathering and fishing to cope with the shortage of food during the 1990s. For example, MK, from Gudigwa,

relied on gathering and fishing after the cull, but claimed: *‘the government helped us, so we didn’t go far to collect these things’*.²³

Those who remained at distant settlements used hunting, gathering and fishing to cope with the drought, CBPP cull and poor floods in the mid-1990s. Men who stayed behind at cattleposts with the smallstock hunted on horseback or on foot (Chapter 4). Similarly, people who remained at Gombo lacked the ability to use economic diversification and were heavily reliant on the natural resource base. Faced with poor floods, a lack of draught power, poor rainfall and declining arable yields the community attempted to use their traditional drought coping strategies, but found them curtailed by the NBF. TM, an elder from Gombo, discussed the problem:

When they build the fence people complained and said “how are we going to cope during droughts now this fence is here, we expected it to go past Mbishi not Gombo”. During the poor floods and droughts around the time of the cull we wanted to go over the fence to Mbishi as we knew there were rivers that were drying out that side and we could collect fish there. We were afraid to go over the fence as the wildlife dept would think we’re poaching. (B18 7.05)

Part of the problem in terms of the fences’ impact on local NR-based coping strategies is that the NBF has enclosed most of the more reliable resource areas. Like most people along the Delta, in the past the community gathered water lily bulbs (*Nymphae nouchali*) and edible fruits such as *morula* (*Sclerocarya birrea*) and *mokutshumo* in areas such as Mbishi (Map 7.1). They also made fish traps in drying channels now south of the NBF to survive droughts and poor floods. MI, an elder from Gombo now lives at Eretsha and explained why he resents the fence:

²³ Interview with MK (G10 7.05)

The fence is not good. When we stayed at Gombo the fence cut off the areas where we used to gather and fish. We lost areas where there were deep channels with lots of water lilies and fish. The areas to the north of Gombo are poor there are only barble fish and the baboons eat all the mukuchomo. Now we are here at Eretsha we may decide to gather mukutshumo when the crops fail and we will be forced to use these areas again. (B40 7.06)

MI's response illustrates an important cultural shift in terms of rural coping strategies in northern Botswana. He suggests that he *may decide* to gather when the crops fail, yet most people now rely on resources close to the settlement or use income to buy food from the village. However, older generations speak of gathering with nostalgia. This was evident during a discussion with one Mbukushu elder about changing drought coping strategies,

Nowadays the Hambukushu are weak. These modern foods like rice and macaroni have made us weak. We used to gather mukutshumo and murula, and we would fish in Mbishi during droughts. This was our culture and even if we had enough grain and money we would still gather these things as they are sweet and nice. (B7 7.05)

Although older generations have a strong cultural attachment to gathering, they have good reason to lament the lack of access to the natural resource base in times of need. In the Okavango Delta permanent channel desiccation also occurs irrespective of water availability. During the 1970s and 1980s a number of key distributaries dried out on the western side of the Delta, and people were forced to migrate to find alternative cultivation areas for *molapo* farming (cf. Bendsen and Meyer, 2003; Mbaiwa, 2004).²⁴ People also lost access to water dependent livelihood opportunities such as fishing and

²⁴ *Molapo* farming is a predominantly Bayei livelihood activity involving flood recession cultivation in drying river channels. Some informants from Beetsha used the technique in the past to cope with droughts, however.

the collection of 'wet' veld products (Arntzen, 2005). Access to these resources was denied by the southern buffalo fence. Elders from Beetsha and Gudigwa were both aware of the long term variability of the Delta environment having experienced poor flooding events in the past and well aware of the permanent drying of the Thaoge River and Tubu floodplains near Gumare.

7.5 Implications for CBNRM in northern Botswana

The above discussion clearly demonstrates how enclosure of the wildlife/livestock interface has restricted resource access and weakened local community control and management of natural resources in northern Botswana, with serious implications for societal vulnerability to environmental variability. This section now turns to examine the implications of these changes for the ability of community-based natural resource management (CBNRM) projects in the region to achieve their conservation and development goals.

The construction of the NBF coincided with a land use planning exercise which redrew Ngamiland's concession areas into 49 controlled hunting areas (CHAs) (GOB, 1991). When the NBF was initially constructed in 1991 livestock numbers were beginning to increase following the Tsetse spraying campaigns of the early 1980s. As discussed above, officials were concerned that without a natural barrier to restrict expansion, livestock would encroach upon the Okavango Delta grasslands (Thomas and Shaw, 1991). Although livelihoods based on wildlife were becoming increasingly restricted in the region with mounting hunting legislation, government planners acknowledged that some

households were dependent on wildlife through the Special Game Licence (SGL) scheme and thus included a CHA on the community's side of the fence (NG12). During the NBF technical meeting of February 1991 government land use planners explained the context:

'we know there is a wildlife resource in this fenced off area [NG12]. We recognise that, and in fact we have put a sub-zone in here that we're going to be exploring the utilization of wildlife resources. We know they [the communities] have livestock here, so the whole program will be to see how far we can go on an integrated basis. But ultimately the people will decide. If they feel wildlife is beneficial to them they may want to concentrate on that although they are currently slightly sceptical about that. If the communities say, 'we now accept that wildlife has real potential here' and if they request that we remove the fence the wildlife department is totally open to that and we will respond by looking at moving the fence' (Lomba, 1991).

Exactly how much the community had the ability to '*decide*' how best to benefit from wildlife or the DWNP the capacity to '*move the fence*' is highly questionable. Since the early 1990s CBNRM activities have increased in Ngamiland, and tourism currently accounts for forty per cent of employment opportunities in the region (Hoon, 2004). Nationally, there now over 80 community organisations most of which are involved in joint-venture partnerships with private safari operators who manage CHAs on behalf of the people and share economic returns. However, while some community trusts have invested in productive assets which may benefit the wider community, few households derive livelihood benefits directly unless employed by the trusts or joint-venture partners (Arntzen, 2005). Critics of CBNRM have suggested that wildlife conservation is unlikely to improve unless individual returns from projects exceed those gained from subsistence hunting (Gibson and Marks, 1995). Thus in Botswana CBNRM has failed to deliver both in terms of its conservation and rural development objectives (Hoon, 2004).

Factional differences between the communities of Beetsha and Gudigwa have also emerged which could threaten the long-term success of CBNRM in the region. These conflicts can be directly linked to the inequitable alignment of the NBF and resultant restricted resource access. Having been grouped with four other non-Basarwa villages under the Okavango Community Trust, Gudigwa claim they have not received equal benefits accrued to the organisation from leasing what they see as their land.²⁵ For Basarwa from Gudigwa the ability of the whole community to decide how they should derive benefits from wildlife and tourism is particularly important. In 1996 individual special game licences were rescinded and replaced by an annual quota allocated to the OCT as a whole (Taylor, 2002). This was a particularly raw issue for Basarwa who feel they sacrificed more, but benefited less from CBNRM than other OCT members for whom hunting is not the only historical tie to the land (cf. Hoon, 2004; Taylor, 2000). The community also complain that the OCT hiring process for major photographic tourism lodges in NG22 and NG23 is biased towards non Basarwa settlements. This was reflected in the employment statistics in 2004 for the main lodges in NG22 and NG23 (Table 7.6), and confirmed during the livelihood survey (Chapter 5). While this may be more a consequence of lower educational attainment of Basarwa from Gudigwa and reluctance to participate or take instruction from others (Mbaiwa and Rantsundu, 2004), it reinforces the urge for the community to strengthen its own capacity to benefit directly from CBNRM.

²⁵ The Okavango Community Trust (OCT) was established to represent the northern Botswana villages' interests within the various CBNRM community-tourism joint ventures currently running within the community concession areas to the south of Beetsha and Gudigwa.

Table 7.6. OCT villagers employed in NG22 or NG23. (Source: Mbaiwa and Rantsundu, 2004)

Village	Seronga	Gunitsoga	Eretsha	Beetsha	Gudigwa
No. Employed	21	25	25	15	7

Besides inequitable employment within OCT concession areas, people from Gudigwa also complained about the unfair distribution of benefits such as meat from hunting concessions and use of the OCT vehicle (Taylor, 2000). However, part of the problem in terms of the capacity of the community as a whole to determine how *their* land and wildlife should be utilised, is that by reducing the diversity of species, the fence has reduced the potential for photographic or hunting safari ventures in areas close to the settlements, yet few analysts are cognizant of this.

People of Gudigwa were most acutely aware of this limitation, which was reflected in the 28 per cent who cited wildlife declines as their primary reason for resenting the fence (Table 7.2). Basarwa resentment for the NBF was summed up during discussions with JB from Gudigwa:

There are no advantages to this fence. As soon as the fence was made the wildlife has been declining. We are living in the Delta and need to make money from tourism. We need [access to] our wildlife. (G27 7.06)

More recently the capacity for individual village-based institutions to determine how best to benefit from CBNRM in the region has been greatly improved by a move towards community run ecotourism ventures. For example, with the support of local NGOs Gudigwa established its own cultural camp in 2003 offering employment for eighteen full-time members of staff along with twenty-nine part-time positions, such as tribal dancers and craft makers (Mbaiwa and Rantsundu, 2004). Similar community-led

projects have been established throughout NG12 and more community lodges are planned.²⁶ However, with a fence-induced reduction in the diversity of key species in NG12 the potential for these ventures to become mainstream destinations for tourists remains in doubt. Gudigwa cultural camp, for example, is currently marketed by Wilderness Safaris as a one night only camp making: ‘*a perfect complement to the wildlife viewing camps of the Okavango Delta and Linyanti*’ (Wilderness Safaris, 2004: 4).

Resource alienation and weakening of tenure can have serious consequences for the future sustainability of resource use at the wildlife/livestock interface as local groups become disenfranchised from the collaborative management process.

Loss of traditional rights can reduce peoples’ interest in long-term stewardship of the land and therefore the creation of a protected area can in some cases increase the rate of damage to the very values that the protected area was originally created to preserve....Putting a fence around a protected area seldom creates a long term solution to problems of disaffected local communities, whether or not it is ethically justified (Carey et al., 2000: 25).

People from northern Botswana, especially the marginalised Basarwa, feel that enclosure by the NBF and subsequent lack of access to wildlife has disenfranchised them from the CBNRM process which they see only really benefiting the state. During a discussion about the future of farming or wildlife based livelihoods in the village SZ, a Basarwa man, demonstrated his feelings of resource alienation.

²⁶ For example, in 1998 the Okavango Polers Trust established Mbiroba camp, a community lodge and camp near Seronga. The trust offers Mokoro trips into the permanent swamps of NG12 and has considerably enhanced people’s financial capital and capacity to cope with risks and shocks (cf. Sorensen, 2003).

I would always choose farming as the government can make money out of wildlife through tourism. The fence should be removed and wild animals should be allowed to run free near the village and cattle kept in NG11. That way we can benefit from tourism. (G32 7.06)

The growing number of successful community-based ecotourism ventures in NG12 are beginning to cause frustrations within both Beetsha and Gudigwa regarding the persistent lack of access to enclosed wildlife resources. Coupled with this, international NGOs continue to lobby for the inclusion of the area within the awaited Kavango-Zambezi Transfrontier Conservation Area (KAZA-TFCA). This could involve realigning northern sections of the NBF along the southern boundary of NG13 (Map 7.2) and a cabinet decision is imminent (Conservation International, 2006). However, many people like SZ above want officials to move southern sections of the fence to the north of the villages thus allowing wildlife to migrate into NG12. During a survey of 44 individuals from both settlements, respondents were asked whether they would support or reject the realignment of the NBF to the north of the villages, even if this meant NG12 became a stock-free zone. 84.1 per cent were in favour of the move which clearly illustrates both the locally perceived resource alienation and desire to benefit more directly from CBNRM and ecotourism.

Real choice or fait accompli?

Analysts of CBNRM in northern Botswana have argued that the state's implementation of the concept was paternalistic and allowed few management decisions to be made by the community (Taylor, 2006). Twyman (1998), challenges the execution of CBNRM in western Botswana and suggests that while official discourse during the consultation

process appeared to emphasize community control and empowerment, there were strong undertones of subordination and manipulation. Part of the problem, which these authors themselves acknowledge, is that the state believed the communities were incapable of resource management and prescribed joint venture partnerships with safari companies as a preferred natural resource management option (ibid: 753).

Yet the above discussion demonstrates that in northern Botswana the state's paternalistic dialogue predates the implementation of CBNRM. While state planners made empowering statements such as '*ultimately the people will decide*', management options were actually determined by resource access after enclosure. By effectively enclosing the most diverse wildlife areas and facilitating the enforcement of preservationist conservation policy within the Okavango Delta, the NBF essentially predetermined how the community could access *their* wildlife: by leasing enclosed CHAs to private safari operators.

Mbaiwa (1999) notes that opportunities for the community of Shorobe to participate in CBNRM were reduced as people were denied access to concession areas to the north of the southern buffalo fence. However, few critiques of CBNRM in Botswana consider the issue of veterinary cordon fence enclosure, particularly in relation to wildlife access, as a factor determining the success of the initiative. Yet it is clear that an individual or community's ability to decide how best to benefit from wildlife tourism is ultimately determined by their ability to access the most biodiverse wildlife areas. By enclosing Botswana's wildlife/livestock interface officials have indirectly extended state control over wildlife resources and privileged a form of CBNRM involving joint-venture partnerships with private safari operators. Thus, improved conservation or development

in northern Botswana is unlikely to be achieved through decentralised resource management unless resource alienation trends caused by veterinary fences are addressed.

7.6 Enclosure and resource conflicts at the wildlife/livestock interface

Post-cull livestock numbers are currently recovering in northern Botswana (Arntzen, 2005; Murray, 2005). At the same time the number of community tourism initiatives continues to grow leading some to predict widespread resource conflict at the wildlife/livestock interface between tourism and livestock interests (Flyman, 2003). At present livestock farming for many people, especially recently sedentarised Basarwa, is an emerging livelihood option facilitated by government rural development initiatives and tsetse control programmes (Chapter 4). For various reasons outlined in chapter four, cattle ownership has historically been the reserve of wealthy elites able to maintain access to the necessary resources to mitigate the risks inherent with pastoralism in the region. Several of these experienced pastoralists strongly oppose proposals to realign the NBF along the southern boundary of NG11 which would necessitate a move of livestock to the zone. While aware of risks associated with sedentary pastoralism in the dry sandveld (borehole failures, veld fires) they also cite ongoing resource conflicts with the OCT as reasons for opposing the expansion of CBNRM in the region.

Leach *et al.* (1999) stress the importance of understanding the dynamic and internally differentiated institutional arrangements within communities in order to facilitate effective decentralised natural resource management.

'Local communities may be shown to be dynamic and internally differentiated, and the environmental priorities and natural resource claims of social actors positioned differently in power relations may be highly contested. These factors point to the importance of diverse institutions operating at multiple-scale levels from micro to macro, which influence who has access to and control over what resources, and arbitrate contested resource claims' (Leach et al. 1999: 226).

Recent critiques of CBNRM also demonstrate how factionalism within the community often threatens the progress of CBNRM (Hulme and Murphree, 1999) and emphasize the need to focus on institutions within these differentiated communities (Agrawal and Gibson, 1999). Some have even called for the wholesale rejection of 'community' within CBNRM in favour of a 'multiscaled comanagement approach' (Turner, 1999). This section analyses how the NBF and associated increase in community tourism ventures in NG12 has begun to create resource conflicts and internal divisions within the local population which could threaten the success of decentralised management in the region.

Herder-OCT resource conflict in NG12

Decreasing dramatically following the droughts of the 1980s, Ngamiland's cattle population recovered to an estimated 310 000 head in the mid-1990s (Arntzen, 2005). Today, like pastoralists throughout the Kalahari, most farmers in the northern sandveld practice 'herd release' management of livestock. This involves a regular cycle of herding cattle into the northern sandveld after milking in the morning and kraaling cattle when they return to drink at the Delta in the evening.²⁷ Livestock owners are therefore heavily reliant on annual Delta floodwater which flows along several channels to the south of the

²⁷ Most livestock at Beetsha and Gudigwa are kept at cattleposts consisting of a cluster of huts and kraal, close to one of the Delta's annually flooded channels. Some farmers from Gudigwa have hand-dug wells as they cannot rely on seasonal floodwater which doesn't always reach the village.

villages (Map 7.1). According to local farmers the water levels declined dramatically in the early 1990s, only recovering after the restocking exercise. This is in agreement with the hydrometric record for the area's main tributary (Wolski and Murray-Hudson, 2006).²⁸ In 1993, several farmers with large herds of cattle were forced to move their main kraal further south to access water in deeper channels. SB, the Bayei headman of Beetsha explained:

In 1993 I took the cattle to the concession areas in the south [NG12] and made a kraal at Khanxe. We went there to find permanent water for the cattle as the rivers were dry at Beetsha. We remained there until the cull and the herd boys would come at the weekends to help. (B14 7.05)

Resource scarcity was also a primary motivation to move. With increasing livestock numbers at the Delta's edge, grazing had become scarce and cattle owners began to run into conflict with arable farmers. 'Beetsha is a poor place to keep cattle, they destroy fields here' claimed NM, 'We took our cattle to Khanxe in 1994 because they were beginning to destroy people's fields at Beetsha'.²⁹ For others the prime motivation to move was grazing, although most people attach a higher value to grazing in the dry sandveld to the north of the village. PM explained why he moved his cattle into NG12:

Before the cull there were a lot of cattle at Beetsha and there was little grazing. The cattle had to trek a long way to find grazing and were at risk from predators. I took our cattle south to find grazing. The grazing is poor at Khanxe, the cattle pick up worms from the grass. However, we went there as the water had dried up at Beetsha and we needed to find permanent water for our livestock. (B38 7.06)

²⁸ Wolski and Murray-Hudson (2006) note that the water levels for Duba channel, the area's main tributary, remained stable from 1970 to 1990, after which water levels dropped until 1996 from where they reached 1980 levels by 2000.

²⁹ Interview with NM (B32 7.06)

Given the choice, and availability of perennial water, most would have preferred to move livestock to cattleposts along the first channel south of Beetsha due to the higher quality of grazing found in the dry sandveld to the north. Access to permanent water, however, for the duration of the poor flooding years forced most large herd owners to move. Those with smaller herds on the other hand, decided not to migrate. This group coped with grazing and water shortages by digging new wells in the dry river channel some distance from the overgrazed village. PM owned a herd of approximately 35 cows in the early 1990s and explained why he preferred not to move and how he coped with the shortage of water and grazing:

When the river dried up in 1993 many people moved their cattle to Khanxe where water could still be found. I decided that it was too far to go with my cattle as it was far from my wife and sisters, so I decided to dig a well near old Matswii. Its easier to dig a well there as the water is close to the surface. (B38 7.06)

Soon after migrating deeper into NG12 herd owners began to compete for resources with the various CBNRM activities emerging in the community concession areas. By the mid-1990s the northern sandveld communities, through the OCT, were becoming increasingly involved with several hunting and photographic safari companies. The community had entered into community-tourism joint ventures and lodges were beginning to be established. Having leased the land from the community these companies were reluctant to share it with the pastoralists and their cattle.

When we arrived at Khanxe we were told by the OCT to move our cattle to Gomteretere as we were too close to the lodges. This was the same year the OCT were given control of NG22/23. Since then more lodges have been built in NG12. (B12 7.05)

Gomteretere is a cattlepost halfway between Beetsha and Gudigwa just south of the main road. Concerned that cattle would roam into leased concession areas the OCT requested that farmers use areas along the northern boundary of NG12. This conflict has caused some farmers to resent the OCT and, more specifically, the NBF which they associate with the loss of access to land. This was reflected in the 3.8 per cent of informants from Beetsha who cited reduced livestock mobility as their primary reason for resenting enclosure by the NBF (Table 7.2). Since the initial conflict arose, more community lodges have emerged in NG12 further intensifying concerns of exclusion. These feelings were expressed by JT, a Mbukushu herder, from Beetsha.

The fence is negative as it has blocked some of our gathering areas and before we could make kraals for our cattle at Tarakae. Now there is a lodge there and we are told by the OCT not to take the cattle there. (B29 7.06)

This account illustrates how people have begun to link the loss of land previously used for hunting and gathering, and the more recent conflicts between herders and the OCT with enclosure by the NBF. While people lost access to some important hunting and gathering areas after they were enclosed by the fence, CBNRM has further restricted resource access and intensified resource conflict in the region, in spite of the recent turn towards community ecotourism in NG12. These are worrying trends given that livestock numbers are beginning to recover after the restocking programme (Arntzen, 2005), thus increasing the likelihood of future resource conflicts between pastoralists and CBNRM activities.

7.7 Conclusion

Co-management policies at the wildlife/livestock interface are unlikely to achieve sustainable development unless accompanied by paralleled efforts to address issues of tenure insecurity (Forrest, 1999). Resource conflicts occur throughout much of the developing world driven by environmental scarcity, itself often a result of weakened property rights and unequal resource distribution following large-scale development projects (Homer-Dixon, 1994). Since the 1980s, veterinary cordon fences have been used to separate Botswana's wildlife/livestock interface in an attempt to secure lucrative beef export revenues. By effectively restricting people's access to, and effective management of natural resources veterinary cordon fences could have a major impact on resource relationships and the success of decentralised management initiatives, yet little specific research has considered the issue. This chapter examined the impact of the northern buffalo fence (c.1991-7) upon resource relationships, conservation and development in northern Botswana.

The chapter began by examining how local groups attempted to negotiate rights of access to natural resources during Botswana's first pre-fence consultation exercise. In Africa, rights of access to natural resources are determined by institutional access which often enables political influence over other benefits from state institutions (cf. Berry, 1989; Batterbury and Bebbington, 1999). Access to recently established village political institutions determined unequal resource distribution following enclosure, with people residing outside these structures further marginalised during this process. These findings support those of an increasingly number of academics which stress the importance of

historical analysis when attempting to determine contemporary meanings and understandings of rights and property relations (cf. Moore, 1993; Twyman, 2001).

The analysis then focussed on both the direct impacts of enclosure upon resource relationships, and the longer-term implications for societal risk and vulnerability to natural environmental variability in the region. The NBF directly impacted upon resource relationships by denying marginalised communities access to both rangeland and wildlife resources. Enclosure indirectly promoted the enforcement of preservationist conservation policy in northern Botswana and could have contributed to factors causing individualised and wasteful community hunting practices.

Analysts of societal vulnerability to natural hazards emphasize the importance of access qualifications in determining the ability of people to engage their optimal risk management strategies (Wisner *et al.* 2004). Local community members, particularly village elders, lament the loss of enclosed natural resources previously used during times of environmental stress. Prior to enclosure both migration and social support networks formed important drought coping mechanisms and both strategies are now hindered by the fence. Today, people are increasingly reliant upon economic diversification and state support schemes to cope with environmental variability which raises some critical questions regarding long-term sustainability of enclosed livelihoods within an area where permanent environmental changes (i.e. channel desiccation) can occur irrespective of overall resource abundance.

This chapter has argued that decentralised resource management is unlikely to succeed in northern Botswana until communities are granted access to wildlife resources and effective control of resource management decisions. In northern Botswana CBNRM has

failed to deliver both in terms of its conservation and development goals (Hoon, 2004). Critics point to the states paternalistic implementation and lack of management options as factors contributing to this failure (cf. Twyman, 1998; Taylor, 2006). However, few examine the role of veterinary cordon fences in determining who has access to, and effective control of, natural resources in the region. An examination of community attempts to benefit more directly from CBNRM reveals that enclosure has denied many people access to wildlife causing frustrations within the community and restricting the potential of village-based ecotourism ventures. Enclosure of the wildlife/livestock interface has extended state control over wildlife resources and privileged a narrow form of CBNRM involving the lease of exclusive rights to access enclosed resources through joint-venture partnerships with private safari operators.

More recently, factionalism and internal divisions within communities has promoted a focus away from community approaches to decentralised natural resource management, towards a 'multiscaled comanagement approach' concentrating on differentiated institutions (Agrawal and Gibson, 1999; Turner, 1999). Understanding the causes of such internal divisions within communities is seen as essential to the long term success of such an approach (Leach *et al.* 1999). Enclosure and the subsequent increase in community ecotourism projects in the region has begun to cause internal divisions within the community as resource conflicts emerge between pastoralists and the tourism industry. These are likely to result in increasing resource scarcity, conflict and environmental change as the post-cull livestock population increases and access to surface water and grazing within the Okavango Delta grasslands remains restricted. These conflicts of

interest must be addressed if decentralised resource management is to succeed in the region.

Chapters 6 and 7 have examined the impact of veterinary cordon fence enclosure on resource relationships in northern Botswana. Enclosure encourages sedentary management amongst pastoralists, while fences at the wildlife/livestock interface restrict access to wildlife and rangeland resources. These changes are likely to increase resource scarcity and thus question the long-term sustainability of these fence restricted resource relationships. The following two chapters examine these issues using a multi-temporal assessment of environmental change over a temporal scale relevant to both the period of enclosure, and for separating management impacts from natural ecosystem dynamics.

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8

Evaluating fence induced environmental change:
ground-based ecological surveys.**8.1 Introduction**

Pastoral activities represent the main form of natural resource use in savanna ecosystems, which occupy a fifth of the earth's land surface, and support the majority of the world's rangeland and livestock population (Sankaran *et al.*, 2004; Sporton and Thomas, 2002; Sankaran *et al.*, 2005). The sustainability of communally-grazed rangelands within savanna ecosystems has and continues to be a major concern for policy-makers throughout Africa and other parts of the world (Vetter, 2005). Detailed information concerning the true direction, cause and extent of ecological change in such regions is undoubtedly required in order to inform policy interventions (Pickup *et al.* 1998).

Overgrazing by domestic livestock within communal rangeland areas is widely perceived as a major threat to biodiversity, declining rangeland productivity and degradation in Namibia (Kuiper and Meadows, 2002), South Africa (Hahn *et al.*, 2005) and throughout sub-Saharan Africa in general (Vetter, 2005; Rowntree *et al.*, 2004). Increased enclosure, structural land use change, and sedentarisation has dramatically increased resource pressure in these areas as governments pursue policies encouraging land privatisation, sedentary infrastructure, and the fencing of communal pastures (Sporton and Twyman, 2002). Evidence from intensive sedentary pastoral systems suggests that savanna degradation often manifests, not in the widely popularised total vegetation removal or desertification, but in less overt declines in productivity due to the proliferation of shrubs at the expense of the grass layer (Dougill *et al.* 1999; Dougill and Trodd, 1999). However, the exact mechanisms underlying this process of change remain uncertain (cf.

Roques *et al.* 2001; Hahn *et al.* 2005). Yet such understanding is essential for studies attempting to interpret management impacts from inherent ecosystem dynamics and suggest effective preventative control measures (Dougill *et al.* 1999).

Maintaining livestock mobility is currently seen as essential for the future sustainability of dryland savannas (cf. Niamir-Fuller, 1999; Fratkin and Mearns, 2003; Homann *et al.*, 2004), and understanding the ecological consequences and causes of restricting herd mobility by rangeland fragmentation is now being highlighted as an important research agenda (Vetter, 2005; Boone and Hobbs, 2003). Veterinary cordon fences represent one persistent constraint to herd mobility and chapters 6 and 7 described how enclosure in northern Botswana curtailed the movement of people and livestock resulting in more sedentary resource use. The remaining chapters (8 and 9) examine how these fence restricted resource relationships and grazing patterns are impacting upon the environment using an assessment of environmental change at multiple spatial and temporal scales.

The research question

In addition to people and livestock, veterinary fences also curtail wildlife, raising concerns over harmful vegetation changes resulting from fence restricted herbivory (Boone and Hobbs, 2003). Furthermore, within savanna ecosystems adverse environmental changes can result from undergrazing by wild and domestic herbivores after their exclusion by veterinary fences (Chapter 2). Thus, veterinary fence enclosure could cause both rangeland scale environmental changes best observed across fencelines and spatial patterns of vegetation community change in relation to agricultural

disturbance (grazing pressure). To begin to address these dual concerns this chapter uses detailed vegetation community studies to investigate ecological changes in relation to grazing or disturbance gradients radiating out from a series of grazing foci (wells, kraals or villages). The second part of the chapter explores rangeland scale changes using the fences as natural grazing experiments (cf. Todd and Hoffman, 1999), whereby fenceline changes in vegetation community structure reveal considerable detail regarding the causes and direction of possible fence-induced degradation. Chapter 9 then extends these findings both spatially and temporally with a multitemporal, rangeland scale account of vegetation change using a modified post-classification change detection methodology on earth observation data.

The results of this assessment contribute to current debates over the long term sustainability of sedentary pastoral livestock systems within Africa's remaining communal rangeland (e.g. Fratkin and Mearns, 2003), along with debates over the environment impact of policies and infrastructure which restrict the mobility of dryland pastoralists and fragment communally grazed rangeland (cf. Boone and Hobbs, 2003; Reid *et al.*, 2003; Niamir-Fuller, 1999; Stokes *et al.*, 2006). To inform this environmental assessment the chapter first includes a review of current understandings regarding the causes and mechanisms of ecological change in drylands, emphasizing the implications for research design and data analysis. Following this, a detailed summary of the methods and data collected during the vegetation community assessment is presented, along with the various multi-variate statistical techniques used during data analysis. Finally, the assessment of veterinary fence induced environmental changes is divided into two sections: (i) an assessment of environmental changes resulting from sedentary

pastoralism around water points, villages and kraals; and (ii) an assessment of fenceline environmental changes resulting from fence restricted herbivory of livestock and wildlife populations.

8.2 Dryland environmental change debates

In dryland savannas trees and grass coexist and the balance between these life forms can shift, whereby woody plant species increase at the expense of the herbaceous layer in a process termed ‘bush encroachment’ (Sankaran *et al.*, 2005). Bush encroachment causes serious declines in the economic potential and heterogeneity of dryland landscapes (Scoones, 1995), and is recognised as a major threat to the future sustainability of pastoralism (Dougill *et al.* 1999). Intensive, fence restricted grazing by domestic livestock has been strongly linked with this process which occurs throughout pastoral lands of southern Africa (Bosch, 1989), and drylands globally (Dougill and Trodd, 1999). While the phenomenon continues to be implicitly associated with areas of intensive livestock use (Perkins and Thomas, 1993), our understanding of the underlying processes driving the change remain limited. Moreover, continued uncertainty over the level of non-equilibrium dynamics found in dryland ecosystems (Vetter, 2005) has serious implications for the permanence of these changes and how contemporary environmental studies are designed (Dougill *et al.* 1999), and the resulting data analysed. This section begins by reviewing contemporary developments within this debate in an attempt to assess the implications for this study.

8.2.1 The bush encroachment process

Several hypotheses have been advanced to explain the presence of, and changes to, the balance between tree and grass species in semi-arid savannas. These can be divided into competition-based mechanisms, where trees and grass species compete for limited resources such as soil water and nutrients (Sankaran *et al.*, 2004), or demographic mechanisms where tree establishment and persistence is limited by factors operating at different spatial scales from localised changes in fire, soil and herbivore pressure, to more large scale changes in rainfall (Sankaran *et al.*, 2005) and atmospheric carbon (Bond and Midgley, 2000; Bond *et al.*, 2003). Savannas are undoubtedly the consequence of a combination of both competition and demographic mechanisms, yet opinions differ on the relative importance of resource limitation versus disturbances in controlling savanna structure. This debate has important consequences for those attempting to understand the role of livestock and the permanence of change in the bush encroachment process.

In the semi-arid savanna and sedentary pastoral systems of the Kalahari the ‘two layer’ model and grazing hypothesis was presented as the most likely explanation of bush encroachment, and gained much support during the 1980s and early 1990s (cf. Perkins and Thomas, 1993). The grazing hypothesis saw competition-based mechanisms as the main cause of bush encroachment and demographic disturbances as one of several factors accounting for the persistence of such changes. The hypothesis was based on the premise that according to Walter’s two-layer competition-based model (Walter, 1964) sustained heavy grazing of grasses reduces their above and below ground biomass, thereby allowing woody plants exclusive access to soil resources (especially moisture in the top

soil), and reducing the severity and occurrence of fire (by reducing levels of flammable biomass) (Roques *et al.*, 2001).

The model had important implications for the permanence of bush encroachment. In addition to favouring the access of bushes to soil moisture, scientists believed livestock grazing also increased infiltration rates resulting in greater leaching of inorganic nitrate ($\text{NO}_3^- - \text{N}$) (resulting from cattle dung inputs being more readily decomposed than residual plant litter) and significant *permanent* increases in “plant available” inorganic nutrient concentrations in the subsoil layers. This was thought to favour the proliferation of bush species and persistence of changes in some sites. However, detailed laboratory or process-based field studies have failed to observe such permanent soil hydrochemical changes on bush encroached Kalahari soils (Dougill *et al.*, 1998).

As a result of these findings, Dougill *et al.* (1999) presented a conceptual state-and-transition model that emphasized the variability in natural environmental conditions such as rainfall and fire alongside grazing management, in order to explain ecosystem changes in Kalahari pastoral systems. Whilst this model recognises the inherent complexity and resilience of dryland ecosystem dynamics and better represents the reversibility of ecological changes, it fails to provide clarity as to the relative influence of grazing over rainfall and fire as drivers of ecosystem change. Furthermore, while Dougill *et al.* (1999) suggest that their model implies that fire is a vital management tool to be used to prevent continued expansion of bush encroachment, they confess that further long-term, multi-scale studies are required in order to better understand the interactions between abiotic environmental variables and biotic grazing levels.

In recent years, demographic explanations have gained favour over traditional competition based theories (Sankaran *et al.*, 2004), after field data and simulation models indicated that resource competition alone inadequately accounts for long term tree-grass coexistence. Dougill *et al.*'s (1998; 1999) soil hydrochemical investigations and various woody plant rooting competition studies (Hipondoka and Versfeld, 2006, Hipondoka *et al.*, 2003, Jeltsch *et al.*, 1996) all suggest that competition processes are not operating independently. This indicates that an integration of both models may be required in order to explain the mechanisms and permanence of the bush encroachment process and tree-grass phenomenon of savanna ecosystems.

More recently, several explanations have been put forward at different spatial scales to shed light on the dynamics of tree-grass coexistence in savannas. According to Wiegand *et al.* (2006) savannas are patch-dynamic systems at the regional scale, consisting of various patches which vary in state between open savanna and woody encroached, within which tree recruitment appears to be determined by both inter-tree competition and rainfall events significant to support tree germination. This model emphasizes the variability in spatial and temporal scales at which trees and grass coexist (e.g. 10 km² and 1000 years) and sees bush encroachment as a natural part of the patch-dynamic system suggesting that management should seek to maintain encroachment at its natural level. However, Weigand *et al.* (2006) fail to suggest the implications of their model for increases in woody vegetation observed in pastoral systems and fall short of suggesting at what level encroachment occurs naturally.

At the macro-scale, Sankaran *et al.* (2005) found that in areas with a mean annual precipitation (MAP) of less than 650mm/yr, tree-grass savannas can be considered

‘stable’ as low rainfall constrains woody canopy closure permitting grasses to coexist and therefore grazing, fire and soil conditions reduce woody cover further.¹ These findings suggest that bush encroachment may be limited to areas of lower MAP (Sankaran *et al.*, 2005), and also help to account for the presence of sub-canopy ecological niches in Kalahari rangelands where palatable grass species persist even in encroached areas (Dougill *et al.* 1998), and therefore the resilience and reversibility characteristics of these lower MAP savannas.

In addition to these advances in understanding tree-grass coexistence in savannas, several studies have proposed alternative explanations for the increased global occurrence of bush encroachment. Bond and Midgley (2000), suggested that increases in atmospheric carbon resulting from post-industrial CO₂ enrichment could be responsible for globally observed increases in woody plant encroachment, due to elevated CO₂ levels favouring the photosynthetic activity of C₃ trees over C₄ grasses. Similarly, Polley *et al.* (1997) proposed that decreased transpiration rates under increased anthropogenic CO₂ levels cause increases in soil moisture resulting in woody encroachment under the competition ‘two layer’ model. However, it is generally agreed that global levels of CO₂ have not yet reached a point where the net photosynthetic activity efficiency of C₃ trees exceeds that of C₄ grasses (Wiegand *et al.*, 2006). Furthermore, the impact of these changes are likely to be global, and therefore the variability of encroachment rates and levels at different sites suggest that other factors such as livestock grazing are more dominate in shaping these environmental changes (Archer *et al.*, 1995).

¹ In higher rainfall areas tree-grass coexistence is explained by herbivory, fire and soil conditions reducing the canopy cover of woody plants thereby producing more ‘dynamic’ systems.

8.2.2 New rangeland theory and bush encroachment: change or degradation?

Theoretical discussions regarding the process of bush encroachment have evolved as part of a wider paradigm shift recognising the nonequilibrium ecological functioning of dryland savannas (cf. Behnke *et al.*, 1993; Scoones, 1995; Warren, 1995), after conventional rangeland science failed to account for the persistence of ‘overstocked’ communal rangelands (Shackleton, 1993). Advocates of the ‘new rangeland science’ maintain that degradation from overgrazing is often ‘non permanent’ as livestock numbers are reduced by drought mortality (Sandford, 1983; Ellis and Swift, 1988). Thus the new approach argues against livestock management as the principle agent of environmental change (Kuiper and Meadows, 2002). While equilibrium models suggest that biotic feedback between herbivores and their resource govern grazing-induced rangeland degradation, non-equilibrium models see stochastic abiotic factors such as variable rainfall, as the primary drivers of vegetation and livestock dynamics (Vetter, 2005).

The new rangeland science of non-equilibrium functioning and cognate opportunistic management recommendations have not gone unchallenged (cf. Cowling, 2000). Illius and O’Connor (1999) questioned the assumption that semi-arid rangelands were uniformly non-equilibrium environments, suggesting instead that equilibrium characteristics are heterogeneous within drylands, with forces tending toward equilibrium decreasing with distance from key dry season resources and water sources. Rangeland economists then queried the widespread applicability of the new rangeland science and suggest that there are contexts where conservative stocking rates would be more appropriate, economically and ecologically (Campbell *et al.*, 2006, Campbell *et al.*,

2000). More recently, Hahn *et al.* (2005) presented a model which demonstrated an opposing view as livestock numbers varied irrespective of changes in rangeland productivity, lending support to view that non-equilibrium conditions dominate dryland ecosystem functioning.

So how much do biotic processes such as livestock grazing influence dryland vegetation changes, given these uncertainties regarding the ecological functioning of these environments? Moreover, what do these theories suggest about the permanence of changes such as bush encroachment and what are the implications for environmental studies attempting to determine management impacts from ecosystem dynamics? Vetter (2005) suggests that in areas of high rainfall coefficients of variability (C.V) non-equilibrium dynamics dominate and vegetation changes are driven more by abiotic processes (i.e. fire, rainfall). She maintains that in more mesic areas with rainfall C.V of less than 33 per cent, vegetation changes such as bush encroachment and changes in grass composition, are likely to represent grazing induced change and therefore equilibrium functioning (ibid: 327). The semi-arid rangelands of north-western Botswana are at the lower end of the Kalahari rainfall variability range with mean annual precipitation (MAP) levels between 400-600mm/yr and rainfall variability between 25-35 per cent (Dube and Pickup, 2001).² Encroachment has been observed around Kalahari boreholes in use for less than a decade (Perkins and Thomas, 1993) and some have suggested that a combined tree and herbaceous cover of greater than 38-40 per cent is indicative of grazing-induced encroachment in southern Africa (Thomas *et al.* 2000; Roques *et al.* 2001). This supports

² Rainfall variability and intensity varies along a gradient in the Kalahari from 200mm/yr and 50 per cent variability in the arid southwest to over 800mm/yr and less than 35 per cent variability in the northeast (Thomas *et al.* 2000).

Vetter's (2005) idea of bush encroachment as representative of grazing-induced change in areas of lower rainfall variability.

8.2.3 Implications for research design

In spite of the strong association between bush encroachment and sedentary pastoralism in the Kalahari, studies must be cautious of using bush encroachment as an indicator of environmental change. State and transition models imply that environmental changes can often occur very rapidly in drylands as a result of a variety of disturbances, one of which being land management actions (Dougill *et al.*, 1999). This has important implications not only for the management of dryland rangelands, but also the design of research aimed at assessing management-induced environmental change in drylands (Table 8.1). Many studies of dryland environmental change have used, and continue to use, short spatial and temporal scale observations as indicators of dryland degradation (Middleton and Thomas, 1997). Contemporary dryland environmental change studies must recognise that in non-equilibrium dryland environments, factors such as variable rainfall, fire and grazing operate at differing spatial and temporal scales (Dougill *et al.*, 1999). Longer term ecological monitoring studies are therefore required which combine data from a variety of spatial and temporal scales in order to understand the impacts of land management policies (Dougill and Trodd, 1999).

Table 8.1. Implications of new rangeland science for Kalahari degradation studies. Source: Dougill *et al.* (1999).

Issue	Implication	Relevance to Kalahari Studies
Temporal Change Vegetation in constant flux.	Degradation cannot be assumed from vegetation change alone.	Changes in vegetation communities used to infer degradation (e.g., Nellis and Bussing 1989; Ringrose <i>et al.</i> 1990; Skarpe 1990; de Queiroz 1993) should be discounted. Some consideration of ecological determining factors (soil water and nutrient availability, fire, and grazing) is required.
Spatial Change Complex mosaics of vegetation may occur.	Necessary to distinguish change caused by management practices from natural heterogeneity.	Some changes clearly ascribable to management (e.g., sacrifice zone by boreholes; Perkins and Thomas 1993a). Other changes need longer-term studies of dynamics to assign a cause.
Thresholds Changes in ecosystem state may occur rapidly due to management actions and/or natural events.	Need to investigate ecological changes in the context of thresholds dependent on climatic conditions and land-use practices.	Need for long-term ecological monitoring to assess when thresholds are crossed. Vitality important are the ecological implications of interactions between grazing levels, drought events, and fire occurrence.

Earth observation data has the ability to provide information on the temporal dynamics of dryland vegetation systems and when combined with fine-scale ground based surveys, the results can reduce the uncertainties in ecological models (Dougill and Trodd, 1999). Satellite remote sensing assessments of rangeland degradation are often considered cheaper than ground based assessments and advocated as being at a scale relevant to land management (Pickup *et al.*, 1994). However, more recently the ability of many remote sensing systems, especially those with temporally useful datasets (i.e. in terms of dryland ecosystem dynamics), to both model dryland ecological functioning and provide information at a scale relevant to land management has been seriously challenged (cf. Trodd and Dougill, 1998, Robbins, 2001). Furthermore, while remote sensing

observations have facilitated the expanded spatiotemporal scale of dryland environmental change monitoring, when used in isolation they continue the methodological failings of past scientific monitoring traditions, which firmly entrenched the now rejected desertification myth (Turner, 2003).

8.3 Methods

Research design

In recognition of the issues raised, a multi-method approach was adopted in order to assess the impact of veterinary cordon fence enclosure on the communal rangelands of northern Botswana. Given the presently contested non-equilibrium nature of dryland environmental changes, and uncertain mechanisms surrounding the bush encroachment process in Kalahari savannas, this approach sought to monitor environmental changes at a range of spatial scales from the species to ecosystem level and over a temporal period sufficient to identify longer-term management induced changes from inherent ecosystem dynamics. Furthermore, the assessment was conducted over a 16 year period relevant to monitoring the impact of veterinary policies, in which the study site has been increasingly enclosed by veterinary cordon fences and disease quarantine zones.

Table 8.2 shows the research framework used to investigate fence-induced environmental change in northern Botswana. Multi-temporal remote sensing based investigations are used to determine longer-term directional trends at both the rangeland and cattlepost scale, the results of which are presented in Chapter 9. Ecological surveys explore the

relationship between vegetation community structure and grazing intensity at the fine cattlepost scale, while fenceline ecological surveys provide an indication of wider rangeland changes. Thus, the ground-based element of this investigation can be divided into two parts, an assessment of: (i) sedentary resource use pressure around villages and cattleposts, and (ii) fenceline changes in vegetation communities.

Table 8.2. Research framework used to assess fence induced environmental changes

Method Used	Fine Scale	Regional Scale
Ecological survey	Explored the links between vegetation community structure and grazing intensity along various disturbance gradients	Explored vegetation community changes across fencelines as indicators of wider rangeland changes in levels of herbivory
Remote sensing	Used subset land cover change map to monitor structural vegetation changes at the cattlepost scale	Used multitemporal RS and change detection techniques to monitor land cover changes from before to after enclosure at regional scale

Vegetation in northern Botswana

The vegetation of northern Botswana is dominated by tree and shrub savanna, giving way to dry deciduous woodland (predominantly *Baikiaea plurijuga*) to the northeast (Ben-Shahar, 1998). Scholes *et al.* (2002) found that in areas such as northern Botswana where the annual rainfall is between 400-600mm, two separate patterns of woody vegetation distribution occur. On freely draining or rocky soils *Combretaceae* (*Terminalia* or *Combretum*) make up half the basal area and on soils with an impeded layer such as calcareous or sodic soils *Colophospermum mopane* dominates (Scholes *et al.*, 2002).

On this basis, the two study sites can be divided ecologically with the shrub and tree savannas of the NBF delta flood plain region characterised by distinctive patches of

C.mopane woodland, along with *T.sericea*, *C.molle*, *Baphia massaiensis* shrubland. In contrast, the shrub and tree savannas of the north-western CBPP site are strongly influenced by the presence of Kalahari age vegetated longitudinal dunes orientated in an east-west direction which support open savanna communities dominated by *Burkea Africana*, *Pterocarpus angolensis* and *B. plurijuga* trees, with densely vegetated areas of *Acacia spp.* and *C. imberbe* utilising moisture found in interdune hollows.

8.3.1 Grazing gradient analysis

Several studies have attempted to assess the impact of sedentary resource use in communal rangelands using vegetation community data changes along a gradient of disturbance. Livestock are constrained by their physiology in dryland environments to graze within several kilometres of drinking water, especially in the dry season (Moleele and Perkins, 1998). Similarly, human disturbance in communal rangelands through intensive use of wood and other resources is known to decrease with distance from settlements (Shackleton *et al.*, 1994). Therefore, both livestock and human disturbances are known to decrease in intensity with distance from water points and settlements in communal rangelands. Veterinary cordon fences and disease management policies have resulted in added restriction and loss of natural resources for communities living in the study region thereby contributing to the myriad of forces encouraging more sedentary resource use (Chapters 6 and 7). Gradient studies based on these disturbance theories can attempt to identify whether these altered management regimes override dominant abiotic variables determining local species composition. Analysing how a multitude of species

respond to external factors such as environmental variables and management regime is a common problem in community ecology (ter Braak, 1988). Many of the gradient studies undertaken in communal rangelands use multivariate statistical ordination techniques in order to investigate how floristic data respond to certain environmental variables along these disturbance gradients.

Vegetation Survey

In the absence of previous long-term ground based ecological monitoring within both study areas, a survey of vegetation community composition changes along various grazing or disturbance gradients was used to evaluate the state of the environment and impacts of sedentary resource use. This was based on the 'piosphere' approach (cf. Moleele and Perkins, 1998), with sample points at distances of 50m, 200m, 400m, 800m, 1000m, 1500m, 2000m, 2500m, 3000m from wells and kraals (Figure 8.1). The vegetation survey was timed to coincide with the end of the southern African wet season and therefore a period of vegetation greening before grass become senescent and many deciduous trees lose their leaves. This facilitated the accurate identification of grass, shrub and tree species with nomenclature following reference to several sources (Coates Palgrave *et al.*, 2002, van Oudtshoorn, 1999).

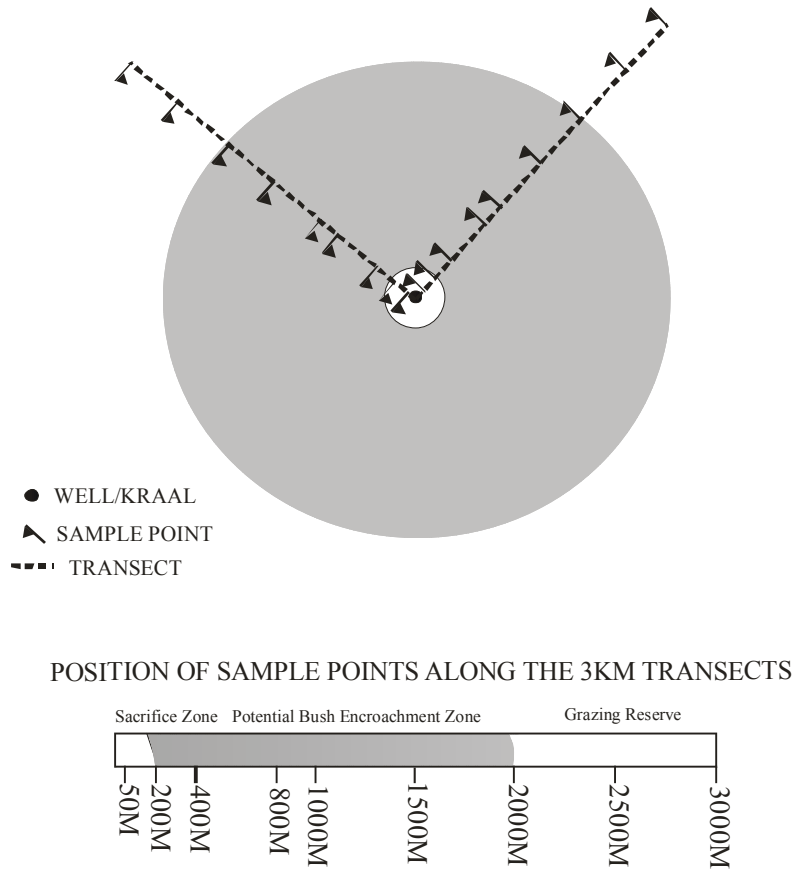
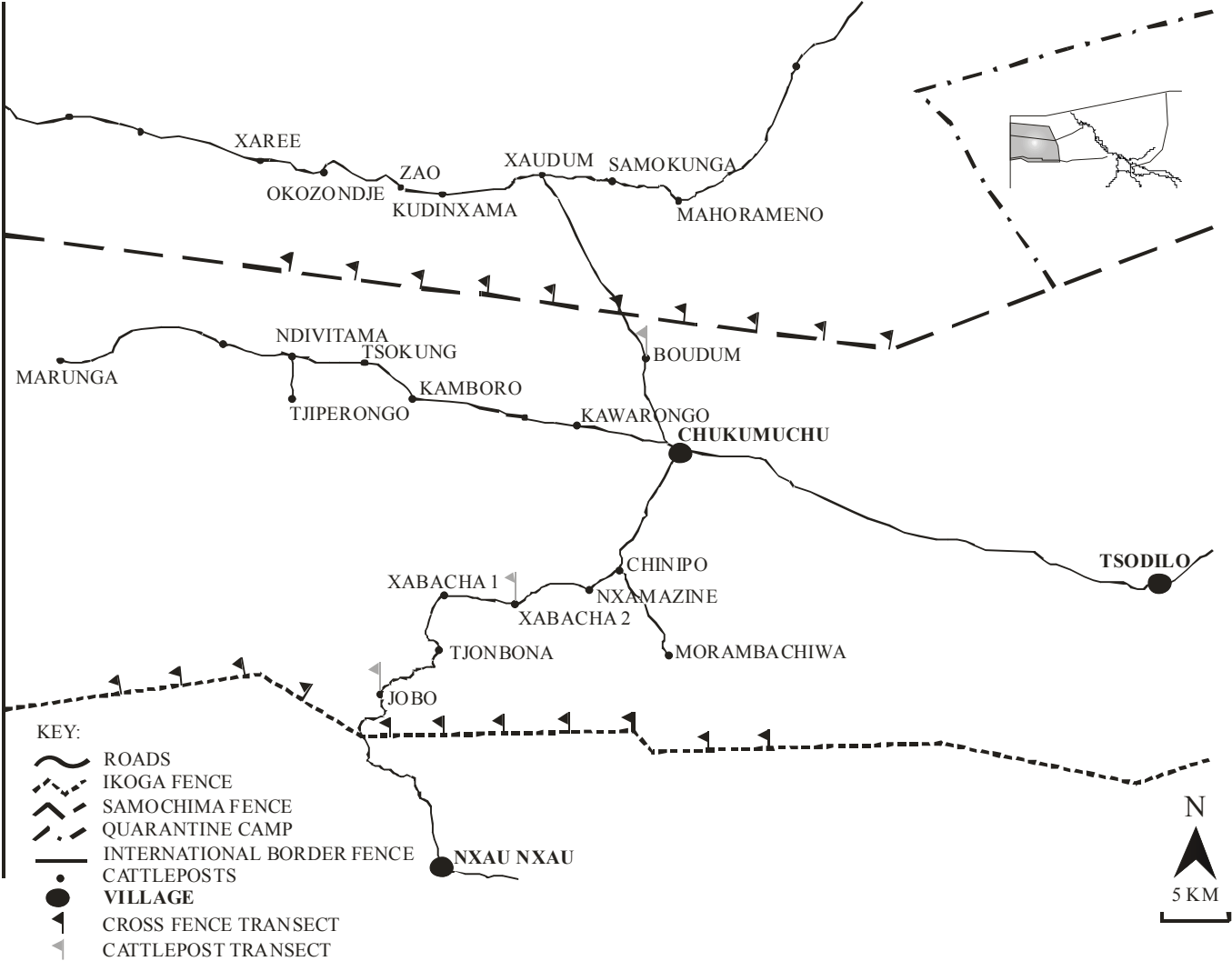


Figure 8.1. Diagram illustrating the location of sample points along transects radiating out from study cattleposts.

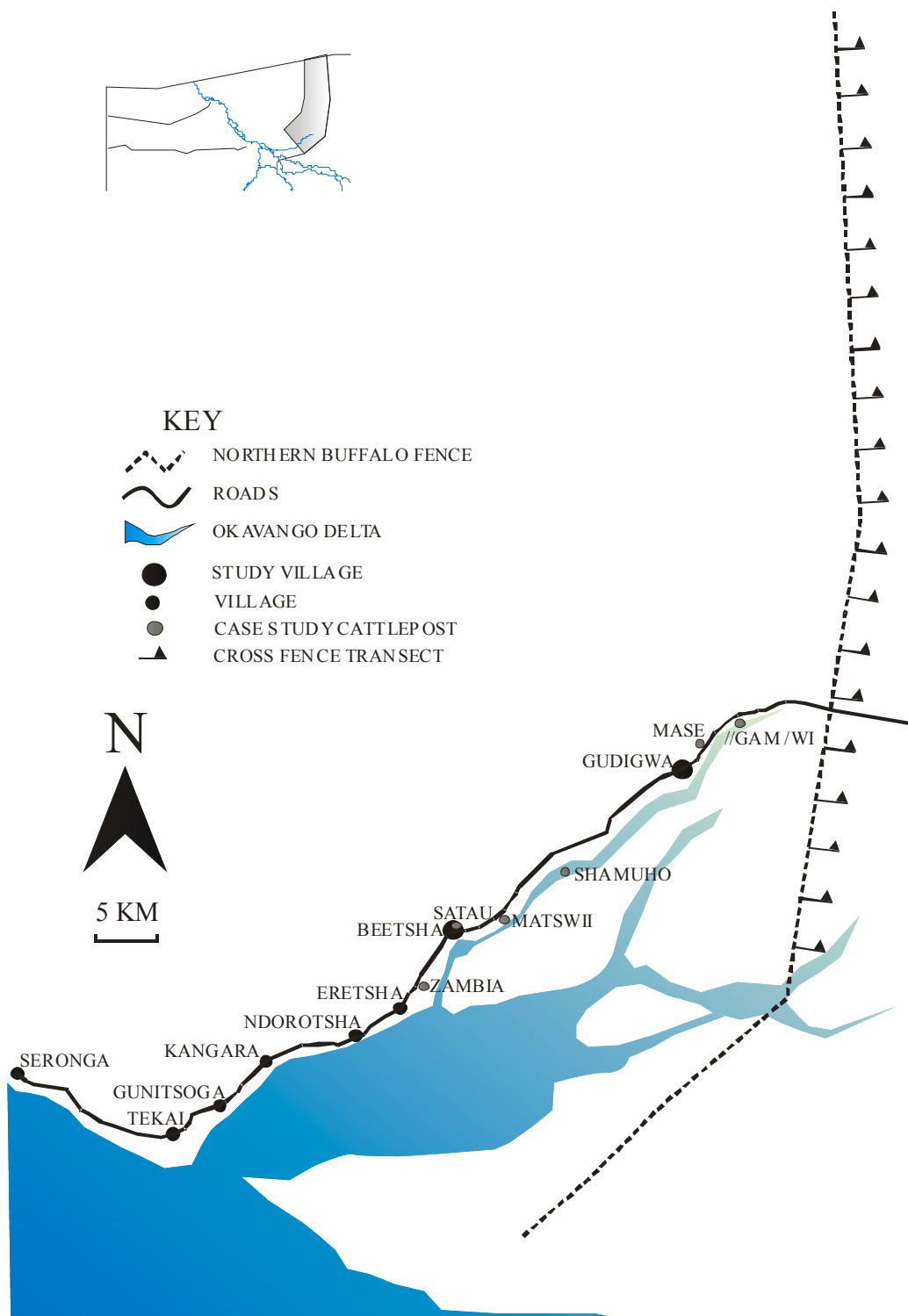
Ecological surveys were conducted at three cattleposts in the CBPP study area: *viz.* Jobo (sample symbol J), Xabacha II (X) and Boudum (BO) (Map 8.1); and six cattleposts in the NBF area: *viz.* //Gam /wi (G2), Mase (G1), Shamuho (B4), Matswii (B3), Zambia (B2) and Satau (B1) (Map 8.2). These were sites where pastoralists are known to have become sedentary following enclosure (Chapters 6 and 7). The Jobo and Boudum sites were of particular importance as sites where pastoralists complain about restricted

grazing given the close proximity of the CBPP fences.³ Where possible, several 3km transects were conducted driving out from each well or kraal with the direction of these guided by a Garmin Etrex 12 channel hand held GPS system.

³ Livestock mobility studies indicate that the average return distance cattle travel under 'herd release' management to be 7km and the CBPP fences are within 3km from Jobo and Boudum (Chapter 6).



Map 8.1. Location of sample points for cattleposts and fenceline ecological surveys in CBPP site.



Map 8.2. Location of sample points for cattleposts and fenceline ecological surveys in NBF site.

At each sample site along these transects, a rapid appraisal of the heterogeneity of the site resulted in a subjective decision to determine the direction of at least three 30 metre line intercept transects in order to fully represent both species and community variability. The line intercept method is especially suitable for the analysis of vegetation in semi-arid environments where the vegetation can often be sparse (Kent and Coker, 1992). An arbitrary shrub-tree boundary of three metres was used to distinguish shrubs from mature trees. The percentage canopy (foliar or crown) cover of individual shrub and grass species present was recorded along each 30 metre line intercept transect. Figure 8.2 shows the technique used to calculate the percentage cover of all shrub and grass species intercepted by the transect. Mean percentage cover data from each sample point was calculated after return from fieldwork.

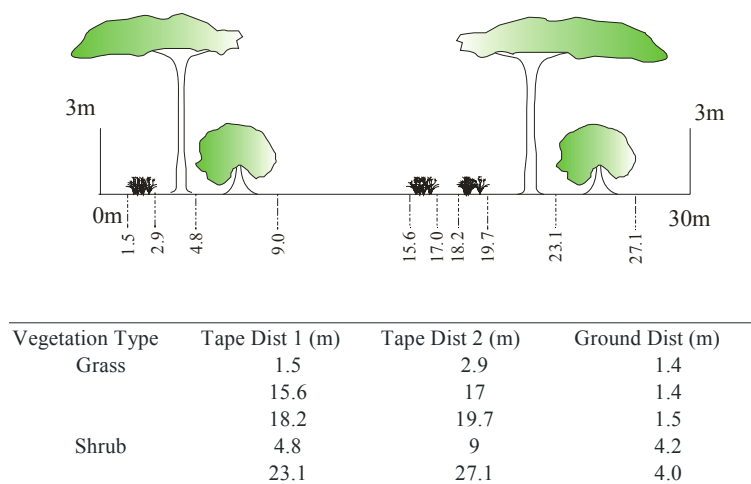


Figure 8.2. The line intercept technique used during ecological survey. Canopy coverage of shrub and grass species were recorded in a table similar to that above. Percentage cover values were then calculated after the fieldwork survey was complete.

Due to the often dispersed nature of tree cover in some of the driest regions of the study area, the density of mature trees above the arbitrary three meters was recorded within a 30 by 30 metre quadrat at each site. Density measurements provided a useful variable to determine the influence of vegetation above the livestock browse layer on community structure. The quadrat technique proved useful in gaining a representative sample of the tree species present in the areas with low tree cover which would have been difficult using the line intercept technique alone. The occurrence of specimens above the three metre level with their trunks inside the quadrat were recorded at the species level, as shown in figure 8.3. Again the location of the quadrat was based on a subjective decision in order to adequately represent species and cover diversity.

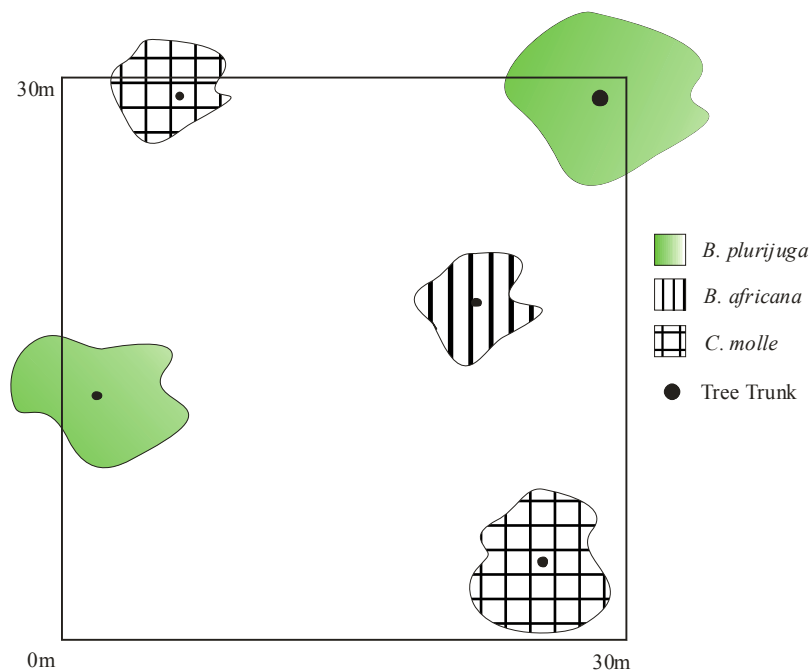


Figure 8.3. Plan view of a 30x30m quadrat used to record density of tree species above arbitrary 3m level. Specimens with their trunks inside the quadrat were included in the count.

Data Analysis

There are a growing number of numerical techniques available for the analysis of vegetation data, an increasing number of which allow for integration of environmental variables such as livestock grazing or disturbance, with a strong case to be made for experimentation with several approaches (Gauch, 1982). Until recently statistical methods available to analyse species and environmental data were restricted to regression analysis of each species response to environmental variables, or those which assumed linear relationships. The computer programme CANOCO⁴ integrates several regression and ordination techniques, and makes the detection of unimodal relationships between species and external variables possible (ter Braak, 1988). The floristic data collected were analysed using several of the ordination multivariate statistical techniques available in the CANOCO version 4.5 computer programme and were classified using the two-way indicator species analysis (TWINSpan) programme (Hill, 1979), in order to determine the main ecological distinctions between study sites. A number of these ordination techniques have the ability to assess species response to certain environmental variables. This is based on the observation that species commonly show bell shaped response curves with respect to environmental gradients (Jongman *et al.*, 1987). In order to investigate species response to these disturbance gradients, several additional environmental variables were analysed alongside the species by site data. Tree density, woody cover, grass cover, and bare ground were all entered as environmental variables using sums of the species data collected during the vegetation survey. In addition, distance to water

⁴ The canonical community ordination (CANOCO) programme combines principle component analysis (PCA), principle coordinate analysis (PCO), redundancy analysis (RDA), canonical correspondence analysis (CCA), canonical variate analysis (CVA).

point/kraal (i.e. livestock intensity) was entered into the analysis as environmental variables after the classification and ordination procedures had been used to determine the main variation in the species data.

8.3.2 Fenceline vegetation change

Changes in similar vegetation communities which are divided by fences and subject to different management practices can represent natural experiments whereby the effects of contrasting grazing regimes and management practices can be monitored (Todd and Hoffman, 1999). The spatial variability of vegetation communities can be altered by grazing animals confined by fences and this has been observed in Australia (Pickup et al. 1998; Graetz and Tongway, 1986), and elsewhere (Boone and Hobbs, 2003). Several studies have attempted to assess fenceline contrasts in vegetation communities using both ground based transects and remotely sensed observations. Trodd and Hoffman (1999), used ground based ecological surveys across fencelines dividing commercial farmland from communally grazed areas in South Africa. They targeted areas of comparable vegetation, soil and topographic characteristics and found significant changes in the abundance of palatable and unpalatable species of both grass and shrubs between plant communities (ibid). Similarly, Graetz and Tongway (1986) used a fenceline contrast in vegetation clearly visible on Landsat imagery to guide their ground investigations on the impact of differing management practices.

Very little work has focused on the impact of large scale fences such as veterinary cordon fences which dissect areas of communal rangeland and wildlife reserves. Ringrose *et al.*

(1997), however, investigated fenceline induced degradation across the southern buffalo fence (SBF) in northwestern Botswana using earth observation data. The authors identified significant cross fence changes in vegetation percentage cover and concluded that lower cover on wildlife side of the fence is indicative of the curtailment of migratory ungulates (ibid: 2362). By relying on one-time observations of the environment the study failed to determine directional trends in land cover change and without combining detailed ground-based ecological surveys, little detail was provided concerning species level changes across the fenceline. In addition, the study would have greatly benefited from an assessment of the changes in these fenceline contrasts with distance along the fence. If combined with ground observations and background data of local resource use, an assessment of this kind may highlight certain pressure points where fences are causing the most impact on herbivores. The results presented in the current and proceeding chapter attempt to move beyond these limitations and provide more detail regarding veterinary fenceline induced vegetation change in northern Botswana.

Ground based cross-fence vegetation surveys

The cross-fence vegetation assessment involved two parts: (i) an investigation of fenceline changes in vegetation community composition using ground-based surveys across the fences and (ii) a multitemporal assessment of land cover change across fencelines using remote sensing. The results of the latter assessment are presented in chapter 9. The ground-based survey involved a series of transects conducted orthogonal to the fencelines and at set distances along them. For the NBF, a 75km sample route from

Sandaroka channel to Dishokora cattlepost was used for survey purposes. In total 16 sites were sampled along the NBF (Map 8.2) at approximately 5km intervals. In order to avoid the confounding effects of landscape heterogeneity, the precise location of these adjacent sites was subjectively positioned within similar patches of vegetation, following reference to a vegetation map derived from pre-fieldwork unsupervised processing of Landsat imagery from 1991 (Chapter 9). This facilitated the selection of sites with similar spectral characteristics and thus vegetation community structure, as it was considered important to eliminate changes resulting from differing soil and vegetative conditions. A similar approach was used to sample the Samochima and Ikoga fences where 11 sites were sampled along both CBPP fences respectively (Map 8.1). These sites were distributed such that they covered the majority of areas where fences come close to the study villages and cattleposts, along with regions some distance from settlements and cattleposts. If cross-fence changes observed with distance along the fences correlates with known settlement patterns or wildlife population increases, the areas of contrasting vegetation communities could highlight resource pressure resulting from fence enclosure.

Several studies have documented that the zone of maximum interaction of game species with a fence starts at 30m (Lewis and Wilson, 1977). Previous investigations of veterinary cordon fences in Botswana have also found wildlife paths running orthogonal to veterinary fences at approximately 30m supporting these findings (McGahey, 2001). Observations along the NBF revealed similar well used animal tracks at approximately 30-40 metres from the fence. To assess the impact of herbivory either side of the fence a series of 30m line intercept transects were conducted at distances of 30m, 100m and 150m either side of the veterinary fences (Figure 8.4). Tree density was also recorded at

each sample point within a series of 30 by 30 metre quadrates using the arbitrary 3m level to distinguish shrubs from trees.

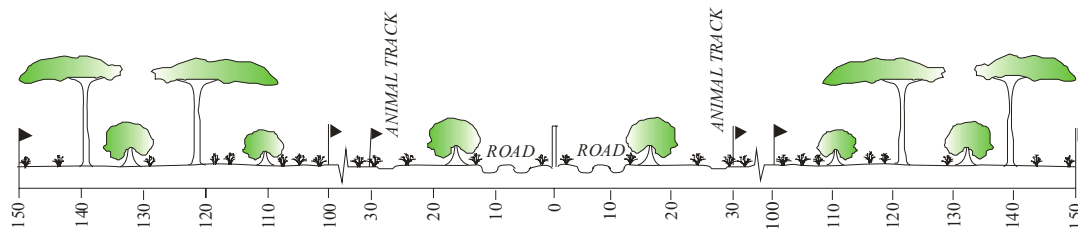


Figure 8.4. Diagram illustrating location of sample points along cross-fence transects. Line intercept transects were conducted at 30, 100 and 150 meters either side of the fences.

Data analysis

T-tests for independent means assuming unequal variances were conducted on the vegetation cover data in order to evaluate significant differences in fenceline vegetation communities. The statistical analysis focussed on both the total cover changes and individual species cover changes. In addition, the significant differences in annual and perennial grasses, as well as increasing or decreasing species of shrubs and trees were assessed across the fencelines. The classification of species into each of these characteristic categories was facilitated following reference to several sources (cf. van Oudtshoorn, 1999; Coates Palgrave *et al.*, 2002; van Vegten, 1981; Moleele and Perkins, 1998).

8.4 Results

8.4.1 Grazing gradient analysis

State of the environment

Bare ground surrounding wells or kraals (sacrifice zones) diminished within 25-30 metres, such that ground cover at 50 metres from grazing foci averaged at least 29 per cent (s.d 15 per cent). Ground cover beyond sacrifice zones was reasonably high with grasses and shrubs occupying over 20 per cent in some places (Table 8.3 and 8.4). Grass cover was particularly high at a distance of 50-200 metres from //Gam /wi (G2) and Jobo cattleposts, as both were located in dry grassy river valleys. At sites B1 and B2 shrub cover was reasonably high within 200 metres, with a correspondingly low cover of grass. Tree density decreased with distance from sites B1 and Jobo. Otherwise few disturbance gradient trends can be detected from the mean density and cover data.

Table 8.3. Tree density, shrub and grass cover changes with distance from wells or kraals in NBF site.

Distance	Tree density						Shrub cover						Grass cover					
	B1	B2	B3	B4	G1	G2	B1	B2	B3	B4	G1	G2	B1	B2	B3	B4	G1	G2
50-200	20	4	3	0	3	1	29	38	14	7	7	17	8	9	14	14	10	28
200-800	14	7	3	2	3	1	36	31	29	10	19	14	12	13	13	11	8	21
800-1500	13	9	4	5	3	3	33	31	41	19	31	19	10	11	11	20	7	21
1500-3000	11	5	12	6	4	6	23	31	33	27	32	17	14	13	16	21	8	17

Table 8.4. Tree density, shrub and grass cover changes with distance from wells and kraals in CBPP site.

Distance	Tree density			Shrub cover			Grass cover		
	Jobo	Xabacha II	Boudom	Jobo	Xabacha II	Boudom	Jobo	Xabacha II	Boudom
50-200	14	7	14	23	15	15	21	18	14
200-800	21	11	23	39	38	27	14	13	13
800-1500	9	13	13	46	31	39	15	16	9
1500-3000	6	8	9	43	30	35	18	21	15

Bush encroachment was evident at several sites between 200-800 metres from wells or kraals. Woody shrub cover and tree density was particularly high at 200-800 metres from Jobo, Xabacha II and Satau (B1) cattleposts. At the NBF site, *Terminalia sericea*, *Dicrostachys cinerea* and *Loncocarpus nelsii* were common encroachers, while at the CBPP site *Baikiaea plurijuga* and *Grewia flava* were also key encroachers, in addition to the above. For unpalatable annual grass species, *Aristida ascensionis* and *Pogonarthria squarrosa* were dominant at both sites along with *Enneapogon desvauxii*, *Schmidtia kalihariensis*, *Perotis patens* which were also present in some disturbed places. In the NBF site the unpalatable annuals *Aristida congesta* and *Dactyloctenium aegyptium* could also be found in some locations.

The cover and density of unpalatable annuals and encroaching woody species show no discernable trends with distance along disturbance gradients in both sites (Tables 8.5 and 8.6). At most sample sites encroaching woody species and unpalatable annuals in fact increase in cover or density with distance from livestock foci points. The exception is the Jobo transect where the density of woody encroaching trees above the 3 metre level decrease with distance (Table 8.6). Similarly, the cover of encroaching shrubs at 200-800 metres from Xabacha II is higher than average for the transect.

Table 8.5. Density and cover changes of encroaching trees and shrubs, and annual grass species with distance from wells and kraals in NBF site.

Distance	Encroaching tree density						Encroaching shrub cover						Annual grass cover					
	B1	B2	B3	B4	G1	G2	B1	B2	B3	B4	G1	G2	B1	B2	B3	B4	G1	G2
50-200	9	4	3	0	1	0	8	13	6	3	5	5	1	5	7	5	8	16
200-800	6	7	3	0	0	1	11	17	6	2	3	6	7	8	5	2	6	12
800-1500	12	8	3	2	2	1	16	22	12	5	8	3	4	2	5	16	5	13
1500-3000	10	4	7	4	3	2	13	19	12	14	6	2	6	3	8	15	4	9

Table 8.6. Density and cover changes of encroaching trees and shrubs, and annual grass species with distance from wells and kraals in CBPP site.

Distance	Encroaching tree density			Encroaching shrub cover			Annual grass cover		
	Jobo	Xabacha II	Boudom	Jobo	Xabacha II	Boudom	Jobo	Xabacha II	Boudom
50-200	10	2	3	13	2	8	6	2	5
200-800	17	7	3	18	18	6	4	2	1
800-1500	7	9	5	16	8	10	4	5	0
1500-3000	3	5	4	11	6	13	2	7	0

Ordination

To determine the main ecological distinctions between sample sites and explain any relationships between disturbance gradients within each sample site, the data sets were firstly explored using detrended correspondence analysis (DCA). It is accepted procedure to search for the greatest variation in the species data before applying the environmental variables to assess which are most influential (Jongman *et al.*, 1987). Correspondence analysis (CA) is an extension of the method of weighted averaging and seeks to construct hypothetical environmental variables which best explain the variability within the species data. Detrended correspondence analysis (DCA) extends this technique further in an attempt to correct the ‘arch effect’ among other limitations with CA (Jongman *et al.*, 1987). The DCA technique organises the site-by-species data within several ordination

diagrams based on latent environmental variables or axis, with the relative location of sites and species forming the basis of interpretation.

The species cover data were prepared for ordination by firstly removing rare species from the dataset. In multivariate ecological analysis rare species which account for less than 0.5 per cent of the total abundance of all taxa are often removed before ordination (Marchant, 2002). Removal of rare taxa in multivariate ordination is subject to debate as some believe that this assumes that environmental degradation will affect abundant species first and to a greater extent. However, it is becoming accepted that common species will provide the strongest response to environmental variables and rare species may provide only weak and confused signals (ibid: 313). Figure 8.5 shows the total abundance of individual species as a percentage of total abundance for all taxa. All species that account for <0.5 per cent of the total abundance of all taxa were removed before analysis.

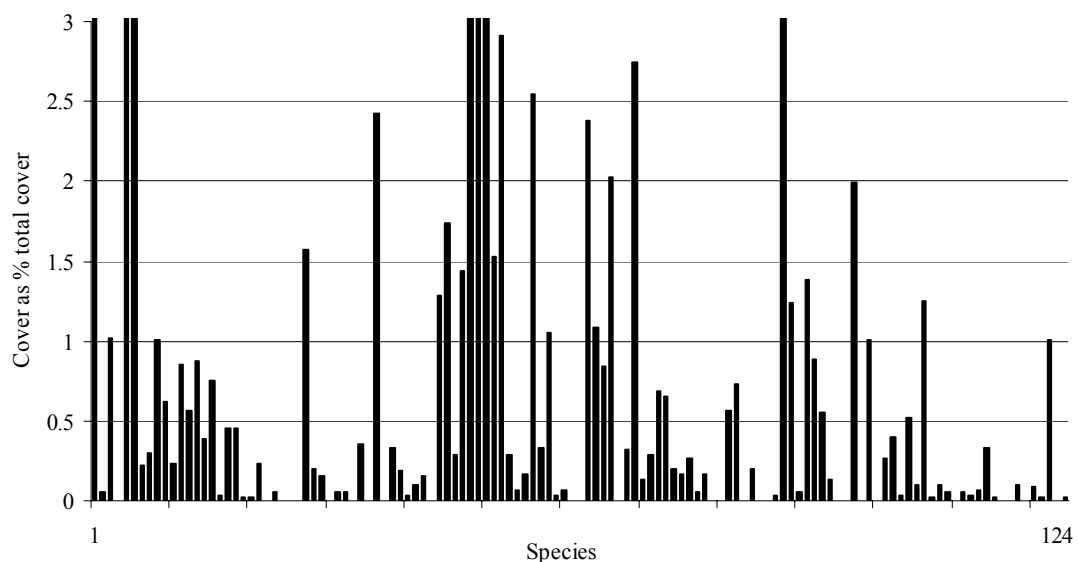


Figure 8.5. Total abundance of individual species as a percentage of the total abundance for all taxa. Rare species below the 0.5 per cent level were omitted from the assessment.

Following removal of rare species, DCA ordination using the CANOCO version 4.5 programme was conducted on the species-by-site dataset. The resultant DCA ordination diagram (Figure 8.6) showed relatively clear separation between the study sites on the first axes only. This was backed up by the significant eigenvalue of 0.7 for axes one and less significant 0.4 eigenvalue for axes two. Only the first two hypothetical axes in DCA and CA are expected to yield biologically significant information and eigenvalues over 0.5 often denote good separation of the species and sites along the axis (Jongman *et al.*, 1987). The NBF site transects were more dispersed along the first axis than the CBPP site indicating a greater heterogeneity of vegetation community types and therefore environmental conditions. Indeed, Jongman *et al.* (1987) point out that sites at opposite ends of long axes (e.g. close to four standard deviations) are likely to have hardly any species in common. The first axis was longer than the second (Ax 1=4.03 s.d., Ax 2=3.677 s.d.) and the NBF sites were more dispersed along the first axis confirming the greater heterogeneity of the NBF site. Further analysis of the species data alongside the site positions in the ordination diagram illustrates that the NBF site is characterised by *Colophospermum mopane*, *Terminalia sericea* and *Lonchocarpus nelsii* vegetation communities dispersed along the first axis. In contrast, the vegetation communities of the CBPP site show concentrated dispersion on the first axes and moderately good dispersal on the second axis with transects characterised by *Burkea africana* and *Baikiaea plurijuga* dry open savanna, with vegetation communities containing a greater number of species in common and can be inferred to have less diverse environmental conditions.

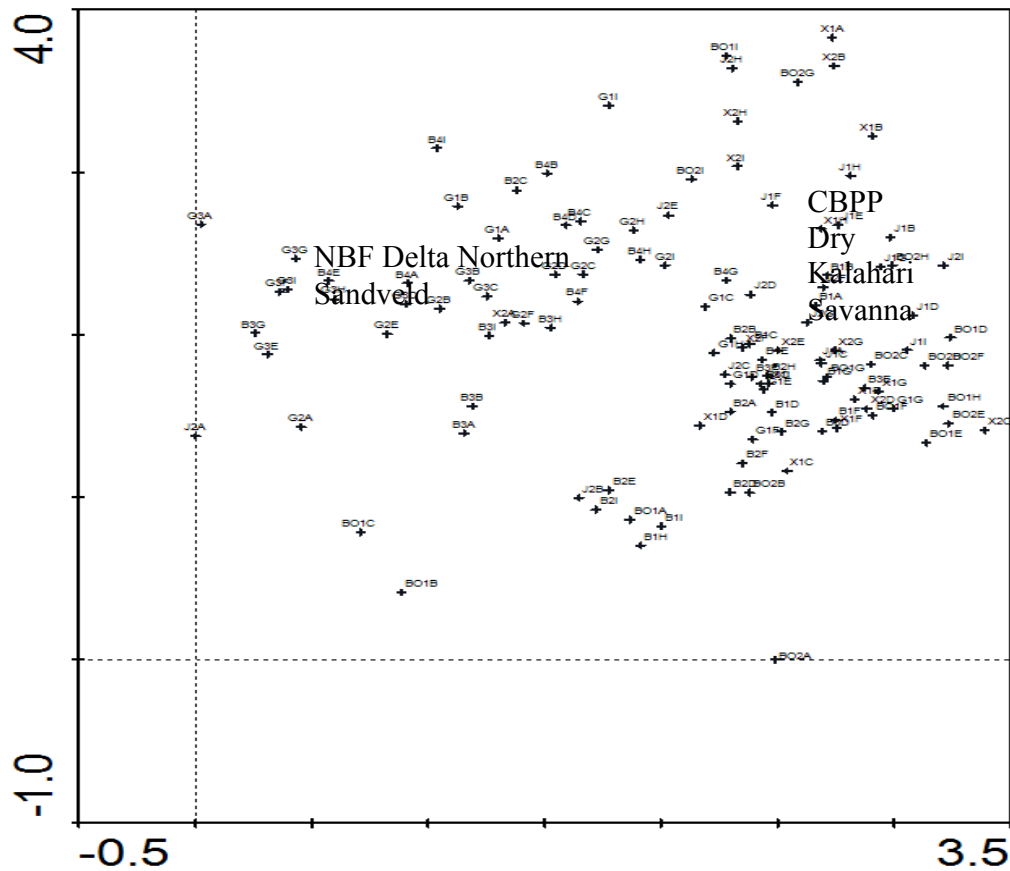


Figure 8.6. DCA ordination plot for transect data from both cattleposts within both study areas showing separation of sample points from the NBF and CBPP study areas over the first two DCA axes.

Canonical correspondence analysis (CCA)

Once the main ecological distinctions of the study sites were established, canonical correspondence analysis (CCA) was conducted using the recorded environmental variables and the site-by-species data. CCA is able to relate community composition data directly to the supplied environmental variables and the axes are then constrained by linear combinations of these variables, rather than the purely hypothetical axes in DCA (ter Braak, 1988). Prior to ordination the environmental variables were analysed for multi-collinearity and those which showed high 'variable inflation factors' (>10 VIF)

were omitted from the analysis. This resulted in the loss of grass cover as an environmental variable due to the inverse relationship with woody cover. The grass cover variable can therefore be assumed to be combined with the woody cover variable as areas of low woody cover are likely to be characterised by high levels of grass. This supposition was affirmed by the position of many grass species on the opposite site of the ordination diagram to the woody cover arrow when plotted alongside the site points. The results of CCA are shown in figure 8.7 with the dispersal of sites and species within the ordination diagram similar to that of DCA. In CCA the importance of the canonical axis is best judged by its eigenvalue, with values of around 0.3 common for ecological data (ter Braak, 1988). The supplied environmental variables accounted for some of the variation in the site-by-species data matrix, with significant eigenvalues for the first axis only ($AX1 = 0.32$) accounting for 5.5 per cent of the variance in the data set.

Table 8.7. Canonical coefficients for the five remaining environmental variables.

	AX1	AX2
Eigenvalue	0.32	0.28
Canonical coefficients:		
Tree	-0.48	-0.0003
Woody cover	-0.19	-0.92
Distance	0.03	-0.11
Bare ground	-0.36	-0.52
Eigenvalues for env. var.		
Tree	0.32	
Woody cover	0.28	
Distance	0.11	
Bare ground	0.04	

Tree cover was the most important environmental variable overall, with a significant eigenvalue of 0.32 and therefore forms the basis of the first environmental axis. Woody cover and distance accounted for the second and third most important variables

respectively, with low eigenvalues (Table 8.7). From the ordination diagram it was clear that several distinct sites and species were influencing the variability of the supplied environmental variables with the majority of species and samples clustered on the ordination diagram (Figure 8.7). Closer analysis of the outlying sites alongside the species in the ordination diagram revealed that these sites were dominated by high percentage cover of only one or two species, and these were generally unpalatable annual grasses or woody species. Table 8.8 lists these dominant sites and provides details regarding the key species that define them, along with cover and density measurements of tree, woody and grass cover factions.

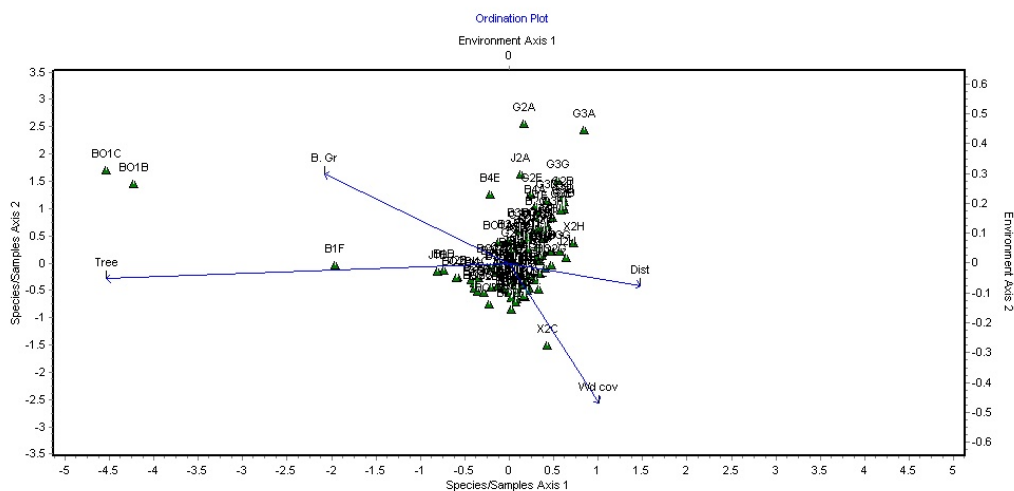


Figure 8.7. CCA biplot of species data from both sites analysed against environmental variables.

Table 8.8. Details of several sites dominating ordination diagram and their corresponding key species and defining environmental variable.

Outlying site	Distance from borehole (metres)	Defining environmental variable			Density woody cover >3m	% woody cover <3m	% grass cover	Defining species	Density/% cover of defining species
		Woody cover >3m	Woody cover <3m	High grass cover					
BO1B	200	X			42	24	21	<i>C. imberbe</i> >3m	34
BO1C	400	X			40	9	25	<i>C. imberbe</i> >3m	36
B1F	1500	X			31	14	6	<i>D. cinerea</i> >3m	27
X2C	400		X		2	71	8	<i>B. plurijuga</i> <3m	52
G2A	50			X	0	14	30	<i>C. dactylon</i>	20
G3A	50			X	0	16	41	<i>A. adscensionis</i>	34

All but one of these distinctive sites occurred within 400 meters of a cattlepost and the remaining site was 1500 meters from a kraal located near the centre of a village. Tree cover accounted for the floristic variance on the first axis due to the high density of *Dichrostachys cinerea* and *Combretum imberbe* trees at sites B1F, BO1B and BO1C. *Combretum sp.* are considered non-encroaching species in Botswana (van Vegten, 1981; Moleele, 1998). However, at sites BO1B and BO1C the species has formed dense thickets with specimens accounting for 81-90 per cent of the density of trees over three metres. Similarly, at site B1F on the outskirts of Beetsha *Dichrostachys cinerea*, a known encroaching species (Moleele, 1998), accounted for 87 per cent of woody species over three metres. At site X2C woody shrubs were particularly dense forming 71 per cent of the ground cover with short *B. plurijuga* trees accounting for much of the diversity. Finally, high grass cover of *C. dactylon* and *A. adscensionis* distinguished sites G2A and G3A which were located in a grassy river valley near Gudigwa. While *A. adscensionis* is a hardy annual grass indicative of disturbance, *C. dactylon* is a creeping grass which forms thick mat-like cover by means of rhizomes and stolons (van Oudtshoorn, 1999).

However, though *C. dactylon* is a popular cultivated pasture grass, it is considered a species which can endure heavy grazing (ibid: 229).

DCA, TWINSpan and CCA for the NBF site

Given that distance from borehole (or herbivore use intensity) failed to account for the variance of the combined species dataset, survey data from both study areas were then analysed independently. The results of DCA for the NBF sandveld data alone showed clear separation of the two study villages Gudigwa and Beetsha along the X-axis (Figure 8.8). In addition, the first axis separation was significant in DCA with an eigenvalue greater than 0.5 ($\lambda_1=0.54$).

TWINSpan identified the main ecological distinctions between the different settlements (Figure 8.10). The first division in the analysis separated the second and third Gudigwa transects on the basis of the abundance of several grass species (*viz.* *C. dactylon*, *P. squarrosa* and *A. adscensionis*). These transects were located to the far east of the study area in a distinctly different ecological area of open dry delta grassland with islands of woody species growing on higher ground. Sites to the west of Gudigwa were characterised by higher woody cover, especially *Baphia massaiensis*.

When this floristic composition was analysed with the supplied environmental variables in CCA, the first axes produced a significant eigenvalue of 0.37 indicating that the environmental variables accounted for a large amount of the variability. Of the four environmental variables woody cover best explained the variability along the first axis with a canonical coefficient of -0.78 (Figure 8.9). The environmental variables are represented as arrows in the ordination diagram, with the arrowhead representing

maximal intensities of that environmental factor and the relative length of an arrow its importance (ter Braak, 1988). Upon examining the CCA ordination diagram, the sites in close proximity to the woody cover arrow are likely to be characterised by a large amount of woody shrub cover, whereas those, for example, on the other side of the ordination diagram are not. The results confirmed those of TWINSpan and illustrated that the Beetsha cattleposts are characterised by a higher percentage cover of woody shrubs (*viz.* *B. massaiensis*), whereas Gudigwa transects were characterised by high percentage cover of grass species (*viz.* *C. dactylon*, *P. squarrosa* and *A. adscensionis*).

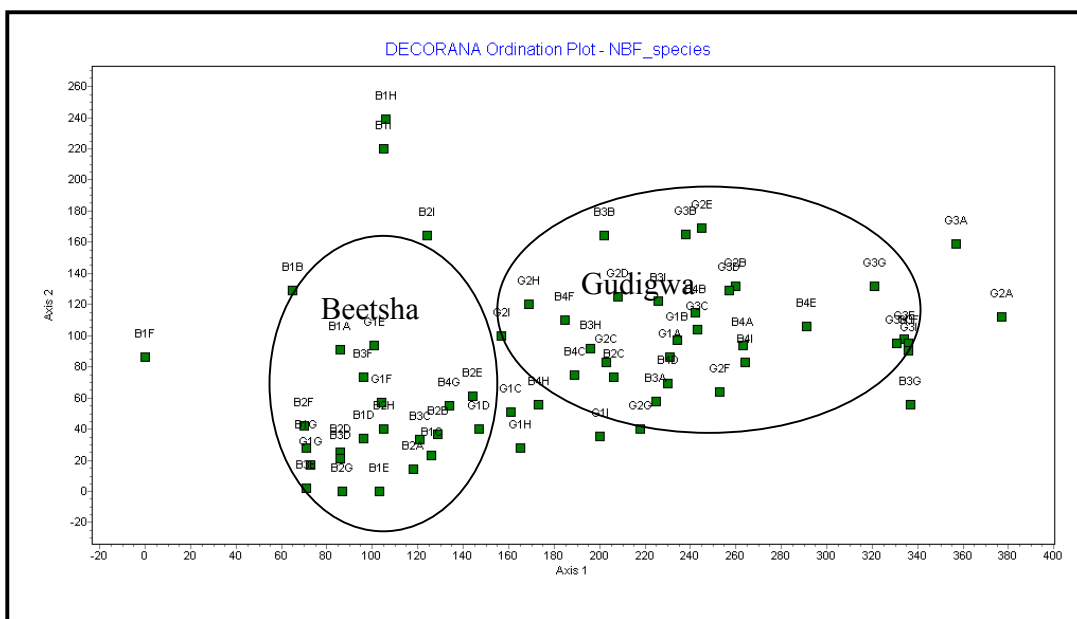


Figure 8.8. DCA results for the NBF site data alone showing separation of study villages

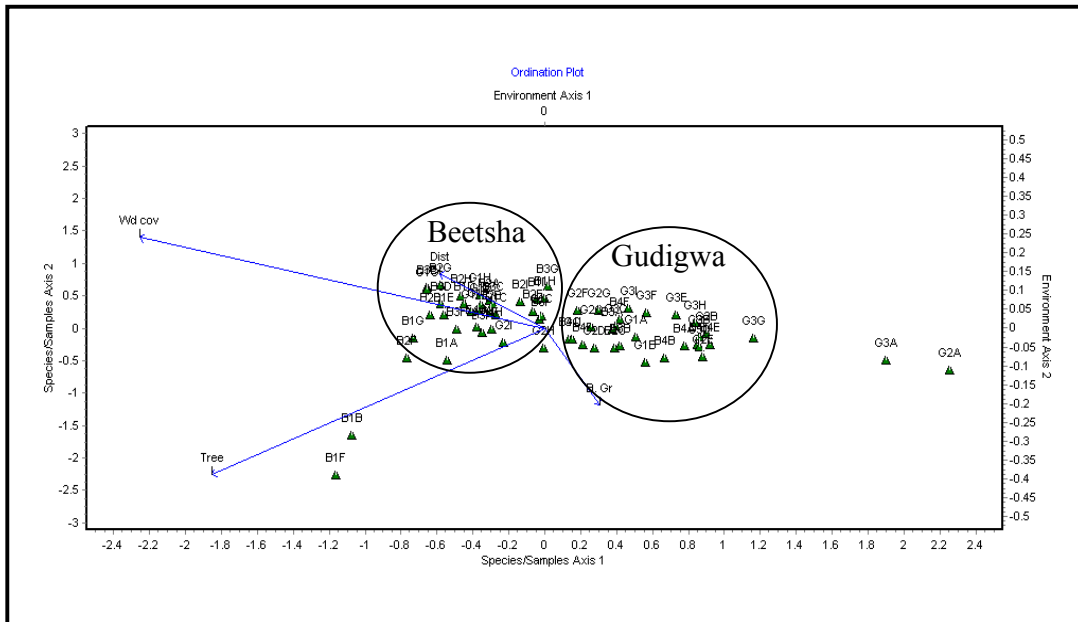


Figure 8.9. CCA results for the NBF site showing good separation on the X-axis and relationship with the woody cover environmental variable

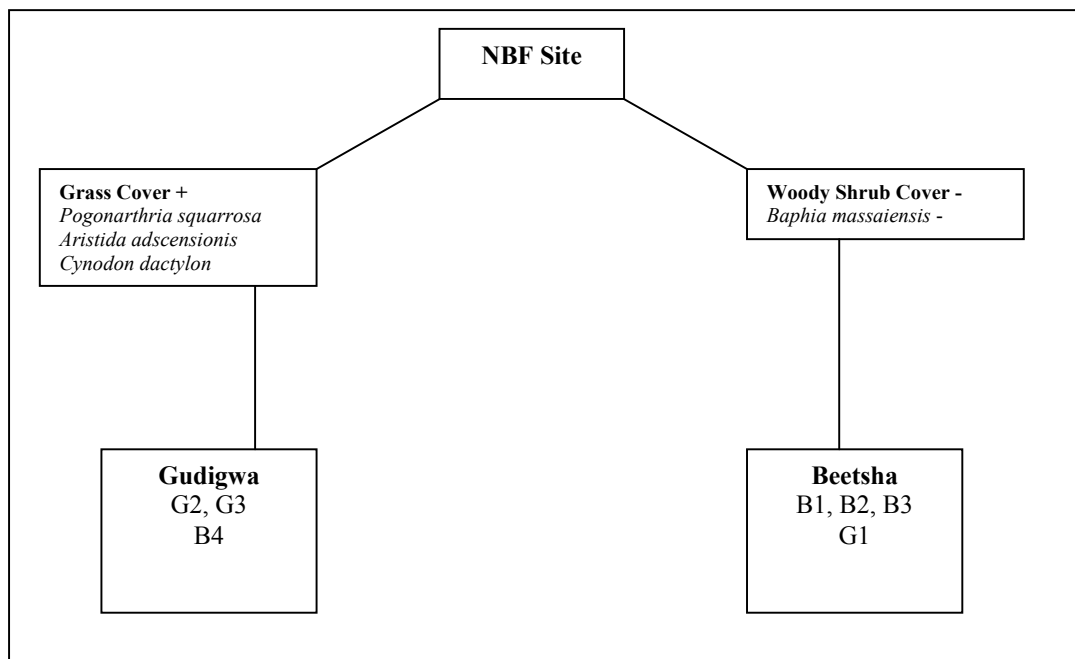


Figure 8.10. TWINSpan analysis diagram identifying the principle plant species and cover types that distinguish the NBF settlements and formed the basis for the first division.

DCA and CCA results for the CBPP site

Analysis of the CBPP study area dataset individually using DCA did not produce the same clear site separation seen in the NBF dataset. However, the resulting ordinations produced more significant eigenvalues for the first axis separation with values of 0.78 and 0.47 for DCA and CCA respectively. Closer examination of the DCA ordination diagram revealed the separation of several distinctive sites situated within the first 400m of the cattleposts in the region (Figure 8.8). TWINSpan confirmed this result as the first division in the analysis separated four sites (J2A, BO1A, BO1B, and BO1C) from the other sample sites on the basis of their distinctive ecological characteristics.

CCA was used to determine whether the supplied environmental variables could account for the presence of these distinctive sites. Before conducting CCA, tests for the multicollinearity of environmental variables found high VIF for woody vegetation. Woody cover was therefore omitted as an environmental variable in CCA ordination. As stated above, the first axis of the CCA produced a significant eigenvalue of 0.47 indicating good separation, although the majority of sites were tightly clustered on the axis unlike the more dispersed results seen using the unconstrained latent environmental variables generated by DCA. Tree density accounted for 11.12 per cent of the total floristic variability with a canonical coefficient of -0.56. When examining the CCA ordination diagram there were two clusters of sites close to this environmental axis (Figure 8.9). The most distant cluster and therefore the sites with the least species in common with the majority of transects were BO1C and BO1B. These transects were characterised by dense cover of mature *Combretum imberbe* and had influenced the original ordinations on the entire dataset (Table 8.9). However, similar to the outlying sites in the original

ordinations, the second cluster of sites were also all found within the first 400m of the cattlepost transects and contained high cover of several encroaching woody species. The dominant species found within these transects are presented in table 8.9 and circled in figure 8.13 below.

Table 8.9. Details of several clustered sites resulting in mature tree cover explaining 11.12% of total floristic variability.

Outlying site	Distance from borehole (metres)	Defining variable	environmental			Density woody cover >3m	% Woody cover <3m	% Grass cover	Defining species	Density/% cover of defining species
		Woody cover >3m	Woody cover <3m	High grass cover						
BO1B	200	X				42	24	21	<i>C. imberbe</i> >3m	34
BO1C	400	X				40	9	25	<i>C. imberbe</i> >3m	36
BO2B	200	X				8	15	11	<i>T. sericea</i> >3m	3
J1C	400			X		19	42	18	<i>D. cinerea</i> <3m	15
J2B	200			X		27	47	10	<i>D. cinerea</i> <3m	20
J2C	400			X		34	51	13	<i>B. massaiensis</i> <3m	18

Sites J1C, J2B and J2C were all located on a heavily vegetated valley side within 400 metres of the Jobo cattlepost. Woody shrub cover under 3 metres was dominated by the encroaching species *D. cinerea* which accounted for 15 to 20 per cent cover at sites J1C and J2B respectively. Total woody shrub cover at all three sites was over 40 per cent and the combined woody herbaceous cover averaged over 60 per cent, well above that considered to be bush encroached (Roques *et al.* 2001; Thomas *et al.* 2000).

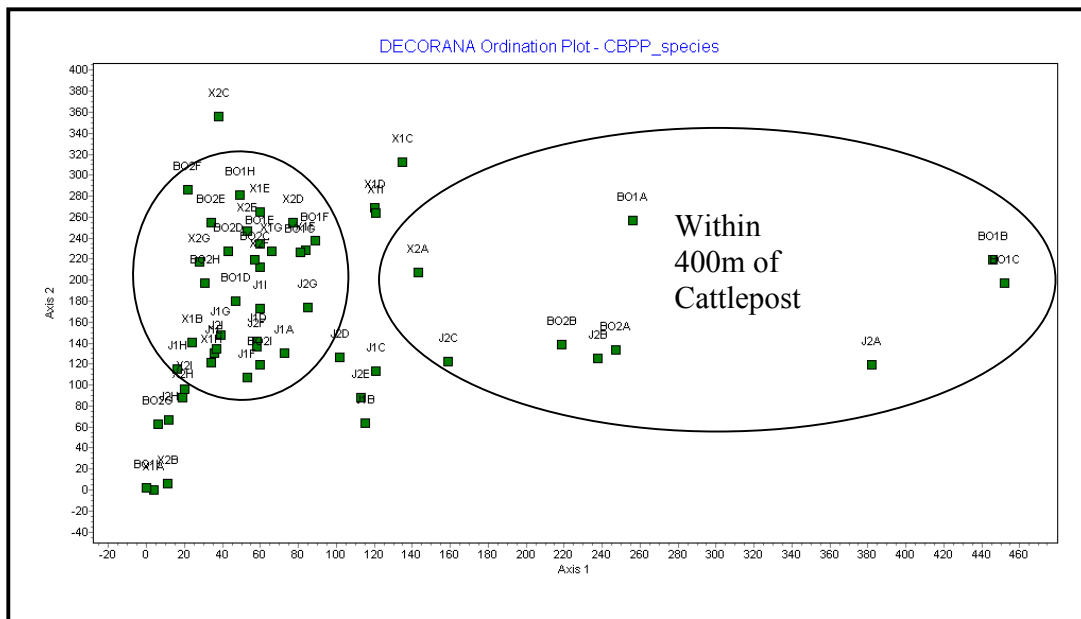


Figure 8.11. DCA ordination diagram of CBPP dataset showing separation of sites found within 400m of the cattleposts and wells

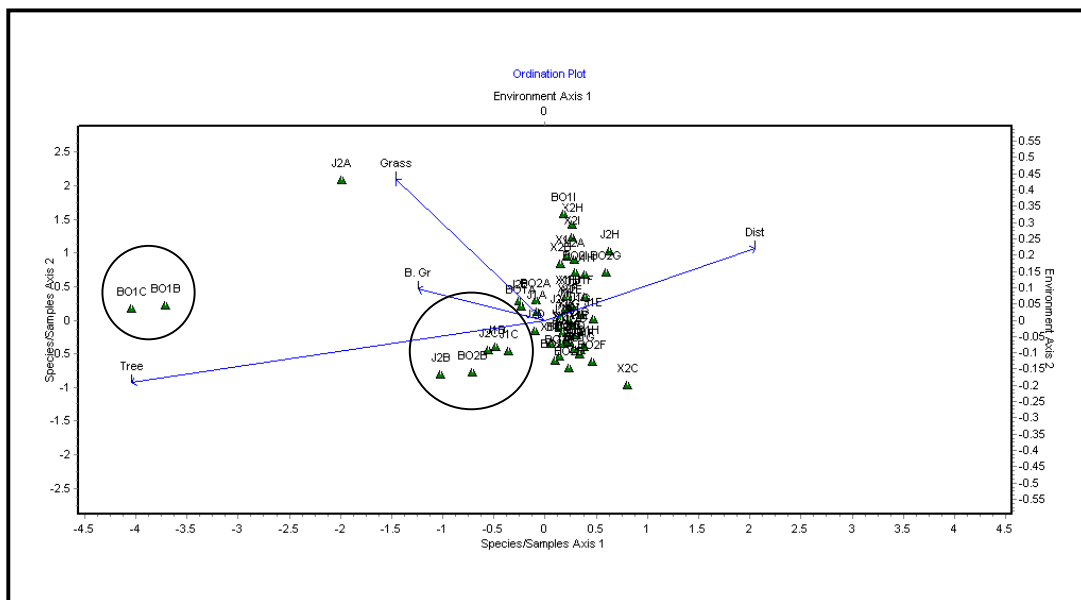


Figure 8.12. CCA ordination diagram showing sites separated on basis of relationship to the environmental variable tree density.

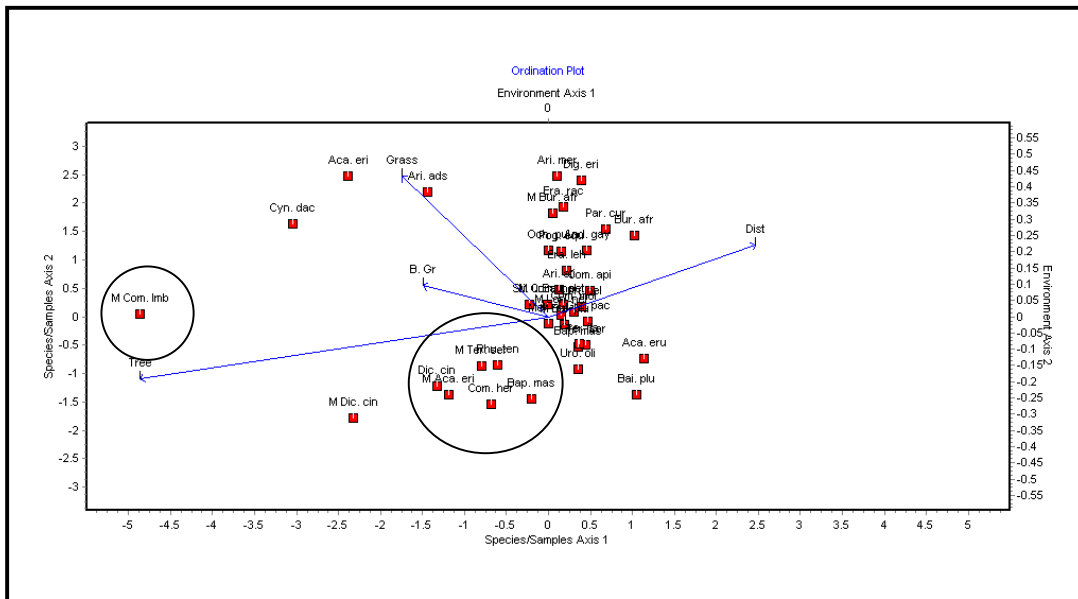


Figure 8.13. CCA biplot showing clustering of woody species resulting in high canonical coefficient for tree density environmental variable.

8.4.2 Fenceline vegetation changes

Vegetation cover changes across the NBF

Vegetation data showed a significant reduction in total cover to the east of the NBF (Table. 8.10). There was no significant difference in the mean total cover of tree, shrub or grass species across the NBF, but the mean total cover of shrubs, grasses and trees was lower on the eastern side of the fence for all three variables. The cover of annual grass species did not differ significantly either side of the fence. However, the cover of perennial grasses was slightly lower (significant at the 0.1 level) to the east of the fence.

Table 8.10 Mean cover and density changes of several indicator species groups across NBF. T-test statistics illustrate significant fenceline changes.

Indicator/species group	NBF east	NBF west	Test stat	df	P
Bare ground	63.5	58.1	2.1	94	0.05
Shrub cover (<3m)	23.8	26.4	-1.3	93	NS
Grass cover	13.6	15.8	-1.2	80	NS
Tree density (>3m)	4.1	5.6	-1.4	93	NS
Annual grasses	6.4	6.1	0.3	75	NS
Perennial grasses	5.9	8.1	-1.8	93	0.1

Species diversity changes across the NBF

A total of 44 different species were identified on both sides of the NBF. Species diversity was slightly lower on the eastern side of the NBF, with 42 and 38 different species identified to the west and east respectively. When separating the differing species found into growth form categories (e.g. shrub, trees, annual grass, perennial grass and creeping grass), a further 4 species were not present (2 east and 2 west) on both sides of the fence. These were all mature trees above the arbitrary 3m level (Table 8.11). However, none of the species that failed to be present on either side of the fences were common species contributing to more than 0.5 per cent of cover as a percentage of the cover of all taxa.

Table 8.11. Species diversity and growth form changes across NBF with % cover as a % of cover of all taxa signifying importance of species.

Species not found to the east	Growth form	% cover as % of all taxa
<i>Cynodon dactylon</i>	Creeping grass	0.006
<i>Pterocarpus angolensis</i>	<3m Shrub	0.18
<i>Dichapetalum cymosum</i>	<3m Shrub	0.05
<i>Boscia albitrunca</i>	<3m Shrub	0.28
<i>Acacia fleckii</i>	<3m Shrub	0.04
<i>Acacia nigrescens</i>	<3m Shrub	0.28
<i>Acacia eriolobia</i>	>3m Shrub/Tree	0.07
<i>Combretum apiculatum</i>	>3m Shrub/Tree	0.04
<i>Pterocarpus angolensis</i>	>3m Shrub/Tree	0.02
Species not found to the west	Growth form	% cover as % of all taxa
<i>Setaria sphacelata</i> var. <i>sphacelata</i>	Perennial grass	0.03
<i>Panicum maximum</i>	Perennial grass	0.006
<i>Guibourtia coleosperma</i>	>3m Shrub/Tree	0.07
<i>Combretum hereronense</i>	>3m Shrub/Tree	0.02

Two alternative explanations exist to explain these patterns. Could the reduced eastern cover changes be indicative of fence restricted wildlife herbivory or could reduced grazing following exclusion of many native ungulates be causing increased cover to the west? Furthermore, would more detailed investigations identify species and vegetation community changes across the fence, facilitate interpretation of veterinary fence impacts?

Species and community changes across the NBF

The results of the more detailed analysis of shrub species cover changes over the NBF revealed that the main shrub species could be divided into those which showed increased cover to the east and those which showed decreased cover to the east (with the exception of *Ochna pulchra*, see Table 8.12). Of the decreasing shrub species *Baphia massaiensis* and *Grewia* sp. were significantly different. The main shrub showing a significant

increase to the eastern side of the fence was *Terminalia sericea*, a species known to react well to disturbance (Hipondoka and Versfeld, 2006). Although the cover differences seen in other species listed were not significant, the total increasing and decreasing shrub mean cover changes were significant at the 0.05 level (Table 8.12). Figure 8.14 and 8.15 illustrate the cross-fence changes seen with the cover data from the total mean cover of each group of increasing or decreasing species. These graphs highlight sites roughly between 20 to 50 km and 75 km north from Sandaroka as areas of major fenceline contrasts in vegetation community structure. Sites from 20 to 50 km relate to an area between approximately S18°34 E23°01 and S18°18 E23°02. The site 75 km north of Sandaroka relates to an area near Dishokora cattlepost at approximately S18°06 E23°01.

Table 8.12. Mean cover changes of main shrub species found either side of NBF illustrating clear division of species into increaser or decreasing groups. The significance of these changes is illustrated by the t-test statistics.

Decreasing shrub species	NBF east	NBF west	Test stat	df	P
<i>Bap. mas</i>	2.0	6.9	-3.1	55	0.01
<i>Col. mop</i>	6.6	7.4	-0.3	92	NS
<i>Bau. pet</i>	0.2	1.1	-2.3	51	NS
<i>Grewia sp.</i>	0.3	0.9	-1.8	71	0.1
<i>Com. apl</i>	0.7	0.9	-0.5	92	NS
Increasing shrub species					
<i>Ter. ser</i>	7.5	4.8	1.8	90	0.1
<i>Lon. nel</i>	2.4	1.5	0.8	80	NS
<i>Com. mol</i>	1.7	0.9	1.1	73	NS
<i>Bur. afr</i>	1.5	1.0	0.8	90	NS
Neutral shrub species					
<i>Och. pul</i>	1.1	1.1	0.1	89	NS
Total increasing shrubs	13.0	8.2	2.3	83	0.05
Total decreasing shrubs	24.5	31.3	-2.2	84	0.05

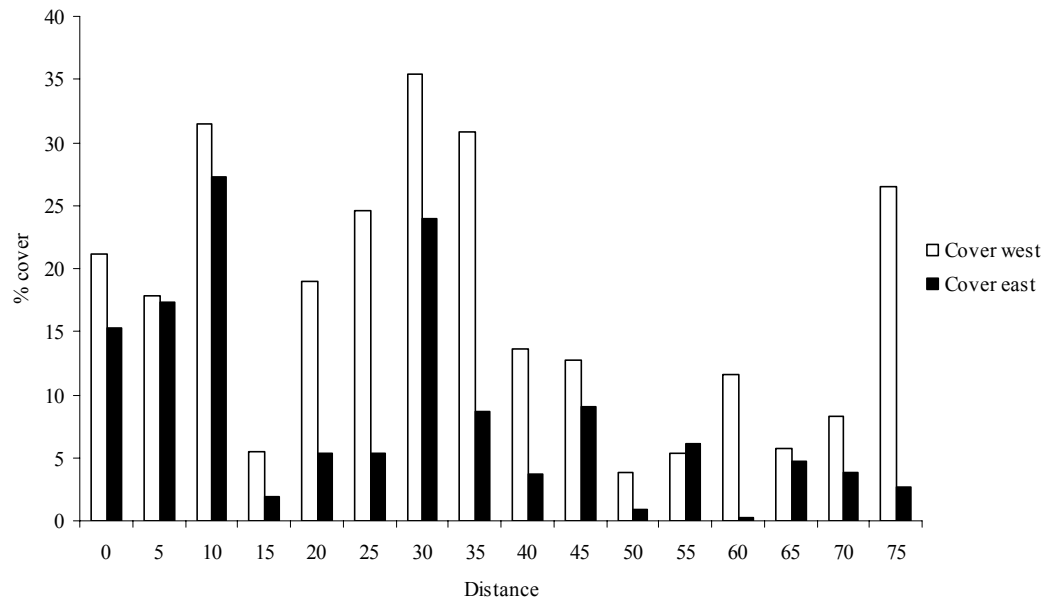


Figure 8.14 Mean cover changes of decreasing shrubs showing lower cover on the eastern side of the fence at several sites.

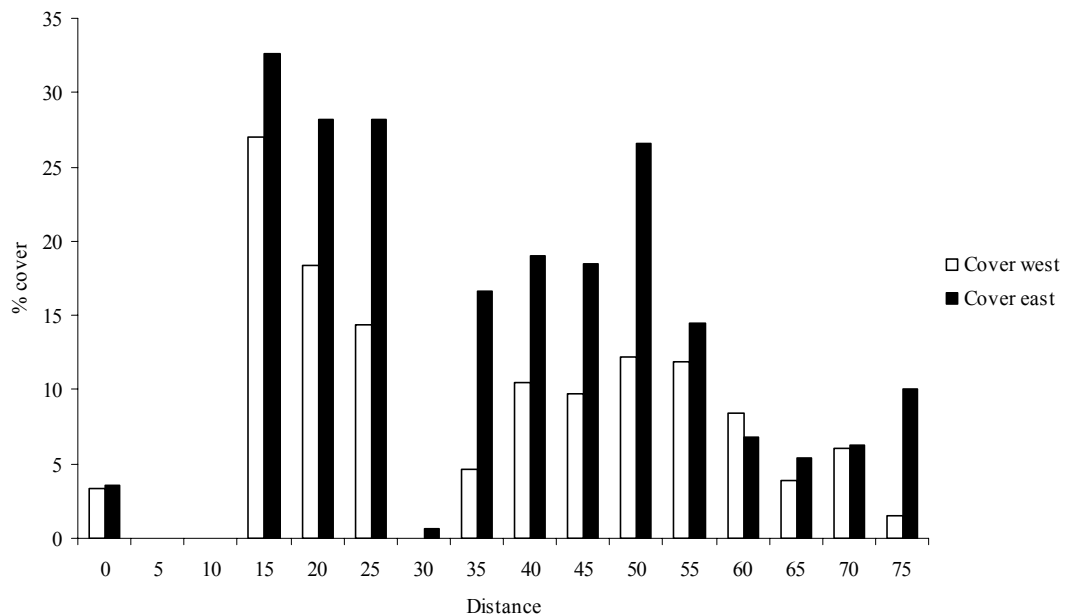


Figure 8.15 Mean cover changes of all the increasing shrub species combined showing sites of major fenceline contrast.

Tree density changes across the NBF

There were no significant changes in the density of the five most common tree species over the NBF (Table 8.13), though *T.sericea*. decreased in density to the east in its mature form. Similarly all other species except *Colophospermum mopane* decreased to the east.

Table 8.13 Mean density changes of main tree species found either side of NBF. The significance of the change is illustrated by the t-test statistic.

Tree density changes	NBF east	NBF west	Test stat	df	P
<i>Ter. ser</i>	1.5	2.4	-1.3	82	NS
<i>Com. mol</i>	0.0	0.4	-1.4	48	NS
<i>Bai. plu</i>	0.3	0.4	-0.4	94	NS
<i>Bur. afr</i>	0.7	1.1	-1.1	80	NS
<i>Col. mop</i>	1.5	1.1	0.4	84	NS

Grass cover changes across the NBF

The cover of most annual and perennial grasses changed little over the fenceline although 3 out of 4 annuals increased slightly to the east and 3 out of 5 perennials decreased slightly to the east. However, the cover of the highly palatable perennial grass *Digitaria erianthia* was significantly lower to the east of the fence which will have contributed to the significant difference at the 0.1 level of total perennial grass cover in table 8.10.

Table 8.14 Changes in cover of main annual and perennial grass species found along NBF. Significance of the change was assessed using t-tests for independent means assuming unequal variances.

Annual Grass Species	NBF East	NBF West	Test Stat	df	P
<i>Ari. Ads</i>	2.5	2.3	0.5	91	NS
<i>Ari. Sca</i>	0.5	1.0	-0.8	60	NS
<i>Pog. squ</i>	2.9	2.7	0.4	85	NS
<i>Sch. kal</i>	0.5	0.2	1.4	68	NS
Perennial Grass Species	NBF East	NBF West	Test Stat	df	P
<i>Ari. mer</i>	0.2	0.3	-0.3	82	NS
<i>Era. leh</i>	2.0	2.1	-0.1	88	NS
<i>Sti. uni</i>	0.3	0.2	0.7	90	NS
<i>Bra. bri</i>	0.3	0.3	-0.2	82	NS
<i>Dig. eri</i>	3.1	5.2	-2.1	87	0.05

Vegetation cover and species diversity changes across the Samochima CBPP fence

The change in total vegetation cover from north to south of the Samochima fence was not statistically significant. Shrub and grass cover, however, differed significantly at the 0.01 level with an increase in shrub cover to the north and decrease in grass cover to the south (Table 8.15). The change in tree density was also statistically significant with an increase to the south of the fence. Furthermore, the cover of perennial grass species was significantly different, whilst annual grass species cover was not. In terms of species diversity, a total of 43 species were found along both sides of the Samochima fence. However, five of these species were not found to the north and five were not found to the south (Table 8.16). Whilst most of these were rare species overall, four were more common species which contributed more than 0.5 per cent as a percentage of the total cover for all taxa. When these absent species were categorised into growth forms, a

further two species on either side of the fence were not present to the south and north in the form of mature trees over the arbitrary 3m level.

Table 8.15 Mean cover or density changes of several species groups and cover types across Samochima fence with results of t-tests for independent means assuming unequal variances illustrating significant differences.

Indicator/species group	SAM north	SAM south	Test stat	df	P
Bare Ground	55.7	52.2	1.5	56	NS
Shrub Cover	20.3	29.1	-4.7	64	0.01
Grass Cover	25.6	19.3	3.9	63	0.01
Tree Density	4.5	7.2	-2.4	64	0.05
Annual Grasses	5.9	4.7	1.0	60	NS
Perennial Grasses	19.7	14.6	2.6	54	0.05
Encroaching Shrubs	11.7	20.2	-4.1	54	0.01
Encroaching Trees	8.6	8.9	-0.2	64	NS
Decreasing Shrubs	1.2	2.0	-1.3	63	NS

Table 8.16. Species diversity and growth form changes across Samochima fence with per cent cover as a percent of the cover of all taxa identified along the CBPP fences signifying the importance of the species and those above the 0.5 per cent highlighted in bold.

Species not found to the north	Growth form	% cover as % of all taxa
<i>Pogonarthria squarrosa</i>	Annual grass	3.81
<i>Acacia sieberiana</i>	<3m Shrub	0.09
<i>Acacia hebeclada</i>	<3m Shrub	0.05
<i>Combretum hereronense</i>	<3m Shrub	0.17
<i>Dichapetalum cymosum</i>	<3m Shrub	0.5
<i>Dicrostachys cinerea</i>	>3m Shrub/tree	0.06
<i>Biakiaea plurijuga</i>	>3m Shrub/tree	0.6
Species not found to the south	Growth form	% cover as % of all taxa
<i>Andropogon gayanus</i>	Perennial grass	0.5
<i>Grewia flava</i>	<3m Shrub	0.10
<i>Ximenia americana</i>	<3m Shrub	0.25
<i>Peltophorum africanum</i>	<3m Shrub	0.13
<i>Grewia pachycalyx</i>	<3m Shrub	0.03
<i>Boscia albitrunca</i>	>3m Shrub/Tree	0.08
<i>Combretum apiculatum</i>	>3m Shrub/Tree	0.18

Species and community changes across the Samochima fence

The overall mean increase in shrub volume to the south of the Samochima fence was not represented by increases in the cover of all shrub species. Table 8.17 categorises the cross-fence response of the most common species (>0.5% cover as per cent of cover of all species) into those which showed increased, decreased or little change in cover to the south of the Samochima fence. The t-test statistics revealed only three shrub species (*Baphia massaiensis*, *Dialium englerianum* and *Terminalia sericea*) to be significantly different across the fences. All of these species showed increased cover to the south of the fence and figure 8.16 illustrates the mean cover changes of all the increasing species combined.

Table 8.17. Mean cover changes of main shrub species found either side of Samochima fence illustrating the division of species increasing, decreasing or little change groups. The significance of these changes is illustrated by the t-test statistics.

Decreasing shrub species	Sam north	Sam south	Test stat	df	P
<i>Aca. eri</i>	0.4	0.2	0.5	54	NS
<i>Rhu. ten</i>	0.7	0.4	1.0	51	NS
<i>Grewia sp.</i>	1.1	0.2	1.3	35	NS
<i>Lon. nel</i>	0.8	0.3	1.0	51	NS
Increasing shrub species					
<i>Bur. afr</i>	5.2	7.6	-1.4	58	NS
<i>Dic. cin</i>	0.4	1.2	-1.3	54	NS
<i>Bap. mas</i>	0.7	3.9	-2.3	41	0.05
<i>Dia. eng</i>	0.7	2.6	-2.3	48	0.05
<i>Ter. ser</i>	0.8	2.5	-2.5	50	0.05
Neutral shrub species					
<i>Bau. pet</i>	2.4	2.4	0.0	63	NS
<i>Par. cur</i>	2.5	2.5	0.0	62	NS
<i>Com. api</i>	1.1	1.0	0.1	55	NS
<i>Com. mol</i>	0.5	0.5	-0.2	61	NS
<i>Och. pul</i>	1.9	2.0	-0.1	64	NS

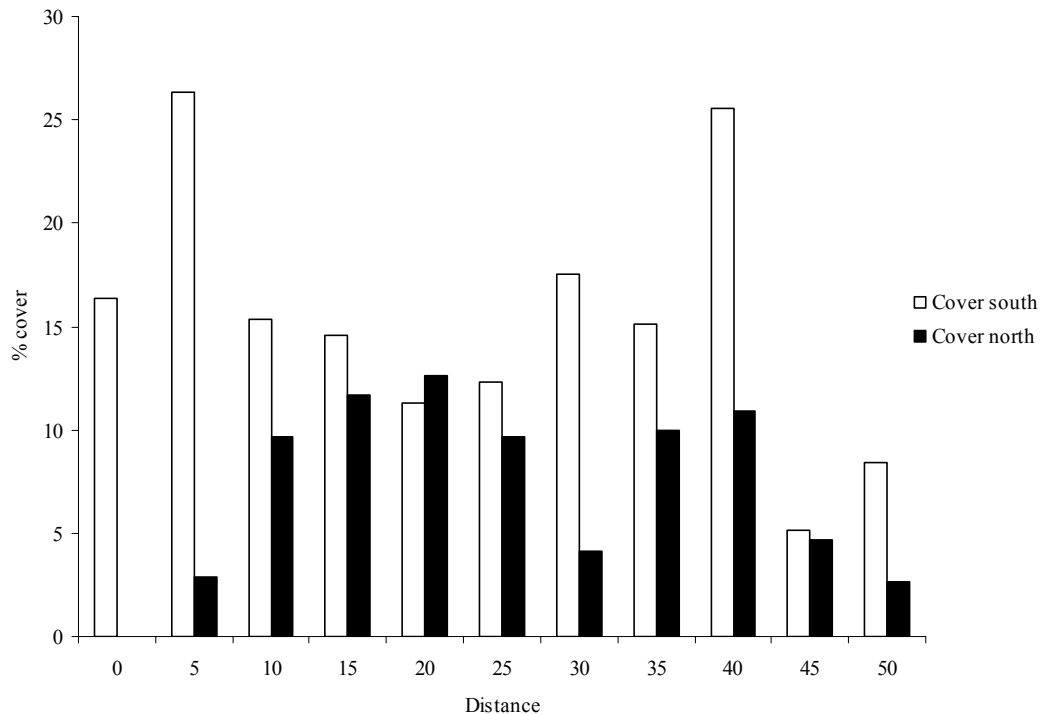


Figure 8.16. Mean cover changes of all increasing shrubs combined showing clear increased cover to the south of the Samochima fence (T-test stat= -5.4; df=56; $P=0.01$)

Tree density across the Samochima fence

Species level changes in the density of common mature tree species were not statistically significant (Table 8.18). However, the density of three out of the four key species did increase slightly to the south of the fence which may have contributed to the statistically significant difference in total tree density found in table 8.15.

Table 8.18. Mean density changes of main tree species found either side of Samochima fence.
The significance of the change is illustrated by the t-test statistic

Tree density changes	Sam north	Sam south	Test stat	df	P
<i>Ter. ser</i>	0.6	0.8	-0.5	58	NS
<i>Com. mol</i>	0.4	1.1	-1.6	51	NS
<i>Aca. eri</i>	0.2	0.2	0.7	50	NS
<i>Bur. afr</i>	2.4	4.3	-1.7	62	NS

Grass cover changes across the Samochima fence

Nine of eleven key grass species showed no significant change across the Samochima fence (Table 8.19). However, whilst the combined total for annual grasses in table 8.15 showed no significant difference, the individual species analysis revealed a significant difference in the commonly occurring annual, *Aristida adscensionis*, which showed increased cover to the north of the fence. The significant difference in total perennial grass cover shown in table 8.15, was a factor of the significantly higher cover of the palatable perennial *Eragrostis leymanniana* to the north of the fence.

Table 8.19. Changes in cover of main annual and perennial grass species found along Samochima fence. Significance of the change was assessed using t-tests for independent means assuming unequal variances.

Annual grass species	Sam north	Sam south	Test stat	df	P
<i>Ari. ads</i>	4.3	2.2	2.0	46	0.05
<i>Sor. ver</i>	1.1	1.8	-1.2	57	NS
<i>Sch. kal</i>	0.4	0.2	1.2	43	NS
Perennial grass species	Sam north	Sam south	Test stat	df	P
<i>Ari. mer</i>	0.5	0.6	-0.3	47	NS
<i>Era. leh</i>	6.7	3.2	2.7	43	0.01
<i>Sti. uni</i>	0.4	0.1	1.5	45	NS
<i>Dig. eri</i>	4.1	3.6	0.5	64	NS
<i>Mel. rep</i>	0.1	0.2	-0.8	53	NS
<i>Uro. oli</i>	0.2	0.6	-1.7	56	NS
<i>Era. nin</i>	4.3	5.1	-0.6	63	NS
<i>Bra. nig</i>	2.7	1.3	1.6	44	NS

Vegetation cover and species diversity changes across the Ikoga fence

There was no significant difference in vegetation cover from north to south of the Ikoga fence. Furthermore the total cover of shrubs, grass, trees, annual grass and perennial grass were not significantly different either side of the fence (Table 8.20). However, although not significant, the cover of all vegetation variables except annual grasses and decreasing trees showed mean cover decreases to the north. The lack of significant differences in vegetation cover was mirrored by the changes in species diversity with 47 species identified in total, with six different species not present to the north and six different species not present to the south (Table 8.21). When separating mature tree density data, a further four different species were not present on each side of the fence in the growth form of mature trees, with two to the north and two to the south. However, *Baikiaea plurijuga* which failed to occur to the south of the fence, was the only commonly

occurring species with the remaining species covering less than 0.5 per cent as a percentage of the total cover of all taxa.

Table 8.20. Mean cover or density changes of several species groups and cover types across Ikoga fence with the results of t-tests for independent means assuming unequal variances illustrating significant differences.

Indicator/species group	Ikoga north	Ikoga south	Test stat	df	P
Bare ground	44.9	42.3	0.9	64	NS
Shrub cover	28.5	30.3	-0.6	64	NS
Grass cover	25.0	26.2	-0.6	64	NS
Tree density	3.8	5.2	-1.5	61	NS
Annual grasses	9.3	8.4	0.4	64	NS
Perennial grasses	15.7	17.7	-1.2	62	NS
Encroaching shrubs	23.0	26.2	-1.3	64	NS
Encroaching trees	2.0	2.8	-1.1	58	NS
Decreasing shrubs	5.5	4.1	1.2	56	NS

Table 8.21. Species diversity and growth form changes across Ikoga fence with per cent cover as a percent of the cover of all taxa signifying the importance of the species and those above 0.5% highlighted in bold.

Species not found to the north	Growth form	% cover as % of all taxa
<i>Brachiaria brizantha</i>	Perennial grass	0.02
<i>Acacia fleckii</i>	<3m Shrub	0.05
<i>Baikiaea plurijuga</i>	<3m Shrub	0.54
<i>Pterocarpus angolensis</i>	<3m Shrub	0.06
<i>Combretum zeyheri</i>	<3m Shrub	0.10
<i>Lonchocarpus nelsii</i>	>3m Shrub/Tree	0.05
<i>Combretum zeyheri</i>	>3m Shrub/Tree	0.18
<i>Combretum apiculatum</i>	>3m Shrub/Tree	0.05
Species not found to the south	Growth form	% cover as % of all taxa
<i>Schizachyrium jeffreysii</i>	Perennial grass	0.37
<i>Ziziphus mucronata</i>	<3m Shrub	0.06
<i>Strychnos madagascariensis</i>	<3m Shrub	0.13
<i>Strychnos spinosa</i>	<3m Shrub	0.07
<i>Commiphora angolensis</i>	>3m Shrub/Tree	0.04
<i>Peltophorum africanum</i>	>3m Shrub/Tree	0.02
<i>Acacia ataxcantha</i>	>3m Shrub/Tree	0.05

Species and community changes across the Ikoga fence

The species analysis confirmed the lack of significant difference in vegetation communities found with the mean cover data in table 8.20. There was no significant difference in any of the most common shrub species (Table 8.22). Similarly the difference in tree density of all the most commonly occurring tree species was not significant (Table 8.23). The only cross-fence significant species level change was the decreased cover of the palatable perennial grass species *Eragrostis nindensis* seen to the north of the fence (Table 8.24).

Table 8.22. Mean cover changes of main shrub species found either side of Ikoga fence illustrating the lack of significant difference. The significance of these changes is illustrated by the t-test statistics.

Decreasing shrub species	Ikoga north	Ikoga south	Test stat	df	P
<i>Aca. eri</i>	0.4	0.9	-1.0	49	NS
<i>Bur. afr</i>	1.9	3.1	-1.3	60	NS
<i>Par. cur</i>	0.7	1.1	-1.1	60	NS
<i>Bap. mas</i>	11.5	13.3	-0.9	64	NS
<i>Lon. nel</i>	0.3	0.4	-0.2	64	NS
Increasing shrub species					
<i>Rhu. ten</i>	0.6	0.2	0.6	36	NS
<i>Grewia sp.</i>	0.5	0.1	1.0	34	NS
<i>Gre. fla</i>	1.0	0.2	1.5	34	NS
<i>Bau. pet</i>	2.5	1.4	1.4	57	NS
<i>Dic. cin</i>	0.8	0.6	0.4	63	NS
<i>Ter. ser</i>	4.8	4.1	0.5	61	NS
Neutral shrub species					
<i>Dia. eng</i>	0.2	0.3	-0.6	64	NS
<i>Com. api</i>	0.7	0.8	-0.1	64	NS
<i>Com. mol</i>	0.9	1.5	-1.1	59	NS
<i>P. Leaf</i>	0.4	0.6	-0.8	62	NS
<i>Och. pul</i>	0.5	0.6	-0.3	60	NS

Table 8.23. Mean density changes of main tree species found either side of Ikoga fence. The significance of the change is illustrated by the t-test statistic.

Tree density changes	Ikoga north	Ikoga south	Test stat	df	P
<i>Ter. ser</i>	0.2	0.2	-0.2	53	NS
<i>Com. mol</i>	0.9	1.1	-0.3	63	NS
<i>Aca. eri</i>	0.9	1.5	-1.0	50	NS
<i>Bur. afr</i>	1.4	1.6	-0.5	57	NS
<i>Bai. plu</i>	0.5	0.7	-0.4	57	NS

Table 8.24. Changes in cover of main annual and perennial grass species found along Ikoga fence. Significance of the change was assessed using t-tests for independent means assuming unequal variances.

Annual grass species	Ikoga north	Ikoga south	Test stat	df	P
<i>Ari. ads</i>	0.4	0.5	-0.2	55	NS
<i>Sor. ver</i>	0.5	0.6	-0.3	62	NS
<i>Pog. squ</i>	4.8	3.7	0.6	63	NS
<i>Sch. kal</i>	0.2	0.4	-0.9	49	NS
<i>Ari. sti</i>	3.4	3.3	0.1	64	NS
Perennial grass species					
<i>Ari. mer</i>	0.6	0.7	-0.2	48	NS
<i>Era. leh</i>	2.3	3.0	-0.9	61	NS
<i>Sti. uni</i>	2.3	0.9	1.9	41	NS
<i>Dig. eri</i>	1.3	2.0	-1.3	64	NS
<i>Mel. rep</i>	0.5	0.5	0.1	64	NS
<i>Uro. oli</i>	0.5	0.6	-0.3	56	NS
<i>Era. nin</i>	6.0	8.9	-2.3	63	0.05
<i>Bra. nig</i>	1.0	0.6	1.1	51	NS
<i>And. gay</i>	0.2	0.3	-0.1	64	NS
<i>Pan. col</i>	1.0	0.3	1.4	44	NS

8.5 Conclusion

Vegetation condition with disturbance intensity

Resource use by pastoralists and natural resource dependent communities in northern Botswana has become increasingly sedentary following the compounding impacts of government settlement policies, commoditisation and enclosure by veterinary cordon fences (Chapters 4, 6 and 7). Permanent grazing by livestock has depleted the herbaceous layer within 25-50m of wells and kraals, while beyond this woody shrubs and trees have reached levels considered to be encroached in a small number of cases, often within 200-400m. However, elsewhere in the Kalahari sacrifice zones are known to extend up to 400m from wells or boreholes and bush encroachment zones can extend to 2km (cf. Thomas *et al.* 2000; Perkins and Thomas, 1993). This indicates that the vegetation changes resulting from sedentarisation do not yet override natural environmental gradients or variability.

Such an assertion was confirmed by mean vegetative cover or density changes with increased disturbance intensity, as no discernable ‘piosphere’ type trends are evident in tree density, shrub or grass cover. The same could be said for trends in the cover and density of unpalatable annuals and encroaching woody species which in most cases actually increased relative to decreased disturbance. This could be interpreted as resulting from a lack of grazing following the CBPP cull and supports local observations established in Chapter 6. However, at two sites in the CBPP study area (Jobo and Xabacha II) the cover of encroaching woody plant species increased relative to disturbance intensity reaching a peak within 800m of the central well or kraal. These

observations match those of Perkins and Thomas (1993) who found that the greatest density of encroaching shrubs often falls within 50-800m of boreholes in the Kalahari and are thus indicative of grazing induced change.

Multivariate ecological analysis comparing site-by-species data to supplied environmental variables confirmed the absence of widespread trends relative to disturbance intensity. Distance from water point or kraal failed to account for significant proportions of variability within either the entire dataset, or the individual study area datasets. In spite of this, tree density or woody cover accounted for significant amounts of variability in both individual and entire datasets, facilitating the identification of several distinctive sites with high density or cover of woody species. Most of these sites were located within 400m of wells or kraals, and were characterised by high densities or cover of only one woody species, often a known encroacher. Such findings supported earlier analysis of ecological survey data indicating that permanent grazing induced changes are limited to areas in immediate proximity (<400m) of water points or kraals.

Fenceline vegetation changes

Results of the assessment of fenceline vegetation change indicate that veterinary cordon fences in northern Botswana are influencing vegetation dynamics at the rangeland scale. Vegetation changes across the NBF are manifest in statistically significant reductions in total vegetative cover and lower perennial grass cover to the east of the fence. Species diversity also decreased to the east of the fence, although none of the absent species were common species overall. Significant increases in the cover of *T. sericea* to the east of the NBF was also indicative of increased disturbance, and analysis of spatial changes in

increaser or decreaser shrubs revealed an area of particular fenceline contrast between S18°34 E23°01 and S18°18 E23°02.

Vegetative cover also changed across the Samochima CBPP fence, with fenceline contrasts evident in increased shrub cover to the north, and decreased grass cover and tree density to the south of the fence. While species diversity changed little over the fenceline, the cover of perennial grasses was lower, and encroaching shrubs higher, on the southern side. Changes in specific shrub species identified three species that increased to the south of the Samochima fence, with an area of particular fenceline contrast between 0-10km and 30-40km along the fence (from eastern sample site). No statistically significant changes were evident in tree, shrub, grass or species diversity across the Ikoga fence.

These results raise an important question: what factors are driving these cross-fence vegetation changes? In the CBPP study area wildlife populations are low and have declined further since enclosure (Chapter 6). The subsequent increase in fire intensity could be a major driver of fenceline vegetation change and was supported by local observations (p. 232). The decline in perennial grasses, and significant increase in encroacher shrubs on the southern side of the Samochima fence could be indicative of fence restricted livestock herbivory. This assumption is strengthened by the proximity of Boudom and Tsokung cattleposts to zones of major fenceline contrast across the Samochima fence (Map 8.1). Studies of fenceline contrasts between heavily restricted communal rangelands and commercial farmland in South Africa found similar declines in palatable grasses and shrubs on the communal side (Todd and Hoffman, 1999).

In the NBF study area livestock are now kept at a series of permanent cattleposts dotted along the delta fringe, and //Gam /wi or Dishokora are the closest cattleposts to the fence

(Map 8.2). Although livestock numbers in the region are increasing, at present the population has yet to reach pre-cull levels (Arntzen, 2005). Thus, livestock grazing is unlikely to be a widespread factor influencing ecological change at the fenceline. Wildlife, on the other hand, graze both sides of the fence, and have been seriously curtailed by the NBF. Enclosure is known to have dramatically altered the diversity and population of species found on the western side (Chapter 7). To add to this the population of large mammal herbivores (LMH) such as elephant to the east of the NBF is said to have increased (Cumming and Jones, 2005), causing concern over the excessive utilisation of woodlands in the region (cf. Ben-Shahar, 1996; 1998).

The significantly reduced vegetation cover to the east of the NBF, along with the increased cover of *T. sericea*, would appear to be wildlife-induced changes. Previous studies of fenceline vegetation change across veterinary cordon fences in Botswana, found reduced tree density cover on the wildlife side to be indicative of over-utilisation by migratory animals curtailed by the fence (Ringrose *et al.* 1997). However, the study fell short of quantifying changes to the species level, or assessing the temporal dynamics of these land cover modifications, due to the limited spatial and temporal resolution of their observations.

Work by Ben-Shahar (1996; 1998) attempted to identify structural elements of changes resulting from the over-utilisation of woodland by elephants in northern Botswana. The studies found that *Acacia erioloba* woodland is little affected by elephant damage, while *C. mopane* woodland is subject to obtrusive damage without any major change in tree density and significant declines in *B. plurijuga* woodland are driven more by fire than elephant damage. Thus, ecological change by LMH such as elephant are difficult to

detect in overall cover or density measurements, and best observed using height or a proxy disturbance measurement.

In spite of the difficulties identifying specific wildlife drivers of ecological change, it is clear that fence restricted wild herbivores can cause undesirable shifts in vegetative cover (van de Koppel and Rietkerk, 2000). Habitat fragmentation by large-scale barrier fences reduces access to landscape heterogeneity, thus excluding large herbivores from key resources, and increasing the potential for overgrazing (cf. Boone and Hobbs, 2003; Boone *et al.* 2005). Furthermore, the increased cover of *T. sericea* to the east of the NBF could be a result of reduced cover, as the species is known for its ability to increase following reductions in herbaceous cover (Hipondoka and Versfeld, 2006).

Given the highly dynamic nature of dryland ecosystems, multitemporal investigations are required in order to determine management induced change from inherent natural variability. The best means by which to study management impacts is by way of an area-by-time factorial experiment (Green, 1979). The lack of long-term ecological data from before the erection of the fences, precludes the use of ground-based surveys. Thus the following chapter uses multitemporal remote sensing at the rangeland scale to investigate vegetation change over the period of enclosure.

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9

Detecting fence induced environmental change in northern Botswana: multitemporal remote sensing

9.1 Introduction

Greater understanding and monitoring of land-cover changes in dryland savannas is an essential prerequisite for effective management and an integral part of evaluating the impact of human disturbances (Yang and Prince, 2000). Chapter 8 explored the link between sedentarisation and environmental change in the study areas, emphasising the need to combine multisource data to thoroughly investigate dryland environmental change. One of the most interesting and useful applications of remote sensing data is the analysis of multi-temporal images for detecting land-cover changes (Bruzzone *et al.*, 2004). Satellite remote sensing provides a means of characterising spatial patterns of vegetation cover at the landscape scale and therefore overcomes the site-specific nature of ground ecological monitoring in heterogenic dryland ecosystems. Furthermore, multitemporal remote sensing using data from sensors of fine resolution with large historical catalogues (e.g. the Landsat series) could provide a means of extending our understanding of vegetation dynamics in the highly contested semi-arid rangeland context (Trodd and Dougill, 1998).

This chapter extends the findings of the previous chapter both spatially and temporally through a multi-temporal rangeland scale account of vegetation change using multi-temporal remote sensing over the period of enclosure (1991-2005). The chapter describes a modified post-classification land-cover change detection methodology which attempts to address several of the limitations associated with multi-temporal remote sensing in

dryland savannas. While the approach used was subject to several limitations, it yielded considerable insight into the environmental consequences of enclosure in northern Botswana. Increased woody vegetation cover around several settlements and cattleposts supported the previous findings in Chapter 8. Similarly, decreases in the cover of woody vegetation to the east of the NBF supported previous assertions regarding wildlife induced change in previous chapter. Academically, this chapter contributes to ongoing debates over the role of multi-temporal remote sensing in monitoring ecological change in non-equilibrium dryland savannas. By focussing on elements of stability within dynamic non-equilibrium landscapes, a more confident multi-temporal remotely sensed land-cover change assessment can be made.

9.2 Multi-temporal remote sensing of environmental change in drylands

There are several approaches to the multi-temporal remote sensing of vegetation cover change, each with varying degrees of accuracy and associated issues of error (Table 9.1). In a comprehensive review, Coppin *et al.* (2004), divide multi-temporal remote sensing techniques for ecosystem monitoring into those which attempt to detect changes between pairs of images (bi-temporal), and those which aim to use time profiles of imagery derived indicators (temporal trajectories). In general, the former approach utilises various hard classification techniques, followed by post-classification change detection, whereas the latter approach relies on image enhancement techniques for the detection of more subtle changes in reflectance.

Land cover change detection using multi-temporal remote sensing involves the analysis of two or more co-registered images for the same geographical area at different times (bi-temporal), with land cover changes detected on the premise that changes in radiance values are large with respect to radiance changes caused by other factors such as differences in atmospheric conditions, soil moisture and sun angles (Mas, 1999; Bruzzone *et al.*, 2004). However, land cover changes in dryland environments are typically represented by subtle modifications rather than distinct changes in overall classification, and therefore separating human-induced from natural changes using multitemporal remote sensing is often challenging (Pilon *et al.*, 1988; Lambin *et al.*, 2001). In the semi-arid rangelands of southern Africa land managers consider the gradual increase in bush dominance (bush encroachment), and undesirable shifts in the ratio of palatable and unpalatable grasses, as major threats to the sustainability of livestock production (Trodd and Dougill, 1998). As a result most attempts at multitemporal land cover change detection in the region have been aimed at using image enhancement techniques to identify structural components of vegetation communities, in an attempt to monitor changes over time. By far the most commonly used imagery-derived indicator for analysing vegetation change in semi-arid rangelands, is the use of image ratios such as the normalised difference vegetation index (NDVI) to monitor changes in total plant cover, greenness or biomass (Prince and Tucker, 1986). NDVI has been used as a proxy to estimate green biomass and leaf area index, along with varying patterns of productivity (Carlson and Ripley, 1997). Vegetation indices (VIs) such as the NDVI utilise the characteristically strong reflectance of healthy green leaves in the near infrared wavelengths (0.72-1.10 μm), in relation to the successful absorption of red visible

wavelengths (0.58-0.68 μm) by leaf chlorophyll. NDVI can be calculated using the formula:

$$\text{NDVI} = (\text{NIR} - \text{RED}) / (\text{NIR} + \text{RED})$$

As the NDVI uses sums of the differences between the red and NIR spectral bands and not absolute reflectance, it is advocated by many as ideal for monitoring vegetation change, as this effectively normalises the images making them less affected by changes in atmospheric conditions (Mather, 1999). However, in dryland environments often typified by sparse vegetative cover, several researchers have questioned the efficacy of NDVI to monitor vegetation changes, due to its susceptibility to radiometric disturbances (Leprieur *et al.*, 2000; Xiao *et al.*, 2003). Atmospheric scattering and absorption contaminate the NDVI signal, causing at-sensor NDVI to be smaller than that at the top of the canopy (Song *et al.*, 2001). As a result, contaminations from the atmosphere to the NDVI can amount to 50% or more over thin or broken vegetation cover (Verstraete, 1994). Similar issues have been raised over the influence of soil brightness and underlying geology in drylands (Major *et al.*, 1990). However, in terms of using multi-temporal remote sensing to detect land cover changes, the NDVI time-series approach has the advantage over bi-temporal image comparisons, as time profiles throughout the vegetation growth season circumvent the issue of the influence of plant phenology on the change detection process (Coppin *et al.*, 2004).

A serious disadvantage, however, is the currently course resolution of satellite-based sensors capable of establishing the high temporal resolution of observations required,

which seriously limits the change categories detected, and fails to match the heterogeneity of dryland ecosystems (ibid: 1569; Dougill and Trodd 1998). However, attempts have been made to sense structural components of semi-arid rangelands using the NDVI on fine resolution imagery. In a review of several image enhancement techniques including NDVI and various darkening indices, Moleele *et al.* (2001) found that whilst the NDVI could successfully separate the browse layer, it failed to distinguish the woody and grass components. Similar results have been found with other image enhancement techniques in semi-arid rangelands. Dougill and Trodd (1998) assessed the ability of a canopy model based on the vegetation darkening approach to determine structural components of vegetation communities. In spite of successfully distinguishing differences in the reflectance of soil, plant litter and grass canopies, they were unable to separate the woody component, due to the limited dimensionality of the reflectance data (Trodd and Dougill, 1998).

In contrast to the temporal trajectory or image enhancement approach described above, the bi-temporal land cover change approach often uses hard classification techniques to classify and monitor changes to spectrally separable land cover types (Foody, 2001). As the bi-temporal approach utilises classification techniques trained using spectral signatures from within individual images, it is advocated as being less sensitive to radiometric disturbances (Bruzzone *et al.*, 2004). In drylands, the post-classification method of change detection has been criticised for being insensitive to human induced land cover changes, which typically manifest in subtle land-cover modifications, rather than obvious changes of overall classification (Diouf and Lambin, 2001; Foody, 2001). In spite of this, several studies comparing the performance of both image enhancement and

classification based change detection techniques in drylands, found the post-classification method to produce higher levels of accuracy (Mas, 1999; Rogan *et al.*, 2002). Furthermore, provided sites of known class membership change are available, the technique can also present the advantage of indicating the nature and magnitude of observed changes (Foody, 2001; Mas, 1999). However, the accuracy of post-classification change detections is largely dependent on the accuracy of individual land cover maps, with studies often producing overall accuracies similar to the product of multiplying the accuracies of each individual classification (Rogan *et al.*, 2002).

Change detection techniques based on land cover classifications are further limited by several assumptions (Mather, 1999). One limitation is that changes can only be detected between cover classes whose spectral signatures are statistically separable, and in some cases spectral confusion has caused problems for workers attempting to classify natural savanna areas (e.g. Mas, 1999). However, work in the semi-arid savannas of northern Botswana and Zamibia has demonstrated the spectral separability of ecologically significant land cover units using a variety of classification techniques (Ringrose *et al.*, 1997; Yang and Prince, 2000; Ringrose *et al.*, 2003). A further limitation is the difficulty in obtaining reliable ground truth or training data in order to classify historical images (Lu *et al.*, 2004). There are several ways to address this problem with studies using auxiliary data such as aerial photography, vegetation maps or hybrid classification techniques to inform the classification of historical image data (e.g. Tommervik *et al.*, 2003).

In general, of the two different approaches used in the multitemporal remote sensing of land cover changes in drylands, techniques based on image enhancement hold most

potential for studies attempting to monitor structural changes such as bush encroachment. However, at present there are several limitations concerned with the image enhancement based approach, such as susceptibility to minor radiometric disturbances, and limited reflectance dimensionality of the most temporally archived datasets. In contrast, the bi-temporal post-classification change detection approach is less susceptible to radiometric disturbances, and although there are several limitations, these techniques have been successfully used to map ecologically significant land cover units in southern Africa. In spite of these limitations, multitemporal remote sensing remains a powerful tool for monitoring and assessing vegetation change in dryland environments. Studies attempting to monitor vegetation change in drylands using multitemporal remote sensing must consider these limitations in detail, and devise innovative multidisciplinary research frameworks which can combine data from a variety of different sources, in order to investigate fully the impact of human management.

Table 9.1. The advantages and disadvantages of most widely used vegetation change detection techniques applied to remote sensing monitoring of dryland vegetation change.

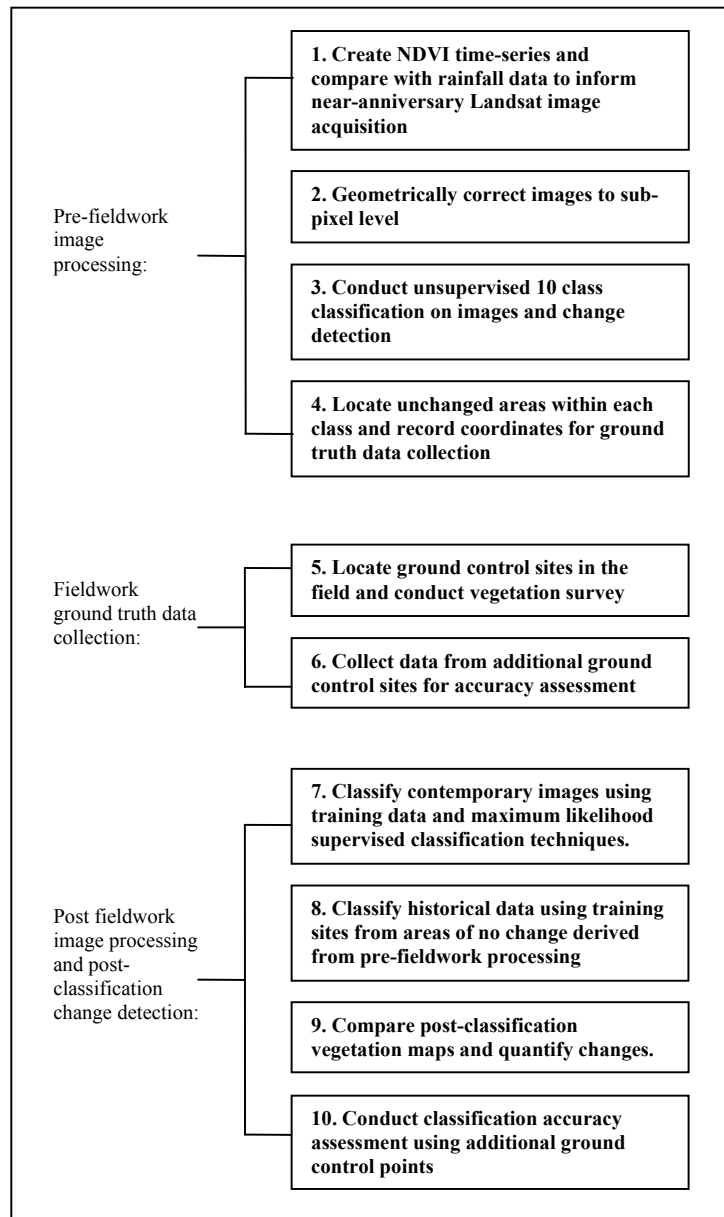
Bi-temporal comparison approach using post classification change detection	
Advantages	Disadvantages
• Less susceptible to subtle radiometric disturbances • no need for radiometric corrections (Song <i>et al.</i>, 2001; Bruzzone <i>et al.</i>, 2004) • Less affected by changes in veg. phenology when compared to some enhancement techniques (Mas, 1999) • Able to determine the nature and magnitude of change if known areas of class change are available (Foody, 2001; Mas, 1999)	• Fails to account for subtle changes in land cover classes or land cover modifications (Rogan <i>et al.</i>, 2002; Diouf and Lambin, 2001) • Image acquisition important and near-anniversary imagery often difficult to acquire in some regions (Mas, 1999) • Only able to map spectrally separable ecological units • requires historical ground truth data to classify images (Lu <i>et al.</i>, 2004; Mas, 1999)
Temporal trajectory approach using subtle image enhancement techniques	
Advantages	Disadvantages
• Able to monitor seasonal changes in vegetation growth avoiding vegetation phenology problem (Coppin <i>et al.</i>, 2004) • Potential to monitor dynamics of non-equilibrium dryland vegetation and improve understanding of ecological functioning (Dougill and Trodd 1998)	• More susceptible to errors resulting from radiometric changes (Leprieur <i>et al.</i>, 2000; Xiao <i>et al.</i>, 2003) • Course spatial resolution of imagery used to monitor seasonal changes in vegetation fails to match heterogeneity of dryland ecosystems (Coppin <i>et al.</i> 2004; Dougill and Trodd 1998)

9.3 The modified post-classification change detection approach

In recognition of the limitations discussed in the previous section, a post-classification change detection approach using bi-temporal comparisons of multitemporal Landsat imagery was used as the basis for monitoring veterinary fence vegetation changes in northern Botswana. However, image enhancement techniques and unsupervised classifications were also used in an attempt to address several of the methodological

limitations of the post-classification change detection approach. The overall land-cover change assessment can therefore be considered as a post-classification change detection using hybrid classification techniques. A similar approach has been applied by Tommervik *et al.* (2003) and Rees *et al.* (2003) to the arctic tundra and mountain heaths of Norway and Russia, an environment with a similarly highly variable growth season. Figure 9.1 below details three main stages involved in the assessment.

Figure 9.1. Outline of the remote sensing methodology used to assess vegetation changes in the two study areas.



9.4 Pre-fieldwork image processing

9.4.1 Informing the acquisition of near-anniversary data

Regardless of the approach used, change detection for ecosystem monitoring assumes overall phenological conditions between imagery dates or growing seasons to be comparable, and therefore the appropriate selection of imagery acquisition dates is crucial in bi-temporal change detection studies (Coppin *et al.*, 2004). The first stage of this assessment involved pre-fieldwork image processing using image enhancement techniques and coarse resolution data in an attempt to address this issue. Therefore, to inform the acquisition of near-anniversary Landsat imagery, an NDVI time-series extending from July 1981 to December 2003 from the Global Inventory Modelling and Mapping Studies (GIMMS) AVHRR NDVI 10-day composite data set was compared with rainfall data recorded at two rain gauges in the study region (Table 9.2). The NDVI dataset was obtained from the University of Maryland Global Land Cover Facility and has been corrected at source to minimise a number of possible radiometric disturbances, such as those caused by volcanic aerosols and differing solar zenith angles (Tucker *et al.*, 2005). Once downloaded, the georeferenced AVHRR dataset was subset to the northern Botswana study area using ERDAS imagine version 8.6. The resulting data were then layer-stacked to create the 22.5 year time series of NDVI values. Using a Landsat ETM+ image from 10th April 2000 as a guide (path 175 row 73, accurately georeferenced at the GLCF), the subset AVHRR image was overlaid and an 8km pixel in the closest well vegetated region from the rain gauge was selected for NDVI profile extraction. The extracted dataset from 1981-2001 was then plotted against rainfall values in order to

evaluate the relationship between NDVI, rainfall and vegetation phenology in the study region. This analysis provided the clear understanding of seasonal vegetation productivity required to guide the process of acquiring fine resolution imagery for further more in-depth change detection analysis. The following sub-sections present the results of this analysis before detailing the fine resolution near-anniversary Landsat imagery acquired and describing the main post-classification change detection methodology used.

Table 9.2. The location of rainfall stations used in northern Botswana and length of available datasets.

Met station	Longitude	Latitude	Years of record
Shakawe met station	S18°23	E21°51	Sep 1979-Aug 2005
Seronga police station	S18°49	E22°24	Sep 1980-Aug 2003

Rainfall in northern Botswana

At the regional scale Botswana lies in the southern African summer rainfall zone where the position of the inter-tropical convergence zone close to the region in the summer months draws in moisture laden air masses enhancing atmospheric instability, causing inter-annual variability of rainfall to be 20 per cent higher than the coastal winter rainfall zones (Tyson, 1986). Sub-regionally both the northern buffalo fence (NBF) and contagious bovine pleuropneumonia (CBPP) fences included in this study lie at the moister end of the Kalahari's aridity gradient in northern Botswana (Scholes *et al.*, 2004). The average annual rainfall of northern Botswana ranges from 400mm in the south to 650mm in the northeast. Rainfall data over the period of analysis from the Shakawe and Seronga meteorological stations (Figure 9.2 and 9.3) show that the long term averages are in the order of 471 mm and 414 mm respectively. However, both stations have recorded

much inter-annual variability in precipitation received. For example, the Shakawe rain gauge recorded as little as 260mm in the 1997-1998 wet season, whereas 780mm were recorded in the 1999-2000 wet season.

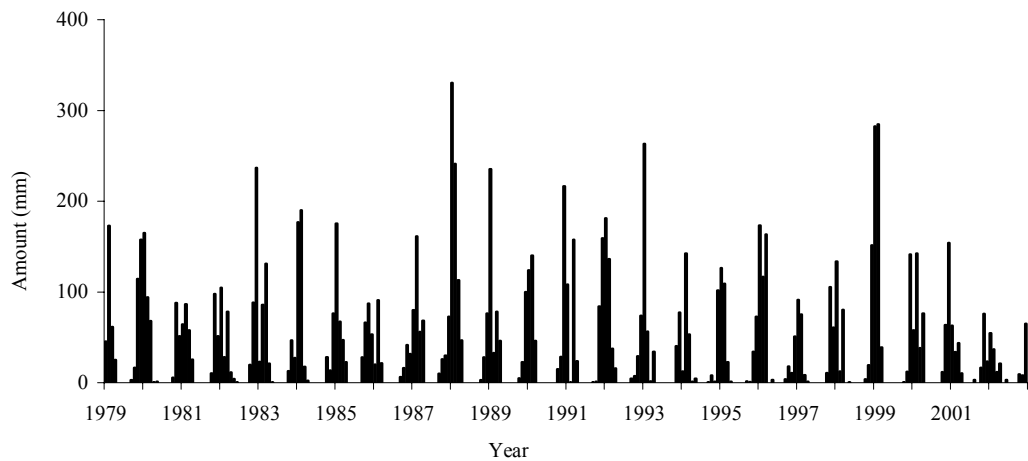


Figure 9.2. Monthly precipitation from Shakawe for the period 1979 – 2003. Source: Appendix 6.

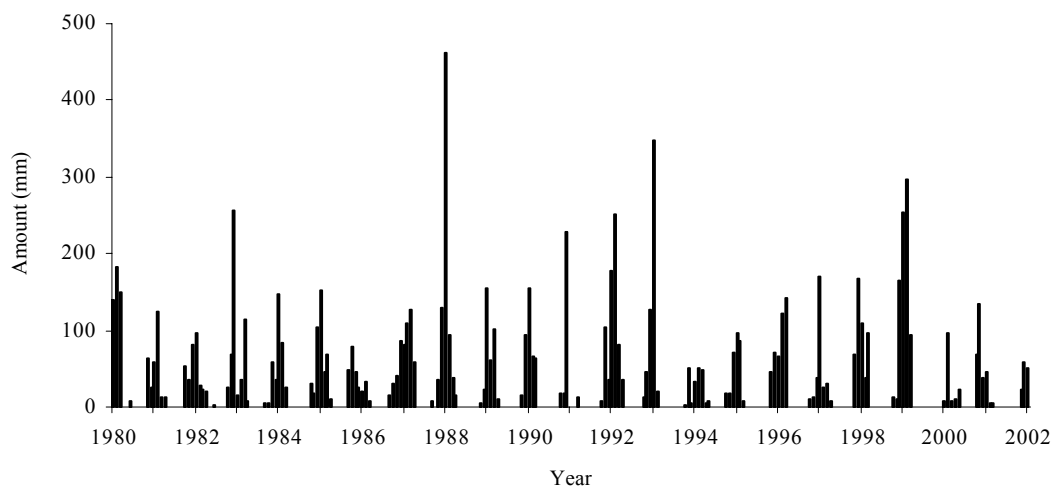


Figure 9.3. Monthly precipitation from Seronga police station for the period 1980 – 2002. Source: Appendix 6.

Figure 9.4 presents the mean monthly rainfall data for the two rain gauges over the period of analysis. Seasonally, 70 per cent of the annual rainfall tends to fall in the months of December, January and February, and the first significant rainfall of the annual cycle (>20mm) tends to occur in either September or October with the last of the rains occurring in April and May. The dry season months of June through to August experience little rainfall. The average monthly rainfall receipts from the two rain gauges illustrates that the mean rainfall in both study sites is highly correlated. However, average rainfall data mask the high levels intra-annual variability in the magnitude and timing of rainfall receipts in the region. Table 9.3 presents the mean, maximum and minimum monthly rainfall receipts over the period of analysis. The maximum and minimum data demonstrates the huge levels of intra-annual variability with some seasons experiencing the late arrival of rain from December onwards.

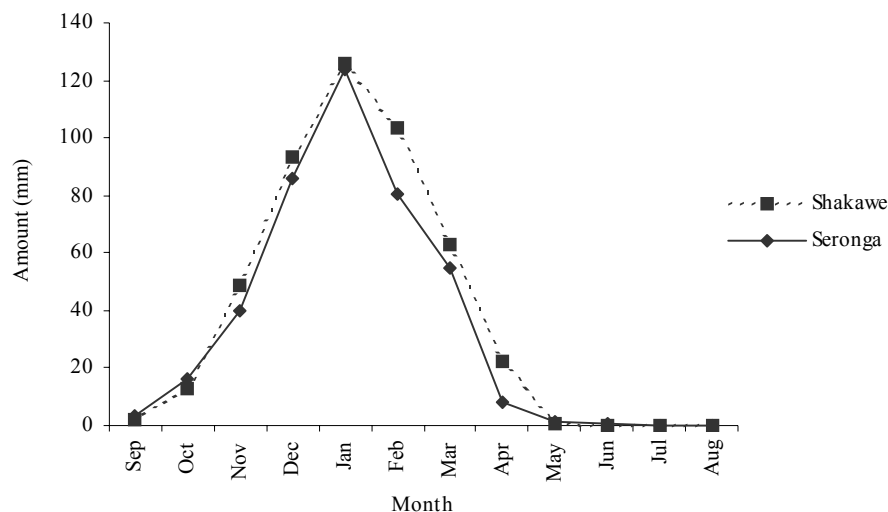


Figure 9.4. Mean monthly precipitation from 1980/1981 wet season to 2002/2003 wet season in both Shakawe and Seronga. Source: Appendix 6.

Table 9.3. Rainfall data from Shakawe and Seronga detailing the mean, maximum and minimum rainfall receipts for each month. (Data from 1980-2003 used in the analysis). Source: Appendix 6.

		Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Shakawe	Max	0.0	3.2	27.8	66.1	114.3	236.7	330.3	284.9	163.2	76.1	4.6	3.0
	Min	0.0	0.0	0.0	0.0	1.0	23.2	12.4	0.3	1.3	0.0	0.0	0.0
	Ave	0.0	0.1	2.5	13.0	50.4	96.3	132.4	102.8	59.5	18.5	0.6	0.1
Seronga	Max	0.0	0.0	49.0	78.0	135.0	256.3	462.0	296.5	150.9	59.0	23.0	7.0
	Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Ave	0.0	0.0	3.3	16.2	39.9	85.9	123.6	80.8	54.6	8.2	1.3	0.4

Vegetation phenology and NDVI in northern Botswana

The NDVI time series data extracted from both study areas was used to investigate the vegetation phenologic cycle in order to inform the process of fine resolution Landsat data acquisition. In semi-arid environments multitemporal satellite sensor data such as NDVI values derived from AVHRR observations, have been found to be strongly correlated with rainfall and are therefore useful for monitoring plant phenology (Schmidt and Karnieli, 2002). Previous studies focussed on the relationship between NDVI and rainfall in Africa have shown strong correlations in regions between 200mm to 1000mm with the best relationship occurring between NDVI and a 3-month average of rainfall in the concurrent and two previous months (Davenport and Nicholson, 1993).

Analysis of mean monthly NDVI data from the 22.5 year time-series confirmed the strong relationship between rainfall and vegetation biomass in the region. In an average NDVI cycle, biomass levels initially increase soon after the first significant rains in November or December (Figure 9.5). Biomass levels then generally increase until they reach a peak in February to March, at which point the NDVI values decrease sharply until reaching a minimum level at the end of the dry season in September and October.

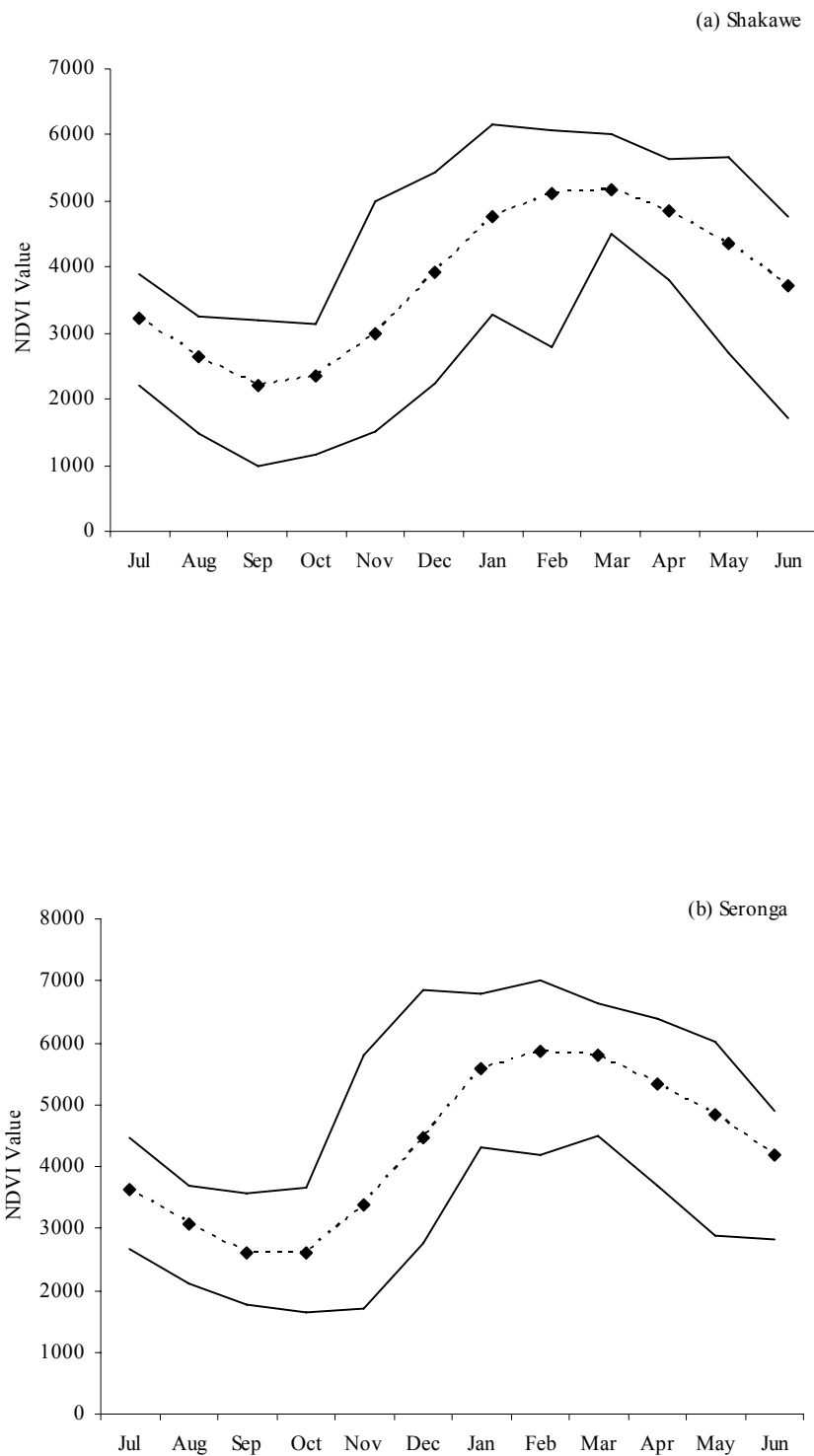


Figure 9.5. Mean, minimum and maximum monthly averaged NDVI values from both, (a) Shakawe, and (b) Seronga study sites, 1981-2003.

Vegetation communities from both study sites responded similarly to rainfall in both wet and dry years (Figure 9.6). However, the delta communities from the Seronga area tend to reach higher NDVI values and retain green biomass for slightly longer periods, perhaps due to the greater efficacy of the calcareous delta soils to retain moisture. This supports the findings of previous studies in Botswana which suggest that vegetation rain-use efficiency is more closely governed by soil type than community composition (Nicholson and Farrar, 1994).

Table 9.4. Characteristics of rainfall and NDVI seasonal data from 1981-2003.

Shakawe Met Station					Seronga Police Station				
Wet Season	First rains >20mm	Initial increase in NDVI	Peak in rainfall	Peak in NDVI	Wet Season	First rains >20mm	Initial increase in NDVI	Peak in rainfall	Peak in NDVI
1981-1982	Nov	Dec	Nov-Feb	Feb/Mar	1981-1982	Nov	Nov	Feb	Mar
1982-1983	Nov	Dec	Nov-Jan	Feb	1982-1983	Oct	Oct	Jan	Jan-May
1983-1984	Oct	Nov	Dec	Jan	1983-1984	Oct	Dec	Dec	Jan-Apr
1984-1985	Nov	Nov	Feb	Dec-Apr	1984-1985	Nov	Nov	Jan	Dec-Mar
1985-1986	Oct	Jan	Jan	Mar-Apr	1985-1986	Oct	Dec	Jan	Jan
1986-1987	Sep	Oct	Nov-Feb	Nov-Mar	1986-1987	Sep	Oct	Sep-Nov	Nov-Mar
1987-1988	Nov	Dec	Feb	Feb/Mar	1987-1988	Oct	Dec	Mar	Feb
1988-1989	Oct	Dec	Jan	Feb	1988-1989	Nov	Nov	Jan	Feb
1989-1990	Nov	Feb	Jan	Feb-Apr	1989-1990	Dec	Jan	Jan	Feb/Apr
1990-1991	Nov	Nov	Feb	Feb	1990-1991	Dec	Dec	Jan	Mar/Apr
1991-1992	Nov	Nov	Dec	Jan	1991-1992	Dec	Nov	Dec	Jan
1992-1993	Nov	Nov	Jan	Feb/Mar	1992-1993	Nov	Nov	Feb	Mar
1993-1994	Nov	Nov	Jan	Feb/Mar	1993-1994	Nov	Nov	Jan	Feb
1994-1995	Nov	Dec	Feb	Mar-Apr	1994-1995	Nov	Dec	Nov-Feb	Feb/Apr
1995-1996	Dec	Jan	Jan	Feb/Mar	1995-1996	Dec	Dec	Jan	Jan/Mar
1996-1997	Nov	Dec	Jan	Jan/Apr	1996-1997	Nov	Dec	Mar	Feb/Mar
1997-1998	Dec	Jan	Jan	Feb/Mar	1997-1998	Dec	Jan	Jan	Feb
1998-1999	Nov	Nov	Nov-Jan	Jan	1998-1999	Nov	Dec	Dec	Jan
1999-2000	Dec	Dec	Feb	Jan-Apr	1999-2000	Dec	Dec	Feb	Jan/Apr
2000-2001	Dec	Jan	Dec-Feb	Mar-May	2000-2001	Feb	Nov	Feb	Mar
2001-2002	Nov	Nov	Dec	Dec-Apr	2001-2002	Oct	Nov	Nov	Dec
2002-2003	Nov	Dec	Nov-Jan	Feb/Mar	2002-2003	Nov	Dec	Dec	Feb

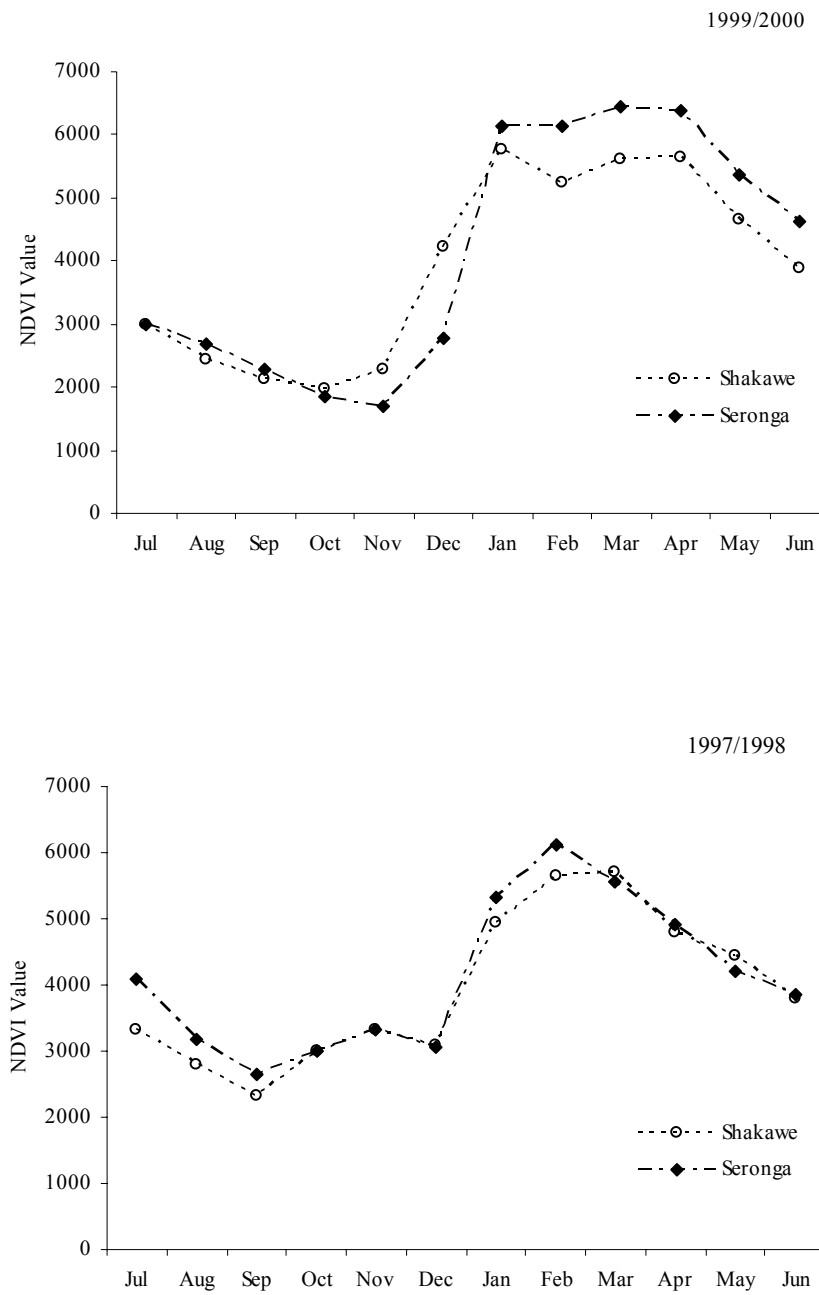


Figure 9.6. Seasonal NDVI variability in wet (1999-2000, 780mm, Shakawe) and dry years (1997-1998, 260mm, Shakawe) in both study sites.

The strong relationship between rainfall and primary productivity was also confirmed by the inter-annual characteristics of NDVI responses over the 22.5 year period investigated. In over 80 per cent of wet seasons, vegetation greening response occurred within 20 days of the first significant rainfall receipt in excess of 20mm (Table 9.4). In addition to this, there was a lag period of between one to two months between the peak rainfall received, and the peak seasonal greening response (Table 9.4). This delayed greening response was confirmed by detailed analysis of NDVI profiles, against rainfall in both wet and dry years (Figure 9.7).

Further analysis of the variability in NDVI response to rainfall revealed a longer term trend over the 22.5 year time scale (Figure 9.8). NDVI seasonal responses from 1980-1989 were distinctly bi-modal or tri-modal, with more than one peak in NDVI values. In contrast, NDVI responses after 1990 are more uni-modal, often with only one peak in NDVI. The cause of this long term trend is a period of below average annual precipitation during the 1980s, characterised by bi-modal rainfall seasons. Annual precipitation during the 1990s has been distinctly unimodal, often peaking in the months of January and February, a shift which was frequently cited by local informants. As this assessment is concerned with environmental changes that have occurred after the construction of fences erected in the 1990s, the affect of this longer term trend on vegetation phenology is not a concern.

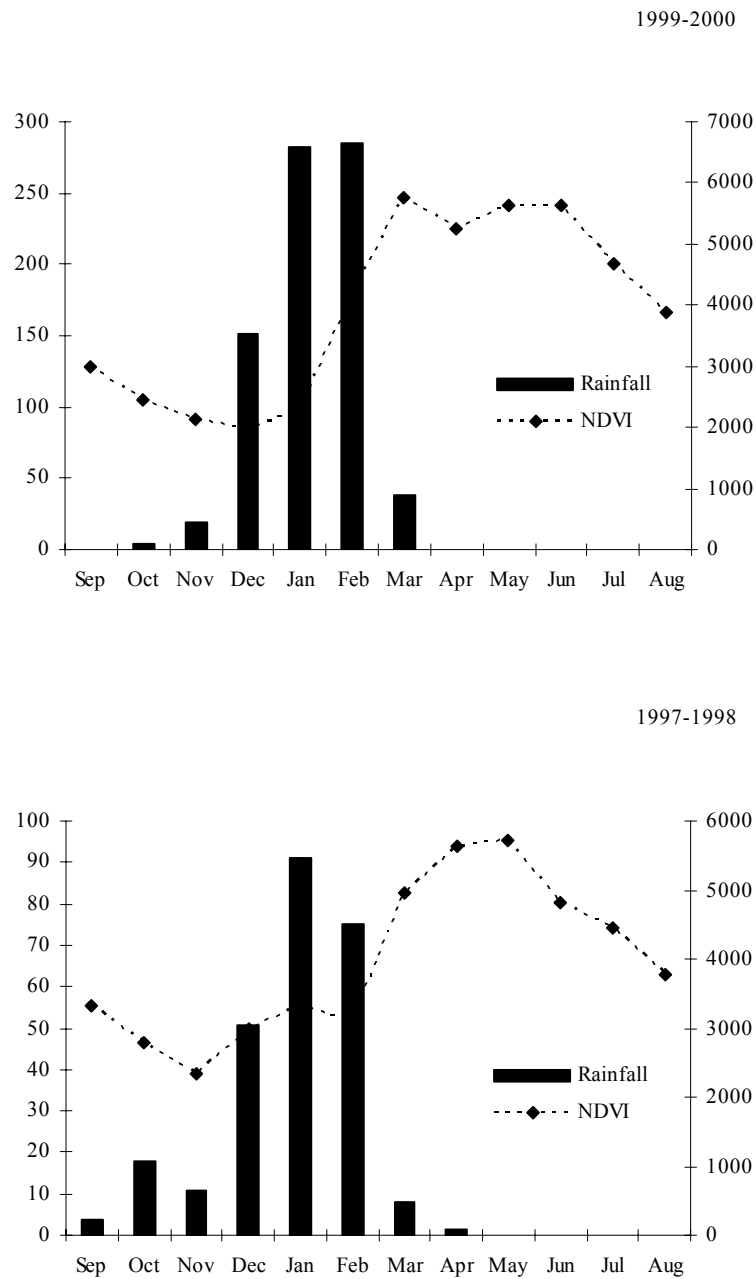


Figure 9.7. Rainfall and NDVI relationship during the 1999-2000 and 1997-1998 wet seasons using data from Shakawe only.

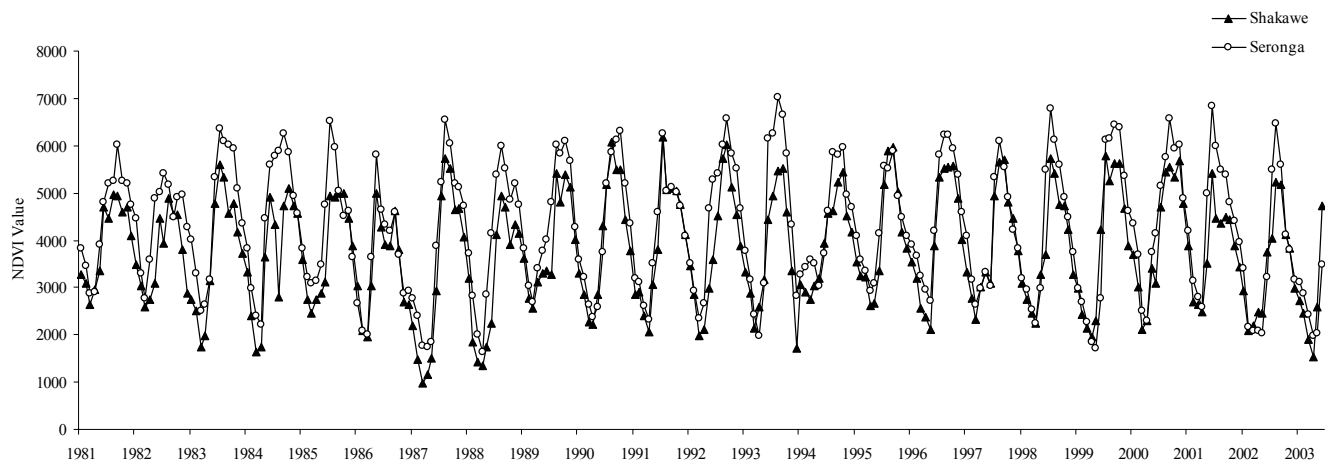


Figure 9.8. Mean monthly NDVI time series from 1981-2003 using data extracted from Shakawe and Seronga.

Near-anniversary data acquisition.

The results described above were used to inform the selection of near-anniversary fine resolution Landsat data for more detailed analysis of environmental change in the region. A total of 4 cloud free Landsat TM images were acquired from either the Global Land Cover Facility (GLCF), Earth Science Data Interface at the University of Maryland in the United States, or from the Council for Scientific and Industrial Research (CSIR) in South Africa (Table 9.5). In semi-arid regions, previous studies evaluating the influence of seasonality on the accuracy of land cover classifications, suggest that vegetation cover units are more spectrally separable during the peak of the growth season before the onset of senescence in some species (Langley *et al.* 2001). The dates of the near-anniversary images were therefore selected to coincide with the peak of the growth season in March

or April, and cover the period of pre-fence construction to present in the study areas. In addition to this, the most recent imagery acquired for the end of the 2004-2005 wet season was timed to coincide with the collection of ground truth data during the fieldwork period. Unfortunately, cloud free data covering the CBPP site were unavailable for March or April 2005 and therefore a scene from the 25th May 2005 was used.

Table 9.5. Dates of end of wet season Landsat TM data acquisitions for both study areas.

Platform/Sensor	Path/Row	Date	Site	Source
Landsat TM	175/73	9-Mar-91	NBF	GLCF
Landsat TM	175/73	16-Apr-05	NBF	CSIR
Landsat TM	176/73	1-Apr-91	CBPP	GLCF
Landsat TM	176/73	25-May-05	CBPP	CSIR

9.4.2 Geometric correction

In change detection studies it is essential that temporal sequences of images are geometrically corrected to the sub-pixel level, to avoid spurious results when detecting changes in reflectance (Phinn and Rowland, 2001). The accepted magnitude of root mean square (RMS) error differs considerably depending on the aim of the change detection methodology. Townsend *et al.* (1992), found that for sparsely vegetated areas such as drylands, a RMS error of 0.5 to 1 pixel is acceptable (Townsend *et al.* 1992). There is also little consensus on the acceptable amount of ground control points (GCPs) needed to run the geometric correction model. However, Mather (1999) suggests 10-15 GCPs are acceptable for Landsat TM images, although over 30 evenly dispersed over the scene is statistically best. Therefore, the full Landsat TM scenes were geometrically corrected to

the sub pixel level using the 1991 scenes obtained from the University of Maryland archive (geometrically corrected and projected on the UTM 1984 grid at source) as a reference image. 30+ GCPs evenly dispersed throughout the scenes were used to run the geocorrection model. Table 9.6 below presents the RMS errors gained, with an acceptable total mean RMS error of 15.91 meters on the ground.

Table 9.6. RMS errors for both study areas after geometric correction of Landsat TM images.

Year	Site	Wet
2005	1	14.62
2005	2	17.36
Total Mean		
Root Square		15.91
Error		

9.4.3 Radiometric correction

When and how to conduct radiometric correction prior to image classification and change detection remains one of the most common questions in multitemporal remote sensing (Song *et al.* 2001). Although Landsat TM band widths are designed to make full use of the various wavelengths less affected by radiometric disturbances (atmospheric windows), atmospheric scattering and variable illumination geometry can cause considerable fluctuations in at-sensor radiances (Mather, 1999). However, radiometric correction procedures are unnecessary for studies utilising the post-classification change detection approach, where multiple images are classified individually, and the resulting maps are compared to identify changes (Song *et al.* 2001; Foody *et al.* 1996). As a result, radiometric correction was therefore not conducted on the Landsat TM scenes.

9.4.4 Guiding the collection of ground truth data

A major difficulty for studies utilising the post-classification comparison method is the selection of sufficiently numerous ground training sites, especially for historical image data classification (Lu *et al.* 2004). Several studies have attempted to circumvent this issue using data such as vegetation maps and aerial photos taken around the period of the historical satellite data (see for example, Tommervik *et al.* 2003). However, there were no vegetation maps available in order to classify the pre-fence satellite images, and the aerial photograph archive proved to be incomplete. An alternative approach was therefore required in order to address this issue.

After georegistering the Landsat TM images, the full scenes were subset to their respective study areas using the area of interest (AOI) tool in ERDAS Imagine 8.6. Following this, a 10 class unsupervised classification was conducted on both the 1991 and 2005 subset scenes, using the iterative ISODATA algorithm to a 95 per cent convergence threshold. The resulting land cover maps were then subject to spatial coincidence analysis using the change matrix function in ERDAS. Through this process it was possible to locate unchanged pixels classified as the same land cover class in both the pre-fence and most recent Landsat TM images. The coordinates for these unchanged sites were then noted in order to guide the collection of some of the ground truth data in the field (Figure 9.9).

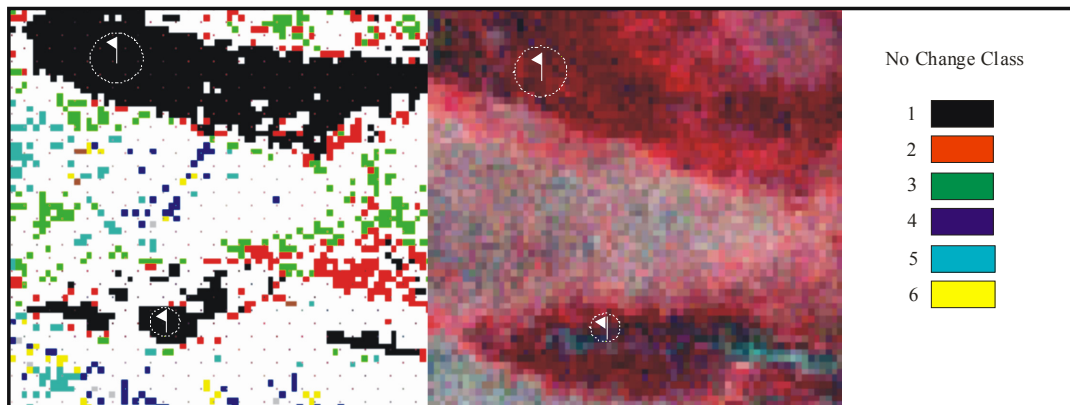


Figure 9.9. Technique used to gather training data from unchanged sites to classify pre-fence Landsat TM image (right) using a change matrix image (left) derived from pre-fieldwork image processing. White dashed circles and tags show the unchanged areas of interest used to gather coordinates for class 1 interdune woodland at the CBPP site.

9.5 Fieldwork ground truth data collection

Although the sample size of ground training sites for supervised classification procedures should increase with the variability of class statistics, a sample of 30 sites per cover class is usually held to be sufficient (Mather, 1999). Furthermore, whilst a random sampling strategy is advantageous in order to gain a represent sample of vegetation cover types, this is often logistically difficult and costly (Foody, 2002). The location of field sites for the collection of ground truth data was therefore guided by a print of the land cover map resulting from the unsupervised classification detailed above. This facilitated targeted field sampling, where ground training sites were dispersed evenly throughout the different classes, determined on the basis of their spectral characteristics, thus establishing the direct association between vegetative cover and multi-spectral reflectance. The fieldwork stage of the assessment was conducted in May 2005, in order

to coincide with the end of the vegetation growth season, thereby facilitating the identification of all taxa. Whilst a total of 30 sites per cover type would have been ideal, in reality this proved difficult to achieve in the time available. Therefore, a total of 20 sites per cover class were used as field training sites, with a further 10 sites per class recorded in order to conduct an accuracy assessment. At least 10 sites per class were located in areas where no changes have taken place, using the coordinates noted as a result of the processing described above. The location of each field training site was recorded using a Garmin Etrex Global Positioning System accurate to $\pm 15\text{m}$. At each fieldsite, the percentage cover of all shrub and grass species was recorded using a 30m line intercept transect subjectively orientated in order to provide a representative sample, following a brief visual assessment. Tree density was also recorded within a 30m x 30m quadrat, also subjectively located to represent average conditions. All species were identified to the species level following reference to a variety of background sources (van Oudtshoorn, 1999; Palgrave, 1981). To save time, at one-third of the sites only the UTM coordinates, a digital photo and brief description of the cover type were recorded.

9.6 Post-fieldwork image processing

Following the collection of ground truth data during the fieldwork stage, a maximum likelihood supervised classification was used as the main classification technique to classify both recent and historical data. Before conducting the supervised classification, the training site data were organised into cover types using the following criteria as a guide: (i) woodland- tree density over 10, (ii) savanna- tree density between 3 and 10 with shrub cover $>10\%$, (iii) scrubland- tree density of <3 and shrub cover $>10\%$, (iv)

grassland- tree density <3 and shrub cover <10%. A similar classification of vegetation units was used by Scholes *et al.* (2002) in their study of savanna structure changes along the Kalahari's aridity gradient.

Through this process it was possible to categorise the data from the CBPP site into the following six classes based on firstly their cover characteristics (i.e. woodland, scrubland or savanna), then location (i.e. dune ridge, interdune valley or open plains) and finally their predominant species (Table 9.7). This resulted in the following cover types: (i) interdune woodland with *Acacia sp.* and *Combretum sp.*; (ii) open plains woodland with *B. africana*, *B. plurijuga*, *C. molle*; (iii) open savanna with *B. africana*; (iv) open savanna *Combretum sp.*; (v) dune ridge scrubland *B. massaiensis*; (vi) open plains scrubland *B. massaiensis*. The ground truth data from the NBF site proved more difficult to classify into cover types using the woodland, savanna, scrubland and grassland criteria as a guide (Table 9.8). For the NBF site the distinctions between woodland and savanna, and savanna and scrubland classes were less clear, both spectrally and in terms of vegetative cover. The initial unsupervised classification used to guide the training site selection led to many areas of similar species, yet differing percentage cover and maturity. For example, *Colophospermum mopane* could be found growing in patches which varied in height and density from savanna to scrubland, yet were classified as the same cover class in the unsupervised classification. As a result the training data were organised into the following six cover types: (i) woodland/savanna with *D.cinerea*/*B.plurijuga*; (ii) savanna *B.africana*; (iii) scrubland/savanna *T.sericea*; (iv) scrubland *B.massaiensis*/*L.nelsii*; (v) scrubland/savanna *C.mopane*; (vi) grassland *Aristida sp.*/*Eragrostis sp.*

Table 9.7. Summary of dominant species and cover characteristics of the six cover classes identified at the CBPP study site.

Class		Total tree density	Total % shrub cover	Total % grass cover	Main tree species	Main shrub species	Main grass species	Total % bare ground
1. Interdune woodland	Max	67	71	35	-	-	-	64
	Min	11	18	11	-	-	-	5
<i>Acacia sp./</i>								
<i>Combretum sp.</i>	Ave	26.6	38.3	24	<i>A. eriolobia</i>	<i>G. flava</i>	<i>Eragrostis sp.</i>	38
2. Open plains woodland	Max	18	21	64	-	-	-	55
	Min	10	7	10	-	-	-	30
<i>B.africana/</i>								
<i>C.molle</i>	Ave	13.2	21.2	33.2	<i>B. africana</i>	<i>G. flava/</i> <i>B.africana</i>	<i>Aristida sp.</i>	45.6
	Max	9	36	40	-	-	-	61
3. Open savanna	Min	3	11	17	-	-	-	38
<i>B.africana</i>					<i>B. africana/B.</i> <i>plurijuga</i>	<i>B. massaiensis</i>	<i>Eragrostis sp.</i>	50.1
	Ave	7	23.9	26.1	-	-	-	50.0
	Max	9	50	31	-	-	-	37.0
	Min	5	21	12	-	-	-	
4. Open savanna					<i>C. molle/C.</i> <i>aplicuatum</i>	<i>B. massaiensis</i>	<i>Aristida sp.</i>	43.4
<i>Combretum sp.</i>	Ave	6.8	31.4	25.2	-	-	-	62.0
5. Dune ridge scrubland	Max	1	75	44	-	-	-	10.0
<i>B. massaiensis</i>	Min	0	25	13	-	-	-	36.1
	Ave	0	39.7	24.2	-	<i>B. massaiensis</i>	<i>Eragrostis sp.</i>	54.0
6. Open plains scrubland	Max	0	56	36	-	-	-	18.0
	Min	0	32	16	-	-	-	
<i>B.massaiensis</i>	Ave	0	44	26	-	<i>B. massaiensis</i>	<i>Eragrostis sp.</i>	30.0

Table 9.8. Summary of dominant species and cover characteristics of the six cover classes identified at the NBF study site.

Class		Total tree density	Total % shrub cover	Total % grass cover	Main tree species	Main shrub species	Main grass species	Total % bare ground
1. Woodland/savanna <i>D.cinerea/B.plurijuga</i>	Max	35.0	70.0	22.0	-	-	-	83.0
	Min	6.0	14.0	3.0	-	-	-	8.0
	Ave	14.5	36.4	10.8	<i>D.cinerea/ B.plurijuga</i>	<i>D.cinerea/ B.massaiensis</i>	<i>Eragrostis sp.</i>	52.8
	Max	39.0	48.0	16.0	-	-	-	90.0
	Min	5.0	8.0	2.0	-	-	-	36.0
2. Savanna <i>B.africana</i>	Ave	11.9	26.2	10.3	<i>B.africana</i>	<i>T.sericea/ B.massaiensis</i>	<i>D.erianthia/ Eragrostis sp./Aristida sp.</i>	63.5
	Max	8.0	68.0	15.0	-	-	-	91.0
3. Scrubland/Savanna <i>T.sericea</i>	Min	1.0	6.0	3.0	-	-	-	17.0
	Ave	4.1	34.3	11.3	<i>T. sericea</i>	<i>T.sericea</i>	<i>D.erianthia</i>	54.3
	Max	4.0	67.0	23.0	-	-	-	76.0
	Min	0.0	21.0	3.0	-	-	-	10.0
4. Scrubland <i>B.massaiensis/L.nelsii</i>	Ave	2.0	40.5	10.1	<i>T. sericea</i>	<i>B.massaiensis</i>	<i>D.erianthia/ Eragrostis sp./ Aristida sp.</i>	49.4
	Max	7.0	66.0	30.0	-	-	-	88.0
5. Scrubland/savanna <i>C.mopane</i>	Min	0.0	11.0	1.0	-	-	-	4.0
	Ave	2.6	38.5	13.2	<i>C. mopane</i>	<i>C. mopane</i>	<i>Aristida sp.</i>	48.4
	Max	0.0	0.0	45.0	-	-	-	59.0
	Min	0.0	0.0	41.0	-	-	-	55.0
6. Grassland <i>Aristida sp./Eragrostis sp.</i>	Ave	0.0	0.0	33.3	-	-	<i>Eragrostis sp./ Aristida sp.</i>	66.7

9.6.1 Classifying the contemporary images

In the next stage of the image processing, the training site data were organised into these six classes, and used to train the maximum likelihood classification of the 2005 Landsat TM images from both sites. At least 20 sites per cover class were used as classification training plots, with a 3x3 pixel array surrounding each site used to gather the training statistics. A further 10 sites per class were used for the accuracy assessment. The resultant training signatures were then evaluated for separability before conducting the classification. Previous assessments of Landsat TM band correlation found the least correlated band to be TM6. Therefore, figure 9.10 and 9.11 on the following pages show scatterplots of the 2005 TM band 5 and band 6 for the different vegetation types at 20 sites in the respective study areas. Figure 9.10 shows that on the whole most of the six cover classes from the CBPP site are clearly separable in the spectral space. However, spectral measurements from open savanna with *C. molle*/*A. eriolobia*/*B. africana* and open savanna with *B.africana* displayed considerable overlap. This similarity was confirmed by transformed divergence analysis which produced a value of 1.40 between the two cover types. Transform divergence is a quantitative measure of the separability between cover classes and values above 1.6 or 80 per cent are considered spectrally separable for supervised classifications (Mather, 1999). For this reason, the two classes were merged into one cover type named mixed open savanna with *B.africana* and *Combretum sp.*.

Cover types in the NBF study site were not as spectrally separable as those from the CBPP site. Figure 9.11 shows the scatterplot of the 2005 TM band 5 and band 6 spectral measurements for the six different vegetation classes identified in the NBF study area.

The scatterplot illustrates the considerable spectral similarity between *T. sericea* and *B. massaiensis*/*L. nelsii* scrubland and between *B. africana* savanna and the scrubland classes. Transform divergence confirmed this similarity with values of 0.94 between *T. sericea* scrubland and *B. massaiensis*/*L. nelsii* scrubland, and 1.15 between *B. africana* savanna and *T. sericea* scrubland. As these classes were below the threshold that enables adequate separation, they were merged into one class named mixed savanna/scrubland.

After evaluating the separability of training signatures from both sites and merging a number of classes, the remaining signatures were used for maximum likelihood classification of the 2005 TM imagery. In all, five classes were classified from the CBPP site: interdune woodland with *Acacia sp.* and *Combretum sp.*, open plains woodland with *B. africana*, *B. plurijuga*, *C. molle*, mixed open savanna with *B. africana* and *Combretum sp.*, dune ridge scrubland *B. massaiensis* and open plains scrubland *B. massaiensis*. A further four classes were classified from the NBF site: woodland/savanna with *D. cinerea*/*B. plurijuga*, mixed scrubland/savanna with *B. africana*/*T. sericea*/*B. massaiensis*/*L. nelsii*, scrubland/savanna *C. mopane*, grassland *Aristida sp.*/*Eragrostis sp.*

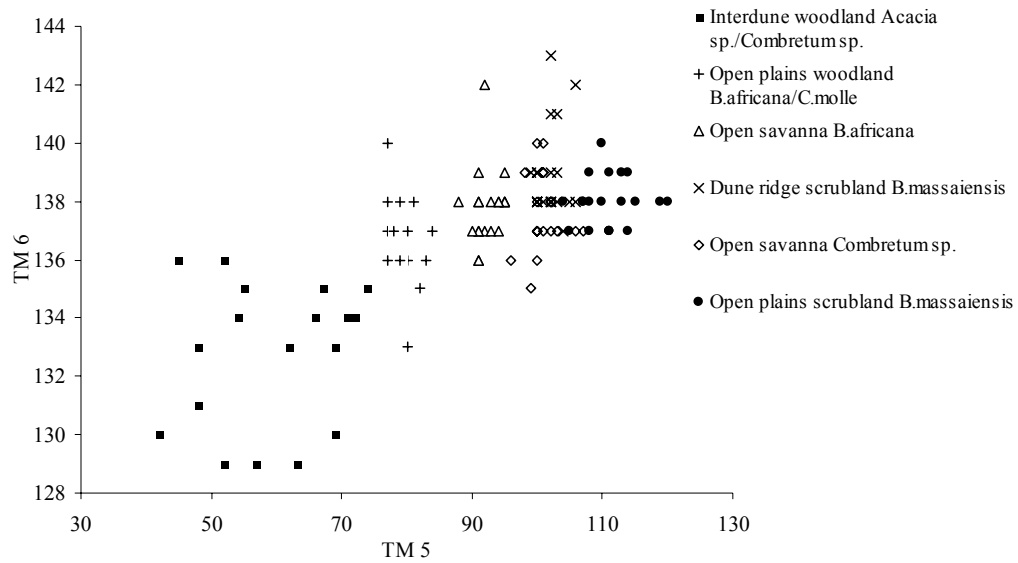


Figure 9.10. Scatterplot of Landsat TM 2005 digital numbers in bands TM5 and TM6 for training plots from CBPP site. Source: Appendix 7.

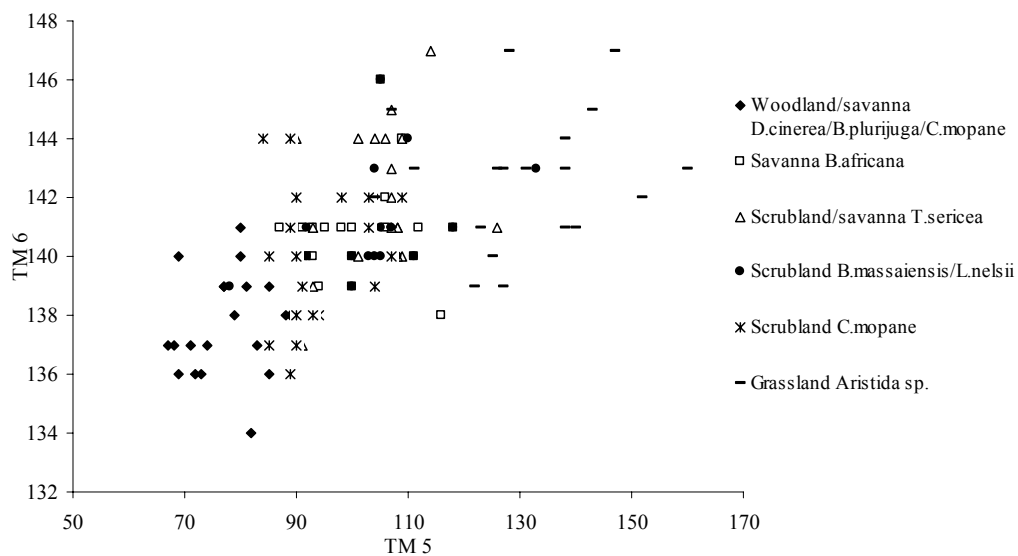


Figure 9.11. Scatterplot of Landsat TM 2005 digital numbers in bands TM5 and TM6 for training plots from NBF site. Source: Appendix 7.

9.6.2 Classifying the historical images

The pre-fence images were then classified using only training sites located within areas known to have not changed over the 15 year period. Section 9.4.4 detailed the technique used to gather training data from unchanged sites in order to classify the historical data. The selection of unchanged training sites proved to be difficult for dynamic savanna, scrubland and grassland cover classes due to the high inter-annual variability of cover and therefore variable spectral response of these areas. However, through using this technique, it was possible to train the classification of historical data to at least 10 areas which contained some pixels known to have remained the same over the pre-fence to present period. Table 9.9 below illustrates the degree of difficulty experienced in locating unchanged training sites for the different cover classes from both study sites. For some classes, mainly woodland areas, the location of unchanged sites proved easier and therefore the change detection results must be cautiously interpreted with this in mind. Furthermore, given the difficulties encountered when attempting to locate unchanged sites in the field, and the resulting reduced amount of ground truth data, it is uncertain that a sample representative of the spectral variability within each class was obtained. However, once the unchanged training sites were located and the spectral signatures were evaluated for separability, the signatures were used to classify the Landsat TM images from 1991-2005 using the supervised maximum likelihood algorithm. It was hoped that this technique would yield at least some information as to the spatial and temporal nature of environmental changes in the study areas.

Table 9.9. Degrees of difficulty experienced when attempting to locate unchanged pixels using the change detection technique described in the text.

Site	Class	Very Easy	Easy	Moderately Hard	Very Hard
CBPP	1	X	-	-	-
	2	-	X	-	-
	3	-	-	-	X
	4	-	-	-	X
	5	X	-	-	-
NBF	1	X	-	-	-
	2	-	-	-	X
	3	-	-	-	X
	4	X	-	-	-

9.7 Results and Interpretation

The classification analysis described above resulted in contemporary land-cover maps based on the 2005 Landsat TM imagery for each of the field sites, along with historical pre-fence land-cover maps based on the 1991 Landsat TM imagery (Figures 9.12 to 9.16). According to Lu *et al.* (2004), a good change detection research project should provide: i) area of change and change rate; ii) spatial distribution of change types; and iii) an accuracy assessment. Sections 9.7.2, 9.7.3 and 9.7.4 detail the results of the change detection analysis including quantitative measures of land-cover changes, whereas the classification accuracy analysis results are presented below (Tables 9.10 and 9.11).

9.7.1 Classification accuracy

Classification accuracy assessments were difficult to achieve for the historical images due to the lack of availability of historical ground data to make the assessment. However, additional ground truth data were collected in order to assess the accuracy of the

contemporary 2005 land-cover maps. Tables 9.10 and 9.11 below list the classification accuracies of the different land cover classes at each of the field sites. Overall, the accuracy of the classifications was 74.1 per cent and 92.50 per cent for the CBPP and NBF field sites respectively. While the overall accuracy and individual cover class accuracy estimates were high for the NBF site, the overall accuracy and individual accuracy of the CBPP cover classes was low with values ranging between 45.5 per cent and 33.3 per cent for the woodland and mixed open savanna classes respectively. After analysing the ground truth data in detail, the cause of the low classification accuracies for these cover classes appears to be the misclassification of some mixed open savanna sites as woodland class in the north of the field site. This could be a factor of similar spectral characteristics of these two cover types, as their spectral responses in TM band 5 and 6 tended to be clustered around the centre of the CBPP scatterplot (Figure 9.10). However, apart from this, the remaining classes at the CBPP site were classified to a high level of accuracy, with values of 100 per cent for the interdune woodland and open plains scrubland classes, and 78.6 per cent for the dune ridge scrubland class.

Table 9.10. Classification accuracy (%) of each land-cover class at the CBPP site in 2005, 1991.

Year	Interdune woodland (<i>Acacia sp. and Combretum sp.</i>)	Woodland (<i>B. africana, B. plurijuga, C. molle</i>)	Mixed open savanna (<i>B.africana and Combretum sp.</i>)	Dune ridge open scrubland (<i>B.massaiensis</i>)	Plains open scrubland (<i>B.massaiensis</i>)	Overall accuracy	Kappa coefficient
2005	100	45.5	33.3	78.6	100	74.1	0.7

Table 9.11. Classification accuracy (%) of each land-cover class at the NBF site in 2005, 1991.

Year	Woodland/savanna with <i>D.cinerea/B.plurijuga</i>	Mixed scrubland/savanna with <i>B.africana/T.sericea/</i> <i>B.massaiensis/L.nelsii</i>	Scrubland/savanna <i>C.mopane</i>	Grassland <i>Aristida</i> <i>sp./Eragrostis sp.</i>	Overall accuracy	Kappa coefficient
2005	100	100	80	90	92.50	0.9

9.7.2 Land-cover changes at CBPP site 1991- 2005

The five land-cover types identified in the CBPP area were mapped from the 1991 and 2005 Landsat TM imagery and the resultant land-cover maps are presented in figure 9.12. In spite of the misclassification of some classes discussed above, the contemporary land-cover map based on the 2005 TM data in figure 9.12 shows that the south-western part of the study area is dominated by open *B. massaiensis* scrubland and mixed open *B. africana* and *Combretum sp.* savanna, and the central and northern areas are dominated by the presence of Kalahari aged longitudinal dunes vegetated by interdune woodland, mixed woodland (*B. africana*, *B. plurijuga*, *C. molle*), and dune ridge *B. massaiensis* scrubland. The 2005 land-cover map also clearly illustrates the ecotonal transition between interdune woodland and mixed woodland areas, as well as the transition between open plains scrubland and mixed open savanna cover classes.

Table 9.11 below lists the percentage of area of each classified land-cover type from the 1991 and 2005 land-cover maps. As figure 9.12 and table 9.11 illustrate, the classification of the historical TM data proved problematic and many of the changes appear to be grossly exaggerated, due to the erroneous cover estimates on the 1991 land cover map.

For example, in 1991 mixed woodland (*B. africana*, *B. plurijuga*, *C. molle*) appears to cover four times as much of the total cover as it did in 2005, which equates to a land cover decrease of 78,118 hectares over the 14 year period. Similarly, the percentage cover of dune ridge *B. massaiensis* scrubland in the 1991 land-cover map is half the 2005 total, which is an increase of 49,939 hectares. Given the difficulties encountered when attempting to gain a representative sample of ground truth data from unchanged sites (see section 9.6.2), and the inability to assess the accuracy of the 1991 classification, it appears that the results of the 1991 classification must be viewed cautiously. Nevertheless, in spite of the problems encountered when attempting to gain a representative sample of ground truth data from unchanged sites for some cover classes, difficulties were not encountered for all the land-cover types (see Table 9.11). For example, the unchanged training data used to classify the interdune woodland and plains open *B. massaiensis* scrubland classes were easily located, thereby increasing the confidence in the accuracy of these estimates. Indeed, the land-cover changes over the 14 year period were much more realistic for these classes with interdune woodland increasing by over 16 per cent and open plains *B. massaiensis* scrubland increasing by four per cent. On closer examination of the spatial distribution of these increases within the land-cover maps in figure 9.13, many of the increases in interdune woodland appear to have occurred around key livestock water points in the region, and much of the increase in open plains scrubland appears in the south-western region of the study area. Figures 9.13 and 9.14 show the increased interdune woodland surrounding the Jobo and Boudum cattleposts and table 9.12 and 9.13 list the land-cover change estimates for these subset areas of interest. Over the last 14 years interdune woodland increased by over 15

per cent at both sites, with the increase centred on the rangelands within 3km of the cattleposts. The south-western increase in open plains scrubland was also confirmed by the five per cent increase at the southern Jobo cattlepost, whereas there was a three per cent decrease around the northern Boudum cattlepost.

Table 9.12. Percentage area of classified land per cover type from Landsat data acquired for the CBPP site in 2005 and 1991.

Year	Interdune woodland (<i>Acacia sp. and Combretum sp.</i>)	Woodland (<i>B. africana, B. plurijuga, C. molle</i>)	Mixed open savanna (<i>B. Africana/ Combretum sp.</i>)	Dune ridge open scrubland (<i>B.massaiensis</i>)	Plains open scrubland (<i>B.massaiensis</i>)
1991	4.91	44.82	22.38	20.5	7.38
2005	21.61	11.80	13.48	41.59	11.5

Table 9.13. Percentage area of classified land per cover type from Landsat data acquired for the CBPP site in 2005 and 1991 for the Jobo cattlepost area.

Year	Interdune woodland (<i>Acacia sp. and Combretum sp.</i>)	Woodland (<i>B. africana, B. plurijuga, C. molle</i>)	Mixed open savanna (<i>B. Africana/ Combretum sp.</i>)	Dune ridge open scrubland (<i>B.massaiensis</i>)	Plains open scrubland (<i>B.massaiensis</i>)
1991	4.6	39.83	22.9	20.76	11.9
2005	20.64	6.31	15.33	41	16.71

Table 9.14. Percentage area of classified land per cover type from Landsat data acquired for the CBPP site in 2005 and 1991 for the Boudum cattlepost area.

Year	Interdune woodland (<i>Acacia sp. and Combretum sp.</i>)	Woodland (<i>B. africana, B. plurijuga, C. molle</i>)	Mixed open savanna (<i>B. Africana/ Combretum sp.</i>)	Dune ridge open scrubland (<i>B.massaiensis</i>)	Plains open scrubland (<i>B.massaiensis</i>)
1991	9.56	59.62	12.48	13.23	4.93
2005	27	18.37	4.94	46.73	2.94

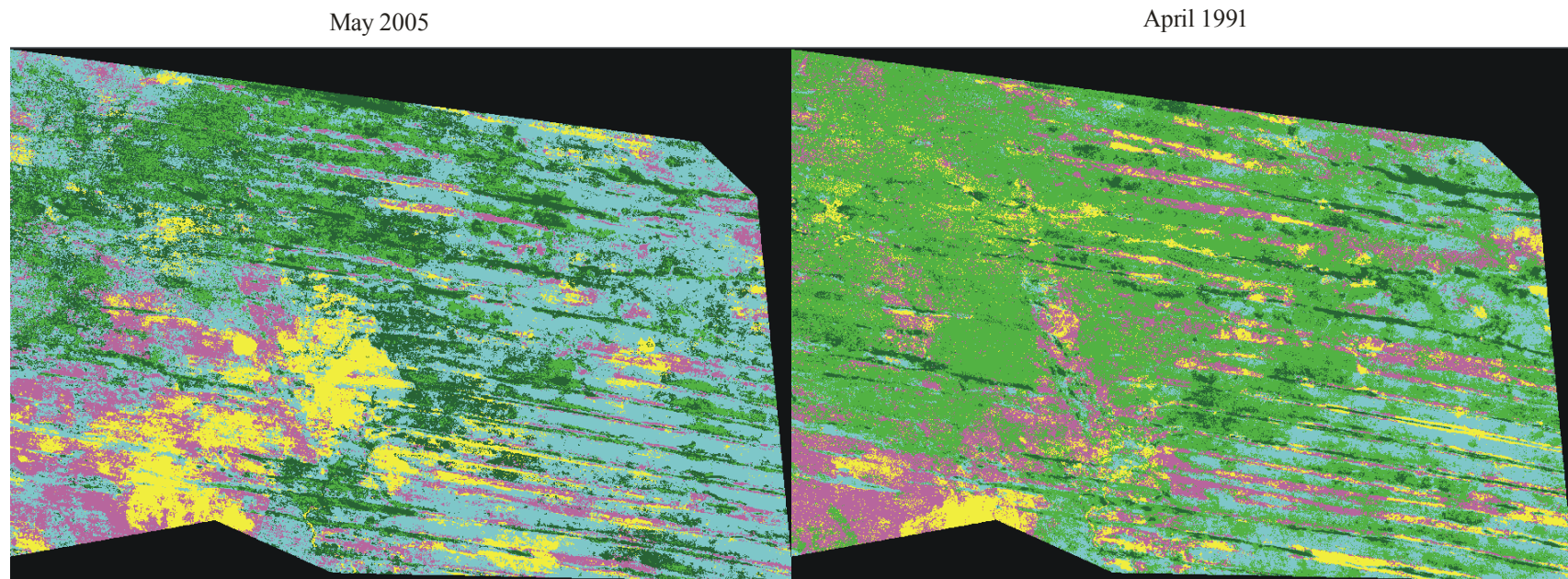


Figure 9.12. Maximum likelihood classifications of Landsat TM images from 1991 and 2005 at CBPP fence site: dark green, interdune woodland; green, woodland; turquoise, dune ridge scrubland; yellow, open plains scrubland; pink, mixed savanna.

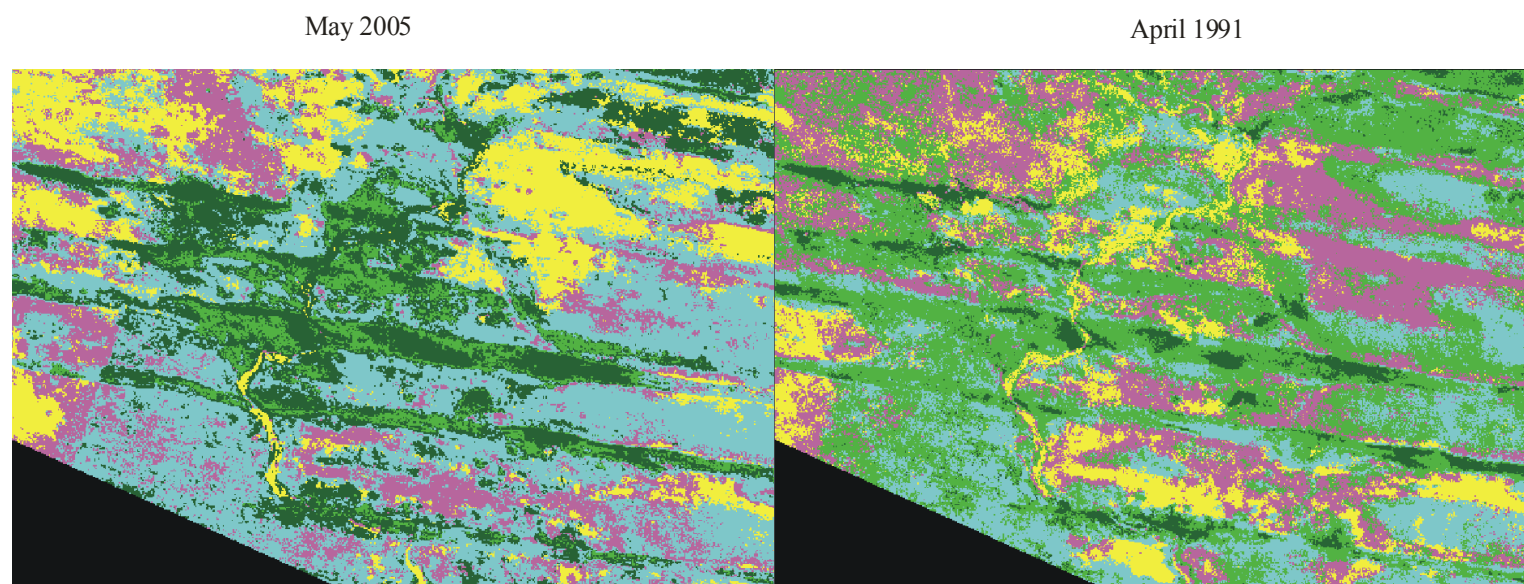


Figure 9.13. Maximum likelihood classifications of Landsat TM images from 1991 and 2005 surrounding Jobo cattlepost at CBPP fence site: dark green, interdune woodland; green, woodland; turquoise, dune ridge scrubland; yellow, open plains scrubland; pink, mixed savanna.

May 2005

April 1991

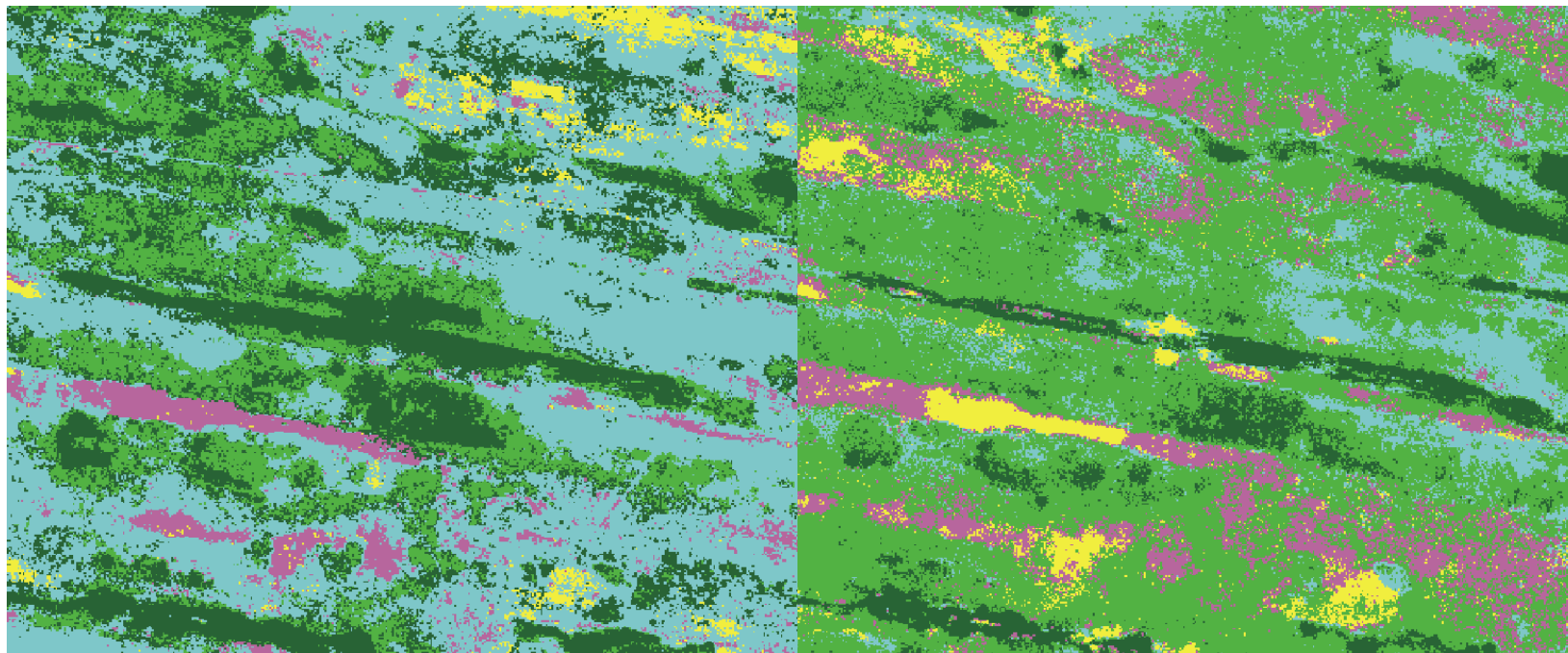


Figure 9.14. Maximum likelihood classifications of Landsat TM images from 1991 and 2005 surrounding Boudum cattlepost at CBPP fence site: dark green, interdune woodland; green, woodland; turquoise, dune ridge scrubland; yellow, open plains scrubland; pink, mixed savanna.

9.7.3 Land-cover changes at NBF site 1991- 2005

The four land-cover classes identified at the NBF site were successfully mapped from the 1991 and 2005 Landsat TM imagery (Figure 9.15 and 9.16). Table 9.15 shows the total percentage area of classified land per cover class from the 1991 and 2005 land cover maps for the whole NBF study area. As described in section 9.7.1 above, the classification accuracy of the 2005 land cover map was high, ranging from 80 per cent for *C. mopane* scrubland/savanna to 100 per cent for woodland/savanna with *D. cinerea/B.pluijuga*. The 2005 land cover map showed that the study area is dominated by patches of woodland or savanna with *D. cinerea/B. pluijuga*, surrounded by monospecific stands of *C. mopane* scrubland and savanna. Dry river valleys in the north and south-western parts of the study area are characterised by grassland with *Aristida/Eragrostis sp.*, and the remaining land cover is made up of mixed scrubland/savanna with *B. Africana/T.sericea/ B.massaiensis/L.nelsii*. While the 2005 land cover map appeared to be largely accurate on the basis of the accuracy assessment, the 1991 map appears to have overestimated the cover of *C. mopane* scrubland/savanna, due to confusion with the mixed savanna/scrubland class. However, the 1991 estimates of woodland/savanna and grassland cover types appear to be accurate, with woodland/savanna showing no change and grassland a slight decrease over the 14 year period.

Table 9.16 and figure 9.16 present the land-cover change results for the rangeland surrounding the village of Beetsha, in the southwestern region of the study area. In spite of the overestimation of the *C. mopane* class, the land-cover maps showed a decrease in grassland of 2.34 per cent, and a decrease in woodland of 3.31 per cent. The decrease in

grassland cover has occurred in areas close to the village, and is most likely the result of a decline in cultivated areas. These findings were supported by personal observations during fieldwork of many areas of abandoned arable land with well established shrubs and grasses. Land-users explained that these areas were abandoned after subsidized land clearance schemes under the Arable Lands Development Programme (ALDEP) were abolished. The decrease in woodland has occurred in the rangelands within three to four kilometres of the village. However, it appears that several areas of woodland close to the village have increased in cover over the 14 year period (Figure 9.16).

Table 9.15. Percentage area of classified land per cover type from Landsat data acquired for the NBF site in 2005 and 1991.

Year	Woodland/savanna with <i>D.cinerea/B.plurijuga</i>	Mixed scrubland/savanna with <i>B.africana/T.sericea/</i> <i>B.massaiensis/L.nelsii</i>	Scrubland/savanna <i>C.mopane</i>	Grassland <i>Aristida</i> <i>sp./Eragrostis sp.</i>
1991	5.62	30.66	54.25	9.46
2005	5.62	62.6	24.83	6.94

Table 9.16. Percentage area of classified land per cover type in Beetsha village from Landsat data acquired for the NBF site in 2005 and 1991

Year	Woodland/savanna with <i>D.cinerea/B.plurijuga</i>	Mixed scrubland/savanna with <i>B.africana/T.sericea/</i> <i>B.massaiensis/L.nelsii</i>	Scrubland/savanna <i>C.mopane</i>	Grassland <i>Aristida</i> <i>sp./Eragrostis sp.</i>
1991	13.02	13.29	66.73	6.94
2005	9.71	46.99	38.69	4.6

9.7.4 Land-cover changes across the NBF 1991-2005

Figure 9.15 shows the 1991 and 2005 land-cover maps for the northern buffalo fence area only, and table 9.17 and 9.18 show the percentage cover estimates for the east and west of the fence over the 14 year period. Firstly, the vegetative cover to the east and west of the NBF was markedly different in the contemporary 2005 land cover map. A large area of grassland with low cover of trees and shrubs could be seen on the wildlife side of the

fence to the southeast of the region (Figure 9.15). In addition to this, the cover of woodland/savanna appears to be far higher on the western side of the fence. These observations were confirmed by the percentage cover estimates, as grassland cover was 10.86 per cent to the east, while it was only 4.78 per cent to the west (Tables 9.17 and 9.18). Similarly woodland cover decreased to the east of the fence, with 6.89 per cent to the west and 1.8 per cent to the east.

When comparing these observations with the 1991 cover map, it appears that such cross fence contrasts in vegetative cover were not always present in the study area. In the 1991 classification, vegetative cover changes little across the fence with four per cent cover of the woodland class to the east and west, along with 9.14 and 10.8 per cent cover of grassland on either side of the fence. The NBF therefore appears to have resulted in a decrease of woodland cover of 2.3 per cent to the east of the fence, and an increase of 2.84 per cent to the west of the fence over the 14 year period. Similarly, grassland cover has increased by 1.72 per cent to the east of the NBF, and decreased by six per cent to the west.

Table 9.17. Percentage area of classified land per cover type to east of NBF from Landsat data acquired for 2005 and 1991.

Year	Woodland/savanna with <i>D.cinerea/B.plurijuga</i>	Mixed scrubland/savanna with <i>B.africana/T.sericea/B.massaiensis/L.nelsii</i>	Scrubland/savanna <i>C.mopane</i>	Grassland <i>Aristida sp./Eragrostis sp.</i>
1991	4.1	31.76	55	9.14
2005	1.8	65.03	22.29	10.86

Table 9.18. Percentage area of classified land per cover type to west of NBF from Landsat data acquired for 2005 and 1991

Year	Woodland/savanna with <i>D.cinerea/B.plurijuga</i>	Mixed scrubland/savanna with <i>B.africana/T.sericea/B.massaiensis/L.nelsii</i>	Scrubland/savanna <i>C.mopane</i>	Grassland <i>Aristida sp./Eragrostis sp.</i>
1991	4.05	35.91	49.22	10.8
2005	6.89	68.8	19.52	4.78

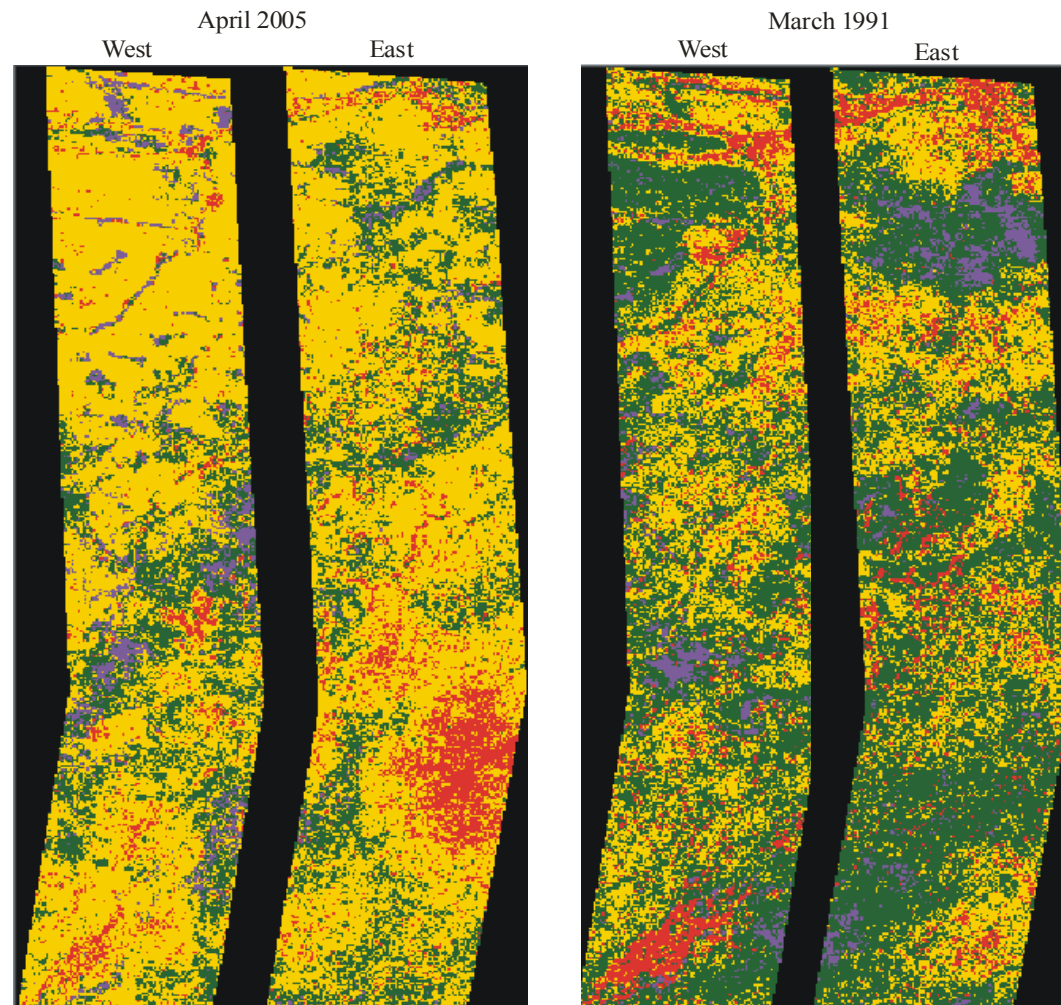


Figure 9.15. Maximum likelihood classifications of Landsat TM images from 1991 and 2005 across NBF: purple, woodland or savanna with *D.cinerea*/*B.plurijuga*; yellow, mixed scrubland or savanna with *B.africana*/*T.sericea*/*B.massaiensis*/*L.nelsi*; dark green, scrubland or savanna *C.mopane*; red, grassland *Aristida sp.*/*Eragrostis sp.*

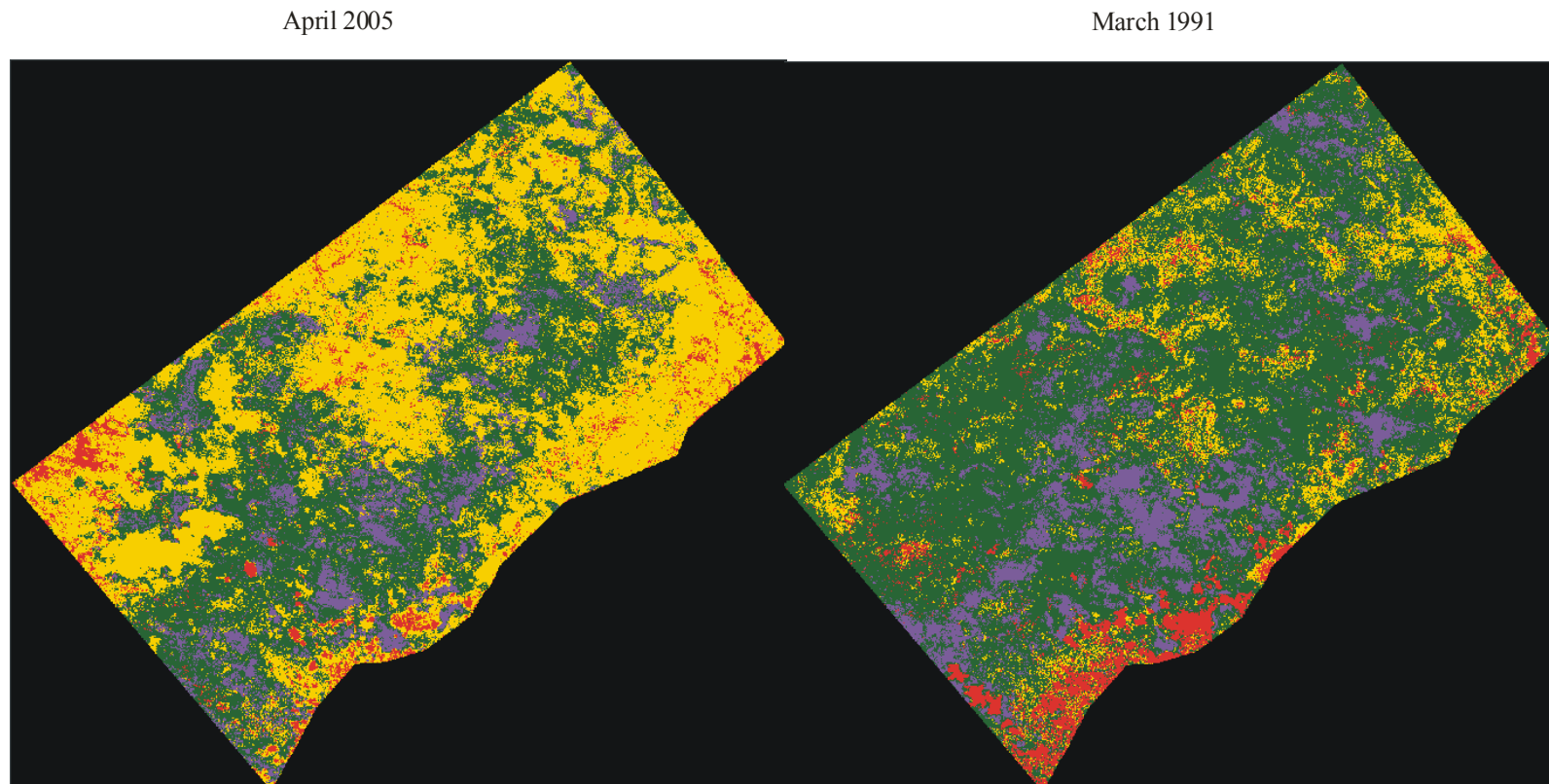


Figure 9.16. Maximum likelihood classifications of Landsat TM images from 1991 and 2005 at Beetsha village in NBF site: purple, woodland or savanna with *D.cinerea*/*B.plurijuga*; yellow, mixed scrubland or savanna with *B.africana*/*T.sericea*/ *B.massaiensis*/*L.nelsi*; dark green, scrubland or savanna *C.mopane*; red, grassland *Aristida sp.*/*Eragrostis sp.*

9.8 Conclusion

The relative impact of reduced livestock and wildlife mobility on communally grazed rangelands is causing an increasing concern for policy makers in Africa and other drylands throughout the world (Vetter, 2005). The modified post-classification change detection assessment of environmental change presented in this chapter demonstrated that multi-temporal remote sensing can provide valuable information to environmental scientists seeking to investigate the environmental impact of human management. Although the methodology was subject to several limitations, when the observed changes are compared to the '*views from below*' presented in the preceding chapters a more accurate environmental change assessment can be made. In general the methodology proved that by focussing on elements of stability within these dynamic dryland landscapes, more confidence can be given to a land-cover change assessment.

The methodology involved the use of image enhancement processes alongside hybrid (unsupervised and supervised) classification techniques, in order to address some of the shortcomings currently limiting the post-classification change-detection approach. Pre-fieldwork image processing involved the use of image enhancement techniques to establish a 22.5 year AVHRR NDVI dataset, which was used to investigate the vegetation phenologic cycle in order to inform the acquisition of fine resolution Landsat data. This placed the findings of the main post-classification change detection assessment into a wider context of seasonal, inter-annual and decadal variability. It is widely accepted that the short-term variability of primary productivity is closely related to rainfall in dryland savannas (Prince and Tucker, 1986). The results of the time-series analysis supported this assertion and suggested that the vegetation greening response was closely related to

rainfall receipts, with the peak greening response occurring one to two months after peak rainfall. Furthermore, the findings demonstrated that the vegetation communities of the delta study site reached higher NDVI values and retained green biomass for longer, suggesting that vegetation rain-use efficiency is more closely governed by soil type than community composition. These findings support previous work on relationship between NDVI, rainfall and soil moisture in Botswana (Nicholson and Farrar, 1994).

The results of the image processing described above were used to guide the acquisition of Landsat TM data to periods of similar vegetation phenology in 1991 and 2005. The contemporary Landsat data from 2005 were classified using supervised maximum likelihood classifications, based on extensive ground truth data collected during the fieldwork period in 2005. On the whole the accuracy of the contemporary 2005 land-cover maps were high and thus enabled the successful mapping of current vegetation community structure. However, poor classification accuracies were recorded for two of the CBPP cover classes, which resulted in some misclassified regions of mixed open savanna vegetation as the woodland class in the 2005 land-cover map. The cause of this confusion may have been the spectral similarity of these cover classes at the peak of the seasonal NDVI response, when both the tree layer and grass layer are green and woodland and savanna are less distinguishable. The CBPP classification may have been more effective using TM data from the early dry season, when trees and shrubs are in leaf while the grass layer is senescing.

Following the classification of the contemporary data, vegetation changes were investigated through a post-classification change detection technique. Unsupervised classifications and change detections had been used to guide the collection of ground

truth data from areas known to have remained unchanged over the 14 year period. The resultant ground truth data was used to train the post-fieldwork supervised classification of the historical 1991 Landsat TM data. Although the methodology was subject to several limitations, and the accuracy of the historical image classification was called into question for some of the most dynamic cover classes, the technique yielded some useful data regarding cross fence vegetation changes, along with vegetation changes surrounding settlements and cattleposts.

Cross-fence comparisons of land cover over the northern buffalo fence on the 2005 land-cover estimate, showed a significant decrease in woodland classes to the east of the fence. At the same time, grassland cover increased significantly to the east of the fence. When compared with the land-cover estimates from the 1991 vegetation map, it appears that these contrasts were not always present, and there has been a significant increase in woodland areas to the west, and an increase of grassland areas to the east, over the last 14 years. These findings supported the results presented in Chapter 8, which demonstrated the significant reduction in total vegetative cover to the east of the NBF. The decrease in the cover of woody vegetation to the east of the fence has undoubtedly been caused by the curtailing of migratory wildlife, especially large mammal herbivores, by the veterinary cordon fence.

Further significant land-cover changes were found surrounding settlements and cattleposts in both study areas. Change detection around cattleposts in the CBPP site showed significant increases in heavily wooded vegetation over the last 14 years. In contrast to this, changes in land-cover surrounding the village of Beetsha in the NBF site were manifested in a decrease in grassland areas close to the village, coupled with a

decrease in woodland areas within three kilometres of the settlement. Such changes are likely to have resulted from a decrease in cultivation after the abolition of the Arable Lands Development Programme (ALDEP), with its emphasis on subsidized land clearance. These observed changes were at odds with those observed in relation to the disturbance gradient assessed in Chapter 8. However, the multi-temporal remote sensing assessment did highlight several patches of increased woody vegetation close to the village centre. These changes support the conclusion made in Chapter 8, that so far it appears that widespread degradation cannot be attributed to sedentarisation in both study areas.

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10

Conclusion

10.1 Introduction

This thesis aimed to examine thoroughly the social and environmental implications of veterinary cordon fence enclosure in Botswana, in order to inform future debates concerning livestock development in southern Africa and the pastoral drylands more generally. This chapter concludes the thesis by drawing together the main findings of the research.

After reviewing the main findings, the discussion reflects on the various benefits and additional insights gained from this interdisciplinary research of a policy that clearly impacts on people-environment relationships. In section 10.4 further avenues for research are suggested for what, until now, has been a neglected subject. Finally, the chapter concludes by discussing some of the recommendations for policy emerging from the research, along with the broader implications of the findings for future pastoral development debates.

10.2 Summary of main findings

Livestock development in Africa has recently experienced a renaissance as elements of the ‘new rangeland science’ (Scoones, 1995) and ‘mobility paradigm’ (Niamir-Fuller, 1999) become more widely accepted by both scientists and policy makers (cf. Scoones and Wolmer, 2006). The old approach saw pastoralists’ mismanagement at the root of environmental and social problems in drylands, and prescribed destocking,

privatization and fencing of communal lands as the solution (Fratkin, 1997). However, maintaining livestock mobility is now seen as fundamental for the survival of pastoralism and sustainability of drylands globally (UNDP, 2003; Niamir-Fuller, 1999; Fratkin and Mearns, 2003). While critics of the old approach are quick to list the many factors restricting pastoral mobility and resource access (Fratkin, 1997; Niamir-Fuller, 1999), few recognise the importance of looking more closely at why such constraints remain so pervasive. This research has demonstrated the importance of veterinary disease control policy and associated infrastructure (cordon fences, quarantine camps) in determining mobility, natural resource access and environmental change within pastoral drylands.

The use of large-scale barrier fences to control livestock diseases currently remains limited to southern Africa and within the region Botswana is uniquely positioned as the only nation determined to extend veterinary cordon fences into remote rural areas. Many African countries are, however, currently planning to reinstate or create disease free export zones, and neighbouring countries plan to expand their fences into communal areas in the near future (Chapter 1). Thus livestock development in Africa is increasingly moving towards high quality export markets which require rigorous disease control standards and the Botswana context could represent the pastoral commons of the future. However, while the impact of veterinary cordon fences upon migratory wildlife in Botswana is conspicuous (Williamson and Williamson, 1985; Owens and Owens, 1980) understandings regarding the social and environmental impacts of enclosure are superficial and short-term, and little specific research has considered the issue (for exceptions see Chapter 2). This interdisciplinary research used a political ecology approach to examine the impact of veterinary cordon fence

enclosure upon natural resource use and environmental change within northern Botswana's communal rangelands.

Before investigating the key research questions it was considered essential to understand the myriad of historical factors contributing to declining resource access and mobility (Objective 2). Chapter 4 revealed how a range of political, economic, and social changes over the last century dramatically shaped resource relationships in the region. The area remained politically and economically marginalised thus retaining dispersed settlements and livelihoods based on mobility far later, perhaps, than more accessible locations. Certain historically risky and inequitable resource uses such as pastoralism expanded and attained a degree of stability and egalitarianism following successful Tsetse eradication campaigns. Meanwhile once open access resources such as wildlife became aggressively protected by preservationist conservation policies which instituted a hunting licence system enforced by the military. Settlement patterns also became more sedentary as people experienced conflicts with anti-poaching measures and rural development schemes encouraged villagisation. This was the local context within which enclosure occurred in the early to mid-1990s.

Chapter 5 set out to provide a thorough grounded analysis of rural livelihoods in both study areas specifically focussed on how contemporary livelihoods are linked to resource availability (Objective 1). In the region proximate to the northern buffalo fence (NBF), access to wildlife, once the most reliable resource, has become restricted and benefits from this asset are limited to those fortunate to gain formal employment in the tourism sector. Meanwhile, commercial sedentary pastoralism forms the mainstay of the local economy and access to both rangeland- and village-based resources is the preferred strategy to establish a diverse livelihood and commercially

viable herd, in the dry Kalahari rangelands enclosed by the contagious bovine pleuropneumonia (CBPP) fences. In general, resource use is not directly linked to availability or abundance. While village-based households are forced to travel further to access natural resources, most rely on land within only a few hours walk of settlements. Thus, natural resource access and mobility has declined significantly in northern Botswana over a period in which the region has been increasingly enclosed by veterinary cordon fences.

The research then focussed more closely upon the impact of veterinary fencing on resource relationships in the period immediately during and after enclosure. In Chapter 6 the direct impacts, adaptations and longer-term implications for pastoralists were investigated. Similarly, in Chapter 7 the impact of enclosure on peoples' access to, and effective control of, the natural resource base at the wildlife/livestock interface was examined. At first the direct impacts emerging from both assessments appeared to support existing understandings of veterinary fence impacts reviewed in Chapter 2. The fences blocked short-cuts and restricted the movement of livestock and meat between villages and cattleposts. Enclosure at the wildlife/livestock interface also directly impacted upon resource relationships by denying marginalised communities access to both rangeland and wildlife resources. However, there are several longer-term implications of veterinary cordon fence enclosure which this research has exposed.

One of the main findings to emerge from the research concerns the impact of enclosure on societal resilience to natural environmental variability. At the wildlife/livestock interface access to social support networks and reliable natural resources has been restricted by the NBF, forcing increased dependence upon economic diversification and state support mechanisms to cope with environmental

variability. This raises some critical questions regarding the long-term sustainability of enclosed livelihoods within an area where permanent environmental changes (i.e. channel desiccation) can occur irrespective of overall resource abundance (i.e. no major change in overall water abundance).

Livestock mobility is the principal means by which people cope with the risks and vulnerability of life within dryland pastoral environments (Niamir-Fuller, 1999; Scoones, 1995). Enclosure by veterinary cordon fences in the Kalahari drylands has increased the vulnerability of pastoralists to risks and natural hazards. Water source failure, veld fires and drought represent persistent risks to which pastoralists are exposed. Aware of the essential mobility required during times of emergency, and the increased vulnerability to risks such as veld fires and hand-dug well failure, experienced pastoralists strongly opposed enclosure. In a direct attempt to mitigate their increased vulnerability to natural environmental variability, some large herd owners have adapted by securing dual well ownership, herd splitting and practicing seasonal mobility. Furthermore, in an effort to reduce labour demands and attract increasingly scarce contract herders, many pastoralists have invested in water pumping technology. Importantly, enclosure by veterinary cordon fences has contributed to advancing a form of pastoralism involving increasing commercialisation, and thus favouring the wealthier pastoral elite.

Although rare, poorer herders can establish themselves as self-sufficient herders and access to extensive rangelands is critical for this to occur (Toulmin *et al.* 2004: 245). Difficulties experienced gaining access to adequate water and grazing caused young pastoral households attempting to 'break with their father' to resent enclosure. Such constraints to access could potentially be creating a growing number of transient households searching for equitable access arrangements. This raises concerns over

future social stratification if enclosure by veterinary fences continues. These findings are similar to those drawn from research investigating rangeland enclosure driven by resource scarcity (cf. Twyman *et al.* 2001; Peters, 1994). Veterinary cordon fence enclosure, however, represents a new form of quasi-restrictive macro-scale enclosure on the pastoral commons whereby pastoralists lose access to distant resources and social networks irrespective of tenure reforms or resource scarcity.

Enclosure at the wildlife/livestock interface by veterinary cordon fences served to reinforce, perhaps indirectly, state preservationist conservation policy and possibly contributed to an increase in individualised and wasteful community hunting practices. By extending state control over wildlife resources Botswana's buffalo fences have weakened community access and control over wildlife and privileged a narrow form of community based natural resource management (CBNRM) involving joint-venture partnerships with private safari companies. Through analysis of community attempts to benefit more directly from wildlife tourism, local frustrations towards the fence and the associated lack of access to wildlife emerged. Thus enclosure and the resultant resource alienation has contributed to the failure of decentralised natural resource management to deliver both conservation and development goals in northern Botswana, yet few appreciate this fact (Chapter 7). These findings serve to reinforce the assertion that fencing protected areas often works against conservation goals (Carey *et al.* 2000: 25).

Further analysis of internal divisions within the community towards CBNRM revealed that resource conflicts have begun to emerge between livestock farmers and community trusts for the increasingly scarce resources found on the people's side of the enclosed wildlife/livestock interface. Such conflicts are likely to intensify if access to surface water and grazing within community concession areas remains restricted,

and post cull livestock populations increase as expected. Decentralised natural resource management in northern Botswana is unlikely to succeed unless such conflicts within differentiated communities are addressed and people are granted effective access to, and control over, both rangeland and wildlife resources.

This research has demonstrated the importance of macro-scale enclosure by veterinary cordon fences as a mechanism structuring and determining patterns of resource access and influencing the use of the natural environment in Botswana's communal rangelands. Findings from both study areas revealed how veterinary cordon fence enclosure has contributed to the myriad of historically embedded social, political and economic factors shaping resource relationships. As demonstrated in Chapter 6, pastoralists who historically practiced seasonal livestock mobility were forced to restructure their livestock management within the CBPP fences. Similarly, Chapter 7 demonstrated that marginalised communities were forced to relinquish rights to reliable resources and proclaimed evocatively that they were forced to, *'leave those trees now and concentrate on these trees around us'*. To address the third objective, the final part of the research (Chapters 8 and 9) assessed the environmental implications of these new fence-induced resource relationships.

Ground-based ecological surveys investigated the state of the environment in relation to known disturbance gradients. Fenceline contrasts in vegetation communities were also used as natural grazing experiments indicative of management impacts, given that wildlife diversity and livestock mobility have both declined following enclosure. While there was some evidence of shrub encroachment in relation to disturbance intensity, on the whole changes resulting from sedentarisation are yet to override natural environmental gradients and are limited to within close proximity of grazing foci (<400m). Fenceline contrasts, on the other hand, reveal that enclosure has begun

to influence vegetation dynamics significantly at the rangeland scale. While the exact drivers of such changes are hard to determine without more detailed longer-term monitoring, some of these changes appear indicative of the curtailment of migratory wildlife.

A multi-temporal remote sensing based environmental change assessment using a modified post-classification change detection technique was used to determine management induced change from inherent ecosystem dynamics. While the technique was subject to several limitations, when complemented by more detailed ecological surveys or ‘views from below’, the approach proved that such investigations can yield considerable insight into management impacts. Cross-fence changes in land cover, for example, showed significant decreases in woodland to the east of the NBF supporting findings from the ecological surveys and clearly indicative of overuse by wildlife. Land cover change detection results from areas surrounding grazing foci also complemented changes evident from the detailed ecological surveys, with increases in woody vegetation detected surrounding some cattleposts in the CBPP area. Furthermore, land cover changes involving localized increases in woody vegetation close to the settlement of Beetsha supported those observed from the data presented in Chapter 8.

10.3 Benefits from an Interdisciplinary Perspective

Given that veterinary cordon fences raise both social and environmental concerns (Chapter 2), this thesis investigated social and environmental changes in parallel. The justification (and hope) was that such an interdisciplinary approach would yield insights additional to that which would have emerged from investigating these

concerns in isolation, and that this process may produce lessons for future efforts at integrative research that combines methodologies from the natural and social sciences. Thus how did the research benefit from investigating social and environmental changes in parallel? Furthermore, what additional insights into the impact of veterinary fence enclosure did the approach yield and can lessons be drawn from these experiences for future interdisciplinary research frameworks?

In seeking to understand the impact of enclosure on livelihoods and patterns of natural resource use the project developed a detailed understanding of changing management practices in relation to veterinary fences (Chapters 6 and 7), which provided justification for an evaluation of the environmental consequences of these fence-induced resource relationships (Chapters 8 and 9). By preceding the environmental change assessment with a detailed account of natural resource management changes, the biophysical element of the research benefited in several ways. First, gaining local knowledge of present patterns of natural resource use in relation to livelihoods enabled the design of a far more targeted environmental assessment, with fine ‘cattlepost-scale’ ecological surveys focused on known grazing foci or disturbance gradients, nested within a wider ‘rangeland-scale’ assessment based on fenceline vegetation changes (p.352). This approach differs considerably from existing ‘science’ led investigations of fence-induced environmental change, which to date have merely relied upon rangeland-scale assessments of vegetation contrasts across fences (cf. Todd and Hoffmann, 1999; Ringrose *et al.* 1997), largely because they were not preceded by an analysis of fence impacts on local land management.

Similarly, until recently most human ecology studies, particularly concerning pastoralism, have been forced to rely on the assessment of existing environmental change science to suggest the biophysical implications of observed management

changes. Stott and Sullivan (2000) explain that some social scientists continue to accept, often uncritically, environmental degradation narratives and are unaware of ideological developments in the biophysical sciences. This research integrated a multiscale environmental change assessment and in doing so gained a far more socially-relevant interpretation of 'change' than that which may have emerged if these issues were studied in isolation.

In Chapter 3 the role of local knowledge in environmental change studies was explored and it emerged that a more accurate account of environmental change could be gained from using local knowledge as the starting point in research, and science as a means to extend local observations to wider areas for management (cf. Forsyth, 1996; Thomas and Twyman, 2004). Yet the process of situating institutionalised local environmental perceptions within differentiated communities and comparing knowledge across the sciences can be time consuming (cf. Batterbury *et al.* 1997; Newell *et al.* 2005). Unfortunately, time constraints prevented specific effort being allocated to recording and situating community accounts of ecological change during the main fieldwork survey. However, local understandings and observations of vegetation dynamics did emerge during discussions with key informants regarding changes to environmental management. This knowledge proved essential to complement, support and even enhance scientific understandings emerging from the field data or present in the literature.

There are several examples in this thesis where observations and understandings of ecological change gained from local knowledge supported or enhanced scientific findings. In Chapter 8 both the interpretation of fence-line contrasts in vegetation community structure and ecological changes in relation to disturbance gradients were aided by land-user observations of vegetation change. In the first case, ecological

surveys revealed findings that appeared contrary to scientific understandings of vegetation change in sedentary pastoral systems; annual grasses and encroaching shrubs actually increased with distance from grazing foci. However, land-users also observed these landscape changes and interpreted reduced grazing following the livestock cull as the main factor driving a widespread increase in encroaching shrubs (Chapter 6). Similarly, local observations of increases in the spatial distribution and temporal frequency of burn mosaics matched those existing in the scientific literature (Chapter 6) and assisted in confirming fire as a major factor driving fenceline vegetation change (Chapter 8). In both cases, local knowledge facilitated the interpretation of scientific results, leading to more grounded conclusions and ultimately a more detailed and useful explanation of environmental change than that which would have been possible from science alone.

Beyond these direct benefits for research design and data interpretation, this study revealed several interesting additional insights into the process of interdisciplinary research, and there are lessons to be learnt. In Chapter 9 satellite remote sensing technology was used to extend the findings of the environmental assessment in both space and time by ‘scaling-up’ the results of ground observations to the rangeland scale. Turner (2003: 255) warns how remote sensing technologies used at increasingly large spatial scales, have reinforced desertification narratives by inferring ecological change from simplistic indicators of human land-use pressures, with little regard for the ‘causal connections between local management and environmental change’. If used, however, at a scale relevant to land management, remote sensing technology could provide political ecologists with a powerful tool to extend detailed process-orientated human-environment understandings to broader spatiotemporal contexts (cf. Rindfuss and Stern, 1998; Turner 2003). This research proved that political ecologists

can critically engage with remote sensing and fully integrate the technology on a scale where local management practices can be directly tied to earth observations. Furthermore, seeking to integrate multitemporal remote sensing into this political ecology study accrued several additional advantages.

The most apparent benefit was that broad-scale ‘views from above’ of land cover change could be linked directly to fine-scaled observations ‘from below’ from detailed ethnographies and environmental assessments. Again, land-user observations of change played a significant role, alongside the results of the detailed ecological surveys, to interpret likely causes of land cover change. In Chapter 9, for example, decreases in grassland and increases in shrubs close to settlements were attributed to the re-growth of abandoned arable lands after direct field observations were clarified by land-user understandings (p. 450). In this case, findings that may have been interpreted by remote sensing scientists as evidence of human-induced land degradation, were tied to known local management changes. Thus, using a combination of local knowledge and detailed ‘ground-truth’ data from ecological surveys to interpret satellite data, allowed a far more useful assessment of land cover change.

Finally, this research demonstrated that by critically engaging in environmental assessment techniques such as remote sensing, political ecologists can serve to avoid the limitations of these approaches when used in isolation. In this study, for example, a modified multi-temporal post-classification change detection technique proved that by focussing on landscape stability and using remote sensing technology within its spatial capability (i.e. rangeland-scale patch dynamics) a more confident environmental change assessment can be made for some of the most stable cover classes. The failure of this methodology to account for some dynamic vegetation

communities may have rendered the approach inoperable to some remote sensing scientists. However, when the results form part of an interdisciplinary assessment, which attaches value to both scientific and land-user knowledge, the analyst is not overly reliant on remote sensing to map all observed changes and can only accept data determined to be scientifically accurate. Whilst it must be acknowledged that this approach may only yield meaningful information when integrated into a much larger multi-source methodology, it serves to move beyond those who dismiss the usefulness of current remote sensing technology in environmental change studies within nonequilibrium drylands (cf. Dougill and Trodd, 1999).

10.4 Further areas of research

Botswana's veterinary cordon fence network has been expanding for over 100 years. One of the most obvious areas for further work would be to build upon the emergent themes within this study of contemporary veterinary cordon fence enclosure, and investigate the longer-term sustainability of livelihoods and environments within rangelands enclosed over a longer timescale. Such a longitudinal approach should attempt to investigate how enclosed communities cope with risk. This temporal approach is especially important given that long-term exposure to hazards can initiate a 'ratchet effect' whereby the ability of households to respond to subsequent shocks may be lessened (Wisner *et al.* 2004: 12).

A temporal approach should also be adopted to assess the sustainability of fence induced resource relationships over the long-term. This is especially important given the early signs of resource pressure and sedentarisation emerging from this study and the obvious environmental changes detected in wildlife areas. The results of the multi-

temporal remote sensing assessment appeared to indicate a transition from woodland into grasslands to the east of the northern buffalo fence. Such changes could be indicative of overuse by curtailed wildlife, especially large mammal herbivores. However, these findings conflict with some long-term ground-based monitoring programmes (Ben-Shahar, 1995; 1998). Further investigations using multi-source data including long-term ecological monitoring using remote sensing and ground based surveys would provide greater detail on the drivers of such changes (i.e. fire, elephants etc.).

This research demonstrated how enclosure by veterinary cordon fences impacts most on vulnerable marginalised groups especially young pastoralists or those with a strong cultural attachment to the natural resource base (i.e. Basarwa). Future studies should focus on the long-term impact of enclosure on the livelihoods of these people, specifically monitoring their efforts to gain access to the requisite assets needed to establish a sustainable livelihood. This is especially important given the difficulties experienced by these groups to establish themselves as fully autonomous pastoralists and exercise their traditional coping strategies (i.e. social support networks, migration). Long-term studies could establish whether enclosure results in a growing number of transient households unable to enter pastoralism or natural resource-based livelihoods given the difficulties transparent from this research (i.e. increased commercialisation of pastoralism and reduced access to grazing and water).

10.5 Recommendations for Policy

Until recently livestock development policy in Botswana has been strongly influenced by preferential trade agreements with the European Union. As a result policy

interventions, especially concerning livestock development, have emphasized national rather than local priorities and favoured commercialisation over local livelihoods and the environment (Thomas and Sporton, 2002). The planning and implementation of veterinary cordon fences in remote rural regions frequently represent the frontier where such conflicts of interest are hotly debated, and the interests of local groups (i.e. pastoralists, conservation groups, safari companies) are pitted against those of the state (i.e. veterinarians, state officials, wealthy cattle exporters). Occasionally, especially when fence planning involves some *a priori* local negotiation, environmental arguments can challenge the hegemony of powerful state veterinarians. This can be seen during the current impasse over proposals to expand the export zone into Ngamiland, which would require extensions to the veterinary cordon fence network (Chapter 2).

In 2008 the Cotonou agreement expired and although Botswana has negotiated a short extension (<http://palapye.wordpress.com/2008/08/18>), at present a Generalised System of Preferences (GSP) represents the only proposed alternative (Meyn, 2007). This would involve the European Union exerting more direct control over national governmental policy (Thomas and Sporton, 2002), and the system requires that Botswana ratifies and implements over 27 international conventions on human rights and the environment (Meyn, 2007). To add to this the export orientated livestock development trajectory may increasingly appear politically and economically risky following the rapid collapse of Zimbabwe's export infrastructure (incl. veterinary cordon fences) and as declining profits make mandatory investments to meet ever stringent EU veterinary regulations hard to bear.¹ In short, alternative rangeland uses

¹ In 2000 traceability became an EU requirement causing large increases in production costs as each cow now requires a bolus and abattoir facilities have been upgraded (Stevens *et al.* 2005). In an economic climate where the Botswana Meat Commission has operated at a loss in most years since

in remote regions such as wildlife tourism will increasingly seem attractive, while future rangeland policy is more likely to be driven by local social and environmental concerns.

Thus Botswana is at a crossroads in terms of its livestock development trajectory and veterinary disease control policy in frontier regions such as Ngamiland. The imminent cabinet decisions concerning development options for Ngamiland may provide a barometer as to the future shape of veterinary disease control policy in the region.² For the proposed expansion of the export zone, state veterinarians favour a development option that would ‘*threaten wildlife and tourism development in western Ngamiland*’, while environmental groups continue to lobby for an option which would balance livestock and conservation interests (Chapter 2). It remains to be seen whether the current market and global economic policy trends will influence state proposals to expand export oriented production and infrastructure into northwestern Botswana. As for existing fences, it seems unlikely that Botswana will adopt the *laissez faire* approach proposed by some environmental groups, involving more flexible, integrated management at the wildlife/livestock interface (cf. Flyman, 2003). Having invested millions of pula in veterinary cordon fencing and livestock eradication campaigns, rural herds now lack natural immunity and the risks posed by allowing the buffer zone to become infected are likely to be too high for state veterinarians and policy makers who have major stakes in the industry.

The lack of certainty notwithstanding, what are the key recommendations emerging from this research for future veterinary policy in northern Botswana? Firstly, policy

1998/9 (ibid) and a 30 per cent cut in the intervention price of beef is predicted under GSP (Thomas and Sporton, 2002), expanding the export zone may increasingly appear unjustifiable.

² Two decisions are expected. Firstly, conservationists have lobbied for the realignment of the northern sections of the NBF to include these areas within the KAZA-TFCA (Chapter 7). Secondly, following the EIA of veterinary cordon fencing in Ngamiland a decision is expected on which option to pursue concerning the proposed extension to the export zone into Ngamiland (Chapter 2).

makers must remove exclusive powers retained by state veterinarians to enclose communal rangelands at will, and ratify the proposed formal veterinary fence planning system involving mandatory environmental and social impact assessments (Chapter 2). Such a planning system should seek to improve existing protocols concerning community consultation and negotiation during planning exercises. Marginalised groups frequently lose most during fencing campaigns (Chapter 7), and the new approach should appreciate the diversity of communities and focus on conducting multiple consultations with various differentiated groups (pastoralists, women, fishermen, subsistence hunters), some of which may reside outside recently imposed village structures.

Second, state officials must recognise that the mobility patterns of wildlife, livestock and people in Botswana do not fit into the more easily defined migratory patterns bestowed upon populations in parts of eastern and Sahelian Africa. This has important implications for land-use planners attempting to investigate resource access requirements in relation to veterinary cordon fence alignments. In such environments access requirements are irregular and opportunistic, with reliance on localised resource areas sufficient for most years and long distance migration occasionally necessary due to a variety of shocks or disturbances (i.e. fire, drought, floods, water shortages, civil unrest, market failures etc.).

Strong consideration should be given to implementing more flexible fencing strategies and movement policies designed to account for these irregular patterns of resource access. Wildlife friendly strategies represent an alternative model for remote frontier fences, but further studies should be conducted to include the interests of other resource users within this approach. For example, during disease free periods access could be granted to pastoralists and their livestock through these “let down” or “roll

back” fences. More work is required to identify the conditions under which pastoralists, fishermen, and natural resource gatherers may require emergency access to enclosed resources, and effective protocols for negotiating such access should be developed.

Finally, policy makers should seek to challenge the implementation of traditional top-down government veterinary policies in Botswana and be aware of innovative new strategies for disease management. Elsewhere in Africa participatory approaches to service delivery and disease surveillance involving para-veterinary professionals or community animal health workers (CAHW) have proved particularly successful (cf. Catley and Leyland, 2001; Scoones and Wolmer, 2006). With pastoralists in Botswana increasingly expressing frustrations over the lack of community members employed by the Department of Animal Health and Production (Chapter 6), such an approach would undoubtedly reduce the costs of disease control.³ Furthermore, by involving rural people more directly with the disease control effort this approach would reduce the need for permanent movement restrictions during disease-free periods.

In conclusion, this research has demonstrated how enclosure by veterinary cordon fences restricts patterns of resource access and mobility within pastoral drylands, with serious implications for both social and environmental sustainability. Rather than intending to replicate Botswana’s disease management policies, countries aspiring to enter lucrative export markets should be wary of the inherent conflict between veterinary science and new rangeland science. Far from successfully balancing commercial and traditional land-use interests, Botswana’s veterinary policy shows

³ For example, one of the main problems causing the rapid spread of CBPP during the outbreak of 1995/6 was pastoralists fleeing the infected red zone after fears that they would lose their livestock. By involving local populations more closely in disease control and surveillance, eradication campaigns would be cheaper and more effective.

scant regard for the social and environmental dynamics of its pastoral rangelands. Future livestock development policies which involve an expansion of export orientated production and associated veterinary infrastructure must be underpinned by a clearer understanding of dryland resource relationships and access requirements, and must consider the impact such developments can have on local understandings of resource rights and concepts of resource alienation. Furthermore, these policies should account for the short- and longer-term mobility requirements of people, livestock and wildlife, while recognising the environmental implications of restricting these patterns of resource access within dynamic dryland environments.

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Appendix 1: Topics covered during baseline livelihood survey**General Reference Information**

1. Date
2. Questionnaire/interview number
3. Settlement name
4. Cattlepost/field/house name
5. Observations (type of roof, fence etc)

Socio-demographic details

6. Name
7. Gender
8. Age
9. Language spoken
10. Ethnic group
11. Education
12. Marital status
13. Head of house? Relationship to household head?
14. Resident household size
15. Non-resident household component
16. Occupation of non-resident members
17. Number of resident members able to work on farm

Mobility/settlement history

18. Length of stay at present location
19. Previous location and year of move?
20. And previous location before this?
21. Why did you move from these places?
22. Describe your move (i.e. sudden or over several years?)
23. Present mobility (i.e. do you move seasonally?)
24. Past mobility (i.e. did you move seasonally in these previous locations?)

Livelihood Income

25. No. of household receiving pension?
26. No. of household receiving food relief?
27. Do you have any savings, loans or credit?
28. Do you or have you been involved in waged or unwaged labour? (rough earnings? location of work? duration?)
29. Did you receive compensation after CBPP cull? (no of cattle?, % cash compensated?, spent on?)

Livestock

30. No of livestock holdings approx? (Cattle, horses, donkeys, goats, sheep, chickens)
31. Where are they watered/kept?
32. Any issues gaining access to resources?

Cultivation

- 33. Do you own or have access to arable land?
- 34. How do you till this land?
- 35. How is this land fenced? (i.e. thorns or wire?)
- 36. What/where do you cultivate?
- 37. What are the household divisions of labour for this?

Hunting and gathering (reassure household you're not from DWNP)

- 38. Does the household ever hunt?
- 39. Who does the hunting?
- 40. What animals do you hunt most often?
- 41. What veld products does the household collect?
- 42. Who does the collecting?
- 43. Other natural resources gathered? By whom? (i.e. honey/fish)
- 44. Approx distance travelled when hunting and gathering? (i.e. no. of hours rtn on foot? no. of hours on horseback? no. of hours in truck?)

Commercial activities

- 45. Do you sell any livestock? Where? How many? How often? Prices?
- 46. Do you sell any cultivated crops? Prices? Where?
- 47. Do you brew beer? How often? Price/quantity sold per week/month?
- 48. Do you make or sell anything else? (Natural resources sold? Curios made? Bricks made?)

Fence impacts and views

- 49. What do you think about the work of the DAHP?
- 50. What is the purpose of the fences? (to gain an idea of local understanding and consultation regarding fences)
- 51. Do you think fences are necessary?
- 52. Are there any positive implications of these fences?
- 53. Are there any negative implications of these fences?

Appendix 2: Natural resource mapping exercises

Contemporary Natural Resource Map

1. Set the paper/aerial photo/satellite image out on the ground.
2. Ask participants to draw on the main features (e.g. Roads, Fence, village, delta, fields, household).
3. Then draw on the areas currently used by the villagers for:
 - Cultivation
 - Grazing
 - Small stock
 - Cattle
 - Hunting and Gathering of veldt products:
 - Thatching grass
 - Honey
 - Beer making products
 - Reeds
 - Fencing Material
 - Housing Material
 - Fishing
 - Hunting

Pre-Fence Natural Resource Map

Then ask the informants to draw a map outlining their NR use prior to 1991 and without the fence.

- Where did they live?
- How mobile were they? Did they move seasonally? Annually?
- Did they visit relatives/friends in other areas? Where?
- Do they still visit/see these people? On special occasions (marriages etc..)?
- Did they move because of the fence or a few years later?
- How did they make a living?
- What impact has the fence had on their lives?
- Did they trade/exchange more to the east before the fence was constructed?
- When was the road constructed?
- How did they get supplies before the road/ferry was constructed?

Appendix 3: qualitative interview topics (settlements and study areas)

Pre-fence settlement patterns and mobility

Where did the household live before the fence, what was this area like, how was it different to the village now, did the household move seasonally before

Movement to the region, explore reasons for moving and more details about the move

Does the respondent move seasonally now

Pre-fence livelihood strategies/resource management, access and use

Previous livelihood strategy

Past income sources in previous location or pre-fence period (details of wages) (Tourism, livestock sales, crafts, migrant labour)

Past nature of agricultural production, livestock owned, fields ploughed by hand or oxen, more or less produced

Past hunting and gathering

Important species, frequently gathered or hunted resources

How were they hunted, harvested or gathered, distances travelled, areas visited, times or seasons when trips conducted, reasons for reduced mobility pre-fence

Changes to livestock management and mobility

How did you manage your livestock, is there more/less mobility now, why

How did you cope with droughts or shocks like water shortages or years of poor rainfall etc.

Direct impact of enclosure

Explore drought/shock coping mechanisms now, how do people cope with risks, what are the main risks

Adaptations to enclosure

Adapting to risks, how do people adapt to shortages of water, why do some pastoralists try and gain access to more than one well, explore pastoralist decision making to mitigate risk

Livelihood problems and constraints now

Fence Views

Reiterate/document their opinion of fence and DAHP and expand on this

Why do you like/dis-like the fence and what changes do you think the fence has made to your life

Have you noticed a change in wildlife numbers or diversity of species

Appendix 4: qualitative interview topics (local and national government)

Local views of DAHP and the fences

Find out what the official thinks about local views of the fences and the work of the DAHP to contrast against local views gathered in the field

What does the official believe local people think about the fences, how do they view the work of the DAHP

Fences and environmental change

Find out whether the government are aware that the fences could be causing environmental change

Find out whether they think the NBF or CBPP fences have changed the diversity and number of wildlife

Fences and local livelihoods and mobility

Does the official think the fences have reduced peoples access to gathering resources
What about grazing and livestock mobility, do they think there are any problems

Fences and natural resource protection

Does the official think that the fences help to protect resources like wildlife and prevent poaching activities

Fences and future development plans in Botswana

Discuss the potential for transfrontier national parks in the NBF area and the disease implications and fence realignment possibilities

Discuss future plans for expanding export zone into Ngamiland and the potential for this

Appendix 5: List of Key Informants Referred to in Chapters 4, 5, 6 & 7

Name	Code/ Village	Mth/ Yr	Age (yrs)	Sex	Marital Status	Ethnic Group	Languages Spoken	Other Comments
<i>Chapter 4</i>								
TJ	B2	7.05	70+	M	Widower	Hambukushu	Mbukushu, Setswana	Crippled from accident at SA mines
MS	B1	7.05	60+	M	Married	Hambukushu	Mbukushu, Setswana	
KS	B12	7.05	65	M	Married	Hambukushu	Mbukushu, Setswana	Owner of Gomteretere cattlepost
KN	B9	7.05	70+	F	Married	Hambukushu	Mbukushu, Setswana	
LN	B5	7.05	60+	M	Married	Hambukushu	Mbukushu, Setswana	
SM	B36	7.06	32	M	Married	Hambukushu	Mbukushu, Setswana	Herder at Gomteretere cattlepost
JM	G2	6.05	65	M	Married	Bugakhwe	Khwe, Mbukushu, Setswana	Originally from Movembe
MK	G10	7.05	50-60	M	Married	Bugakhwe	Khwe, Mbukushu, Setswana	
KB	G1	6.05	80+	M	Married	Bugakhwe	Khwe, Mbukushu	Died 2006
<i>Chapter 5</i>								
MS	Ch38	7.06	55	M	Married	Hambukushu	Mbukushu, Setswana	Headman (<i>kgosi</i>) of Chukumuchu
SS	Ch9	10.05	53	F	Married	Hambukushu	Mbukushu, Setswana	
MR	Ch12	10.05	70+	M	Married	Hambukushu	Mbukushu, Setswana	Nxamazine cattlepost
MK	G10	7.05	50-60	M	Married	Bugakhwe	Khwe, Mbukushu, Setswana	
<i>Chapter 6</i>								
DS	Ch10	10.05	65	F	Married	Hambukushu	Mbukushu, Setswana	Wife of headman of Chukumuchu
KK	Ch19	10.05	58	M	Married	Herero	Herero, Setswana	Owner of Jobo cattlepost
MR	Ch12	10.05	70+	M	Married	Hambukushu	Mbukushu, Setswana	Nxamazine cattlepost
KM	Ch15	10.05	35	M	Married	Hambukushu	Mbukushu, Setswana	Xabacha II cattlepost
KB	Ch20	10.05	45	M	Married	Hambukushu	Mbukushu, Setswana	Mbukushu ZCC priest
MS	Ch38	7.06	55	M	Married	Hambukushu	Mbukushu, Setswana	Headman (<i>kgosi</i>) of Chukumuchu
KB	Ch26	11.05	60+	M	Married	Herero	Herero, Setswana	Owens cattle at Boudom cattlepost
KH	Ch14	10.05	40	M	Married	Herero	Herero, Setswana	Recently moved to Nxamazine cattlepost
MB	Ch57	7.06	45	M	Married	Herero	Herero, Setswana	Owner of Kamboro cattlepost
WK	Ch25	11.05	32	M	Married	Herero	Herero, Setswana	Karawonga cattlepost
MK	Ch6	10.05	52	M	Married	Hambukushu	Mbukushu, Setswana	
SJ	Ch11a	10.05	27	M	Single	Herero	Herero, Setswana	
KG	Ch11b	10.05	19	F	Single	Hambukushu	Mbukushu, Setswana	
MJ	Ch52	7.06	39	M	Married	Hambukushu	Mbukushu, Setswana	
MT	Ch1	11.05	75	M	Married	Hambukushu	Mbukushu	
NK	Ch30	11.05	52	M	Married	Herero	Herero, Setswana	
KE	Ch33	11.05	50+	M	Married	Herero	Herero, Setswana	Owner of Zao cattlepost
SM	Ch2	10.05	50+	M	Married	Herero	Herero, Setswana, English	Local councillor
MM	Ch21	10.05	55	M	Married	Hambukushu	Herero, Setswana	SM's brother
<i>Chapter 7</i>								
MB	B3	7.05	55-60	M	Married	Hambukushu	Mbukushu, Setswana	
ST	B26	7.05	50+	M	Married	Hambukushu	Mbukushu, Setswana	
M	B11	7.05	53	M	Married	Hambukushu	Mbukushu, Setswana	Owner of Matswii cattlepost
PM	B38	7.05	55	M	Married	Hambukushu	Mbukushu, Setswana	

MW	G11	7.05	65+	M	Married	Bakgalagadi	Khwe, Sekgalagadi, Setswana	Owner of Kaodube cattlepost
AW	G8	7.05	35-40	M	Married	Bugakhwe	Khwe, Setswana	Originally from Dishokora
MS	B1	7.05	60+	M	Married	Hambukushu	Mbukushu, Setswana	
LK	B19	7.05	45	F	Married	Bayei	Wayei, Setswana	Originally from Gombo
JB	G27	7.06	44	M	Married	Bugakhwe	Khwe, Setswana	
OP	G21	7.06	41	M	Married	Bugakhwe	Khwe, Setswana	Originally from Movembe
SZ	G32	7.06	40	M	Married	Bugakhwe	Khwe, Setswana	Originally from Dishokora
KB	B23	7.06	45	M	Married	Hambukushu	Mbukushu, Setswana	
DI	B27	7.06	70+	M	Married	Hambukushu	Mbukushu, Setswana	
BB	B7	7.05	60+	M	Married	Hambukushu	Mbukushu, Setswana	
BM	G20	7.06	21	M	Single	Bugakhwe	Khwe, Setswana	Works in Gudigwa camp
SB	B14	7.05	55	M	Married	Bayei	Wayei, Mbukushu, Setswana	Headman of Beetsha
NM	B32	7.06	33	F	Married	Hambukushu	Mbukushu, Setswana	
KS	B12	7.05	65	M	Married	Hambukushu	Mbukushu, Setswana	Owner of Gomteretere cattlepost
JT	B29	7.06	28	M	Married	Hambukushu	Mbukushu, Setswana	
MM	G17	7.06	39	M	Married	Bugakhwe	Khwe, Setswana	
MK	B37	7.06	40	M	Widow	Hambukushu	Mbukushu, Setswana	
JM	G2	6.05	65	M	Married	Bugakhwe	Khwe, Mbukushu, Setswana	Originally from Movembe
MN	B8a	7.05	47	M	Married	Hambukushu	Mbukushu, Setswana	
RN	B8b	7.05	45	F	Married	Hambukushu	Mbukushu, Setswana	
DT	G15	7.05	49	M	Married	Bugakhwe	Khwe, Setswana	Originally from //Gam /wi
PB	G6	7.05	81	M	Widower	Bugakhwe	Khwe, Setswana	Originally from Dishokora
SM	B20	7.05	20	M	Single	Bayei	Wayei, Setswana	Originally from Gombo
KM	B15	7.05	27	M	Married	Hambukushu	Mbukushu, Setswana	
MK	G10	7.05	50-60	M	Married	Bugakhwe	Khwe, Mbukushu, Setswana	
TM	B18	7.05	80+	M	Married	Bayei	Wayei	Originally from Gombo
MI	B40	7.06	70+	M	Married	Bayei	Wayei	Originally from Gombo

Appendix 6: Rainfall Data from Shakawe and Seronga Rain Gauges

SHAKAWE MET. STATION S18' 23 E21' 51													Seasonal Rainfall mm/yr
mm/month	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	
Season													
1979-1980	0	18.6	50.6	55.1	45.2	172.8	61.3	25	0	0	0	0	428.6
1980-1981	2.7	16.5	114.3	157.4	165	94.1	67.9	0.2	1.2	0	0	0	619.3
1981-1982	0	5.6	87.7	51	64	86.6	57.5	25.3	0	0	0	0	377.7
1982-1983	0	10.4	97.8	51.1	104.5	28.1	78.2	11.2	4	0.2	0	0	385.5
1983-1984	0	19.6	88.2	236.7	23.1	85.6	131.1	20.9	0.5	0	0	0	605.7
1984-1985	0	12.6	46.5	27.2	176.6	190.1	17.5	1.9	0	0	0	0	472.4
1985-1986	0	28	13.4	76.1	175.4	67.1	47.1	22.6	0	0	0	0	429.7
1986-1987	27.8	66.1	87.3	53.3	20	90.8	21.3	0	0	0	0	0	366.6
1987-1988	6.2	16.1	41.5	31.6	79.8	161.3	55.9	68.1	0	0	0	0	460.5
1988-1989	10.1	25.9	29.8	72.8	330.3	241.2	112.8	46.6	0	0	0	0	869.5
1989-1990	0	2.6	27.8	76.3	235.3	32.7	78.3	45.9	0	0	0	0	498.9
1990-1991	0	4.8	22.8	99.7	123.7	140.1	45.9	0	0	0	0	0	437
1991-1992	0	14.7	28.6	216.4	108	0.3	157.4	23.6	0	0	0	0	549
1992-1993	0.5	0.9	84.1	159.1	181.1	136.2	37.3	15.8	0	0	0	0	615
1993-1994	4.4	7.1	29.1	73.7	263.2	56.2	1.3	33.8	0	0	0	0	468.8
1994-1995	0	0	40	77.2	12.4	142.4	53.3	0.9	4.6	0	0	0	330.8
1995-1996	0.2	8	1	101.5	126.2	109	22.5	0.9	0.1	0	0	0	369.4
1996-1997	1.5	0.8	34	72.8	173.3	116.5	163.2	0	3	0	0	0	565.1
1997-1998	3.7	17.8	10.7	50.9	91.3	75.2	8.1	1.2	0	0	0	0	258.9
1998-1999	0	10.5	105.2	60.7	133.5	12.2	80.2	0	0.5	0	0	0	402.8
1999-2000	0	3.7	19.2	151.4	282.5	284.9	38.6	0	0	0	0	0	780.3
2000-2001	0	0.4	12.1	141.3	57.5	142.4	38	76.1	0	0	0	0	467.8
2001-2002	0	11.5	63.4	153.9	62.9	33.7	43.6	10.4	0	0	0	3.2	382.6
2002-2003	0	16.3	75.7	23.2	54.7	36.8	11.8	21	0	3	0	0	242.5
2003-2004	0	9.3	8	64.8	140.6	109.8	143.5	120	0	0	0	0	596
2004-2005	0	0	40	86	38.3	47.2	61.6	14.7	0	0	0	0	287.8
													Mean Total :471.8538
Mean													
Monthly	2.196154	12.60769	48.41538	93.12308	125.7077	103.5885	62.89231	22.54231	0.534615	0.123077	0	0.123077	

SERONGA POLICE STATION S18' 49 E22' 24

mm/month	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Seasonal Rainfall mm/yr
Season													
1980-1981	0	0	0	109.8	138.5	181.7	150.9	0	0	7	0	0	587.9
1981-1982	0	0	63.3	26.4	59	125.5	12.6	11.5	0	0	0	0	298.3
1982-1983	0	53.5	36.8	80	95.6	29	22.1	20.4	0	3	0	0	340.4
1983-1984	0	24.9	68.1	256.3	15.2	36.5	113	7.5	0	0	0	0	521.5
1984-1985	4.5	5.3	58.8	36.2	147.5	85	26.5	0	0	0	0	0	363.8
1985-1986	0	30.6	18.6	103.7	152.2	44.6	69.2	10.6	0	0	0	0	429.5
1986-1987	49	78	44.5	24.5	20	33	8.1	0	0	0	0	0	257.1
1987-1988	14	31	41	85.4	80	108	126	59	0	0	0	0	544.4
1988-1989	7.5	1	35	129	462	95.1	38.5	15	0	0	0	0	783.1
1989-1990	0	0	5	23	156	60	101	9	0	0	0	0	354
1990-1991	0	0	14	95	155.5	67	64	0	0	0	0	0	395.5
1991-1992	0	18.1	18.1	228	0	0	12	0	0	0	0	0	276.2
1992-1993	0	8	105	36.5	178.4	251	80	36	0	0	0	0	694.9
1993-1994	0	13.6	45	128	348.8	20	0	0	0	0	0	0	555.4
1994-1995	0	3	50.5	5.5	32.5	50	47	4	8	0	0	0	200.5
1995-1996	1	17	18	71	96	85.1	6.8	0	0	0	0	0	294.9
1996-1997	0	0	45.5	72	66.6	122	142.5	0	0	0	0	0	448.6
1997-1998	0	9	13	37.2	169.5	25.3	31.7	7	0	0	0	0	292.7
1998-1999	0	0	68	168	110.4	39.2	97	0	0	0	0	0	482.6
1999-2000	0	12	10.7	164.5	255	296.5	95	0	0	0	0	0	833.7
2000-2001	0	0	0	0	8	97.2	7	9	23	0	0	0	144.2
2001-2002	0	67.7	135	38	46	6	4	0	0	0	0	0	296.7
2002-2003	0	0	23.8	57.5	50	0	0	0	0	0	0	0	131.3
													Mean Total : 414.2261
Mean Monthly	3.304348	16.20435	39.9	85.8913	123.5957	80.76957	54.56087	8.217391	1.347826	0.434783	0	0	

Appendix 7: Spectral Reflectance Data for Land Cover Classes

Class 1		Class 2		Class 3		Class 4		Class 5		Class 6		Class 7	
Interdune Woodland		Open Plains Woodland		Open Savanna (B.afr)		Dune Ridge Shrubland (B.mas)		Open Savanna (C.mol)		Open Plains Shrubland (B.mas)		Open Woodland (T.ser)	
TM5	TM6	TM5	TM6	TM5	TM6	TM5	TM6	TM5	TM6	TM5	TM6	TM5	TM6
55	135	83	136	91	136	106	138	100	136	108	139	87	137
74	135	84	137	91	137	102	138	96	136	111	139	91	137
67	135	80	136	92	137	105	138	99	135	114	139	88	138
45	136	80	137	95	138	104	137	100	137	110	140	85	137
45	136	83	136	95	138	100	138	100	137	111	137	84	137
52	129	82	135	91	138	102	139	101	139	114	137	83	138
63	129	79	136	95	139	103	138	98	139	111	137	86	138
57	129	77	137	91	138	99	139	106	137	115	138	88	138
62	133	79	138	92	142	103	141	107	137	110	138	83	139
54	134	80	133	95	138	100	139	101	139	120	138	87	138
71	134	78	137	91	139	102	138	101	140	119	138	85	138
72	134	80	136	91	137	103	139	100	140	113	139	86	137
66	134	80	136	93	138	100	139	103	137	104	138	87	137
74	135	77	136	93	137	100	138	100	137	108	137	91	137
48	131	81	138	90	137	101	138	102	137	105	137	90	137
69	130	81	138	88	138	100	139	102	138	107	138	90	137
48	133	77	140	94	138	102	141	102	138	107	138	85	137
52	136	80	137	94	137	102	143	102	138	113	138	88	136
42	130	79	136	91	136	100	138	101	137	108	138	87	137
69	133	77	138	94	138	106	142	100	138	111	137	87	137