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Dedicated to the memory of Mrs Ada Billam (1917-1998)
THE CONTRIBUTION OF ARABLE LAND ALLOCATIONS TO CATTLE PRODUCTION SYSTEMS IN COMMUNAL AREAS OF CENTRAL EASTERN CAPE PROVINCE, SOUTH AFRICA

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ABSTRACT

The communal (former homeland) areas of South Africa are characterised by high concentrations of black people many of whom live in extreme poverty. In recent years this has been exacerbated by the collapse of state-run farmer assistance schemes, which has resulted in very low levels of agricultural production in these areas. The new South African government has proposed the revitalisation of small-scale agriculture as an important mechanism for uplifting rural livelihoods here.

This research was undertaken in the former homeland of Ciskei, in what is now central Eastern Cape Province. Here agricultural decline has resulted in large areas of land designated for crop production lying fallow in the long term. Livestock production offers greater livelihood potential in this region, and it was therefore posited that this essentially abandoned cropland might be better utilised as a permanent grazing resource for livestock, particularly cattle. The research sought to characterise current levels and patterns of utilisation of arable land by livestock and how this land might be more effectively managed as a grazing resource and thereby improve levels of livestock production.

Enormous variation was found in the contribution made by arable land allocations to cattle production systems in communal areas of this region. From a social perspective grazing management systems were found to depend largely on the availability of grazing resources. Where these were plentiful, control was exercised at a communal level although this tended to devolve to the individual level as grazing areas became overutilised. Considerable variation was also evident at the ecological level. Pasture quantity and quality was largely dependent on local ecotopes and land management strategies. This in turn exerted a strong influence on cattle foraging behaviour and the extent to which they could satisfy their nutritional intake requirements and thereby maintain body condition. Recommendations are advanced for improving cattle production systems, which take adequate account of the social and ecological heterogeneity of the central Eastern Cape region.
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CHAPTER 1 – INTRODUCTION

1.1) SOCIAL AND POLITICAL CONTEXT OF RESEARCH

1.1.1) CURRENT DEVELOPMENT POLICY

The promotion of sustainable strategies to improve rural livelihoods in developing countries is currently a fundamental part of development policy in developed countries (DFID, 1997) and is increasingly being adopted by many developing countries. The concept of sustainable development evolved from a gradual recognition during the 1970s and 1980s that the twin goals of human development and conservation of resources were not mutually exclusive. Rather it became clear that both were vital to the long-term viability of interventions aimed at improving livelihoods. Sustainable development was defined explicitly during the World Commission on Environment and Development (WCED) in 1987 as “Development which meets the needs of the present without compromising the ability of future generations to meet their own needs.” (WCED, 1987 in Elliot, 1994: 5). The concept has since become the cornerstone of international development policy. In particular in recent years there has been a move away from an approach that emphasises technical solutions towards one which is focused very much on people and their needs. This is known generically as the sustainable rural livelihoods (SRL) approach and has been defined as: -

“A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base.” (Carney, 1998: 4).

The SRL approach specifically targets the poorest and most vulnerable sectors of communities and aims to assist these people primarily by expanding the livelihood options available to them and ensuring that the structures and processes which define these options are working in their favour (Carney, 1998).
There is now considerable evidence to suggest that the SRL approach is being adopted by policy makers in South Africa. Since the collapse of the former apartheid system in South Africa the alleviation of poverty in the rural areas of the country has been high on the political agenda. The Government’s commitment to this cause has been articulated in the Reconstruction and Development Programme (ANC, 1994) and more explicitly in the Rural Development Framework (Government of South Africa, 1997a). The latter document clearly spells out that whilst it is the Government’s role in rural development to support people, it is up to the people themselves to set the development agenda. The government sees itself principally as a facilitator in rural development whose role is to create an appropriate political, economic and social climate in which rural development can take place. Primarily it sees itself as provider of:

- Governance and physical infrastructure (water supplies, electricity, etc.) and social services (education and health care);
- An enabling framework essential for rural livelihoods to expand and thrive, principally by restoring basic economic rights to marginalised rural areas.

(Government of South Africa, 1997a: 11).

The document also gives an explicit recognition to the need to reduce poverty in rural areas although it has yet to define a specific target or timescale for this.

In addition to the implementation of development projects to improve rural livelihoods within the country, there is also a considerable amount of ongoing research being conducted in order to provide an empirical basis for the design and implementation of effective poverty alleviation strategies. This is being undertaken by researchers from institutions within South Africa and by those from overseas and frequently occurs on a collaborative basis. The research work for this PhD falls within this area.

This introductory chapter will highlight the relevance of this research within the current political and social climate in South Africa. It will begin with a brief overview of the poverty situation in South Africa and the current state of black agriculture. This will be followed by an historical overview of African peasant
production systems and an outline of some of the main areas of debate concerning the rehabilitation of this sector. Finally, the potential of livestock production in rural development both generally and within the specific regional context of the research area will be discussed, and the specific aims and objectives of the research set out.

1.1.2) POVERTY, LIVELIHOODS AND AGRICULTURE IN SOUTH AFRICA

In 1998 almost 50% of South Africa’s population was defined as poor using a poverty line equivalent to about $2.40 per person per day (DFID, 1998). Such high levels of poverty persist despite the relatively high level of social support and infrastructural development that exists within much of South Africa. What is more disturbing is that, as a result of the separate development policies introduced under colonial rule and formalised under apartheid, the problem is almost completely polarised along geographical and racial lines (Pillay, 1996). Indeed, at the national level almost 75 per cent of poverty is in rural areas and blacks account for 95 per cent of this share (Pillay, 1996). Extreme variations in Human Development Indices\(^1\) (HDIs) exist between races. HDIs for white South Africa in 1991 would have ranked 19 (out of 173) on a global scale while the black population would have ranked just 117 (DFID, 1998). The disparity in poverty share is equally severe between provinces. Present day Eastern Cape Province comprises many areas that were neglected under the apartheid system. Primarily these consist of the former homelands of Ciskei and Transkei. The province thus has a legacy of poverty that manifests itself at many different levels. According to Davies (1996) the monthly income of the average black family in Eastern Cape (745 Rand) is only about one third of the overall national average (2,089 Rand) and about three-quarters of the national black average household income (1,005 Rand). Poverty thus afflicts the majority of the province’s rural black population, particularly those in former homeland areas.

Livelihood strategies employed by blacks in South Africa reflect the endemic levels of poverty in rural areas and are characterised by their diversity. The Rural

\(^1\) The Human Development Index is a combined measure of life expectancy, educational attainment (adult literacy and combined primary, secondary and tertiary enrolment) and adjusted income (United Nations Development Programme, 1998).
Livelihoods Research Project in South Africa defined a livelihood as "any combination of income streams that sustains households at a level of living above the poverty threshold." (Eckert, 1996: 245). Rural households gain their income from multiple sources in an attempt to minimise risk. Furthermore, income sources are often irregular and the amounts earned small. Sources of household income include local employment, remittance income from migrant workers, pensions and the consumption and sale of crop and livestock products (Baber, 1996; May, 1996). However, the proportion from each is highly variable.

Agriculture makes little contribution to rural livelihoods amongst black people in the former homelands. Rose and Williams (1988), using data from socio-economic surveys undertaken in both the Ciskei and Transkei homelands during 1987, reported that only 5.6% of household income came from agriculture. Furthermore, during 1988, 42% of fields in the Ciskei were left unploughed. By 1995 it was estimated that the amount of unploughed land in the former Ciskei area had increased to 60% (Eckert and Williams, 1995). The authors attributed this decline in cropping primarily to the collapse of ploughing services provided by the former Ciskei government during the time of political transition. Recent surveys have further underlined the minimal contribution of agriculture to household income (e.g. Ainslie et al., 1997; Monde-Gweleta et al., 1997).

These findings must be considered in the context of historical change. In Rabula village in the former Ciskei, crop and livestock production contributed 19.9% to overall household income as recently as 1949, compared to just 7.9% in 1990 (Sperber, 1993, cited in De Wet, 1995). Indeed, if one delves into the not too distant past it is clear that small-scale farming was able to provide almost all income requirements for many Africans. There is an overwhelming body of evidence that a successful black smallholder peasant class emerged during the nineteenth century, particularly in the Cape Province (Bundy, 1988). These peasant farmers were able to respond to the demands of a growing economy during the period 1870-1910, and were able, in many cases, to out compete white farmers. In fact both Beinart (1992) and McAllister (1992) have proposed that agricultural production in many parts of the Transkei probably increased until the 1930s. It is apparent that this period of relative
prosperity is now well and truly over in the Transkei as in other South African homelands. The steady decline of agriculture as a livelihood strategy in these areas during the twentieth century is underlined by Beinart:

"...it is clear that the contribution of farming activities to family income has declined steadily in this century; an increasing amount of food has been 'imported' and poverty has become widespread and changed in character." (Beinart, 1992: 178).

To understand exactly why agricultural production by black farmers has declined so dramatically since the early part of this century, it is necessary to trace the history of black agriculture in South Africa, particularly with regard to the impact of government policy.

1.2) HISTORY OF BLACK AGRICULTURE IN SOUTH AFRICA

1.2.1) THE COLONIAL PERIOD

From the mid-nineteenth century onwards, colonial influence and policy began to impact significantly on the traditional agricultural production practices of black farmers [the pre-colonial agricultural practices of the southern Nguni peoples of South Africa are dealt with in some depth by Bundy (1988) and for the Transkei region by McAllister (1992)]. In the eastern part of the Cape, pressure from white settlers and a series of frontier wars between the 1840s and 1870s limited the extent to which new land could be occupied. Furthermore, the Xhosa people, who occupied this area, were steadily being dispossessed from much of their land during this period which, combined with increasing population, placed great pressure on available resources (McAllister, 1992). Nevertheless, the demands of the rapidly growing economy heralded something of a golden age (albeit short lived) in African farming at this time. Peasant farmers were able to expand production to meet these demands and, as a result, a relatively successful class of African peasant farmers emerged. Bundy
(1988) has described these increases in production as being characterised by three fundamental features.

Firstly, the rapidly expanding role of sheep and wool in the peasant economy. Prior to 1850 sheep ownership amongst Africans in the Cape was negligible. However, there was an enormous growth in the number of sheep owned during the 1860s and 1870s in direct response to the recognition by peasant farmers of the value of wool as a cash crop. By the mid-1870s wool provided the chief item for exchange or sale in the Eastern Cape. For example, in 1875, of the £19,000 worth of agricultural products sold by African peasants to traders in Alice, wool accounted for £12,000 (Bundy, 1988).

Secondly, there was the increased use of the plough and wagon amongst African farmers. The adoption of the plough constituted the key technological adaptation of the peasant farmer and was the most effective means of increasing crop production. It had been widely adopted by the mid-1870s. For example, in 1872-3, 188 American ploughs were sold to peasant farmers in Alice alone, at an average price of £5 each (Bundy, 1988). The contribution of the plough to increasing crop production amongst African farmers cannot be over-emphasised. Peasants no longer grew crops merely for subsistence and were able to sell their often-abundant grain surpluses to local white traders. Indeed, it has been acknowledged that African peasants were frequently making more effective use of the land than their white counterparts at this time (Bundy, 1988). This manifested itself in the fact that many white landowners preferred to rent their land out to black peasant farmers as it made more commercial sense. The adoption of wagons by peasant farmers had two important commercial implications. To begin with they were able to use them to transport their own crops for sale at the nearest large town. Furthermore, they were able to transport the produce of local merchants and traders. This was a profitable enterprise and one that many peasants resorted to once their own crops had been harvested.

The third notable feature of increased agricultural output during this period was diversification. Reference has already been made to diversification in livestock ownership through the acquisition of large numbers of sheep for the value of their
wool. With regard to crop production, peasant farmers increasingly turned their attention to wheat, barley and oats that had a greater market value than their own staples of maize and sorghum. Even peas, beans, fruit and root crops were grown because of their potential for raising cash. These experimental advances in crop production were accompanied by technological adaptations. It was not only the plough and harrow that became widespread at this time, enclosures and irrigation were increasingly used as a means of improving crop production.

The marked advances taking place in the Cape Colony during this period were nowhere more notable than in the region in and around the former homeland of Ciskei, in what is now central Eastern Cape Province. Reference has been made to the large volume of trade taking place between local peasants and traders in the town of Alice, which was the most important regional centre in Ciskei at this time. Indeed, the district of Victoria East, in which Alice lies, was in many ways an archetypal district of Ciskei: it had a considerable African population, a number of white farmers and storekeepers, a well established missionary and educational presence and a firm agricultural foundation amongst both blacks and whites (Bundy, 1988). Whilst agriculture in Victoria East was dominated largely by sheep (for wool) and crop production, other districts in Ciskei could boast similar levels of peasant enterprise and trade but with a greater focus on livestock production. During the 1870s, Peddie district became renowned for the number and quality of livestock (particularly cattle) it produced for slaughter, to the extent that it was reputed to surpass the neighbouring European district of Albany in its productivity (Bundy, 1988).

It is important to view these agricultural improvements in the context of the considerable social and institutional change that had taken place and was continuing to occur in the area. Fundamental in this was the annexation by the British in 1847, of the land between the Fish and the Kei Rivers. This became known as "British Kaffraria" and its function was essentially to act as a buffer between the Cape Colony and the Xhosa nation (Thompson, 1995). The annexation of this land followed the 1846-47 frontier war between the British and the Xhosa and was consolidated following Mlanjeni's War of 1850-53 (Thompson, 1995). The latter was a particularly ruthless campaign waged by the colonial forces, which left many Xhosa
dead and many more homeless. Following the cessation of hostilities the remaining Xhosa rebels were systematically dispossessed of their lands and these became available for resettlement (Crais, 1992). The colonial government encouraged settlement by Europeans and "loyal natives". The Europeans were mainly of British origin although some 6,000 German soldiers (veterans of the Crimean War) and their families were also settled in the area (Crais, 1992). The "loyal natives" consisted largely of the Mfengu and Gqunukhwebe tribes, who had fought alongside the colonial forces during the 1850-53 War (Thompson, 1995).

Resettlement began in 1853 under three different tenure types: communal tenure, and individual tenure in the form of both quitrent tenure and freehold tenure (see Appendix 1.1 for a more detailed description of these tenure types). In Ciskei, the earliest grant of individual tenure to Africans was by annual quitrent tenure in Victoria East district in 1849 (Mills and Wilson, 1952; Haines and Cross, 1988). This was followed in 1853 by the granting of a considerable amount of land in the Crown Forest Reserve to loyal Mfengu, also under quitrent. In 1858 a proclamation allowed Africans to purchase Crown Land at £1 per acre and by 1864, 508 purchasers held 16,200 acres (Bundy, 1988). Land was also allocated to white settlers in this area, in line with the colonial government's policy of close settlement of the races. Indeed, some 317 farms were set aside for whites in British Kaffraria (Davenport and Saunders, 2000).

The overall effect of introducing individual tenure together with the integration of European farms with African farms and settlements was (as the colonial administration had hoped) the gradual stratification of the African population. Although this was taking place throughout the Cape and within the independent Transkei, it was nowhere more pronounced than in the Ciskei (as British Kaffraria became known). By the 1870s several differentiated classes were clearly visible amongst the rural African population in Ciskei. At one end of the spectrum there were a small, but significant, group of full-time farmers making a good living from their, often extensive, lands. Then there were the rural majority who had access to a limited amount of land and practised a subsistence existence during good years, supplemented by work during poor years. These were essentially of two types: those
who held title to their own land and those who leased land from white farmers - the so-called squatter peasants. The latter group exemplified the tenacious desire of many Africans to remain attached to the land as subsistence producers. At the lower end of the spectrum were also many proletarianised Africans who sold their labour to white employers in order to make a living (Bundy, 1988).

Nevertheless, the level of proletarianisation was not substantial enough for the colonial government, particularly outside the Ciskei. The discovery of diamonds in the Transvaal region in 1867 had provided even greater demand for cheap labour to service the rapidly expanding mining industry. The colonial government envisaged the rural African areas (reserves) as being the ideal source of an inexpensive and readily available workforce. The continued presence of a sizeable and permanent peasant farming class amongst Africans in the Cape was thus not viewed favourably in government circles. The distinct conflict of interest between Africans and the colonial government at this time is underlined by Bundy: -

"...two opposing and dialectically related sets of interests are plainly visible: the increased demands by white employers for black labour, and an increased attempt by Africans to find alternative forms of income than low-paid wage labour whereby to meet the demands of the state and their own steadily rising consumption."
(Bundy, 1988: 78)

In an attempt to remedy this situation the government adopted a series of measures to try and force peasant farmers to leave their rural homes and join the migrant labour market. These included revised tax laws, pass laws and vagrancy laws. More importantly, Location Acts were passed in 1869 and 1884, aimed directly at reducing the number of black squatters on white owned lands (Bundy, 1988). These were resented not only by the peasants themselves but also by the landowners who received a substantial amount of money from leasing their land. As a consequence, these laws were frequently bypassed or ignored and were not particularly effective in achieving their desired aims.
Nevertheless, by the 1890s greater enforcement of the Location Acts was beginning to succeed in driving an increasing number of peasants away from agriculture and onto the labour market. This was exacerbated by a downturn in prices for most agricultural produce, increasingly fierce competition from white farmers (who had by this time begun to recognise the economic potential of farming), and the rinderpest epidemic which devastated cattle (peasant capital). In the face of this combined legal, economic and environmental onslaught many small African farmers could no longer survive. This was particularly true of the marginal peasants who were generally the most vulnerable and most directly impacted by anti-squatter laws (Bundy, 1988).

The survival of the African peasant class was dealt a further blow by the introduction of the Glen Grey Act in 1894. Indeed, this was not confined only to squatters, but was more ambitious in its aim to proletarianise significant numbers of blacks from tribal areas (Haines and Cross, 1988). The act proposed a limit of just four morgens (approximately eight acres) on the size of individual holdings in the reserves and a conversion of tenure to perpetual quitrent (Davenport and Saunders, 2000). However, as Yawitch points out: -

"...these four morgen plots were uneconomic and were never intended to provide for subsistence, but rather to guarantee the provision of a migrant labour force both through the need to supplement subsistence production, and also through the creation of a landless class in each generation." (Yawitch, 1988: 102)

Furthermore, the limitation on the size of land holdings by individuals also seems to have been directed at curtailing the growing number of African farmers producing at a commercial level. Thus, for the first time the use of the law to protect vested white interests was not limited just to the generation of adequate labour for the white industries, but also to reducing competition faced by white commercial farmers.
In the post-unification period, following the Anglo-Boer War of 1899-1902, the Union of South Africa was constituted in 1910. This was the culmination of a period of gradual acceptance amongst the white peoples that co-operation was the best way forward in the common goal of exploitation of the resources and indigenous peoples of the country. This was literally the death knell for the black peasant farmer, as thereafter the majority of whites were united in their desire to proletarianise en masse the remaining African peasants. This desire was formalised in the Natives Land Act of 1913. This was an important turning point as it was the first Act to set aside areas exclusively for black occupation, and paved the way for the later formalisation of these so-called "scheduled areas" into homelands under the apartheid system. It severely limited the extent to which Africans could gain access to land outside these areas, not only through purchase, but also by leasing, and thus sought to deal once and for all with the question of squatter peasants (Haines and Cross, 1988).

The 1913 Act was followed by the Native Trust and Land Act of 1936. This Act established a body known as the South African Native Trust to administer those areas set aside for black occupation under the 1913 Act ("scheduled areas") as well as additional areas ("released areas"), designated for black occupation under the terms of the 1936 Act itself (Yawitch, 1988). These latter areas were composed mainly of farms previously owned by whites allocated during the resettlement of British Kaffraria in 1850s. Thus, the 1936 Act replaced the original policy of close settlement with one of segregation. A fourth form of tenure known as "Trust Tenure" (see Appendix 1) was introduced in these additional homeland areas, which was effectively the same as communal tenure (De Wet, 1987a). From this period until democracy in 1994, the land system crowded the majority of rural Africans onto pockets of land that only accounted for some 13% of the total area of the country.

The South African Native Trust was empowered to combat the perceived deterioration of natural resources in the homelands (especially soil erosion) and to improve agricultural production amongst blacks living in these areas. The empirical
basis for these "remedial measures" appears to have been the Report of the Native Economic Commission from 1930-32 which suggested that large parts of the reserves were overstocked and eroded (De Wet, 1987a). This seems to have alerted the national government to just how badly degraded the reserves were becoming and how this was reflected in declining agricultural production and a population living largely in abject poverty and semi-starvation. The latter situation was viewed as problematic not from an altruistic perspective, but because it may have had serious implications for the availability of cheap labour for industry.

The mechanism adopted for improving the situation in the homelands was the system of “betterment planning” or “rehabilitation”. De Wet (1987a) has divided betterment into two distinct phases. The first occurred from 1936 through to the end of World War II. This was primarily concerned with the conservation of resources and involved the construction of contour banks, dams, roads and dipping tanks and the implementation of a forced culling scheme to combat the perceived problem of overstocking.

By contrast the post-war approach was directed explicitly towards agricultural viability. The key feature of this approach was the creation of two distinct groups of people in the reserves: full-time peasant farmers and full-time wage labourers. This may have been feasible to some extent if the government had implemented betterment in the way it was originally intended. However, as De Wet (1987a), has conclusively demonstrated, betterment planning was increasingly hijacked by the political goals of apartheid, and the initial development objectives became secondary. The apartheid government, which came to power in 1948, refused to warm to the concept of developing a full-time peasant farming class within the reserves. Consequently, the recommendations of the Tomlinson Commission Report of 1955, which were intended to serve as the blueprint for post war betterment, were so watered down as to make the entire process completely unfeasible. Thus, betterment was implemented in a very limited fashion in order to ensure that little changed in reality. These actions also reflected the fact that the reserves (or homelands as they were now termed) were increasingly being viewed by the apartheid government less as a source of migrant labour and more as a source of social control over the growing black population.
(Yawitch, 1988). As such they served as a repository for large numbers of labour tenants\(^1\) from white farms, and the inhabitants of black settlements outside the reserves ("black spots") who were displaced as part of the forced removals which occurred from the 1950s onwards (Lodge, 1981, cited in De Wet, 1987a).

Betterment was the final major agricultural imposition by the former white government on Africans in the homelands of South Africa and it categorically failed to achieve an increase in agricultural output. Indeed, there is a considerable body of evidence to suggest that betterment has, in many cases, had a detrimental effect on black agriculture in the majority of villages where it was implemented. This seems to have been particularly true in the former Ciskei where 78.7% of the area was planned (Trollope and Coetzee, 1975). Crop production frequently declined, largely as a result of people being allocated smaller fields, or losing them altogether (De Wet and McAllister, 1983; De Wet and Leibrandt, 1994). In addition, many of the fields that were allocated under betterment were a considerable distance from the centralised residential area, which acted as a further disincentive to crop production. What is also clear is that the effect of betterment was very different between villages depending on their circumstances prior to its implementation (De Wet and Leibrandt, 1994). Whilst the overall impact on agriculture has tended to be negative this has not always been the case. Ndlovu (1991) has described two villages in Middledrift district of Ciskei, in which betterment was pioneered during the late 1930s and argues that as a result of the considerable land holdings (both arable and rangeland) which the villagers already had, betterment was able to facilitate an increase in agricultural production. Nevertheless, these villages were somewhat exceptional in their landholdings and it would be fair to say that betterment left the majority of small agricultural producers in the Ciskei in a worse position.

\(^1\) Individuals who worked on white farms in return for a plot of land upon which they could subsist.
1.2.3) SUMMARY

In short, the entire history of black agriculture in South Africa under minority rule government has been one of neglect and systematic undermining. From the passing of the first Location Act in the 1860s, to the post war implementation of betterment planning, the government attempted to deprive black farmers of sufficient land to allow them to compete at a commercial level. Nowhere has the rise and fall of the African peasantry been more accentuated than in the region in and around the former Ciskei, which forms the central area of modern day Eastern Cape Province. The process of social stratification amongst Africans, which was by the 1890s probably most advanced in the former Ciskei, was firstly curtailed and then progressively undone through direct intervention by government in response to the political exigencies of the white minority. Thus, a region that once supported a burgeoning African peasant farmer class at a variety of different scales during the latter part of the nineteenth century, now finds itself with one of the highest levels of dependence on cash income (remittances and state transfers) in the country, and the lowest on agricultural production. Furthermore, this scenario, normally associated with a fairly developed regional economy, has evolved in an environment where poverty remains endemic for the majority of the region's population. This somewhat contradictory situation is a direct manifestation of the dualistic policies of successive minority governments, particularly during the apartheid era. The question is how this situation can best be redressed and the extent to which agriculture has a role to play in this.
1.3) AGRARIAN REFORM AS A MECHANISM FOR ENHANCING RURAL LIVELIHOODS IN SOUTH AFRICA

The post apartheid government has pledged to address the poverty situation amongst Africans in rural areas of South Africa and has implemented policies aimed at rebuilding (at least partially) a black peasantry. This raises a number of pressing questions. First, and most fundamentally, does agriculture have a role to play in the development of rural livelihoods in modern day South Africa, given the degree of reliance on wage labour which now characterises many rural households? Second, if so, then how can this most effectively be implemented given the considerable constraints of high resource pressure and poor infrastructure facing former homeland areas such as the Ciskei?

The following section will address these questions. Particular emphasis will be given to former homeland areas, such as the Ciskei, wherever possible. The discussion will begin with an overview of the policy objectives of the democratic government with respect to agrarian reform in South Africa and the debate that this has engendered.

1.3.1) THE LAND REFORM PROGRAMME

Since democracy in 1994, the Reconstruction and Development Programme (RDP), and its successor Growth Employment and Redistribution (GEAR), has provided the blueprint for development at a national level (ANC, 1994). This has been focused primarily on the improvement of livelihoods amongst black people, especially those in rural areas. Particular emphasis has been placed on agriculture (ANC, 1994: 102-104) and associated land reform policies (ANC, 1994: 19-22) as a mechanism for facilitating development (and hence improving livelihoods). The centrepiece of government policy to date has been the Land Reform Programme (LRP). This has three principal tenets: -
1. Land Restitution
This provides priority treatment for those who lost their land after the Native Lands Act of 1913 and were not fairly compensated. With respect to rural areas, eligible individuals are generally those who were removed from "black spots" (areas inhabited by black people in what became "white" South Africa after 1913). Where feasible the state has undertaken to restore their land to them or provide equitable compensation (De Wet, 1997).

2. Land Redistribution
Land redistribution is intended as a mechanism by which the poor can gain access to land for residential and productive purposes in order to improve their livelihoods. The government envisages its role as being facilitative and that most land exchanges will take place via a free market. To this end it has made a one-off Land Acquisition Grant of R17,500 available to those individuals earning less than R1500/month (De Wet, 1997).

3. Land Tenure Reform
Many rural people currently only have informal rights to land in their capacity as labour tenants, renters or squatters. The main objective of land tenure reform is to upgrade these informal rights into secure forms of tenure recognised in law (De Wet, 1997).

Additional policy and legislation pertaining to land reform has also been forthcoming at national level in recent years. This has included the Communal Property Associations Act (1996), the White Paper on South African Land Policy (1997) and the Draft Land Rights Bill (1998). More specific developmental policy has also emerged at both national and provincial level. The Eastern Cape agricultural policy, for example, has laid down a number of specific objectives with regard to the development of farming as a livelihood in the province:

- To increase agricultural production in the former homelands in order to export basic foods, but to do this on a sustainable basis of ecological integrity, economic viability and socio-political acceptability,
• To make agricultural production market-orientated,
• To focus financial support on resource-poor and beginner farmers to enable them to buy land,
• To provide support to farmers in production, marketing, financial aid, institutional infrastructure, technology development and training.
(Province of the Eastern Cape, 1997).

1.3.2) THE AGRARIAN POLICY DEBATE IN SOUTH AFRICA: ISSUES OF SCALE AND TENURE

Despite the more specific policy that has emerged in recent years, the general emphasis has been on policies advocating the acquisition of land and its use for agricultural production as a panacea for improving rural livelihoods. In conjunction with land acquisition, the smallholder development path has also been encouraged both by government and other sources. Explicit support for this has been provided by the RDP, which emphasises that restructuring of the agricultural sector consists of spreading the ownership base, encouraging small-scale farming and increasing production and employment (ANC, 1994). This has its foundation in the World Bank's Options for Land Reform and Rural Restructuring in South Africa, which functioned as the empirical basis for much of what was laid out in the RDP (World Bank, 1993). This document supported ideas of restructuring based on the development of smaller scale units (in a manner synonymous with the concept underpinning much of the Betterment process) and viewed land reform as a vehicle for promoting a variety of land use activities including small-scale farming. It also mooted the somewhat ambitious target, subsequently embraced by the RDP, of transferring 30% of white owned farmland to landless blacks in the first five years of government (for a comprehensive critique of this and other policy options identified in the World Bank's paper, see Williams, 1996).

Support for the small-farmer development path has also come from academic circles, most notably Merle Lipton and Michael Lipton. It is their belief that agricultural reform must enhance rural livelihoods by promoting a labour-intensive, efficient
small-scale agriculture. They argue that small-scale production is eminently suited to
developing countries where capital is scarce and labour abundant. That small-scale
agriculture is not widely practised in South Africa is a result of gross distortions in favour of large-scale white farmers, who not only have access to the majority of land but also to vastly superior marketing facilities and support services (Lipton & Lipton, 1994). These distortions are reflected in the fact that the contribution of agriculture to Gross Domestic Product (GDP), is far below the level expected given its GDP per person (Lipton, 1996).

At the other end of the spectrum are those who advocate that the effective generation of rural livelihoods through agriculture can only occur through a large-scale approach to farming. They argue for the intrinsic superiority of large-scale production from the perspective of greater efficiency due to economies of scale and labour division, both of which lead to gains in productivity (Bernstein, 1997). The main proponents of this approach in South Africa have been the Macroeconomic Research Group (MERG) of the University of the Western Cape.

Bernstein (1997) has offered an effective critique of both the large and small-scale approaches to agriculture in the South African context with regard to their lack of potential to deal effectively with poverty. Whilst Bernstein recognises the importance of issues of farm size and efficiency, he advocates that they need to be formulated into a different agenda - one which focuses on characterising social relations and how they allow for different outcomes, constraints and possibilities. In other words, the emphasis must be on a political solution which recognises existing social diversity, in particular power structures at the local level, rather than simply concentrating on issues of scale.

Furthermore, the relevance of prolonged debate over issues of scale can also be questioned with specific regard to the former homelands. In areas such as the former Ciskei, land is at a premium, and for the foreseeable future land holdings will never be large enough for households to depend on agriculture as a livelihood. Thus, it can be expected that agriculture will continue to form part of a multi-stranded survival strategy rather than a sole income source, and that agricultural interventions to help
the majority of the rural poor in these areas will, out of necessity, have to be small-scale in nature. The important point is that policy and interventions must recognise and deal with immediate practical constraints. That current provincial policy in the Eastern Cape advocates increasing agricultural production in former homeland areas on a commercial basis, such that they become net exporters of food, suggests that policy makers are still far removed from the social and economic realities in these areas (Province of the Eastern Cape, 1997).

The other major component of the government's Land Reform Programme has been land tenure reform. In recent years there has been considerable debate as to the most effective form of tenure system for facilitating successful agricultural and rural development in South Africa. Reference to Appendix 1 shows that the land tenure types of the former homelands fall into two broad categories: communal tenure (including communal tenure proper and Trust tenure) and individual tenure (quitrent and freehold).

Communal tenure is widely recognised as having a number of constraints with regard to agricultural production. These are:

- Land is not available to people from outside the community
- Land cannot be sold and thus used as security for loans or debts
- As a result of the previous two points, land cannot be accumulated and this prevents it moving to those who could use it most efficiently
- The rigidity of the tenure system leads to land being under-utilised
- Conversely, communally grazed land belongs to the entire community and so there is frequently no incentive to conserve the resource, which leads to over-utilisation and low levels of production.

(Adapted from De Wet, 1987b).

It is clear that in most respects communal tenure is not ideally suited to encouraging increased agricultural production. This is particularly true of crop production where the rigidity of the tenure system, combined with the fact that land cannot be sold, prevent people from accumulating sufficient land to grow a crop large enough to
provide a living. However, with regard to livestock production, communal tenure
does appear to have some strong allies. Cousins (1995 &1996a) has suggested that
common property regimes have a key role to play in livestock production. Incentive
to invest is maintained as long as the user group is well defined and a strong
institutional structure exists to enforce rules and regulations. In these situations
communal livestock production can be an effective means of improving rural
livelihoods (see section 1.4.3).

Individual tenure is generally envisaged as being superior to communal tenure in
terms of its potential for promoting agriculture as a sustainable livelihood (Moll,
1988). However, distinction must be made at this point between quitrent and freehold
tenure. Quitrent tenure provides greater security than communal tenure so long as
quitrent fees are paid. It is also more flexible than communal tenure in the fact that
land can be sold and used for a wider variety of purposes. However, in all other
respects it suffers the same constraints as communal tenure, particularly with regard
to land holdings being small and uneconomical. Furthermore, the advantages of
quitrent tenure do not extend to grazing land in the reserve areas as this is always held
under communal tenure. Freehold tenure is generally deemed to offer the greatest
opportunity for agricultural development in that: -

- It offers the greatest flexibility of land use and thus allows for optimum use of
  land leading to increased outputs.
- It allows the most efficient farmers to gain access to land.
- Over time farm sizes would tend towards optimality.
- It provides the security of tenure necessary to encourage investment.
- It promotes resource conservation as it is in the owner's best interest to do so.
- It can be taxed which makes money available for the development of
  infrastructure in the local community.
(Adapted from De Wet, 1987b).

A number of advocates believe freehold is the most effective means of improving
agricultural production in former homeland areas (e.g. Louw, 1988; Anim & Lyne,
1992). However, concern has been expressed in many circles that the widespread
provision of freehold tenure in rural areas may lead to increased landlessness as a result of families selling their land (Government of South Africa, 1997b). With widespread poverty in rural areas, there is the very real danger that in times of cash flow crisis, rural households may be tempted to sell their land. This may extend not only to arable allocations but also to residential sites, and could serve to exacerbate current problems of overcrowding and homelessness.

The government's position is that people should be free to choose the type of tenure they want, although it adopts a positive attitude towards communal tenure (for security reasons) and group tenure (Government of South Africa, 1997b). Moor and Nieuwoudt echo these sentiments, when they advocate that: "Accepting diverse forms of tenure is pragmatic, as the issues are sensitive ones." (1996: 67). Indeed, they recommend something of a compromise through the adoption of what they term "adaptive policies". These are not explicitly defined, but would allow for the gradual change towards more exclusive rights while still retaining the safeguards provided by communal tenure (Moor and Nieuwoudt, 1996).

However, the reality of the situation is that productivity may be low regardless of tenure type as other more important factors may act to stifle investment (Place & Hozell, 1993, cited in Moor and Nieuwoudt, 1996). In areas which have been historically neglected (e.g. former homelands), it is important to question if the prevailing land tenure system really is the major constraint to agricultural development. De Wet (1987b & 1988) concluded that tenure was only part of the overall problem of low agricultural production in the Ciskei. Far more pressing was the need to address some of the more fundamental shortcomings in both infrastructure and support services, which will improve the standard of living in rural communities and impact on agricultural production both directly and indirectly. These include:

- Improved access to water. The introduction and maintenance of additional windmills and standpipes in rural villages would make more water available both for agricultural and domestic purposes.
• Improved transport facilities. Improvements in both road networks and transport services would enable greater access to local markets both for producers and consumers.

• Improved access to credit facilities. The provision of credit facilities would enable people to purchase vital agricultural inputs. Loans could be guaranteed by pledging stock as collateral or debts could be repaid by provision of labour for local government development initiatives.

• Improved extension services. The reintroduction of dipping and veterinarian services for livestock and of tractor hire schemes for crop production would be a major advance. So too would be training courses on the effective use of scarce agricultural resources.

(Adapted from De Wet, 1988).

What is clear is that in areas such as the former Ciskei where the above systems are underdeveloped or unavailable, policy must be geared towards addressing these considerable shortcomings if sustainable agriculture is to remerge as a livelihood option. That the ongoing debate on effective strategies for the development of sustainable livelihoods in rural South Africa continues to focus on issues of scale and tenure in the context of commercial agriculture, demonstrates little understanding of social realities in former homeland areas.

1.3.3) BEYOND LAND AND AGRICULTURE

Indeed, the legitimacy of the whole Land Reform Programme as an appropriate vehicle for enhancing rural livelihoods in South Africa has been questioned by many. The emphasis on land redistribution has been branded as a "populist" and "welfarist" approach by many (see for example McIntosh and Vaughan, 1996; Bernstein, 1997). Whilst the policies of the Land Reform Programme have in principle recognised the need to use land productively, acquisition of land for the purposes of agricultural production has not, in practice, been the central concern (McIntosh and Vaughan, 1996). Rather, the policies have been informed by the "undermining impacts of apartheid policy on communities and individuals" and "by specific experiences of
land dispossession." (McIntosh and Vaughan, 1996: 92). Thus, many viewed the primary goal of land reform, particularly in its early stages, not as developmental but as political. Furthermore, the policy that initially guided land redistribution was very general and lacking in clear criteria for the acceptance of project applications. The absence of a coherent policy framework, and the fact that communities have been encouraged towards communal purchase (whereby individual land acquisition grants are pooled by a group of people and used to purchase land under communal tenure), has tended to produce land reform projects of a single type. These have frequently been large and unviable undertakings with only limited potential for the generation of sustainable livelihoods in agriculture or any other pursuit (McIntosh and Vaughan, 1999).

The type of rural transformation envisaged by post-apartheid planners has remained elusive. The fundamental stumbling block has been the lack of appropriate mechanisms for integrating and overseeing both land reform and development at the rural level. Many view the fact that vast tracts of the South African countryside lie beyond the reach of democratic systems of governance and administration as the main problem. Bernstein (1997: 28) suggests the need for a "national democratic revolution" as a means of releasing and advancing the political energies, ideas and effectiveness of oppressed social classes and groups within the framework of capitalist society. At a more practical level McIntosh and Vaughan (1996 & 1999) have also advocated the importance of developing representative local administrations. However, they accept that traditional authorities and other community management systems remain the structures through which rights and resources are allocated in many rural areas of South Africa. These frequently have their own vested interests and can make the process of implementing land reform and development initiatives extremely difficult (see for example Ntsebeza, 1999 for the Transkei area of Eastern Cape and McIntosh et al., 1996 for KwaZulu-Natal).

Nevertheless, the limitations of the state both financially, and in terms of the democratic apparatus currently available, suggest that this situation is likely to continue into the foreseeable future. Thus, developing close working relationships with existing community management structures will be essential for effective service delivery in the short term. In the longer term, it may be possible to replace existing
structures with more representative ones, but this is likely to be a decision that will have to be made by local municipalities on a case by case basis (McIntosh and Vaughan, 1999).

In the former Ciskei, problems with vested interests amongst non-elected power structures are less immediate. With the fall of the Lennox Sebe regime in 1989 communities demanded change to the existing system of local governance. They rejected the tribal system based on village headmen, chiefs and tribal authorities, which was the foundation of the homeland system of administration, and instead embraced community governance by democratically elected civil structures (Van Averbeke, 2000a). Thus, in central Eastern Cape democratic structures of local governance are widespread, although the old tribal powerbase is sometimes perpetuated despite this (Holbrook, 1998a). Of more pressing concern for development at the grassroots level is the need for more effective interface between representative bodies at the village level and local councils (Christianson, 1995).

1.3.4) THE REALITY OF AGRICULTURE IN RURAL DEVELOPMENT

The above discussion has served to highlight some of the major debates with regard to the most effective means of developing sustainable livelihoods in rural areas of South Africa. The focus has been on agriculture and land reform and more particularly on the issues of scale and tenure. At a broad level it has questioned whether land reform in tandem with agriculture really can play an effective role in the development of sustainable rural livelihoods or whether the real objectives of this "populist" approach are political rather than developmental. Furthermore, it has served to question if many of the more specific issues currently being debated really are of paramount importance in light of the overwhelming constraints at the local level, particularly with regard to effective mechanisms for the implementation of development initiatives.
In reality there are no specific answers. Rather a practical case by case approach to the planning of development projects needs to be adopted such that specific needs and constraints are adequately accounted for. In light of this it can be concluded that:

- Both agriculture and land reform have an important role to play in rural development, but the two do not have to occur in tandem. Land can be redistributed for a variety of specific objectives and agriculture can be developed as a sustainable livelihood without the need to redistribute land or reform the tenure system that governs it.

- Farming as a livelihood strategy amongst rural blacks will evolve at a variety of scales and tenure types suited to the prevailing objectives and constraints at the local level. Farming may be on a full-time commercial basis or as a stream feeding into a more diverse livelihood strategy.

- An effective system of local representation will be essential for the viability of any development project.

These tenets essentially form the starting point of this research. More specifically, the fundamental principle governing the research was that: "…perhaps the most that can be achieved is to ensure that existing resources are managed more efficiently." (McIntosh and Vaughan, 1996: 117). This approach recognises the overriding social and ecological constraints at the local level and tries to work within them by setting realistic objectives. The research undertaken for this project focused on cattle production in communal areas of the former Ciskei. Before introducing the aims of the project, consideration will be given to some of the issues in the debate surrounding communal livestock production as a sustainable livelihood strategy.
1.4) COMMUNAL LIVESTOCK PRODUCTION AS A SUSTAINABLE LIVELIHOOD STRATEGY

1.4.1) THE ROLE OF LIVESTOCK

The cultural role of cattle in the lives of black people in Southern Africa has been well documented (Coertze, 1986; Comaroff and Comaroff, 1992; Schmidt, 1992). This has led to the widely held perception that cattle were kept primarily for reasons of status and prestige (the so-called "cattle complex") and that this has imposed severe limitations on the ability of owners to manage them productively for the purpose of generating income (Düvel and Afful, 1996 & 1997). Whilst the keeping of cattle amongst black peoples is not production oriented in the sense of commercial livestock farming, it must be accepted that cattle contribute to their rural livelihoods in a variety of different ways. According to Hundleby (1991), the five most important reasons for keeping cattle amongst black peoples are: -

1. Milk for domestic consumption.
2. Animals for social exchange (lobola) and security.
3. Animals for slaughter (ceremonies).
4. Animals for sale to meet short term cash requirements.
5. Draught purposes.

The reasons for holding stock are likely to vary considerably between regions and households according to cropping potential of the area, proximity to urban centres and markets and the stage of development of the household (Hatch, 1996).

Although, livestock ownership is centred on cattle, small stock also have a particular role to play that may complement rather than compete with that of large stock. Studies have indicated that goats and sheep are especially valued for providing meat as well as for the rapid mobilisation of cash in times of emergency. The higher turnover (due to greater fecundity) that is possible with small stock means that these
losses can be quickly recovered. They are also of particular value to poorer households since they can be sold without disposing of a high proportion of household assets (Colvin, 1991).

The inherently general purpose nature of livestock in Xhosa life was summarised eloquently by one old man interviewed by ARDRI researchers, who equated the reasons for ownership to those of keeping a toolbox: -

“When you have a toolbox, you will use the different spanners and tools at different times, depending on the particular problem that requires attention. You cannot say that you keep a toolbox for any particular incident only” (ARDRI, 1996: 9).

Attaching actual values to herd output under communal tenure is problematic since most of them are of an indirect nature. However, several attempts have been made and considerably higher returns under communal tenure than private tenure have been reported. Scoones (1992, cited in Hatch, 1996) has demonstrated that the value of herd (cattle and goats) output from communal lands in Zimbabwe was Z$104.5/ha provided the full range of benefits from communal tenure was considered. This compared to just Z$5.80-Z$14.10 for commercial beef ranching under private tenure. The higher returns under communal tenure could be attributed to higher stocking rates relative to commercial production, inclusion of the value of goats, and consideration of the full range of values of cattle including draught, hides, transport and manure. The differences also result from the low costs of holding stock under communal tenure since grazing is effectively free and herding costs are kept low by the use of schoolboys. Similarly, Buchan (1988, cited in Colvin, 1991) quantified the value of livestock to owners in Maputaland (in what is now KwaZulu-Natal province) in terms of the local economy. He deduced that the product value from cattle was in the order of R277/head/year, which represented an excellent return on investment compared to commercial cattle farms in the region.

Together these demonstrate the potential of communal livestock production as a sustainable livelihood strategy for rural areas of South Africa. Although herd size is

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1 Lobola is an agreed price paid by the family of a bridegroom to the family of his bride.
generally insufficient for most households to subsist solely from livestock production, they are able to provide a valuable (largely indirect) source of income and security and require relatively little investment in terms of both time and money.

1.4.2) LIVESTOCK NUMBERS AND ECOLOGICAL SUSTAINABILITY

Livestock number in relation to resource degradation has been the source of considerable debate in recent years. Previously, the widely held view had been that high livestock numbers led directly to loss of vegetation cover and ultimately soil erosion. This was first articulated in South Africa in the Report of the Native Economic Commission of 1930-32, which stated that large areas of the reserves were degraded and that excessive numbers of livestock was the major contributory factor. This ultimately led to the implementation of betterment as a mechanism for "rehabilitating" these areas (see above). Government policy throughout the apartheid administration perpetuated this stance and forced destocking was a common feature in many betterment areas (De Wet, 1987a). Such policies were given credence by the continuous claims of many pasture scientists during this period that overstocking was the primary cause of range degradation in communal areas (e.g. Trollope and Coetzee, 1975; Forbes and Trollope, 1991).

However, over the past two decades the link between high stock densities and rangeland degradation has been increasingly questioned. For pastoral systems in East Africa, Hary et al., (1996) have demonstrated that it is not high stock densities per se that result in range degradation but the sub-optimal distribution of livestock numbers in time and space. Similarly, Abel (1993), modelling pastoral systems in Botswana, has shown that soil loss from range areas is only marginally greater under very high stocking rates than very low ones. Whilst neither study denies a link between livestock numbers and range degradation, the overall conclusion in both cases is that a drastic reduction in stock numbers would do little for resource conservation but would impact severely on the productivity of pastoral production systems.
For South Africa, Tapson (1993) has demonstrated the inherent resilience of communal rangelands in KwaZulu in the face of constant warnings over a 50-year period that the system was "overstocked" and facing imminent ecological collapse. If the ability of the veld to support livestock had really been impacted during this period then a decline in stock numbers would have been expected and an increase in mortality. Using available data from 1974-88, he has shown that there was in fact an increase in livestock numbers from 1.27 million in 1974/75 to 1.515 million in 1987/88. Over this time numbers have fluctuated around a mean of 1.39 million with a coefficient of variation of just 0.05. Furthermore, mortality has actually declined over this period. A similar story emerges from other communal areas in South Africa. Cattle numbers in the former Transkei have remained constant at 1.3-1.5 million since the 1930s (Beinart, 1992). This situation persists despite the fact that the communal range areas in these former homelands may be carrying stock densities that are up to five times higher than would be recommended for commercial farming in equivalent vegetation types (ARDRI, 1996; De Bruyn, 1998).

That communal rangelands have been able to support such high stocking densities over prolonged periods of time has been attributed by many range scientists to their natural "resilience". Walker (1980) contends that the semi-arid grasslands, of the type that dominate much of South Africa, fit in well with this concept of resilience. These areas are inherently unstable and low and erratic rainfall plays a major role in determining community dynamics (Ellis and Swift, 1988) and forage production (Hatch and Tainton, 1995). However, stocking pressure may interact with rainfall to influence compositional change within the vegetation community (O’Connor, 1991). Their resilience manifests itself in the fact that even under conditions of high grazing pressure and substantial vegetation change (such as under a communal grazing system) good rainfall will allow them to recover rapidly to an equilibrium state. Conversely, well-managed grasslands of the type used on commercial farms are characterised by a lack of resilience. Despite the fact that they are in a stable, climax condition and thus are not readily influenced by conditions of stress, any serious perturbations (e.g. drought) that result in a critical level of change may prevent the system from returning to an equilibrium condition (Walker, 1980).
The above model explains the inherent resilience of semi-arid grassland systems but not that of grasslands occurring in moist and mesic environments. These are characterised by considerably greater levels of stability due to dense grass cover, inherently stable soils and relatively reliable rainfall. Increased grazing pressure, and changes in the frequency and intensity of fires, leads to changes in composition, but not the cover of these grasslands (Hatch, 1996). The inherent stability of these systems would be expected to decrease their resilience and leave them open to irreversible vegetation change under adverse conditions of prolonged heavy grazing or drought. However, evidence from high rainfall areas of the former Transkei suggests that the situation is not this clear. McKenzie (1982) found that under heavy stocking conditions communal grazing lands were degraded in terms of the decline of more desirable climax species, but that the veld had frequently reached a new level of species composition which although poorer in production terms, was highly resilient to further change. Thus, resilience can also manifest itself in more stable systems under appropriate circumstances.

A more radical approach to the relationship between livestock numbers and range degradation has been taken by proponents of the so-called "new thinking" in range ecology. They suggest that the range dynamics in most arid and semi-arid rangelands is primarily non-equilibrial in character (e.g. Ellis and Swift, 1988; Behnke and Scoones, 1993). In these non-equilibrial (NE) systems feedback relationships between plants and animals are absent or severely attenuated and climate is the overriding factor driving rangeland dynamics. Thus, carrying capacity concepts based on traditional (equilibrial) density dependent ecological relationships are not applicable. They are highly variable systems in which the coefficient of variation (CV) of annual rainfall exceeds 30% (Ellis et al., 1993). They are also characterised by severe (sometimes multi-year) droughts that may occur more than once every decade and which prevent livestock from reaching densities that induce vegetation change (Coppock, 1993). Indeed, much of the support for NE dynamics comes from the lack of evidence linking rates of stock loss during droughts to stock densities prior to the drought (Behnke and Scoones, 1993). The new thinking has been closely linked to communal production systems since the uncoupling of livestock numbers and vegetation provides a strong ecological underpinning for the pastoralist practice.
of maximising livestock numbers whenever conditions allow. The opportunistic, tracking strategies employed by pastoralists and agro-pastoralists in Africa are thus viewed as being highly appropriate in heterogeneous arid and semi-arid environments (Behnke and Scoones, 1993). This applies not only at an ecological but also at an economic level. Sandford (1983) has suggested that the opportunity costs of a conservative stocking strategy increase as variability in rainfall increases. Conservative stocking strategies are based on the number of livestock which can be maintained when forage is scarce and therefore a cost exists in terms of unrealised livestock potential when forage is abundant. He argues that an opportunistic management strategy which tracks primary production will realise far more production potential under highly variable rainfall conditions.

The use of NE concepts to support opportunistic livestock management strategies on African rangelands has been heavily criticised. Illius and O'Connor (1999) argue that NE concepts have limited application to ecosystem processes in African rangeland because they do not justify the view that herbivory has little impact in climatically variable systems. Rather, they maintain that despite the apparent lack of equilibrium in these systems animal numbers are regulated in a highly density dependent manner by the limited forage available in "key resource" areas, which are utilised in the dry season. The implication for user groups is that management should be concerned with spatial heterogeneity in relation to grazing impacts, and with preserving the productive capacity of key resource areas. At the South African level the NE concept has also been subject to a sustained critique from range scientists (e.g. Scogings et al., 1999; Fynn and O’Connor, 2000). One of the major criticisms has been that the non-equilibrium paradigm predicts that the more climatically variable (unstable) range areas of South Africa will be the least impacted by high livestock densities since rainfall is the overriding factor in plant production. However, there is considerable evidence that these are actually the most degraded areas in South Africa at both a commercial (Dean and McDonald, 1994) and communal level (Hoffman et al., 1999). Furthermore, it would appear that this degradation is not of a short term or climatically reversible nature (Dean and McDonald, 1994).
Ainslie et al. (1998) have criticised the non-equilibrium paradigm in that it has only found direct application in extensive rangeland systems in which opportunistic herd management strategies track resource variability over large areas. It is not possible for livestock to track resource availability over large areas in the communal rangelands of South Africa because most communal areas have been subject to some form of planning. This has inevitably involved fencing of grazing areas, which has severely restricted livestock movement. This is particularly true of the former Ciskei, where 78.7% of the area was subject to Betterment planning and 86.5% of these planned areas were under some form of range management (Trollope and Coetzee, 1975). Nevertheless, with the lack of enforcement of government culling schemes high densities of livestock have frequently been maintained in these areas over considerable periods of time with varying and debatable levels of resource degradation. This suggests that opportunism in terms of maximisation of livestock numbers at appropriate times remains an effective management strategy for livestock owners in communal areas of central Eastern Cape Province, despite the lack of applicability of the NE concept in this area.

In sum, the above discussion does not conclusively deny the link between communal livestock production and rangeland degradation. In essence, this is because range scientists have been unable to provide sufficient empirical evidence to support or refute a causal relationship between the two. Indeed, there are still many anomalies that cannot be adequately explained by current theory. However, the discussion does serve to demonstrate that warnings of impending ecological catastrophe since the 1930s have not been realised. Furthermore, destocking as a mechanism for limiting resource degradation in communal areas of South Africa is unlikely to be successful, and would probably serve only to compromise the livelihoods of those who depend on livestock as a source of income. Whilst range continues (for whatever reason) to sustain relatively high livestock densities, opportunistic management strategies will continue to be employed by livestock owners in communal areas. Indeed, there is considerable evidence that the communal rangelands of South Africa are fully stocked and have been for some time suggesting that the situation is stable and sustainable (Hatch, 1996). However, more adequate theory needs to be developed through long-
term studies at the plant-animal interface before anything definitive can be said about the long-term viability of high stock densities on communal range in South Africa.

Having established (or at least failed conclusively to disprove) the legitimacy of communal livestock production as a sustainable livelihood strategy in South Africa from an ecological perspective, some of the institutional aspects necessary to ensure its effective implementation will now be considered.

1.4.3) COMMON PROPERTY INSTITUTIONS

Thus far the discussion has made extensive use of the term "communal" with reference to the production systems existing in former homeland areas of South Africa. In communal areas throughout Africa there has been a tendency to associate communal grazing with Hardin's "tragedy of the commons" paradigm (1968). However, Hardin's paradigm fails to distinguish between open access in which there are no limits to resource access, and common property (Ciriacy-Wantrup & Bishop, cited in Cousins, 1995). It must be emphasised that common property is not "everybody's property". Rather, the concept of common property implies that potential resource users who are not members of a co-equal group of owners are excluded. The major features of common property systems can be summarised as follows:

1. no single individual has exclusive rights to the use of the resource;
2. group members have secure expectations that they can gain access to future use of the resource;
3. there are functioning membership criteria;
4. there are communally defined guidelines for resource use;
5. there is an enforcement mechanism for punishing deviant behaviour.


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1 For the purposes of the research project, communal areas of South Africa are defined as those in which rangeland (although not necessarily arable or residential land) is held by a community and governed as a common property resource (see section 1.4.3).
Under common property the rights of individuals can be defined and regulated to prevent overexploitation of the resource. Thus, overgrazing is not the inevitable result of communal livestock systems, but arises because individuals are unable or unwilling to co-operate effectively to utilise resources in a sustainable manner. This highlights the major vulnerability of common property regimes: they depend on the incentive of local users and the authority of central institutions. Lawry (1990) has pointed out that the incentive to maintain common property regimes can be limited because common pool resources are not always of critical importance to local users. Furthermore, user groups are frequently heterogeneous in nature, which leads to differences in use strategies and the degree of interest in these resources. With regard to authority, the integration of local economies into larger systems has frequently led to the decline in importance of local political institutions. The result is that local groups are unable to defend their commons in the face of encroachment from outsiders, and traditional authorities and local committees are no longer in a position to enforce rules.

In light of these experiences, it seems appropriate to consider how common property institutions can be developed and re-orientated in order to deal effectively with contemporary conditions of extensive livestock production in South Africa. Cousins (1995), identifies a number of critical issues which must be addressed in this process many of which have relevance in former homeland areas: -

**The structure and definition of user groups.** Common property regimes must define who has access to resources and who is excluded. Membership criteria must therefore be clarified, including the rights and duties of absentee members of rural communities. The size of user groups is also of importance as there is less likelihood of transgressions in smaller, more cohesive groups. Finally, it is crucial to have a clear understanding of the socio-economic structure of user groups and the likely impact of this on the use of common resources. As noted above, heterogeneity within user groups is a potential source of conflict and appropriate rules governing resource use have to be negotiated.
Power structures. Lawry (1990) has highlighted the problem of the demise of effective common property institutions in many situations. Under these circumstances it is inadequate simply to advocate the decentralisation of state authority as a prescription for effective management of communal resources. Rather, there appears to be a need for the "nesting" of local level institutions in a larger state structure. This "co-management" approach would involve the state creating the conditions for effective local management by clarifying group territories and providing technical and infrastructural support. However, this approach should aim to be facilitative and supplementary and should not attempt to replace or undermine local institutional capacity.

A further problem alluded to previously, is that of traditional authorities. Many feel that the presence of a democratic central government in South Africa should be accompanied by the emergence of "organs of civil society" at the local level (Bernstein, 1997). The presence of unelected customary authorities such as chiefs and headmen presents something of an obstacle to this goal. These have a popular following in several areas and have consistently resisted attempts to erode their power base or suggestions that they offer themselves as candidates in local democratic elections (Ntsebeza, 1999). However, whilst these may pose serious problems for local governance in former homeland areas such as Kwa-Zulu and Transkei, the emergence of effective civic organisations in much of the former Ciskei has largely eliminated this problem.

Resource management rules. These govern the way in which a communal resource is used with regard to the definition of jurisdictional boundaries and the partitioning of resource use. The latter imposes limits on where, when and to what degree resources can be exploited by group members. It is vital that these rules take adequate account of technical and ecological realities in each area as well as giving due recognition to local knowledge.

Enabling policies. One of the key steps in this area in South Africa has been the recognition of common property regimes in law. The Communal Property Associations Act (1996) has put in place a legal framework for the governance of
communal resources on a group basis. This was to have been taken a stage further by the proposed Land Rights Bill of 1998, which recognised existing community practices with regard to land management and allocation and allowed for different levels of security of tenure. Importantly, it also acknowledged the role of local institutions in managing land rights and made provisions to ensure that existing community practice follows the appropriate course. Unfortunately, this Bill was scrapped when the new government took power following the June 1999 elections. In its place a new tenure framework is being developed which provides, amongst other things, for the transfer of land to “tribes” (Claassens, 2000). How practical such a system will be and how much provision it makes for control of resources at the community level remains to be seen. What is clear is that legislation of the type proposed in the draft Land Rights Bill will be vital if communal livestock production in former homeland areas is to meet the objectives the government have defined for it.

Much of this discussion is of direct relevance to the former Ciskei, where huge pressure on available grazing resources has frequently led to a collapse in existing common property systems such that user groups are no longer adequately defined. In these situations common property has become more like open access with many communities, particularly those displaced from elsewhere, making use of grazing land over which they have no entitlement (Higginbottom, 1995). This has resulted in the authority of existing power structures being undermined, as they are bypassed by those individuals over which they have no jurisdiction, and viewed as ineffectual by their own constituents in the face of increasing resource degradation over which they have little control (Higginbottom, 1995). Consequently, resource management rules no matter how well defined, are of little use as they can no longer be effectively enforced. In such situations new legislation which recognises the role of local institutions in managing their own grazing land, will be of little practical use unless it also brings the weight of the state behind the enforcement of rules at the local level. A vital part of the solution will also be provision of formal grazing resources for those who do not currently have official entitlement.
1.4.4) INTERVENTIONS IN THE SOUTH AFRICAN CONTEXT

It is clear that communal livestock production in South Africa can be justified from both an economic and ecological perspective as a livelihood strategy for rural South Africans. Essential to the effective governance of the production system will be strong common property institutions that are able to define and enforce grazing rules, resolve conflicts between users and cultivate linkages with local government. However, it must be recognised that one of the fundamental barriers to the more widespread adoption of communal livestock production as a livelihood strategy is the shortage of grazing land. Opportunism as an effective management strategy requires substantial quantities of grazing land such that efficient use can be made of patchy resources and animal numbers remain discoupled from vegetation availability. However, when land is a limiting factor there will always be feedback between livestock and available forage. Land redistribution might provide a solution in a limited number of cases, but it is generally a lengthy and complicated process. Moreover, in most former homeland areas there is often a very limited amount of land available for redistribution, which prevents this from being a practical option. Thus, at least in the short term, the focus of interventions must be on increasing the efficiency of opportunism as a management strategy in these areas (Sandford, 1994, cited in Cousins, 1996b). The following broad suggestions from Cousins (1996b) for increasing rangeland productivity can be seen to have relevance in many communal areas of South Africa:

- provide more water points or boreholes;
- improve veterinary care to increase the health of herds;
- improve the productivity of key resource patches;
- develop more stable feed supplies by encouraging the adoption of forage;
- engage in breeding programmes to improve the physiological capacity of indigenous breeds to track environmental variability;
- invest in improved marketing systems and infrastructure.

These reinforce many of the general constraints facing agriculture in former homeland areas that were outlined previously. In essence one of the key features of improving
livestock productivity at the village level will be making more effective use of available grazing resources. This was the general rationale adopted for this research.

1.5) THE RESEARCH PROJECT

1.5.1) THE SUITABILITY OF THE CENTRAL EASTERN CAPE REGION TO THE RESEARCH UNDERTAKEN

The central Eastern Cape region is delineated as the land that falls between the Kat and Great Fish Rivers as the western boundary, and the Kei River as the Eastern boundary (Figure 1.1, overleaf). It covers an area of some 18,024 km$^2$ and includes the former homeland of Ciskei (8,100 km$^2$) and the so-called "Border" region (9,924 km$^2$) that adjoins it, and formed part of what was until 1994 East Cape (Van Averbeke, 2000b). The communal grazing areas lie almost entirely in what was Ciskei and all subsequent discussion will be with regard to this former homeland.

The former Ciskei is highly variable both in terms of climate and topography. It stretches from sea level along the Indian Ocean coastline to more than 1800m above sea level in its more mountainous areas. The majority of the environment can be described as arid or semi-arid (Hundleby et al., 1986). Rainfall varies from less than 500mm in low-lying inland areas to more than 1000mm in the mountains. Most rain falls during the summer months and follows an essentially bimodal pattern with peaks around November and March (Austin, 1989). Winters are generally cold and dry. Approximately 13% of the area of the former Ciskei is classified as arable (Charton, 1980). However, at a general level it can be said that due to considerable climatic variability, lack of soil depth and lack of soil moisture content, the former Ciskei does not have a great deal of potential for dryland crop production (Hundleby et al., 1986). Although, extensive levels of crop production were achieved in the Ciskei region during the latter part of the nineteenth century this was not without considerable cost to the environment. Some 47% of the former Ciskei area has been classified as “moderately” to “seriously” eroded (Ciskei Commission, 1980, cited in Weaver, 1989). This has generally been attributed to the high concentrations of stock on what
are now communal rangelands. However, there is now evidence to suggest that current erosion levels are mainly a legacy of much of the land being ploughed up for crops during the rapid expansion of the African peasantry in this area (M. Coleman unpublished data, cited in Scogings et al., 2000a). Thus, the former Ciskei must be perceived essentially as a land best suited to livestock production from natural grassland (veld) and pasture.

Figure 1.1: General overview of the central Eastern Cape region

The vegetation types broadly follow the different climatic zones and reflect the suitability of the area for grazing. 51.1% of the natural vegetation can be classified as sweetveld. Vegetation types falling within this classification are important for
livestock production as they retain their nutritional value during the winter. 20.7% of the vegetation is sourveld, which loses its nutritional value during the winter. The remainder (28.2%) is mixed veld, which is a combination of sweet and sourveld in varying proportions (Hundleby et al., 1986).

The propensity for livestock production in this region is further reflected in the statistics on gross value of agricultural production. In 1979/80, livestock production was the most valuable form of agricultural production in Ciskei, accounting for 61% of gross value (Van Rooyen et al., 1987, cited in Van Rooyen, 1990). By 1987 this had further increased to 81.9% (Development Bank of Southern Africa, 1989, cited in De Lange, 1991). The preference for livestock production is shown not only at a communal level but also within commercial agriculture within the region. Data from 1991 in the former East Cape (the “white” area of what is now Eastern Cape Province), show that livestock production accounted for approximately 75% of the total gross income from agriculture (Antrobus et al., 1994, cited in Scogings et al., 2000b).

At a more general level, communal livestock production also has the benefits of requiring low levels of investment, which, as noted previously, allows it to realise relatively high levels of return on investment. This gives it an inherent advantage over crop production, which even in communal areas can be very costly in terms of both time and money. Indeed, detailed studies of black farmers in communal areas of the former Ciskei have found that the returns on crop production are frequently negative (M.C. Mbuti, unpublished MSc data).

The applicability of livestock production is also explicitly recognised in current government policy. In devising and testing small scale farming systems in the Queenstown area of Eastern Cape (the central Eastern Cape region), the Government’s Land and Agriculture Policy Centre (LAPC) considered the following two factors to be of particular relevance: -
• There is a cultural aptitude for keeping livestock and a preference for the consumption of animal products like meat and sour milk, suggesting that any farming system with a large livestock component will find ready markets.

• Livestock have the further advantage of being more resilient to droughts – to which the area is prone – than are crops, the chief of which maize, may produce nothing if the rain fails at a critical stage.


Having stated the case for the applicability of the region to livestock production from both a physical and economic perspective, consideration will now be given to the origins of the research project and its structure.

1.5.2) ORIGINS AND STRUCTURE OF THE RESEARCH

The decline in crop production in communal areas of South Africa, has led to large amounts of cropland being left fallow in the medium to long term. This has been particularly problematic in the former Ciskei, where the collapse of state run farm support services such as the Farmer Support Programme (FSP) since the early 1990s, combined with already marginal environmental conditions for crop production, have had a devastating impact (Deliwe, 1995). The desire to use this agricultural land more productively was articulated by local villagers at a series of discussion groups conducted during 1995 in several communities in the former Ciskei. These were essentially participatory rural appraisal (PRA) sessions organised by staff from the Agricultural and Rural Development Research Institute (ARDRI) at the University of Fort Hare (ARDRI, 1996). They provided an opportunity for villagers to express their immediate needs at the local level. The outcome of these discussions was the development by ARDRI of a broad Land Use Systems Research Programme, a specific component of which was a project that focussed on making more efficient use of arable land allocations for agricultural production.
The research work undertaken for this PhD fell within this specific branch of ARDRI’s LUSRP. The overall goal of the research was to assess the current and potential use of arable land allocations for agricultural production. Particular emphasis was given to linkages between livestock and arable land as this has received relatively little research attention in South Africa, and has been especially neglected in former homeland areas (Colvin, 1991). Indeed, the lack of adequate integration between the use of arable land and livestock production has been identified as one of the most serious constraints to deriving full benefits from livestock holdings under traditional management systems in Eastern Cape Province (De Lange, 1991). An holistic overview of current livestock management systems, together with an empirical investigation of the current and potential role of the forage occurring on arable lands in livestock production, formed the basis of this research. A parallel although separate study of the current and potential use of arable land allocations for crop production was undertaken as a Masters project (Mbuti, unpublished MSc data).

1.5.3) RESEARCH PARAMETERS

The research scope of the project was limited to cattle. The reason for this was largely practical, as cattle are known to make most use of the bulk of the available forage on arable lands because, of all the livestock species, they are best adapted from a physical perspective to do so (Hanley, 1982). The intention from the onset was not to focus on particular aspects of cattle production, but rather on ways of improving animal maintenance, particularly during the dry winter months when forage quality becomes a real constraint to animal production from communal range areas. This gives explicit recognition to the multi-purpose nature of cattle in the livelihood strategies of the black peoples of South Africa, particularly the Xhosa people in Eastern Cape Province. The overriding consideration in the definition of the objectives was that forage resources were a limiting factor and that the most effective way of improving livestock production in the first instance was to find ways of utilising them more efficiently. This would necessitate a detailed characterisation of

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1 For the purposes of the research, arable land allocations are defined as those areas of land, which were specifically designated for crop production through betterment or other land allocation processes. Their current use, however, may not necessarily follow this original designation.
the way these resources are currently utilised as this had not been adequately documented in communal areas before. This characterisation would need to deal with both ecological and social aspects of utilisation, and combine these with investigation of alternative management regimes in order to produce a set of recommendations that were realistic.

It was also vital that the objectives of the project were compatible with both current development thinking and the specific vision of the South African government with regard to agriculture as a mechanism for uplifting rural livelihoods. The sustainable livelihoods approach to development has a strong focus on both people and poverty. It was thus important that both of these aspects were recognised in the research objectives that were defined. It has been mentioned above that the desire of the communities to utilise arable land allocations for agriculture more effectively had been expressed during the earliest participatory appraisal meetings held in 1995. There was thus a people focus from the earliest possible stage. In addition, by working in villages in a former homeland area the project was by definition targeting people who are amongst the poorest in the country. However, the extent to which a project that centred on cattle production could effectively target the most needy sector of this rural population was unknown. It was therefore important that some assessment of this be undertaken as part of the research. To this end one of the initial goals of the research was to identify those social groupings which stood to gain most from interventions with a cattle focus. With these considerations in mind the following broad objectives were set out:

1. To assess the potential of agriculture as a mechanism for alleviating poverty within each village by investigating existing relationships between particular social groupings and involvement with land and agriculture.

2. To ascertain the current agricultural use of the arable land allocations, and in particular how they are managed as a grazing resource for cattle.
3. To determine the contribution of the arable land allocations to cattle as a forage reserve by investigating, both qualitatively and quantitatively, the behaviour of free-ranging cattle, the forage they consume during the winter and its nutritional value.

4. To identify and investigate alternative management regimes for the arable lands with potential for improving cattle production. Specifically, the effect controlled grazing during the summer time has on the resultant winter forage.

5. To develop a series of proposals for improving the cattle production systems that are acceptable to the communities involved, and are likely to result in a sustained improvement in the livelihoods of the people involved.
1.6) **SUMMARY**

This chapter outlines the rationale for the research work undertaken. The starting point for this thesis is that agriculture can play an effective role in enhancing rural livelihoods in the central Eastern Cape region. During the nineteenth century agriculture was practised almost ubiquitously amongst rural blacks at a variety of levels. Indeed, there is considerable evidence to suggest that during this time a class of relatively wealthy black peasants emerged, farming at a commercial level. They were able to persist until the early part of the twentieth century when the debilitating policies of the white minority government finally destroyed them. Since this time it has only been possible for the majority of blacks to engage in agriculture at a very limited level. Nevertheless, for many black people in rural areas agriculture still forms an important part of their inherently multi-stranded livelihood strategies (Monde-Gweleta *et al.*, 1997). Agriculture often functions as a "fall-back" measure - a form of security - for many rural households and thus its contribution to livelihoods cannot easily be quantified in direct economic terms. This is particularly true of livestock, which serve many purposes and often only realise their economic potential when sold in times of need.

The new democratic government of South Africa is keen to rebuild a limited African peasantry, which can compete effectively with the larger commercial farms and provide a livelihood for many black smallholders. This is particularly true in former homeland areas where the lack of industrialisation means that agriculture is one of the few areas with potential for improving rural livelihoods. In the central Eastern Cape region, livestock production has always had considerable potential as a livelihood strategy. From an ecological perspective the majority of the area is dominated by sweetveld which supports livestock production throughout the year. Culturally, the Xhosa people of rural Eastern Cape have always had a strong affinity with livestock, particularly cattle, which have traditionally played an important part in their lives.
There are now signs that the potential of communal livestock production as a mechanism for improving rural livelihoods is finally being recognised in government policy. The concept of communal property has now become enshrined in law and several other measures are planned to improve community control over grazing resources.

Thus, it is clear that a research project focused on cattle production as a means of improving rural livelihoods is highly appropriate to the central Eastern Cape region from both a cultural, political and ecological perspective. However, these are not the only considerations in assessing the suitability of a project. The project also needed to acknowledge economic and social realities at the village level. For example, not all villagers own cattle and those that do are generally acknowledged to be the more affluent members of a community (Schmidt, 1992). Thus it was vital that the research sought to identify the extent to which a project focussed on cattle could hope to deal effectively with poverty at the village level. Given the current people-centred approach to development, the research also needed to focus on the needs that had been articulated by the communities themselves. To this end the research focused on making more effective use of the arable land allocations for agricultural production, an issue which was consistently raised by the communities that were involved in the PRA sessions undertaken by ARDRI. Indeed, given the limited amount of land and institutional support available in the central Eastern Cape region, the overriding focus throughout the research was on making more effective use of local resources. These factors all had to be taken into account in defining the objectives of the research.

The following chapter will describe the research sites, why they were selected and some of the obstacles faced by the researcher in undertaking the fieldwork.
CHAPTER 2 - THE RESEARCH SITES

2.1) INTRODUCTION

Two sites were selected in order to undertake the research: Guquka and Koloni. The selection of only two villages reflected the detailed research objectives (see page 44). These demanded an in-depth characterisation of communities in the central Eastern Cape region in order to develop specific recommendations for limited management interventions which might improve cattle production by utilising arable land more effectively. The hope was that these recommendations might then form the basis for policy formulation at the regional level. The selection of just two villages was therefore a reflection of the need for the research to be both sufficiently representative of the region and sufficiently detailed to allow meaningful conclusions to be drawn.

There was an inherent danger in extending the research to more than two villages of it becoming too superficial. The selected villages were deemed appropriate because they were representative of a wide range of the social and ecological heterogeneity which characterises the central Eastern Cape region (see below). Moreover, both villages had expressed the need for more effective utilisation of the arable land allocations during the original participatory appraisal meetings held between villagers and ARDRI staff. They were therefore considered appropriate environments in which to undertake the research as the villagers themselves would have a direct interest and desire to be involved in the research being undertaken.

This chapter will begin by providing a comprehensive sociological and ecological overview of each of the villages in turn. It will then outline the principal selection criteria for the two sites, before moving on to cover some of the more important positional and ethical factors to be considered in research of this nature and how these were affected by the particular social environment at each village.
Figure 2.1: Location of research sites
2.2) DESCRIPTION OF STUDY SITES

2.2.1) GUQUKA

OVERVIEW OF VILLAGE ORIGINS AND LAND USE PATTERNS

Guquka (32° 39’ S, 26° 56’ E, elevation 840 m) is located some 25 km north east of Alice, Eastern Cape Province, South Africa (Figure 2.1). The village lies in the upper Tyume Valley in the former magisterial district of Victoria East and together with the neighbouring villages of Gilton, Msompondo and Phundu constitutes the AmaKhuze Tribal Area (Van Averbeke et al., 1998, Figure 2.2). Little is known about the history of the village, although it is likely that it evolved from a tribal settlement dating back to the nineteenth century, when Europeans had settled on the western banks of the Tyume River and Mfengu people (a sub-group of the Xhosa) on the eastern side (Van Averbeke et al., 1998).

Figure 2.2: The Amakhuze tribal area in the Upper Tyume Valley, with Guquka and its surrounding lands located in the middle distance and Gilton beyond.

According to Masika et al. (1997), Guquka and the other villages in this Tribal Authority were never subject to betterment planning. However, more recent research
suggests that Guquka was subject to limited betterment interventions during the mid-1960s (Smith, pers. comm.). This was confined mainly to formalising the residential and arable land allocations into distinct areas by means of fencing, culling of livestock and registering existing residential sites. The situation is somewhat vague, but it would certainly appear that some form of limited planning did take place, which is still reflected in current land use patterns (Figure 2.3). What is clear, however, is that the village shares the available range area with Gilton (Van Averbeke et al., 1998).

Figure 2.3: Current land use patterns at Guquka village

Historically, Guquka has been involved in a number of struggles over access to traditional grazing areas. These began in the late 1950s with the creation of the township of Kayalethu on the eastern bank of the Tyume River, immediately adjacent to Guquka. This was founded in order to accommodate displaced workers from
white-owned farms in the Cathcart-Hogsback area (Cook, 1980). It also acted as a repository for a number of people displaced from communities lower down the Tyume valley following the construction of Binfield Dam (Goqwana and Scogings, 1997). Kayalethu has no formally allocated arable or grazing land and livestock from the community graze the range area of the AmaKhuze villages. This has greatly increased pressure on this grazing resource.

Far more detrimental has been the loss of much of the available mountain pastures since the 1970s. Until 1970 the Hogsback mountain plateau, which lies immediately above the AmaKhuze villages, was covered in natural forest and grassland and constituted a key grazing resource for the AmaKhuze community. The plateau was divided into four separate grazing camps, which were rotationally grazed by cattle. Cattle were driven up the mountain after ploughing had been completed in spring and remained there throughout the summer. The cattle had access to most of the mountain until just below the summit (Gaika's Kop) where the perimeter fence of the camps ended. Rangers from the District Agriculture Department were responsible for the management of the grazing system, protecting the camps in rest and impounding any animals they found grazing on them (Van Averbeke et al., 1998).

This system operated unaltered over several decades until around 1970 when a decision was taken by the state to plant pine trees on the mountain. The Forestry Department undertook initial plantings in areas that did not conflict with the grazing rights of the people. However, in the late 1970s planting began on one of the grazing camps designated to the Khuze people. When delegates were sent to protest over this, they discovered that these developments were taking place with the full knowledge of their Chief, Tandisizwe Mqalo who had effectively sold them out in a private deal with the government. Attempts to halt the planting through the courts met without success and several of the local villagers resorted to sabotage by burning the mountain area during the dry winter months. The authorities responded strongly and a number of the ringleaders ended up in prison. Fearing more reprisals the arson campaign was suspended and the villagers were powerless to prevent the remainder of the grazing area being planted to pine seedlings during the early 1980s (Van Averbeke et al., 1998).
Currently, village cattle can still get access to the grazing area. However, in recent years driving stock up the mountain has become less widespread amongst the AmaKhuze as the majority of the area is now covered in trees and relatively little of the original pasture remains. Cattle also run the risk of being impounded by forestry wardens as they are blamed for damaging pine seedlings (Van Averbeke et al., 1998). Furthermore, without the rangers to police the mountain camps, there have been numerous incidents of stock theft in recent years and this has deterred many owners from allowing cattle to access these vulnerable areas (ARDRI, 1996). The restrictions these factors have placed on the grazing area available to the AmaKhuze have resulted in a substantial reduction in cattle ownership amongst villagers in the past few decades (Van Averbeke et al., 1998).

According to ARDRI (1996), the remaining range area amounts to some 400 ha and stretches from the villages in the foothills of the Amatola Mountains, to a height of around 1500 m. Here the original perimeter camp fencing still restricts cattle from gaining access to adjoining white farms. During the winter the arable land allocations are opened as a forage reserve to supplement the range. These are not shared between communities. The arable lands allocation at Guquka amounts to some 150 ha in extent and contains 41 fields, many of which are fenced (see Figure 4.4, p140). The other villages in the Tribal Area have similar allocations.

Land at Guquka is held under communal tenure (see Appendix 1). In 1991, the village consisted of 127 demarcated residential sites and had a population of 650 (Republic of Ciskei, 1991). However, the agricultural office in Alice currently lists only 58 official registrations of tenure under the PTO system for the entire village (Republic of Ciskei, nd). Of these, 49 were allocated in January 1965, one in 1967, a further seven between 1970 and 1976, and a single allotment transfer was registered in 1984 (see Appendix 2.1). From the available data it would appear that the village was surveyed in the mid-1960s as part of a drive by the resident magistrate to administer the African villages of what was then Victoria East District (Holbrook, 1998a). As part of this process, 120 residential allotments were recorded at Guquka (not all of them occupied) and 49 certificates of occupation were then issued to individuals who were actually occupying residential sites at the village. Assuming that the majority of individuals resident in the village at this time came forward to
claim their certificates of occupation, it would appear that the village more or less doubled in size between 1965 and 1991. This is quite possible given the number of forced removals from white farms at this time and the large population displacement caused by the construction of Binfield Dam. However, it would seem that since this initial series of registrations, most people who have taken occupancy of residential sites at the village have failed to officially register their title with the magistrate's office in Alice. Neither is there any existing record of title to arable land although most of this is controlled by individuals who were amongst the first 49 registered land-owners or their descendants (Holbrook, 1998a).

GOVERNANCE AND SOCIAL RELATIONS

Under the previous Tribal Authority system Guquka was governed by a headman who was responsible for decisions at the village level. He in turn was responsible to the chief of the local Tribal Authority who reported to the local magistrate. With the collapse of the Ciskei homeland system in the early 1990s democratic structures of civil governance were adopted in most villages (Van Averbeke, 2000a). The democratic structure adopted at Guquka is known as the Resident's Association (RA). The RA is basically the democratic decision making body of the village and is potentially composed of all the residents of the village, as well as those who maintain a home at the village but may live and work elsewhere. With the abolition of the tribal system the RA has now assumed responsibility for many of the decisions taken at the village level as well as many other village matters. Similar structures exist in the three neighbouring AmaKhuze villages (Van Averbeke et al., 1998).

Meetings of the RA at Guquka are reputedly held on a weekly basis in the village primary school. These are presided over by an executive body, the Resident's Committee, which consists of six members, namely a Chairperson, Deputy Chairperson, Secretary, Treasurer and two additional members. All members of the committee are elected democratically (Van Averbeke et al., 1998). Additional committees also exist to deal with specific aspects of resource distribution although these tend to be constituted on a fairly ad hoc basis (Holbrook, 1998b).
Despite the apparent democratic revolution that has occurred at the village with the emergence of an essentially younger and more dynamic governing body, it seems that the old vested interests are still very much at the fore at the political level. Although many of the members of the Resident's Committee appear to have been elected on merit, nearly all of them are members of the old land-owning families of the village whose heads had served under the Tribal Authority system (Van Averbeke, 2000a). Furthermore, at a day to day level these old families still hold a considerable amount of political power as they control the majority of ad hoc committees that deal with resource distribution and management (Holbrook, 1998a). Thus, although in theory the new system embodies a necessary compromise between the vested interests of the old guard and the democratic aspirations of the younger members of the village (Van Averbeke, 2000a), much of the effective decision making power remains with the privileged (land-owning) political minority. This supports the conclusions of other researchers in South Africa, that in many former homeland areas land relations and power relations are effectively synonymous (Buckle, 1995). However, some cause for hope lies in the fact that at the end of 1999 a relatively young, popular and democratically elected chairman emerged. He comes from a landless family with a relatively recent history within the village (Smith, pers. comm.). With this background he may be able to restore a sense of credibility back to the RA amongst the landless majority.

At a broader political level the Residents' Committees of all four of the AmaKhuze villages (Guquka, Gilton, Msompondo and Phundu) unite to form a political "umbrella" structure for the local area, which corresponds roughly with the old Tribal Authority (Holbrook, 1998b). This body is in direct contact with the Transitional Rural Council (TRC) for the district, based in Alice, and is responsible for articulating the interests of the four settlements at the local authority level. It has been instrumental in the implementation of several development initiatives in the area in recent years, including the installation of a windmill at Guquka in 1998 that pumps water to a holding tank where villagers can access it (Van Averbeke et al., 1998).
OVERVIEW OF AGRO-ECOLOGICAL PARAMETERS

Guquka lies in the upper part of the Tyume valley in the foothills of the Amatola Mountains. The substrate of the area consists almost entirely of sedimentary rocks including sandstones, shales and mudstones (Verdooit et al., 2000). The soils found on the arable land allocation have been mapped in detail with their distribution being closely related both to the topography of the arable area and the underlying rock-type. Briefly, soils of the Valsrivier, Katspruit and Kroonstad type are abundant in low-lying areas, whilst on steep slopes shallow Mispah and Glenrosa soils dominate interspersed with limited amounts of Westleigh and Longlands type soils. The higher ground supports mostly Oakleaf-type soils (Verdooit et al., 2000). The majority of these soil types have limited potential for cultivation, with low organic carbon and poor soil drainage being highlighted as key limiting factors (Ngwadla and Thys, 2000; Verdooit et al., 2000).

Climatically, the area in which Guquka lies can be described as sub-humid. Reliable long-term rainfall records (1930-1968) from the nearest rainfall station at Pleasant View show a mean annual rainfall of 637 mm with a Coefficient of Variation (CV) of 0.23 (see Appendix 2.2). However, it is difficult to judge how representative this rainfall figure is for Guquka as Pleasant View Farm no longer exists and no accurate indication of where it was located could be obtained. The rainfall gradient changes very rapidly up the Tyume Valley, particularly in its upper extent, and so even just a few kilometres distance between Pleasant View and Guquka could translate into a large discrepancy in rainfall. Furthermore, the CIRADA rainfall data package provided a mean annual rainfall figure of 839 mm for the village (Austin, 1989). However, this seems somewhat high and it is likely that the true mean annual rainfall lies somewhere between these two figures in the 700 - 800 mm range.

The local veld type is a combination of Dohne and Highland Sourveld (Acocks, 1988). These sour veld types are not well suited to livestock production, as they are nutritionally deficient during the winter months and do not generally tolerate high grazing pressures (Hatch, 1996). However, the relatively high mean annual rainfall gives Guquka considerable potential for the rainfed cropping of local staples such as maize (Van Averbeke and Marais, 1991). Given these agro-ecological conditions the
village must be viewed as being best suited to crop production with effective livestock production possible only with judicious management, particularly during the winter.

**LIVESTOCK PRODUCTION**

Historical livestock numbers are unavailable for Guquka, but the 1996 figures showed 230 cattle, 400 sheep, and 120 goats to be held by villagers amounting to 317 Animal Units (AU) in total (ARDRI, 1996). Based on a recommended stocking rate for the area of 6 ha/AU, ARDRI pasture scientists concluded that the available range (400 ha) could support 67 AU and thus was almost five times overstocked by commercial standards (ARDRI, 1996). However, this calculation does not take account of the arable land allocation, which provides an additional 150 ha of grazing during the winter months (June-September). Nevertheless, the limited additional carrying capacity this area provides is more than nullified by the fact that the range is shared with the livestock of several other communities, particularly Gilton. If the level of livestock ownership at Gilton is comparable to that at Guquka then the level of overstocking provided above can be expected to be a gross underestimate of the true rate. The very high stocking rate is reflected in the poor condition (in terms of a large proportion of unpalatable plant species) of the range area, as assessed by ARDRI researchers in September 1996 (ARDRI, 1996). They found large quantities of the unpalatable Karoo shrub *Chrysocoma tenuifolia*, which is a widely accepted indicator of overgrazed veld (Trollope, 1986).
2.2.2) KOLONI

OVERVIEW OF VILLAGE ORIGINS AND LAND USE PATTERNS

The village of Koloni (32° 53’ S, 27° 05’ E; elevation 680 m) is situated some 30 km south east of the nearest large town, Alice, in Eastern Cape Province, South Africa (Figures 2.1 & 2.4). The village falls within the former magisterial district of Middledrift and is one of several which constitute the AmaGqunukwebe Tribal Area. Historically, the Gqunukwebe do not constitute one of the true Xhosa chiefdoms of the region, but rather are a people of mixed Xhosa and Khoikhoi descent (Manona, 1980). With regard to its origins, Koloni can be described as a "mission village" as it is believed to have been developed in the latter half of the nineteenth century on land donated by a missionary priest named Perksdale (Harris, 1998). Indeed, the mission station, "Perksdale Mission", adjoins the residential area of the village and is still in use today. Land was allocated to individuals under quitrent title (see Appendix 1). A total of 118 arable and residential allotments was demarcated with each arable allotment being three morgen (2.57 ha) in extent (Bantu Affairs Commission, 1962).

Figure 2.4: The southern section of Koloni village during winter 1999. Note fence line contrast between the range (LHS), and arable land (RHS) areas.

Koloni was one of the pioneer villages for betterment planning in Middledrift District the village being declared a betterment area in August 1939, with planning having
already been initiated in May 1937 (Bantu Affairs Commission, 1962). Indeed, the then headman of the village, Mr Ngxoweni is believed to have actively encouraged the establishment of betterment at Koloni in the belief that it would lead to improvements in agricultural production (Ndlovu, 1991). The initial betterment interventions were largely agricultural in nature and began in 1938. The village grazing area was fenced off and divided into two camps and dams for watering livestock were constructed in each camp. Furthermore, European breeding stock was introduced for cattle and sheep, and a wool shearing shed constructed (Ndlovu, 1991). Later interventions in 1961 involved the introduction of contour banks on the arable fields, the subdivision of the two existing grazing camps into four and the renewal of much of the old fencing. A rotational resting system was also introduced for the grazing camps and the number of stock the location should hold was officially determined (Bantu Affairs Commission, 1962). The overall effect of these interventions was largely positive, particularly in the early stages of their implementation. After the introduction of betterment planning most individuals were self sufficient in grain crops, and many were able to sell surplus onto German traders who sold them in King Williamstown. The shearing shed and dairy that betterment introduced also allowed people to generate cash through the sale of wool and cream (Ndlovu, 1991).

Beyond these positive agricultural interventions, betterment seems to have had relatively little impact on the physical structure of the village. The village was already divided into separate residential, arable and grazing entities (Figure 2.5) and so there was no need to relocate homesteads and fields, as was the case with many other villages where land was not held under title (De Wet and Leibrandt, 1994). Betterment simply reinforced the physical division of these areas through the use of fencing. The only detrimental change of any note occurred at the onset of betterment in 1937, when the Bantu Affairs Commission allocated a disputed grazing area of 162 morgen (139 ha) to the neighbouring village of Mnqaba (Bantu Affairs Commission, 1962).

According to the last population census, the residential land at Koloni supports some 97 households and the village has a total population of 514 (Republic of Ciskei, 1991). This reflects a fairly considerable increase in population since the time of
betterment. The annual agricultural report of 1938 for Middledrift district lists Koloni as having a population of just 190 (cited in Ndlovu, 1991). By 1962 this had increased to 329, an increase of approximately 73% over this 24-year period (Bantu Affairs Commission, 1962). However, not all of the increase can be attributed to natural population growth. It appears that the Native Commission settled several Mfengu families in Koloni around the time of betterment, as a means of encouraging increased agricultural production (Ndlovu, 1991). By the 1980s, the number of individuals desiring their own allotment on which to establish a home had exceeded the available residential sites. Consequently in 1985 an area of 3.5 ha was excised from one of the grazing camps and 32 new residential sites were demarcated there, these being of similar size (1/8 morgen) to those allocated under quitrent (Republic of Ciskei, 1985). However, title to these sites was provided not in the form of quitrent but communal tenure (PTO). This entitled an individual and their family to occupy the site and gave them rights to the grazing camps, but did not provide them with access to arable land. Consequently, these landless individuals have become known as the "squatters" of the village (Harris, 1998).

Figure 2.5: Current land use patterns at Koloni village
Current land use patterns at Koloni thus reflect a history of residential and arable allotment under quitrent title during the nineteenth century, the delineation of more clearly defined grazing areas during betterment planning in the 1930s and the establishment of additional residential sites under PTO during the 1980s. The various sections of the village and their areas are summarised in Table 2.1:

Table 2.1: Land use types at Koloni and their areas in 1962.

<table>
<thead>
<tr>
<th>LAND USE TYPE</th>
<th>AREA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MORGEN</td>
</tr>
<tr>
<td>Mangambugabu</td>
<td>169</td>
</tr>
<tr>
<td>Emlangeni</td>
<td>168</td>
</tr>
<tr>
<td>Gqatso A</td>
<td>213</td>
</tr>
<tr>
<td>Gqatso B</td>
<td>214</td>
</tr>
<tr>
<td><strong>SUB-TOTAL FOR CAMPS</strong></td>
<td><strong>764</strong></td>
</tr>
<tr>
<td>Residential area</td>
<td>43</td>
</tr>
<tr>
<td>Woodlots</td>
<td>27</td>
</tr>
<tr>
<td>Arable land</td>
<td>466</td>
</tr>
<tr>
<td><strong>OVERALL TOTAL</strong></td>
<td><strong>1300</strong></td>
</tr>
</tbody>
</table>

(Adapted from Bantu Affairs Commission, 1962).

The arable land allocation is divided into three separate sections and still contains 112 of the original 118 fields demarcated under quitrent title (see Figure 4.8, p155). The rest have either been lost due to erosion or obscured by excessive bush encroachment. Efforts are still made to maintain some form of rotational grazing system, although the system introduced under betterment has currently degenerated into one in which three camps are simultaneously grazed and one is rested (Goqwana and Scogings, 1997).

GOVERNANCE AND SOCIAL RELATIONS

With the abolition of the Tribal Authorities in the early 1990s, Koloni switched from being part of a tribal society ruled by a headman and chief, to a village governed by the organs of civil society. However, this transition process was far from smooth with clashes (occasionally violent) occurring between supporters of the old guard and those favouring civil community governance. Indeed, by the late 1990s memories of this time still reputedly influenced relationships between residents (Harris, 1998). Despite
an outward veneer of unity the village remains politically divided with one minority faction aligning itself with the largely unpopular former headman, and the majority with the new democratic dispensation (pers. observ). However, it is true to say that the minority faction has so little support within the village that their political influence is almost negligible (pers. observ).

The democratic structure adopted in Koloni is essentially similar to the Resident's Association model adopted by many villages. However, unlike Guquka an elected body does not preside over the village, but rather a single individual. He has the title of "chairman" of the village and conceptually there appears to be little difference between his position and that of the former headman, except that he is democratically elected and not appointed by the state (Harris, 1998). Indeed, the current chairman comes from a family to which several previous village headmen belonged. Nevertheless, he seems to genuinely represent the more progressive and democratic face of the village (pers. observ).

The village meets to discuss matters of concern to the community on a regular basis. Meetings are open to all village residents and are presided over by the chairman, sometimes with the assistance of a secretary who will make a record of attendance and note the main points of the meeting. Meetings proceed in African tradition, with older males, particularly landowners, speaking first. These individuals generally exercise greater authority at meetings relative to young males and women, but widowed women also have considerable authority (Harris, 1998).

The general objective of meetings is to achieve community consensus on issues of concern to the village. For relatively mundane issues such as those relating to the grazing of camps and arable land allocations, a vote is generally taken and the majority rules. For matters that are of more fundamental concern to the community such as the instalment of electricity poles and cables a different tactic is often adopted. If no consensus can be reached at the end of a meeting then the matter is left open ended and those who wish to participate in a subsequent meeting to resolve the situation do so (Harris, 1998).
OVERVIEW OF AGRO-ECOLOGICAL PARAMETERS

The substrate of the Koloni area consists almost entirely of sedimentary rocks that belong to the Beaufort series. These consist of fine textured sandstones, shales and mudstones (ARDRI, 1994). Soils of the Glenrosa type dominate both the arable and grazing areas of the village. These are able to sustain grassland or wooded grassland vegetation but are poorly suited to cultivation (ARDRI, 1994). The soils found on the arable land allocation have recently been mapped in detail and include Glenrosa, Oakleaf, Mispah, Valsrivier, Katspruit and Estcourt with their distribution being closely related to the topography of the arable area. This study also emphasised the poor potential of these soils for cultivation with low organic carbon and soil drainage being highlighted as key limiting factors (Bonroy et al., 2000).

Climatically, the area in which Koloni lies can be described as semi-arid. The estimated annual potential evapotranspiration is 1,750 mm with an aridity index of 0.27 (ARDRI, 1994). Reliable long-term rainfall records (1934-1976) from the nearest rainfall station at Middledrift, show a mean annual rainfall of 488 mm with a CV of 0.23 (see Appendix 2.2). However, it is difficult to judge how representative this rainfall figure is for Koloni as the town of Middledrift lies some 10 km north west of Koloni, and the former Ciskei is characterised by large variation in rainfall over relatively short distances (Van Averbeke, 2000b). Nevertheless, it is believed that this figure is reasonably representative as it is close to the mean annual rainfall prediction of 471 mm obtained from the CIRADA rainfall data package (Austin, 1989). Furthermore, the betterment planning report for the village gives a locally based estimate of rainfall of 21" (533 mm) per annum (Bantu Affairs Commission, 1962).

The village lies in a veld type known as the False Thornveld of the Eastern Cape (Acocks, 1988). This is a type of sweetveld making it well suited to livestock production, as it remains relatively nutritious during the winter months. The low level of rainfall makes rainfed cropping marginal in most years (ARDRI, 1996). This, combined with the favourable veld type, has led to an emphasis on livestock production at the site and, indeed, in the surrounding area (Hundelby et al., 1986).
LIVESTOCK PRODUCTION

Cattle have always featured prominently in the lives of the villagers from both a social and production perspective. However, many residents assert that in recent years there has been a shift towards small-stock production (Van Averbeke et al., 1998). This reflects the fact that sheep and goats are more easily disposed of than cattle for both meat and cash at the local level. It also results from the relaxing of the prohibition on goat ownership in the area, which existed until Ciskei gained independence in 1981. The shift in production emphasis is reflected in the livestock figures for the village detailed in Table 2.2. One point worthy of further discussion is the large number of sheep held at Koloni in 1938. That 1,035 animals were held in a village, which at the time only contained 37 households, suggests that they were of considerable importance to villagers at this time. However, it is most probably a reflection not of their value for meat or sale, as is currently the case, but as a source of wool which was an important source of cash income until the early part of the twentieth century (Bundy, 1988).

Table 2.2: Livestock figures for Koloni.

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<tbody>
<tr>
<td>CATTLE</td>
<td>194</td>
<td>281</td>
<td>410</td>
<td>321</td>
<td>336</td>
<td>373</td>
<td>393</td>
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<tr>
<td>SHEEP</td>
<td>1,035</td>
<td>375</td>
<td>810</td>
<td>633</td>
<td>595</td>
<td>508</td>
<td>486</td>
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<tr>
<td>GOATS</td>
<td>0</td>
<td>0</td>
<td>320</td>
<td>223</td>
<td>264</td>
<td>266</td>
<td>232</td>
</tr>
<tr>
<td>TOTAL (AU)</td>
<td>367</td>
<td>344</td>
<td>598</td>
<td>464</td>
<td>479</td>
<td>502</td>
<td>513</td>
</tr>
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</table>

1 Source: Ndlovu, 1991: 45
2 Source: Bantu Affairs Commission, 1962: 8
3 Source: ARDRI, 1996: 6
4 Source: Middledrift Agricultural Records Office, 2000

Koloni is well suited to livestock production not only from a climatic and ecological perspective, but also because of its extensive and fairly well maintained range areas (Goqwana and Scogings, 1997). These include both the range camps (654 ha) and, during the winter months, the arable land allocation (400 ha), which becomes available for grazing for a period of four to five months after crops have been harvested. This amounts to a total area of 1054 ha available for grazing (see Table 2.1). Using the 1996 livestock data, and a recommended stocking rate of 4 ha/AU for
the area, researchers at ARDRI concluded that the range camps alone (654 ha) could support 164 AU and thus were 3.7 times overstocked by commercial standards (ARDRI, 1996). If the arable allocation were included in the grazing area then, during the winter at least, a more realistic assessment of carrying capacity at the same stocking rate would be 251 AU, suggesting that the available grazing area is only 2.3 times overstocked.

Moreover, when determining the livestock carrying capacity of the village in 1961, government officials not only included the arable land allocation in the calculations, but used a higher stocking rate of 3 morgen (2.57 ha)/AU. This resulted in a recommended carrying capacity of 410 AU for the village (Bantu Affairs Commission, 1962). This suggests that until relatively recently the number of livestock maintained at Koloni was within its determined carrying capacity. Indeed, government records indicate that an active culling policy was in operation until the late 1960s to maintain livestock numbers within this stocking rate (Bantu Affairs Commission, nd). Furthermore, the livestock figures available for the 1990s suggest that even within recent years the carrying capacity of the village has remained within twice that of the 1962 assessment. This may explain the recent favourable assessment of veld condition on the range camps at the village (Goqwana, 1998).
2.3) **RATIONALE FOR SITE SELECTION**

Guquka and Koloni were selected for the study on the basis of a number of criteria discussed below.

### 2.3.1) **REPRESENTATION OF SOCIAL AND PHYSICAL CONDITIONS FOUND IN CENTRAL EASTERN CAPE**

The most important criterion for site selection was that the villages should be representative of a broad range of the social and agro-ecological conditions found in the former Ciskei. The two villages are eminently suitable in this respect since they are quite different from each other with regard to the following criteria:

- **Village origins.**
  The two villages differ fundamentally with regard to their origins and early history. Guquka is an Mfengu settlement of fairly traditional origin. Exposure to western systems of governance and teaching has been limited until relatively recently and the majority of people hold strongly to traditional values and religious beliefs. Koloni on the other hand is a settlement that was established in a very formal manner on land belonging to a mission station. The people, who are of mixed Xhosa and Khoi-Khoi origin, thus have a long history of contact with western structures of religion and teaching, the majority holding Christian beliefs and being relatively well educated.

- **Land use patterns.**
  Land use at Guquka has essentially remained unchanged. The village was subject only to limited betterment planning. Furthermore, the range area is not clearly defined and is shared with neighbouring communities in a manner, which can essentially be described as "open-access". By contrast, the different land use types at Koloni are all clearly defined by fencing. The residential and arable areas were laid out on the establishment of the village, and the implementation of betterment planning resulted in the delineation of grazing camps exclusive to the village. This allowed for management of the grazing resource, a limited form of which is still practised today.
Land tenure system.
The tenure systems in operation at the villages differ markedly with regard to the levels of security they offer to landholders. At Guquka land tenure is communal by means of the Permission to Occupy (PTO) system. However, this only seems to extend to the residential site and grazing rights on the range area. The arable land at the village does not seem to be held under any formal tenure system. Furthermore, the PTO system has not been effectively enforced at the village, and currently less than half of the owners of homesteads at the village possess a certificate of occupation securing their land rights. By contrast the majority of landowners at Koloni have individual title to land by means of quitrent tenure. This guarantees a title-holder secure access to a residential site, an arable field and grazing rights on the range camps. A minority of more recent residents has access to land only through PTO. This secures access to a residential site and commonage grazing but not to arable land. The communal and quitrent tenure systems represent the most common form of land tenure in the former Ciskei.

Governance systems.
Although democratic governance structures exist at both villages they are quite different in their organisation. Governance at Guquka is by means of a democratic Resident's Association (RA) presided over by a six-person Resident's Committee. Other committees exist to deal with specific resource allocation and user rights. The RA is linked to those of adjacent villages to form an "umbrella structure" which liaises at the Local Authority level with the District Council in Alice. By contrast the system of governance at Koloni, whilst still democratic, remains centralised as it was under the former Tribal Authority system. A single figure known as the "Chairman" presides over village meetings although his function is one of adjudicator and decisions are taken by means of a vote. There is no formalised mechanism for liaison with Local Authority structures.

Agro-ecological parameters.
The two villages are broadly representative of the major veld classifications that exist in the area. Guquka is a sourveld site, wherein the available forage is nutrient
deficient during the winter months. By contrast, Koloni is a sweetveld site where the veld remains nutritious throughout the year. Differences also extend to rainfall patterns at the two sites. Although no accurate figure for the mean annual rainfall is available for Guquka it is believed to be in the region of 700-800 mm. This is considerably greater than the mean figure of about 500 mm for Koloni. Taken together these differences suggest that at the broad agricultural level Guquka is best suited to rainfed crop production with livestock production possible only with judicious management of the grazing resource. Conversely, Koloni is suited to year-round livestock production with rainfed crop production feasible but requiring careful management of water resources.

2.3.2) PREVIOUS RESEARCH HISTORY OF THE VILLAGES

The previous research history of the two villages also had some bearing on their selection. ARDRI has been working with the inhabitants of both villages since 1995 and has built up a good working rapport with their respective structures of governance. Furthermore, both villages were part of a comprehensive socio-economic survey undertaken by ARDRI during 1997. This meant that a great deal of baseline information was already available for many households, which could be used in investigating social and economic stratification in each village. Importantly, the data from the 1997 survey also allowed for triangulation of social data collected as part of the fieldwork.

Against this had to be balanced the frequently discussed problem of a site being ‘over-researched’ and the inhabitants being uncooperative due to too much contact (and often very little feedback) from outside researchers (Buckle, 1995; Robson, 1995). This was not expected to be a problem, as ARDRI was actively involved in providing something tangible in return for the research it had undertaken. This included organising functions at each village for which it provided all the food and drink, and transporting some of the villagers to farmers’ days at Fort Hare University.
2.4) POSITIONALITY AND ETHICAL CONSIDERATIONS

Positionality and ethics are important considerations when undertaking social science research in any developing country. However, in a politically sensitive country such as South Africa with its turbulent record of race relations these issues are of particular relevance. Some of the more important considerations emerging from the research undertaken are discussed below and include issues of race, gender, the expectations of those being researched and political affiliation.

2.4.1) A WHITE RESEARCHER IN "BLACK SOUTH AFRICA": THE INFLUENCE OF RACE

The way in which race and culture define both the researcher and subject and influence the way in which the researcher is perceived by people in developing countries can have a serious bearing on the fieldwork being undertaken (Howard, 1995; Robson, 1995). Moreover, for a white researcher it is important not only to be familiar with the culture of those being researched, but also the previous history of relations the people have had with Europeans. This is of particular relevance in a country such as South Africa where the relationship between Africans and Europeans has frequently been one of oppressed and oppressor. Nevertheless, the chequered history of racial relations in areas such as the former Ciskei mean that considerable and localised differences in attitudes towards whites do still occur amongst black South Africans. In order to understand how this may have impacted on the research work undertaken for this thesis, it is necessary to consider the history of relations of the inhabitants of both Guquka and Koloni with white people in general, and the state in particular.

It has been noted that Guquka is a fairly traditional settlement, with limited contact with western structures of governance and teaching until relatively recently. Nevertheless, the village was situated in close proximity to several white farms and, until the enforcement of racial separation under apartheid, contact with local white farmers appears to have been both regular and cordial. Evidence for this comes from
several of the older members of the village who maintained that prior to the 1960s, when the last white farmers were moved out of the area, it was quite common to borrow machinery from them at harvesting time for threshing wheat and maize (Interviews with key informants, March 1998). However, from the late 1950s onwards relations with white structures of authority seem to have deteriorated. This began with the establishment of the township of Kayalethu adjacent to Guquka in 1958 as a repository for displaced workers and squatters from local white farms (Cook, 1980). The disturbance and additional resource pressure this caused was resented by the AmaKhuze. More deeply felt was the loss of the traditional mountain pastures to the National Forestry Department during the 1970s. This left a lasting sense of bitterness and animosity amongst the AmaKhuze people towards the state and particularly towards white people. These feelings were further exacerbated by the Ciskei Government's use of both Kayalethu and the AmaKhuze villages for the resettlement of people displaced during the construction of Binfield Dam in the 1980s.

However, since the mid-1990s Guquka's relationship with government does appear to have improved. The new democratic governance structures at the AmaKhuze villages have developed a close working relationship with local authorities, resulting in the implementation of several development initiatives as outlined above. Whether relations with white people have also improved during this period is however debatable.

In contrast to Guquka, Koloni has had an extended history of close association with European structures of teaching, religion and governance. This stems back to the founding of the village on a religious footing, closely affiliated with a white minister. With the consolidation of the homeland areas during the late 1930s the then headman of Koloni (an attorney by profession) was one the first members both of the Local Council and of the Ciskei General Council (Ndlovu, 1991). Indeed, it was he who, convinced of the need to adopt progressive European agricultural techniques, pressed for Koloni to embrace betterment planning in all its forms. His commitment to this course is evident in a poignant statement he gave to the Ciskei General Council during the early stages of betterment planning: -
"People who are in darkness will never admit that they are in darkness. I am really pleading that the world should be civilised.....The Trust is there to put on a better footing people who want to progress....The locations who are against it should stay as they are but let the Trust do its work." (Bantu Affairs Commission, 1948; cited in Ndlovu, 1991: 49)

Association with government continued through the apartheid years with the village benefiting from the implementation of the second major stage of betterment in the early 1960s. Indeed, agricultural support to the village in terms of tractor hire, animal husbandry services and other government schemes appears to have been well maintained until relatively recently. It is only really since the Ciskei administration took power that the situation in terms of agricultural support has begun to deteriorate. This has become particularly bad in the post-apartheid era with the breakdown of many state-run schemes such as the Farmer Support Programme. Consequently, it was not uncommon to hear several of the older generation openly espousing the belief that life was much better in the apartheid days as the new government did nothing for them. Some of these individuals even went as far as having an annual subscription to the National Party Magazine (pers. observ.).

Indeed, it may be that it is only now, under the new democratic dispensation, that the political connotations of this extended affiliation (some might say collaboration) with white power structures are being felt. Some sense of political retribution is evident in the fact that the village has repeatedly been overlooked when asking for development assistance from the local authority for minor projects (Van Averbeke et al., 1998).

In light of these very different historical relationships with white authority it was expected that the presence of a white researcher would be perceived quite differently in each village. This was indeed the case. At Guquka it quickly became clear that the majority of villagers were suspicious of the presence of a white person in the village. Moreover, a minority seemed to decidedly resent this fact. Whilst this suspicion and resentment was only rarely overt it was brought home in a number of ways. For example during interview work in the village people would frequently not be at home even though an appointment had been made to speak with them. In several instances this may have represented a genuine oversight on their part, but there were certainly
individuals who were keen not to be seen associating with a white person. Furthermore, even when an interview had been secured, interviewees would sometimes need to be reassured that the researcher was not there on behalf of the government, before agreeing to be interviewed.

This cautious and suspicious attitude cannot entirely be explained by the political history of the village. Whilst it is fair to say that this was probably the major contributing factor it was undoubtedly not the only one. That the researcher was not formally introduced to the village until August 1998 did little to help the situation. It was initially agreed with ARDRI that the researcher would be introduced to both villages in a relatively informal way by helping to administer the interview schedule for the broad socio-economic survey ARDRI was conducting in 1997. However, this did not work well at Guquka as most of the interviews had been completed before the arrival of the researcher and there was only the opportunity for involvement with a few outstanding cases. There was therefore little opportunity for the researcher to familiarise himself with the residents of Guquka. Thus, prior to the formal meeting of August 1998, the researcher was known only by those people who had been used as key informants or interviewed as part of the research. This was only a relatively small group of people, most of whom where prominent village figures. The less powerful majority remained largely out of reach. However, it is questionable whether an earlier formal introduction to the village would have improved the rapport between researcher and researched, as the meeting of August 1998 was poorly attended and the majority of people present had already participated in the research work in some capacity.

Another contributory factor to the general lack of acceptance of the researcher was the inherently weak nature of the RA and the somewhat elusive nature of its committee members. Much of this can be attributed to an ongoing struggle for central control that was occurring at the time within the village. This was triggered by the retirement of the first chairman of the village RA in 1996 and continued over the next three years with a succession of chairmen and their committees making unsuccessful attempts to run the village (Smith, pers. comm.). Indeed, throughout the period of fieldwork for this thesis, the researcher was unable to establish a definitive point of central contact within the village. The unfortunate result of this was that despite attempting
introductions through the appropriate channels, the role of the researcher was not adequately disseminated to the inhabitants of Guquka. This was evidenced by the fact that even towards the end of the research, some people were still largely unaware of why a white person was spending so much time in the village. It may also account for the difficulties encountered with the experimental grazing work at the village (see Section 3.3.2.4)

The contrast in the way in which both the researcher and the research was perceived by the inhabitants of Koloni could not have been more marked. Helping to administer ARDRI's socio-economic survey during September 1997 provided an excellent opportunity to meet a broad section of the village's inhabitants as well as the chairman and his associates. It was clear from the onset that although people were curious as to why a white person was working in the village they were not suspicious. Indeed, the majority seemed very keen to have an overseas researcher around as it was perceived as being beneficial to the village (see section 2.4.3). The generally positive attitude towards the researcher at Koloni undoubtedly stemmed from the historically close and largely beneficial ties the village has had with white structures of governance and teaching. This was strengthened by ARDRI's extended affiliation with Koloni and adjacent villages, which can be traced back to the early 1990s. The local people thus had a fairly positive rapport with outside researchers, which did not exist at Guquka.

Within Koloni itself the very centralised structure of governance also helped in gaining acceptance in the village. The chairman took it upon himself to brief the community of the presence of a white researcher in the community and the nature of the research work being undertaken. This, combined with the initial interview work undertaken on ARDRI's behalf enabled the researcher to quickly become known on first name terms by the majority of village's inhabitants. Indeed, the fact that the chairman was such a popular, respected and ever-present figure in the village was fundamental to the acceptance of the researcher by the community and the relative ease with which the research work proceeded.
2.4.2) GENDER

Gender was also an important factor in the positionality of the researcher given the nature of the research being undertaken. The project focused on cattle and in Xhosa culture the ownership and husbandry of cattle is almost exclusively a male concern. Thus, given that most of the interviewees were men, it is likely that being male made the researcher privy to more information than they were likely to divulge to a female, regardless of her race or culture. Being male also allowed for general participation in the male environment. For example, conversation was possible with some of the older men (generally the prominent livestock owners) whenever they were found gathered under a tree or adjacent to a livestock kraal. These occasions were a useful way of obtaining general information about the villages, much of which had relevance to the research. It also helped the researcher to gain wider acceptance within the villages.

Being male is often seen as having negative connotations with regard to interviewing women of different cultures, particularly where there are distinct gender divisions (Howard, 1995). This did not appear to be a problem in the context of the research undertaken as the women interviewed were the de facto or de jure heads of household. Widowed women in particular exercised a great deal of control at the household level and fraternised with men at a variety of political levels. They therefore generally did not have a problem talking to a male researcher about the livestock they owned. Indeed, many seemed pleased that an effort had been made to come and talk to them rather than the research being restricted entirely to men.

2.4.3) THE EXPECTATIONS OF THE VILLAGERS

An important ethical consideration when undertaking research in developing areas is the expectation it generates on the part of the local people (Robson, 1995). Howard (1995), has emphasised the need for researchers to be as realistic as possible with regard to what the research can hope to achieve and to avoid generating false expectations amongst those being researched. Thus, throughout the period of the fieldwork it was made as clear as possible that the research was not being conducted
as part of a development project but was strictly an academic exercise, the benefits of which were only likely to be realised in the long term if at all. However, it was sometimes difficult to convey this message to a largely impoverished people who expected the prolonged presence of a European in their village to bring them some tangible reward in the shorter term. The South African situation is particularly sensitive in this regard. The debilitating policies of colonial and apartheid governments engineered a situation in which black people in South Africa came to depend almost entirely on whites for employment. Thus, the presence of a white person still brings with it a strong sense of expectation amongst black people, especially the older generation. In light of this, the almost certain knowledge that majority of the inhabitants of each village were unlikely to see any direct benefit from the research, either during or after the period of fieldwork, presented a particular ethical problem for the researcher. However, the practical limitations of academic research in this respect had to be accepted and worked within. The most that can generally be hoped for with a research project is that the findings are used to try and benefit the people being researched at an indirect level, by influencing local policy makers and researchers. Howard (1995) has pointed out that this has a greater chance of success if the research was undertaken in conjunction with a local research institute. In the case of this project the research was undertaken in collaboration with ARDRI. In this way it is hoped that the recommendations it makes will indirectly benefit the people of the central Eastern Cape region as a whole.

Despite the practical limitations of a research project from a development perspective, it was still possible at a day to day level to give something back to both communities, albeit at a somewhat limited level. This provided the researcher with some more immediate moral justification for undertaking the research. The specific expectations experienced by the researcher in each village and the means used to provide the inhabitants with something tangible in return for their prolonged co-operation with the research is discussed below.

Expectations in both villages manifested themselves at two distinct scales: the village (communal) level and the individual level. Expectation at the village level was most marked at Koloni. Here the majority of villagers owned cattle and most also had access to land (see section 4.2). Thus, there was a general perception that the research
being undertaken would benefit them (even if they were not always exactly sure of what the work was trying to achieve) and so it was in their interest to assist as best as they could. There was also a separate level of expectation from the chairman and his close associates who had the interests of the village firmly in mind. Although they were keen to support the research being undertaken in the village, they also saw the extended presence of both ARDRI and an overseas researcher in the village as an opportunity for raising more immediate development needs.

It has been mentioned above that Koloni's recent efforts at initiating development projects in the village through local government were unsuccessful. One such project was the provision of water to the more recently established residential (PTO) section of the village. The chairman was very keen to renovate one of the windmills used to supply water to a concrete reservoir as a means of achieving this. The project was eventually taken up by ARDRI in June 1998 as a means of thanking the residents of Koloni for their long-term co-operation with the institute. However, by the time the fieldwork for this thesis was completed in October 1999 an inability to obtain sufficient funding meant that no progress had been made with the windmill project. Money was eventually procured during 2000 and the windmill was repaired during October of that year (Mbuti, 2000). However, a courtesy visit by the researcher to the village during December 2000 found the chairman deeply unhappy as the windmill had once again broken and the concrete reservoir was no longer filling. The matter currently remains open-ended as ARDRI is no longer actively involved in research at the village.

Despite the problems encountered with this initiative, Koloni did benefit from the research at a tangible level. During the research period the researcher helped the community out in several small ways. For example, spare poles and barbed wire were contributed for the repair of the perimeter fences of the village and arrangement was made for an additional gate to be fitted providing access to the main arable land allocation. Furthermore, in November 1999 at the end of the fieldwork period, a workshop was organised in the village. This provided an opportunity for the researcher, and other ARDRI researchers, to outline findings and to express gratitude to the villagers for their extended co-operation. ARDRI provided food and refreshments and in return the villagers organised a display of traditional dancing and
made several very moving speeches thanking ARDRI and the researcher for their efforts.

In contrast to Koloni there seemed to be far less expectation from the inhabitants of Guquka at the communal level. The fact that Guquka had recently succeeded in securing several development initiatives through its relatively strong links with local government was at least a partial explanation for this. With specific regard to the research project, there seemed not only to be a general lack of expectation, but also a distinct sense of disinterest amongst most of the population. Part of the explanation for this undoubtedly lay in the fact that relatively few people owned cattle or had access to land at Guquka and thus few felt that the research could benefit them. The lack of a stable central governance structure at the village during the fieldwork period did not improve the situation.

Expectation at Guquka tended to be expressed far more at the individual than the communal level. It quickly became clear that many villagers viewed the long-term presence of a "wealthy" European in the village as an opportunity to make some money and were keen to involve themselves in the research for personal gain. Robson (1995) has emphasised the need to avoid unnecessary displays of wealth when undertaking research in developing areas. To this end the researcher always took care to avoid wearing expensive jewellery and to dress down when undertaking fieldwork. However, the continued economic dependence of most black people on whites in South Africa has perpetuated the belief that all white people are wealthy. This is particularly strong in rural areas and is embodied in the popular adage "see umlunghu (white person), see money". It was thus impossible not to be perceived by many as a potential source of money. Indeed, in the early stages of the research the researcher was approached for money by adults who were in no way involved with the fieldwork and by children who were sent out by their mothers. It had to be made clear that this was unacceptable to avoid setting a precedent. Nevertheless, an attempt was made to try and reward everybody who was involved with the research and to involve as many people as possible. Individuals who were employed as field assistants received 50 Rands per day as payment in line with the standard policy of ARDRI. However, it was not usual practise to pay people for information they provided. Rather, an arrangement was reached whereby these people were given gifts of small luxury items
such as biscuits. Some of the key informants who were particularly helpful were also provided with any left over fencing materials. In addition rental payment was provided on a monthly basis to the owner of the field used for the grazing experiment conducted as part of the research (see section 3.3.2). The owner insisted on being paid, even though he had no interest in using the field at the time and despite it being agreed that he would be able to keep all the sections of fencing that were erected or improved (at considerable cost) as part of the experiment. This underlies the fairly strong ethic of self-enrichment that existed amongst several individuals at Guquka.

In marked contrast to Guquka the degree of individual expectation experienced at Koloni was negligible. People were generally quite happy to give up their time for interviews without expecting recompense, although for the sake of consistency interviewees were rewarded with gifts of biscuits as they were at Guquka. The lack of expectation at the individual level also extended to the use of one of the villager's fields for the grazing experiment conducted. The owner was quite happy for the field to be used for the experiment for an indefinite period as he had no intention of ploughing. He did not expect any payment for this and was more than happy with the fact that he could keep all the fencing erected in the construction of the grazing plots. In general, the "handout" culture common in many former homeland areas of South Africa seemed to be frowned upon within the village, particularly by the chairman who was keen to foster good working relations with ARDRI researchers. Indeed, in one memorable situation a key informant refused the financial recompense offered to him. He had given up a considerable amount of his time and been extremely helpful in providing information about the whereabouts of livestock owners in the village. However, he would not accept any form of payment because it was only information that was common knowledge within the village and he was happy to assist if it was going to benefit the village. This was quite a poignant expression of the communal spirit that existed amongst the majority of residents at Koloni.

In accounting for the fundamental differences in desire for personal gain between the two villages, history and the way this has shaped the social structure of each settlement must be seen to play a large part. The people of Koloni have a history of relatively positive dealings with white people, which have pre-disposed them to research and extension work and to an ethic of productivity and self-sufficiency.
Moreover, the social structure of the village remained relatively unaffected during the apartheid era, maintaining a solid communal foundation in which individual needs were generally secondary to the needs of the community. At Guquka however, the considerable social upheaval experienced by the AmaKhuze villages during the apartheid era resulted in the influx of a large number of displaced people from white farms. Many of these people and their descendants currently constitute the lowest social strata in the village - those who have no access to land and no livestock and are largely dependent on remittances for income (see section 4.2). They brought with them a culture of dependence that has been maintained and exacerbated by close proximity and easy access to white centres of work and residence such as Alice/Fort Hare and Hogsback. Furthermore, the high pressure on resources, and the apparent lack of a strong and effective central governance structure within the village, has led to the breakdown of communal relations and the emergence of a deep-rooted ethic of individuality amongst many inhabitants. This finding is corroborated by the research of Smith (pers. comm.) and is a theme that will be investigated in more detail in Chapter 4.

2.4.4) POLITICAL AFFILIATION

The final important ethical consideration with regard to the research was the political affiliation of the researcher. This can have a variety of both positive and negative effects on the research being undertaken. Batterbury (1995), drawing on his own research experiences in Burkina Faso, has outlined how affiliation can be an invaluable means of quickly becoming accepted at the village level. In South Africa, the country’s historical legacy of discrimination under minority rule, has made communities often reluctant to accept the presence of researchers and quick to question the legitimacy of their research work (Binns et al., 1997). Affiliation with a local institution can help to bridge these historical divides, as demonstrated by the research conducted by Buckle (1995), in the former Border region of Eastern Cape.

With specific regard to the research undertaken for this project, the fieldwork was from the outset undertaken in collaboration with ARDRI. As a result of the previous involvement of the institute in research in the area this affiliation had a positive effect
at Koloni. Most of the ARDRI researchers were well known to the chairman of Koloni and the prolonged involvement of the institute in the village was appreciated by most inhabitants. This allowed the researcher to quickly and easily become acquainted with the village. However, at Guquka the level of distrust that existed within sections of the community towards outsiders was underlined during one of the first research visits to the village. The researcher and an ARDRI colleague approached a man who was working in his garden with a view to interviewing him. However, once he recognised the purpose of the visit he began to shout in Xhosa and wave his spade in a very aggressive manner making it clear that he in no way wanted to talk to us or be interviewed. It was subsequently explained that he "did not want to waste his time answering questions from university people." Although, this extreme attitude was not the norm at Guquka, it did serve to illustrate that a number of people in the village resented the presence of an outside agency and those affiliated to it.

It was also important to consider the potential impact of the affiliation of the researcher with specific political groupings within each village itself. Political factions are a common feature of many rural communities in South Africa as elsewhere. It is easy for a researcher to inadvertently become associated with a particular faction simply by fraternising with some of its members. Where factions are deep-rooted this can result in sections of the community becoming alienated from the researcher.

As discussed above, broad political factions existed at both Guquka and Koloni. At Koloni these were based on political ideology and were grouped loosely around support for the old system centred on the previous headman, and the current democratic system of governance embodied by the chairman. This political division was known to many ARDRI researchers throughout the fieldwork period, but the researcher was not aware of it until it was formally brought to light at the end of 1998, in an internal ARDRI report (Van Averbeke et al., 1998). This was frustrating because it allowed the researcher to unknowingly align himself from the onset with the democratic chairman, when a simple verbal explanation of the situation would have prompted greater caution. Fortunately, however, these divisions were no longer as deep as they had been. Thus, affiliation with the political majority represented by the chairman was unlikely to have had a negative influence on the research.
Moreover, cattle and land ownership at the village were ubiquitous amongst both factions and thus each had a vested interest in the research being undertaken and was involved with it as key informants and interviewees. This was exemplified by the fact that the ex-headman, at the prompting of the current chairman, provided the researcher with a spare metal gate he had for use in the grazing experiment. He was also quite willing to be interviewed individually as part of the research.

At Guquka the situation was quite different. A distinct hierarchy still existed within the village based, not on political ideology, but access to resources. Those established families who owned the majority of livestock and land continued to have the greatest influence on village politics despite being in the minority. Due to the nature of the research these were the people with whom the majority of time was spent. Close affiliation with this privileged group may have caused disinterest and possibly resentment amongst the less powerful majority. As the researcher became gradually more aware of this division, and the general political instability in the village, attempts were made to reduce this level of affiliation. This involved ensuring that individuals employed as field assistants (fencers, interpreters, etc) were from politically disempowered (landless) households and that a proportional number of stock-holders interviewed were also from landless households. However, only a small number were able to benefit in this way and a degree of resentment undoubtedly persisted. Nevertheless, it is unlikely that this resentment contributed to the unfortunate incidents that befell the experimental grazing work conducted (see Section 3.3.2.4). These seemed more a result of ignorance on the part of the perpetrators, due to the research not being adequately disseminated within the community (see Section 2.4.1), than actual vindictiveness.
2.5) **SUMMARY**

This chapter has provided an overview of each of the research sites with regard to their origins, land use patterns, governance systems and potential for agricultural production. It is clear that the two villages are very different from one another in many of these aspects. Not only are they located in quite different agro-ecological zones, but the governance structures that have evolved at each site since the collapse of the homeland systems in the early 1990s are also quite distinct. These differences are important, as the villages were selected to be as representative as possible of the wide range of social and ecological parameters found in communal areas of the central Eastern Cape region. In this way, it is hoped that the recommendations developed at each site will also find a broader application at the regional level.

The chapter has also explored some of the major positional, ethical and practical issues facing the researcher in undertaking the fieldwork. Whilst these were broadly similar at each village, the historical development of each community and the general social and political environment within each village at the time of the fieldwork had a strong bearing on how they affected the research. These factors had a particularly strong bearing on two aspects of the fieldwork.

The first was how clearly the villagers understood the objectives of the research. Given the historical legacy of failed top-down development interventions under the apartheid regime, every effort was made to ensure that the research was conducted in an open manner and that its aims and objectives were articulated clearly and at the earliest possible date at both villages. At Koloni this was made relatively easy by the strong degree of social cohesion within the village. Regular well-attended meetings were held, which provided an ideal venue for the intentions of the research to be conveyed to the community and considered by them. However, at Guquka these meetings were generally erratic and poorly attended. This meant that it was very difficult for the researcher to convey the specifics of the research to the community. This was exacerbated by the absence of a recognised political leader in the village for the duration of the fieldwork.
Social and political factors also had an important part to play in the very different levels of expectation the researcher experienced at each village. Koloni has a recognised history of successful dealings with the old regime which, combined with the strong community ethic that still existed in the village, helped to engender a sense of belief amongst the villagers that the research would benefit them and a desire to assist in undertaking it. This was strengthened by a lack of faith in the present government’s ability to provide for them and the belief of the chairman and his associates that all other available avenues must therefore be pursued. By contrast at Guquka the community ethic was not strong. The village was split into two distinct political factions: the landed minority and the landless majority. The lack of strong central control exercised by the Resident’s Association in community decision-making prevented these factions being united. In this political environment a project with an agricultural focus thus found limited popular support. The majority of villagers showed little interest in how the research might assist the community as a whole and appeared more interested in the potential of the researcher in assisting them at an individual level.

This overview essentially provides the frame of reference for the subsequent chapters, which explore in greater detail the social and ecological aspects of cattle production from the arable land allocations at each village. Much of what has been documented in this chapter will be crucial in interpreting these later chapters, particularly with regard to power structures and decision-making.

Before moving on to present the bulk of the research findings in Chapters 4, 5 and 6, Chapter 3 will provide an overview of both the social and ecological components of the research methodology adopted during the fieldwork.
CHAPTER 3 - RESEARCH METHODOLOGY

3.1) INTRODUCTION

In order to achieve the comprehensive objectives of the research, a multi-stranded research methodology was adopted at each village, incorporating techniques from both the social sciences and ecology. This enabled the current use of the arable land allocations for agriculture to be characterised holistically, and the potential of a variety of different management options for improving the contribution of these areas to cattle production to be investigated. Such an all-encompassing assessment was necessary in order to develop meaningful recommendations for improving the current land use systems at each village, particularly with regard to cattle production. It also made the research fairly unique in the sense that the researcher was obliged to adopt the mantle of both natural scientist and social scientist during the fieldwork. Indeed, these mantles were worn simultaneously throughout the fieldwork period such that the findings of the social component of the investigation were constantly used to inform the ecological work being undertaken and vice-versa. The multi-disciplinary nature of the research is reflected in the comprehensive nature of the methodology employed.

A full description of the social methodology employed during the research is provided in section 3.2 below. This is followed in section 3.3 by a description of the ecological techniques employed to characterise the use of the arable lands as a winter forage reserve for cattle and in the experimental grazing work.
3.2) **SOCIAL METHODOLOGY**

This section of the fieldwork aimed to achieve the first two of the overall research objectives outlined in section 1.5.3, namely:

1. To assess the potential of agriculture as a mechanism for alleviating poverty within each village by investigating existing relationships between particular social groupings and involvement with land and agriculture.

2. To ascertain the current agricultural use of the arable land allocations, and in particular how they are managed as a grazing resource for cattle.

The second of these overall research objectives was somewhat broad. In order to give more specific guidance to the research method adopted, two sub-objectives were defined:

1. To characterise within each village current arrangements for access to the fields on the arable land allocations and their recent cultivation history.
2. To undertake a detailed characterisation of current livestock management strategies and to determine how these differ between the villages, with particular emphasis on the use of the arable land allocations as a forage reserve.

A multi-stranded methodology was adopted for the social component of the work. This involved analysis of existing data sets from the two villages in order to achieve the first objective. Fieldwork to achieve the two sub-objectives from the second overall objective, made use of a variety of well known Rapid Rural Appraisal (RRA) techniques (McCracken et al., 1988; Waters-Bayer and Bayer, 1994; Mikkelsen, 1995). The research was divided into three basic phases, which coincided with achieving the objectives outlined above.
ANALYSIS OF RELEVANT INFORMATION FROM ARDRI'S 1997 SOCIO-ECONOMIC SURVEY

This was the first phase of the research and was a desk-based exercise, which aimed to identify any relationships that might exist between agricultural activity and particular social groups within each village. Data for this purpose were available from a comprehensive socio-economic survey undertaken in 1997 by ARDRI at both Guquka and Koloni (Van Averbeke, 1999). This survey involved a very detailed structured questionnaire, which was administered by ARDRI researchers on a door to door basis to all available households at both villages. Response rates were good at both villages. At Guquka interviews were undertaken with 78 out of a possible 127 households, equating to a response rate of 61.42%. At Koloni 54 out of a possible 97 households were interviewed, resulting in a response rate of 55.67%. Inferential statistics can be used to draw valid conclusions from samples of this size. Importantly, nearly all of the households that were actively engaged in agriculture were captured in the survey, as households not available for interview tended to be those that lived and worked outside the area. The researcher assisted the ARDRI staff in administering the schedule at Koloni in October 1997 and also assisted with several follow-up interviews at Guquka in November 1997.

The survey generated a considerable amount of agricultural data at household level. This included access to arable land, ability to crop and livestock holdings. A variety of statistical methods including chi-squared tests, t-tests and correlation analysis (Sokal and Rholf, 1995) were employed to investigate if any significant relationships existed between these parameters and three major social factors: age, income and gender. This provided a more detailed picture of the social structures and hierarchies that existed in each village and an indication of which groups exercised greatest influence over agriculture in general, and livestock production in particular. It was important to identify these social groups, as they are most likely to benefit from the implementation of any of the management recommendations resulting from the research. Since current development policy has a strong focus on improving rural livelihoods for the most needy, the existence of such social biases within the villages would likely compromise this objective.
The major social groupings identified from this phase of the work were also used as a basis for sampling in the interview work that was subsequently undertaken (see Section 3.2.3).

3.2.2) LAND OWNERSHIP AND ACCESS DETAILS

Since the research was concerned primarily with the role of arable land allocations in cattle production systems, it was necessary to identify ownership and access details for individual fields at each site. This information provided a foundation not only for much of the subsequent fieldwork, but also for the management recommendations developed for each site with regard to the role of the arable land allocations in cattle production systems.

In order to obtain this data transect walks (McCracken et al., 1988; Mikkelsen, 1995) were undertaken with two or three key informants over the entire arable field allocation at each village. An aerial photograph of the arable land allocations at each village was used to identify individual fields and in each case the following information was requested from the informants: -

1. Name (family name and given name where known) of field owner.
2. Name of individual who currently has access to the field (if different from 1).
3. The approximate time since the field was last cultivated.

Informants were also asked to verify the location of fields in situations where massive bush encroachment had resulted in their apparent disappearance. Key informants were chosen on the basis of being well acquainted with the history of land allocation at each village and current land access arrangements. In both villages the individuals selected were active farmers of retirement age, who had spent their entire lives in the village. The fieldwork was undertaken at Koloni in November 1997 and in Guquka in January 1998. For the most part the informants were able to provide names of field owners and those who currently had access to the field without any difficulty.
The next stage was to determine where each of the field owners/users lived within the village, so that they could be approached for additional information if required. This was achieved using existing maps of the residential areas of each village drawn up by ARDRI staff for the 1997 survey. The name listed next to each household on the residential map (only family names were available) was linked to the names provided for the arable fields. In cases in which the same family name occurred several times, the key informant was used to make the correct match. At Guquka, where there were relatively few field owners, this exercise was quite straightforward. However, at Koloni where there were many fields and many owners with the same family name it proved quite complicated. It was necessary to sit down with both the residential and field maps and several key informants from the village until the situation was resolved. This frequently involved walking around the village with the informants such that they could orient themselves more easily with respect to the residential site map.

Difficulties were also encountered at both villages with informants providing an approximate time since fields were last cultivated, particularly where cultivation had not taken place for some time. Once the work of linking field owners to specific households had been completed this problem was largely resolved by speaking to the field owners in person. This follow-up work was conducted between January and April 1998 and the opportunity was also used to verify that they did indeed have access to the field they had been linked to by the key informants.

The completed data set was assimilated into table format for each village and presented as an internal report in ARDRI (Bennett, 1998). The major findings from this are presented and discussed in Section 4.3 of Chapter 4.

3.2.3) CHARACTERISATION OF CURRENT LIVESTOCK MANAGEMENT SYSTEMS

The goal of the first stage of this work was to characterise the current grazing systems as they operated in theory at each site, with particular emphasis on the rules and regulations governing the use of arable land as a winter forage reserve. A short,
qualitative, informal interview schedule was designed consisting of a few broad subject areas to be discussed and associated prompts (Robson, 1993; Mikkelsen, 1995). A copy of this is included in Appendix 3.1. Suitable interviewees were identified through networking with key informants. Interviews were conducted during March and April 1998.

Individuals were purposively selected according to social status within the village and ownership of livestock. Status was used as one of the defining criteria for selection as those individuals who were of higher social standing in each village were generally affiliated to the committees responsible for resource allocation and management. They were thus assumed to be most knowledgeable about the rules and regulations governing the grazing of livestock. The individuals selected were generally old people or those who held positions of authority such as the chairman or deputy chairman at each village. All of those interviewed were men as there were very few suitable women and none of them were available for interview at the time. In total four individuals were interviewed at Guquka and three at Koloni. The responses from the individuals interviewed at each site were analysed systematically such that a consensus as to how the grazing system should theoretically operate was reached for each village (Turner, 1981; Robson, 1993). The results of these analyses are presented in Section 4.4.

This first round of interviews was followed during September/October 1998 by a second series of largely qualitative semi-structured interviews with individual villagers. The main aim of these interviews was to generate data on exactly how people managed their livestock on a day to day basis particularly over the winter period when the arable land allocation was available for grazing. A copy of the informal interview schedule devised is provided in Appendix 3.2. The interview data were also supplemented by observation data generated as part of everyday work in the village and on the arable land allocations.

The individuals interviewed were selected from those who were known to own livestock. These were then divided into those who also had access to arable land and those who did not. The individuals included in these categories were identified from the results of the 1997 socio-economic survey conducted by ARDRI. These
categories were then further stratified according to gender to give four groupings as represented in Figure 3.1: -

![Figure 3.1: Sample from which interviewees were selected (indicated by shaded area on diagram)](image)

50% of the individuals from each grouping were then randomly selected for interview. However, the degree of randomness in this selection was sometimes compromised by the availability of individuals for interview. The number of interviewees and social groupings from which they were selected is outlined in Table 3.1

<table>
<thead>
<tr>
<th></th>
<th>GUQUKA</th>
<th>KOLONI</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Stock only</td>
<td>Stock &amp; land</td>
</tr>
<tr>
<td>NUMBERS</td>
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<td></td>
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<tr>
<td>Total</td>
<td>M</td>
<td>F</td>
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<tr>
<td>50% sample</td>
<td>M</td>
<td>F</td>
</tr>
<tr>
<td>Actual interviewees</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

At Koloni all of the intended male-headed households were successfully interviewed. However, amongst the female-headed households the intended interviewee from the stock only grouping could not be located and only three out of the four candidates from the stock and land category were successfully interviewed. At Guquka, it transpired that of the 11 male-headed households identified for interview, three were
actually *de facto* female-headed, as the male head was a migrant worker and one was actually *de jure* female-headed. Thus, only seven interviews were actually conducted with males who were the *de jure* head of the household, three with females who were the *de facto* head of the household in the absence of their husband and four with females who were the *de jure* head of household (all widows).

The resulting responses were again analysed in a systematic manner to provide an overall picture of how cattle had been managed during the winter. This was supplemented by general observation data where appropriate. The results are presented in Section 4.4.

In April 1999 a small number of follow up case study interviews were undertaken with individuals whose cattle management practices differed substantially from the theoretical management rules defined from interviews with key informants. Case study interviews were conducted only at Guquka, as there was little deviation from accepted grazing management practices amongst livestock owners at Koloni. Interviewees at Guquka were purposively selected on the basis of information obtained from the second round of interviews and also, to a lesser extent, through general networking within the village. Interviews were largely unstructured and qualitative (Yin, 1989; Robson, 1993). They aimed specifically to identify how and why the selected individuals had taken the management decisions they had with regard to the grazing of their cattle. They also provided an opportunity for a more detailed investigation of management issues constraining livestock production at the village. Four detailed case studies were undertaken at Guquka, all with male-headed households. The results are presented and discussed in Section 4.4.

For every interview undertaken, an interpreter was required to translate the questions from English to Xhosa. Buckle (1995) has suggested that it would have been worthwhile having his interview questions translated into Xhosa first to prevent the problem of questions becoming loaded during translation. However, this was unlikely to have been a problem in this study, as the questions were all relatively simple and were used repeatedly such that the interpreter became very familiar with them. More problems were likely to have been experienced in the translation of the interviewees'
responses from Xhosa back to English. However, particularly towards the end of the fieldwork, the researcher was familiar enough with Xhosa to identify words that had not been translated and this undoubtedly helped to ensure that interpreters provided accurate translations of responses. At the beginning of the fieldwork interpreters were always ARDRI staff or those affiliated to the institute. However, in the latter part of the fieldwork, once the researcher had been able to establish a network of contacts at the villages, interpreters from within each community were used. This had the advantage of providing a few villagers with money (see Section 2.4.3) and also of allowing local people to feel part of the research process. Interview fatigue was rarely a problem for any interpreter, as interviews generally lasted no more than half an hour. Answers provided by interpreters were noted by the researcher on individual copies of the interview schedule that were prepared for each interview to be undertaken. Responses from case study interviews were recorded in a field notebook.
3.3) ECOLOGICAL METHODOLOGY

The ecological methodology was designed to achieve the third and fourth of the overall research objectives. The ecological phase of the fieldwork was divided into two broad components, both of which focussed on the arable land allocations at each site and were largely restricted to the winter period when they were being used as a forage reserve. The first of these was the measurement of cattle grazing on the arable land allocations under free-ranging conditions. The second was an experiment in which cattle were grazed in plots under controlled conditions. These are discussed in turn below.

3.3.1) MEASUREMENT OF FREE-RANGING CATTLE GRAZING ON ARABLE LAND ALLOCATIONS

This first component of the ecological fieldwork aimed to achieve the third of the overall research objectives set out in section 1.5.3. This is as follows:

To determine the contribution of the arable land allocations to cattle as a forage reserve by investigating, both qualitatively and quantitatively, the behaviour of free-ranging cattle, the forage they consume during the winter and its nutritional value.

This rather broad overall objective was split into a number of sub-objectives in order to provide more clearly defined goals for this section of the fieldwork:

1. To subdivide the vegetation on the arable lands into a number of separate categories.
2. To determine the number of livestock making use of the arable land allocations.
3. To characterise, both qualitatively and quantitatively, cattle feeding patterns during the winter, at both the vegetation category and species level.
4. To quantify the level of forage removal by cattle during the winter months, at both the community and species level and its nutritional quality.
The methodology employed to achieve these sub-objectives can be divided into three basic components, each of which is discussed below.

3.3.1.1) DETERMINATION OF DIFFERENT LAND USE TYPES, VEGETATION COMMUNITIES AND THEIR AREAS

The first stage in the ecological investigation was to divide the arable land allocations at both villages into different land use categories. This provided an important foundation for all subsequent ecological work at each site. A common key for land categorisation was developed at both sites on the basis of both historical land use patterns and the current vegetation types occurring. The first phase in the development of the key was the mapping of former land use treatments. The arable land allocations at both sites were classified according to the following categories:

i) Fields
- areas which are planted to crops
- areas which are lying fallow

ii) Non-arable areas
- commonage/grazing area
- Tracks between fields

Land use classification was achieved largely by reference to 1: 10 000 and 1: 5000 ortho-photo maps of the two sites. Visual reconnaissance in the field was also undertaken where further clarification of the land use type was necessary. This was achieved during transect walks with key informants (see Section 3.2.2).

The second phase of the land categorisation was the determination of the different vegetation types that occurred within each of the land use types. This was achieved by walking through the arable land allocations with tracing paper overlays of the relevant 1: 5000 ortho-photo maps of each site. A visual assessment of the main
vegetation types present in each area and their approximate proportions was made on the tracings. Notes were also made on the key grass species occurring in each area. The initial categorisation system for the vegetation was based on the broad categories developed during preliminary research in nearby areas by Lo Presti (1996). These categories were refined on the basis both of the notes on species composition made during the ground verification exercise and using the information on time since the field was last cultivated obtained from key informants.

The resulting key used in the categorisation of the arable land allocations at both sites was thus a combination of the defined land use types on each allocation, the history of cropping within fields and the main vegetation species present. The key was common to both land allocations although not all of the categories within the final key necessarily occurred at each site. In order to provide a visual representation of the different land use categories occurring at each site the 1:5000 scale ortho-photo maps of the arable land allocations were digitised into a Geographical Information System (GIS) using the ARC-INFO package. The different land use categories were then overlaid onto the map using ARC-VIEW. This provided an estimation of the proportion by area of the arable land allocation at each site that fell within each land use category. This information was crucial in the derivation of feeding preferences for the cattle using the animal observation data (see below). The information was initially overlaid for the 1997/98 growing season and then was updated in accordance with changes in land use that occurred the following season (see Sections 5.2 and 5.3).

3.3.1.2) OBSERVATION OF FREE-RANGING CATTLE

Behavioural observations of free-ranging cattle foraging on the arable land allocations were made during the winter periods of both 1998 and 1999. These were undertaken from the time the arable land allocations were officially opened to grazing after harvesting was completed, until they were once again closed to grazing as people began to prepare their land for cropping.

At the broadest level this work consisted simply of counting the total number of livestock present on the arable land allocations during this period on a weekly basis.
This involved making a dot on a paper map of the arable land allocation at each site, indicating in which field and vegetation category each animal was located. Different colours were used for the different livestock species found. In the case of cattle (by far the dominant species) distinction was also made between adults and calves to provide a true indication of stocking rate. This was undertaken by the researcher during 1998. However, this proved overly time consuming during this busy period and a key informant at each village was trained to undertake the work during the subsequent winter. Furthermore, at Guquka the continuous presence of livestock on the arable lands throughout the summer necessitated the monitoring work being continued throughout the year. The data collected from this monitoring work provided an important overview of the number of livestock present on the arable land allocations and how this fluctuated throughout the year. It also provided an indication of any bias in the distribution of animals within each vegetation category. By comparing observed frequency count data with expected frequency count data, it was possible to assess the extent to which animals distributed themselves randomly within each category. The degree of departure from randomness in animal distribution was determined by log ratio analysis (Elston et al., 1996) according to the following equation:

\[
G = 2 \sum \ln \left( \frac{f_i}{\hat{f}_i} \right)
\]  

(1)

where \( f_i \) = the observed frequency of \( i \)
\( \hat{f}_i \) = the expected frequency of \( i \).

(Sokal and Rohlf, 1987: 299).

The results of these analyses are presented in Chapter 5.

More detailed observations of cattle grazing behaviour were conducted over a period of three consecutive days during one week in each month of the winter period on a herd of cattle pre-selected by arrangement with their owner. Herd selection depended simply on the owner having a sufficiently large number of adult cattle, consisting of a broad cross section of ages and genders and the willingness of the owner to co-operate with the researchers. At Guquka, animals to be observed were kraaled overnight and
released to graze in the arable fields early each morning. The behaviour of the animals was monitored from the time they were released onto the arable land in the morning (approximately 08:00 hours) until the time they are returned to the kraal at sunset (approximately 17:00 hours). In all cases this was taken to be representative of the normal foraging period for cattle at Guquka as the majority of animals were kraaled overnight. At Koloni, animals were observed for the same time period but the animals used were randomly selected from amongst those already present on the fields as the majority of the cattle were left on the arable lands overnight. This process simply involved identifying and allocating a number to all the herds of appropriate size that were visible from a central vantage point on the main arable land allocation and then randomly selecting one of them. After approaching the selected herd (generally consisting of five-eight animals of mixed age and gender), the animals were given 10 minutes to adjust to the presence of the researcher and then observations were initiated in line with the methodology outlined below.

I) Scan observations
Observation work began with a scan of the behaviour of the herd. This was conducted simultaneously on all animals in the herd once per hour. In each case the following details were recorded: -

A) Composition of herd (age/sex)
B) Activity type (from the four described below).
C) Field in which animal was located.
D) Vegetation type in which animal was located (according to the categories defined).

(After Diarra et al., 1993).

II) Focal animal observations
Following the scan observations of the whole herd, a focal animal was randomly selected and observed for a period of one hour. Observations were divided into three separate 15-minute periods in each hour with a five minute break between each to allow the observer to make any notes and corrections from the previous period and to prepare themselves for the next observation period. During each 15-minute focal observation period the amount of time the animal spent undertaking the following activities was recorded: -
• Walking (recording number of steps)
• Feeding
• Resting-ruminating
• Watering

(After Diarra et al., 1993).

During each individual feeding bout within the 15-minute focal period the following information was recorded: -

• The number of bites over a period of 30 seconds;
• The dominant species being consumed at the end of each 30 second interval;
• The height at which the animal was feeding on the dominant species;
• The mean overall height of the sward in which the animal was feeding.

The data from the grazing observations provided information on forage preference and other aspects of cattle behaviour, and how these changed during the course of the season. Preference was determined by calculation of preference indices (Pi). At the vegetation category level the equation used was as follows: -

\[
P_i = \frac{\% \text{ time spent feeding in particular vegetation category during winter}}{\% \text{ of total area of vegetation category during winter}}
\]

(After Scoones, 1995).

The percentage time spent feeding in each vegetation category was obtained by taking the mean of the time allocated to grazing by each individual focal animal over the three days during which the observations were conducted. The results of these preference determinations are presented in Chapter 5.
3.3.1.3) MEASUREMENT OF THE QUANTITY AND QUALITY OF FORAGE REMOVED DURING THE WINTER

I) Determination of the amount of forage removed

Determination of forage removal by cattle from the arable land allocations at each village was undertaken during winter 1999. This made use of the harvested quadrat method (Chambers and Brown, 1983) and involved the clipping of grazed and ungrazed (control) plots. This is a relatively crude, but well utilised technique for the estimation of net primary production and herbage consumption in grazing ecosystems (McNaughton et al., 1996; Mitchell and Wass, 1996). Quadrat harvesting was undertaken in each of the grassland communities identified at each site. At Koloni this included the commonage, Sporobolus-Eragrostis grassland and Hyparrhenia grassland communities with the latter area being sub-divided into patch and non-patch areas (see section 5.3.1). At Guquka it included just the Sporobolus-Eragrostis and Hyparrhenia grassland communities (see section 5.21). There were thus four sampling categories at Koloni and two at Guquka. Forage removal from the crop residue and forb-dominated vegetation categories at each site was determined by another ARDRI researcher as part of a separate but related MSc study (Mbuti, unpublished data).

The first step in the procedure was to demarcate appropriate sampling plots within each of the vegetation categories to be sampled. The size of each plot was only about 1% of the total area of each vegetation category at Koloni and 2% at Guquka such that the plots varied in size between 4000 m$^2$ and 16000 m$^2$. Sampling within such a small proportion of the total population immediately raises questions about how representative the plots were of the true level of grazing. In spatially heterogeneous grassland systems it is vital that plots are of sufficient size to capture the variability in above-ground biomass (Bork and Werner, 1999). Moreover, it is widely acknowledged that cattle do not graze randomly throughout an area of range. Rather they display preference for grazing in certain areas on the basis of environmental conditions (e.g. topography, distance from water) and the presence of preferred forage species (Rouguet et al., 1998). Thus, in using relatively small sampling plots there was a danger that they would not reflect the true extent of grazing on the arable lands, either because they were ignored by cattle due to unfortunate location, or excessively...
grazed because of being located in a preferred grazing area. However, given the often considerable extent of the vegetation categories being sampled (>150 ha for the *Hyparrhenia* grassland community at Koloni), their frequently patchy nature and the very limited time available for sampling this was seen as an unavoidable compromise in the sampling design. Nevertheless, every effort was made to try and ensure that the selected sampling plots were as representative as possible with regard to the grazing pressure they were likely to be subject to. To this end they were located in areas that were not too close to the residential area (to avoid the higher concentrations of livestock), but not too far from areas in which cattle spent considerable amounts of time grazing during winter 1998.

Once the sampling plots had been demarcated, a single 10 m x 10 m grazing exclosure was then set up within each sample plot (Figure 3.2).

![Figure 3.2: 10 m x 10 m grazing exclosure constructed in *Sporobolus-Eragrostis* grassland at Koloni.](image)

These were essentially controls to account for changes in biomass other than those resulting from grazing consumption (e.g. dieback and growth). The exclosures were fixed for the duration of the sampling period (May-September 1999). McNaughton *et al.* (1996) have pointed out that the moveable cage method has several advantages over the fixed season-long-cage method. Most notably it accounts for leaf turnover
and compensatory re-growth of vegetation due to grazing, which fixed cages do not. However, for the purposes of the study the use of fixed exclosures was unlikely to have been disadvantageous. This is because sequential sampling was undertaken in the exclosed as well as the grazed areas (see below), which accounted for leaf turnover. Furthermore, the fact that the fieldwork was being conducted during the dormant winter period severely limited the amount of compensatory re-growth that was likely to occur.

All harvesting undertaken in the grassland vegetation categories at both sites made use of a square $0.25 \text{ m}^2$ ($0.5 \text{ m} \times 0.5 \text{ m}$) quadrat. This was a standard shape and size for the type of grassland vegetation being sampled (Wiegert, 1962; Chambers and Brown, 1983). An initial idea of the number of quadrats to be harvested to obtain a reasonably accurate estimate of the mean standing biomass in each vegetation category was obtained from trial sampling work undertaken at both sites during winter 1998. Data on the variance of the standing biomass at each site were available from this work and was used to determine the number of quadrats required for an estimate of the mean biomass that was within +/- 10% of the true mean (standard level of accuracy) at the 95% confidence level. In each case the number of quadrats required was calculated using the following equation for determining sample size from an infinite population:

$$n \approx \frac{4 \sum S^2}{d^2}$$

Where $n$ = Required sample size

$S^2$ = Observed population variance

$d$ = Desired precision of mean (10%)


This suggested that for the majority of grassland communities, harvesting 50 quadrats would give an estimate of mean biomass to the required level of precision. However, for the Hyparrhenia grassland at Koloni, the relatively high variance resulting from large differences in biomass between patch and non-patch areas suggested that at least 100 quadrats would be required to provide the required level of accuracy. Given that quadrats had to be sequentially sampled throughout the winter period from both
grazed and exclosed areas in five vegetation categories at two different sites, harvesting all of the quadrats would have taken too much time. A more rapid technique for biomass estimation was required.

The comparative yield method of Haydock and Shaw (1975) was chosen. This method involves the researcher making a visual estimate of pasture yield within a quadrat, with respect to a set of carefully selected reference quadrats. Five quadrats are generally used to represent the entire range of biomass with one representing the lowest biomass and five the highest. Assessment is made using either a nine point (1, 1.5, 2 etc.) or a seventeen point (1, 1.25, 1.5 etc.) scale. The technique is not frequently utilised as observer estimation is somewhat error prone (Friedel et al., 1988). However, given sufficient practice at rating, relatively accurate biomass estimations can be achieved and few techniques have such a rapid and versatile application in a range of sward types (Haydock and Shaw, 1975; Kelly and McNeill, 1980). Certainly the disc pasture meter method of biomass estimation (Bransby and Tainton, 1977), a frequently used technique in South Africa, would have been unsuited to the taller swards encountered in the study.

At Guquka and Koloni the five reference quadrats were set up in each grassland community immediately prior to grazing beginning on the arable lands. In line with the recommendations of Friedel et al. (1988) for improving accuracy with the technique, these quadrats were photographed and compiled into booklet format, to act as a field reference guide (Appendix 3.3). The researcher also performed all the visual estimates undertaken for the sake of consistency. All assessments were made on a nine-point scale. As an initial check of the researcher's accuracy in using the method, all of the initial quadrat samples were both harvested and visually assessed. Quadrats were positioned according to randomly generated co-ordinates from a scientific calculator (Texas Instruments TI-83). 100 quadrats were sampled in the Hyparrhenia grassland community at Koloni. These were proportionally allocated between the patch and non-patch areas on the basis of area such that 60 samples were taken in the non-patch areas and 40 in the patch areas (Krebs, 1989). Figure 3.3 overleaf summarises this. In all other vegetation categories 50 quadrat samples were taken. The vegetation in each quadrat was clipped to stubble height (approximately 3 cm) and placed in a labelled paper bag. Clipping was undertaken in both the open and
exclosed areas, with the location of the quadrats harvested from the exclosures being marked with a 50cm metal stake to prevent re-sampling. The position of quadrats harvested from the open areas was not marked, as the chance of resampling here was negligible due to the size of the sampling plots.

![Diagram](image)

**Figure 3.3**: Diagrammatic representation of the quadrat sampling process from exclosed and grazed areas of the patch and non-patch portions of the 125m x 100m *Hyparrhenia* grassland community sampling plot at Koloni.

Harvested vegetation was oven dried at 60°C for 48 hours and then weighed to two decimal places using a top pan balance (Chambers and Brown, 1983). The mean biomass assessments obtained from both harvesting and visual rating were in fairly close agreement for all vegetation categories with $r^2$ values for the regression of
visually assessed biomass against actual harvested biomass, ranging from 0.71 to 0.94. Subsequent assessment of mean biomass in each vegetation category was by visual assessment only and again made use of the Type 2 method of Haydock and Shaw (1975). The quadrat samples were visually assessed against the five reference quadrats in each category and a fraction of them were also harvested. The harvested values were used to adjust the initial biomass regression and thus account for observer bias.

In order to determine what proportion of the quadrats should be harvested in each category the standard equation for double sampling with regression was used: 

\[
SE_y = \sqrt{\frac{S^2_y (1 - r^2)}{n_2} \left[ 1 + \frac{1}{n_2} \right] \left[ 1 - \frac{n_2}{n_1} \right] + \frac{S^2_y}{n_1}}
\]  (4)

Where: 
- \(SE_y\) = the standard error of the mean yield 
- \(S^2_y\) = the variance of the harvested samples 
- \(n_1\) = the number of quadrats rated 
- \(n_2\) = the number of quadrats harvested 
- \(r^2\) = the coefficient of regression

(Sampford, 1962 cited in Kelly and McNeill, 1980)

For each vegetation category, standard error values that gave an estimate of the mean to within +/- 10% of the true value at the 95% level were derived from tables. Knowing the variance and the \(r^2\) values from the initial set of biomass samples various combinations of \(n_1\) and \(n_2\) were then evaluated. In each case harvesting 20% of the rated quadrats was found to provide sufficient accuracy in the estimate of mean biomass. Thus, 20 quadrats were harvested from the 100 rated in the \textit{Hyparrhenia} vegetation at Koloni and 10 from the remaining vegetation categories in which 50 quadrat samples were rated. Harvesting was undertaken systematically with every fifth quadrat being harvested.

The above methodology allowed the amount of biomass removed from different vegetation categories to be determined at different points during the winter period.
This was simply the change in the difference between the standing biomass in the exclosures and that in the non-exclosures areas at each sampling point. Furthermore, the quadrat biomass data was also used to provide inferences about cattle feeding preferences at the species level by looking at the change in biomass of key species within each vegetation category during the course of the winter. This was achieved using the dry weight rank method (t’Mannetjie & Haydock, 1963). This is a quadrat-based technique, in which the three most abundant species in each quadrat are visually assessed and ranked on a scale of 1 (highest biomass by proportion) to 3 (lowest biomass by proportion). Each of these ranks corresponds to a standard multiplier, which allows for the determination of the percentage contribution of individual species to overall pasture biomass. The technique has found widespread application in vegetation studies both in South Africa (Barnes et al., 1982; Scogings and Theron, 1990) and in the United States (Gillen and Smith, 1986; Dowhower et al., 2001). Relatively accurate and replicable results have been achieved with great rapidity and relatively little observer training. Ideally, it should be applied only in plant communities in which the sward is fairly heterogeneous in terms of species composition. Some of the vegetation categories in the study were fairly monospecific, particularly the Hyparrhenia grassland. However, by using the improvements developed by Jones and Hargreaves (1979) the method was successfully employed in all categories.

Overall percentage species composition derived from these multipliers was weighted using the biomass (comparative yield) ratings derived for each vegetation category according to the following formula: -

$$WC_i = \frac{\sum_{j=1}^{3} (W_{ij} \times M_j)}{W_T}$$

Where: $WC_i = \text{weighted % composition of species i}$

$W_{ij} = \text{number of plots in which species i received rank j}$

$M_j = \text{multiplier for rank j}$

$W_T = \text{total number of quadrats}$

(Gillen and Smith, 1986).
These weighted species composition values provided a measure of the proportional contribution of each species to overall biomass at each stage of sampling. Differences in the proportion of species by biomass between each sampling stage provided an indication of how species composition within each vegetation category changed through the season. This in turn allowed inferences to be made about cattle feeding preferences at the species level. Since the data were not normally distributed and could not easily be transformed, the statistical assessment of the significance of these differences was undertaken non-parametrically (see Chapter 5).

Biomass sampling using the above techniques was undertaken at three points during the winter period: before, during and after grazing. These measurements generated an approximate picture of the amount of plant material removed from each grassland community at both an overall and species level. This data is presented in Chapter 5.

II) Determination of forage quality

Once plant material from each harvested quadrat had been dried and weighed, a proportion of the quadrat samples from each vegetation category was randomly selected for separation into dry and green components ready for nutritional analysis. Ten vegetation samples were randomly selected from the *Hyparrhenia* grassland category at Koloni and five from the remaining vegetation categories for separation into dry and green sward fractions. Half of these samples (five from the *Hyparrhenia* grassland vegetation category at Koloni and three from the remainder) were then selected for nutritional analysis. The effect of sub-sampling and then further sub-sampling was to greatly reduce the amount of time and money spent undertaking laborious separations and analyses. Inevitably, this compromised the number of samples available for statistical analyses, although it is believed that sufficient samples were still available for meaningful inferences to be made with regard to forage quality. Data on the proportion of dry and green material in the sward were first transformed using the arcsine transformation (Zar, 1999) and then analysed parametrically using ANOVA (see Chapter 5).

Nutritional analysis required the dried necromass and phytomass components of the dried grass samples to be milled through a 1mm sieve. Following milling the
necromass and phytomass components were stored in plastic jars and analysed for the following parameters:

- Crude Protein (CP)
- Neutral Detergent Fibre (NDF)
- *In Vitro* Organic Matter Digestibility (IVOMD)

All analysis was undertaken by the ARC laboratories in Pretoria. For analysis of crude protein values the Copper Catalyst Kjeldahl Method was used to determine the nitrogen content of the vegetation samples (AOAC, 1995). In line with standard procedures the nitrogen values were then multiplied by 6.25 to give the protein equivalent. For determination of fibre content the standard method for the analysis of dietary fibre in food was used (Van Soest, 1963). For the determination of organic matter digestibility the two-stage technique of Tilley and Terry (1963) was used. This involved a 72 hour rumen fluid incubation followed by a 24 hour pepsin incubation because of the fairly low quality of the samples. Analysis of all three parameters was also undertaken using Near Infra-Red Spectroscopy (NIRS). A NIR Systems 5000 Spectrometer and Windows ISI Near-Infrared Software was used to interpret the results. The NIRS data provided a back-up to the wet chemistry data and, in a few cases, the only source of data for samples which were too small for analysis by wet chemistry to be undertaken. The results from determination of these three nutritional parameters were analysed statistically using ANOVA. These analyses are presented in Chapter 5.

These standard parameters provide an overview of the level of nutrition in the plant material being analysed and an indication of how much of it the grazing ruminant can actually utilise for production (O’Reagain, 1994).
3.3.2) EXPERIMENTAL GRAZING WORK

This was the second stage of the ecological fieldwork and aimed to achieve the fourth of the overall research objectives set out in section 1.5.3. This is as follows: -

To identify and investigate alternative management regimes for the arable lands with potential for improving cattle production. Specifically, the effect controlled grazing during the summer time has on the resultant winter forage.

3.3.2.1) RATIONALE

The experiment was conducted in the *Hyparrhenia* grassland vegetation category at both sites. The vegetation in this category consists largely of *Hyparrhenia hirta* (thatching grass) a tall grass species very common on arable land that has been fallowed in the long term (Gibbs-Russell *et al.*, 1990; Theron, 1991). The species although relatively tall and stemmy, makes good grazing during the summer when it produces plenty of green leaf material and the stems are less fibrous. However, during the winter period it has a tendency to become dry and develop tough, woody stems that are highly unpalatable, making it difficult for the grazing ruminant to access what little leaf material remains. The experiment aimed to test the effect that intensively grazing the *Hyparrhenia* sward during the summer would have on the subsequent winter sward in terms of its nutritional quality and its accessibility to grazing by cattle. Specifically, it aimed to test the following hypotheses: -

1. The lower average height and decreased stemminess of the sward on the treatment plot would enable cattle to achieve greater mean intake rates of forage than on the control plot;
2. The nutritional quality of the herbage available in the treatment plot would be greater (in terms of higher proportion of green material, higher crude protein content, lower fibre and greater *in vitro* digestibility) than that in the control plot.
3.3.2.2) EXPERIMENTAL DESIGN

Experimental sites were situated on the arable land allocations at each village and were selected on the basis of being representative of the *Hyparrhenia* grassland vegetation community and of being relatively accessible. In each case the permission of the owner of the field in which they were situated was also required.

At both villages the experimental design consisted of a single control and a single treatment plot. Grazing plots were constructed during winter 1998 using local village labour. At Guquka each plot was 1ha in size and at Koloni 0.5ha. The smaller plot size at Koloni was dictated by the nature of the sward. It tended to be more patchy at Koloni and thus large expanses of *Hyparrhenia hirta* - dominated grassland were difficult to find. Furthermore, the *H. hirta* - dominated sward tended to be denser at Koloni and so similar initial amounts of herbage were present in plots at both villages despite the difference in plot size.

Treatment plots were grazed by cattle during early March 1999 just prior to the second peak in summer rainfall, to allow the plots sufficient time to recover before the subsequent winter. Grazing was intensive (approximately 25 AU per plot) over a relatively short period (5-7 days) in line with the recommendation of O'Reagain (1994). Cattle were borrowed from a number of livestock owners at each village who were remunerated at the rate of R1/animal/day. The animals were kraaled overnight and grazed under a daily regime from approximately 08:00 – 18:00 hours with breaks for watering as and when necessary. Grazing was continued until the sward was grazed down to an average plant height of 20-25 cm, which is the point at which intake rate for cattle is believed to be maximised (O'Reagain, 1994).

The experimental regime undertaken during the subsequent winter involved three intensive grazing periods in both the control and treatment plots at the beginning, middle and end of the winter 1999. These were undertaken at approximately six-week intervals beginning in late June and finishing in mid September. During each grazing period five adult cattle (5 AU) were introduced into the control and grazing plots for 8 hours over three consecutive days. Cattle were kraaled overnight and grazed between 09:00 hours and 17:30 hours each day, with a 30 minute break at
lunchtime during which they were watered. A stocking rate of 5 AU over three days was designed to simulate the grazing pressure the arable lands were actually subject to during the winter period, based on livestock counts from winter 1998.

During each three-day grazing period a number of parameters were measured as follows:

- **Measurement of the amount of forage consumed and its nutritional quality**

  The amount of forage removed during each grazing period was assessed by measuring the standing herbage before and after grazing in the control and treatment plots. The methodology adopted was the same as that used for the free-ranging biomass measurements in the *Hyparrhenia* grassland. One hundred quadrats were visually rated according to a pre-determined set of reference quadrats on a scale of 1 to 5. These were again photographed and compiled as a field guide to assist with the rating procedure in each plot (Appendix 3.4). Every fifth quadrat was also harvested as a running check on the accuracy of observer estimation. The measured biomass from these quadrats was used to adjust the biomass regression in each case. There was no control for non-grazing induced changes in biomass (i.e. growth or dieback), as it was assumed that this would be negligible during each three-day grazing period.

  Of the 20 quadrats harvested before each grazing period from the control and treatment plots three were randomly selected for separation and analysis. The samples were separated not only into dry and green components but also stem and leaf components. This allowed the amount of stem and leaf material (by mass) remaining in the sward to be directly measured at different sampling points. It was hypothesised that these measurements would be important in explaining any differences in cattle intake rates between the control and treatment plots. Once separated, the four components (dry leaf, green leaf, dry stem and green stem) were then subjected to the same nutritional analyses outlined in Section 3.3.1.3.
• **Sward measurements**
Prior to each of the three grazing periods, measurements were also made of the sward in both the control and treatment plots. These were undertaken in conjunction with the quadrat sampling work outlined above. In each of the 100 quadrats sampled, the nearest *H. hirta* plant to the top right hand corner of the quadrat was located and the following parameters were measured:

- maximum plant height, defined as the extended height above ground level of the tallest leaf on a vegetative tiller;
- leaf table height, defined as the height below which the majority of the plant’s leaves are subjectively judged to occur;
- stemminess, being the proportion of stems within each plant, subjectively assessed on a scale of 1-5;
- greenness, defined as the proportion of green leaf material within each plant, also subjectively assessed on a scale of 1-5.

All four of these measurements and the methodology employed to achieve them are based on the work of O'Reagain (1994). Height measurements were fundamental to testing the first experimental hypothesis. Subjective measurements of stemminess and greenness were undertaken as a triangulation of the mass data from the separation of the phytomass and stem components. They also served as a crude indication of nutritional quality, in case laboratory analysis of the nutritional parameters could not be undertaken for some reason (e.g. lack of funds to cover the cost of sample analysis).

• **Animal observations**
These were undertaken during one day of each grazing period in both the control and treatment plots. In both plots observations were conducted on the second grazing day and the introduction of animals into the plots was staggered in order to achieve this (see Table 3.2 below). The parameters recorded in each case were exactly the same as for the natural grazing work (see Section 3.3.1.2).
A summary of the day to day schedule adopted for the sampling work in each plot is provided in Table 3.2 below:

Table 3.2: Sampling schedule for each grazing period in the experimental plots

<table>
<thead>
<tr>
<th>DAY</th>
<th>CONTROL PLOT</th>
<th>TREATMENT PLOT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>None.</td>
<td>Pre-grazing measurement of standing biomass and sward measurements.</td>
</tr>
<tr>
<td>2</td>
<td>Pre-grazing measurement of standing biomass and sward measurements.</td>
<td>1st day of cattle grazing in plot.</td>
</tr>
<tr>
<td>3</td>
<td>1st day of cattle grazing in plot.</td>
<td>2nd day of cattle grazing in plot. Animal observations undertaken.</td>
</tr>
<tr>
<td>4</td>
<td>2nd day of cattle grazing in plot. Animal observations undertaken.</td>
<td>3rd day of cattle grazing in plot.</td>
</tr>
<tr>
<td>5</td>
<td>3rd day of cattle grazing in plot.</td>
<td>Post-grazing measurement of standing biomass.</td>
</tr>
<tr>
<td>6</td>
<td>Post-grazing measurement of standing biomass.</td>
<td>None.</td>
</tr>
</tbody>
</table>

3.3.2.3) CRITIQUE OF EXPERIMENTAL DESIGN

The limitations of the experimental design must be acknowledged from the outset. Under ideal research conditions each treatment plot would have been replicated at least twice. However, this was not possible within the prevailing research environment, due to the limited amount of money available both for the purchase of fencing materials and for the construction of the plots and the limited logistical support available for overseeing replicated grazing trials. The lack of replication between seasons was also problematic and was a symptom of the limited time available for the fieldwork. Both of these limitations undoubtedly raise questions about the validity of the experimental findings. A detailed discussion of the problem of pseudoreplication, which arises when applying inferential statistics to non-replicated treatments, can be found in Hurlbert (1984). The problem is discussed in more detail in the presentation of the experimental results in Chapter 6.
3.3.2.4) LOGISTICAL PROBLEMS

Problems also arose in attempting to conduct the experiment at both research villages. At Guquka, it was necessary to hire the field from its owner. This was symptomatic of the level of individual expectation at the village (see Section 2.4.3). A rental contract was drawn up between the researcher and the field owner in which the latter was obliged to ensure that the field was not disturbed in any way when not being used for experimental purposes. In return it was agreed that he would receive payment of R50/month and be allowed to keep the improvements made to the fencing at the end of the experiment. The validity of such an agreement is dubious since land in the village is held under communal tenure and reference to Appendix 1 shows that the owner of a communal field has no authorisation to rent out the land and risks losing it if they do so. However, given that no official form of title to the arable fields existed the situation was somewhat unclear. In any case the situation was resolved in May 1998, when the rental agreement was terminated due to failure of the owner to meet the stipulations of the agreement.

From the time of their construction the control and treatment plots at Guquka were sporadically being grazed by trespassing livestock, which gained access when local boys cut the wires on the gates. This problem was largely resolved by fitting metal gates with padlocks on each plot. However, irreparable damage was inflicted on the experiment when in May 1999 a woman from the village gained access to the control plot, mistaking it for another field, and harvested the majority of the tall H. hirta sward for roof thatching purposes. So little of the tall sward was left in the control plot that it could no longer function as an effective control (see Figure 3.4, overleaf). Since no similar expanses of ungrazed sward could be found on the fields, there was no alternative but to cancel the experimental work at Guquka. This was a bitter blow, as by this stage summer grazing had already been undertaken in the treatment plot and winter grazing was due to commence in both plots the following month. Moreover, in light of the grazing management system at Guquka, it was felt that it was particularly important to conduct the experimental work here, as controlled summer grazing was a more realistic management option at Guquka than Koloni (see chapter 4). However, in practical terms the loss was not that great. The March-May rainfall during 1999 was very low at Guquka (see Appendix 2.1) and sward recovery was consequently...
very poor (pers. observ.). It would therefore have been almost impossible to undertake any experimental grazing work on the treatment plot. Despite only having data from one site it was nevertheless felt that the results from Koloni could find realistic application at Guquka despite the ecological differences between the sites. The data from Koloni were in any case of such a preliminary “look-see” nature that these ecological differences were relatively unimportant (see Chapter 6).

Figure 3.4: Harvesting of grass from control plot at Guquka, May 1999. Note small patch of original, tall sward on left of the photograph and short, harvested sward on the right, which dominated the remainder of the plot.
3.4) SUMMARY

In summary the research methodology adopted was unusual in that it was multi-disciplinary, drawing on several well-utilised techniques from both the social sciences and ecology. This was necessary in order to achieve the holistic characterisation of the production system the research demanded. However, this holistic treatment of the system resulted in a necessary compromise in the level of detail in which the social and ecological components of the system were examined. This compromise is embodied in the fact that some of the more time-consuming aspects of the ecological fieldwork, such as the assessment of biomass removal on the arable lands and the experimental work, were only undertaken during the second winter. However, this is justifiable in respect of the overall research goal. It was never the intention of the research to provide a rigorous treatment of specific ecological aspects of the arable grazing system. Rather, a broad overview was called for, which allowed for the identification of particular aspects of the grazing system where limited and practical alterations to current practices could result in improvements in livestock production. These might then provide a foundation for the development of recommendations at the regional level. The specific research objectives defined for both the social and ecological sections of the fieldwork reflect this goal.

To this point, the first three chapters of this thesis have provided an overview of the research work undertaken. This includes, the historical, social and political context in which the research is framed, an overview of the study sites selected for the fieldwork and, in this chapter, an outline of the methodology adopted to achieve the defined research objectives. Having provided this important foundation, the remainder of the thesis will now focus on the presentation of the research findings, beginning with the social component of the research.
CHAPTER 4 - MANAGEMENT OF THE ARABLE LAND ALLOCATIONS FOR AGRICULTURE

4.1) INTRODUCTION

There were two overall objectives for this section of the work: -

1. To assess the potential of agriculture as a mechanism for alleviating poverty within each village by investigating existing relationships between particular social groupings and involvement with land and agriculture.

2. To ascertain the current agricultural use of the arable land allocations, and in particular how they are managed as a grazing resource for cattle.

The remit of the second objective was necessarily broad, as although the research focussed on the role of the arable lands in cattle production, the arable land allocations support both crop and livestock production at different types of the year. Thus, in making meaningful recommendations for improving cattle production systems at the two sites it was necessary to undertake an holistic assessment of current land use patterns. However, for the purposes of this research, assessment of the use of the arable lands for cropping was limited simply to analysing data from ARDRI's socio-economic survey, and documenting the history of cultivation of the fields as part of the fieldwork. A more detailed characterisation of crop production practices was undertaken as part of a complementary MSc study (Mbuti, unpublished data).

The chapter will begin with a broad overview of land and agriculture at the two villages based on an analysis of the data from ARDRI's socio-economic survey. It will then deal in detail with two particular facets of land access that have strong implications for effective land use at each village. Finally, a comprehensive account of the livestock management systems at each village will be provided. This will focus on the role played by the arable land allocations and highlight particular constraints facing the systems as they currently operate.
4.2) **LAND AND AGRICULTURE: AN OVERVIEW**

The objective of this section of the work was:

To assess the potential of agriculture as a mechanism for alleviating poverty within each village by investigating existing relationships between particular social groupings and involvement with land and agriculture.

Any project that aims to provide recommendations for possible development interventions must ensure that the foundation upon which these recommendations are grounded is sound and that they reflect current development thinking. Present policy emphasises egalitarian principles with a particular focus on the poorest and most needy sectors of society (DFID, 1997 & 1998; Carney, 1998). However, much traditional, black agriculture in South Africa has an inherent male bias. This is particularly true of cattle production, which has the added drawback of being associated with higher income households (Schmidt, 1992). Thus, there is the danger that the recommendations of a project focused on cattle production will serve only to benefit those sectors of the community (relatively wealthy, male-headed households) that are already in an advantaged position. With this concern in mind the following section will provide an overview of the key social and agrarian parameters from each village (a greater discussion of these parameters and why they were selected is provided in section 3.2.1). Significant relationships that exist between the two sets of parameters will be highlighted and an attempt made to account for them. The implications that these relationships have for possible intervention work at each village will then be discussed in light of current development theory.

The section will begin with a brief overview of the social parameters selected to investigate social bias with regard to land and agriculture at the two villages. It will move on to discuss arable land and the social factors which constrain both access to and productive use of available fields at each village. Finally, an overview will be provided of ownership of livestock including cattle, sheep and goats. Social bias in the ownership of any of these species will be highlighted with particular emphasis on cattle.
4.2.1) **SOCIAL PARAMETERS**

The three key social parameters selected for the inferential statistical analysis at each village were gender, age and income. An overview of these parameters based on the population samples interviewed by ARDRI in 1997, is provided in Tables 4.1 and 4.2.

**Table 4.1: The proportion of male and female-headed households from interview samples at Guquka and Koloni.**

<table>
<thead>
<tr>
<th>GENDER</th>
<th>GUQUKA</th>
<th></th>
<th></th>
<th>KOLONI</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>Percent</td>
<td>Frequency</td>
<td>Percent</td>
<td>Frequency</td>
<td>Percent</td>
</tr>
<tr>
<td>Male</td>
<td>45</td>
<td>57.7</td>
<td>33</td>
<td>61.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>33</td>
<td>42.3</td>
<td>21</td>
<td>38.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sample size</td>
<td>78</td>
<td>100.0</td>
<td>54</td>
<td>100.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: ARDRI, unpublished survey data

From Table 4.1 it is clear that the proportion of male and female-headed households was similar at each village. However, it is important to point out that these figures are based on interviews conducted only with households that are present throughout the year. The sample may therefore contain an element of bias because many male heads of households are migrant workers who are absent for much of the year. In their absence households are generally headed by their wives. Thus, the true proportion of *de jure* female-headed households is likely to have been overestimated at both villages. Nevertheless, provided the bias is consistent at both villages the conclusions drawn from the inferential statistics with regard to gender and land and agriculture will still be valid.

**Table 4.2: Descriptive statistics for age of household head and annual household income at Guquka and Koloni.**

<table>
<thead>
<tr>
<th>STATISTIC</th>
<th>GUQUKA</th>
<th></th>
<th>KOLONI</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample size (n)</td>
<td>78</td>
<td>78</td>
<td>54</td>
<td>54</td>
</tr>
<tr>
<td>Minimum</td>
<td>35</td>
<td>462</td>
<td>37</td>
<td>1296</td>
</tr>
<tr>
<td>Maximum</td>
<td>87</td>
<td>44200</td>
<td>91</td>
<td>72400</td>
</tr>
<tr>
<td>Mean</td>
<td>59.9</td>
<td>9550.1</td>
<td>62.7</td>
<td>13643.5</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>12.9</td>
<td>8803.7</td>
<td>12.5</td>
<td>12194.8</td>
</tr>
</tbody>
</table>

Source: ARDRI, unpublished survey data
Table 4.2 shows that there is little difference between the villages with regard to the mean age of the head of household. However, there is a substantial difference in the statistics relating to household income. Consideration of mean household incomes at each village shows that it is almost 43% greater at Koloni than at Guquka. According to DFID, the poverty line for South Africa is $2.40/person/day and that for extreme poverty $1/person/day (DFID, 1997 & 1998). By these standards the average household at Koloni is poor and that at Guquka would be classified as extremely poor. However, both villages contain varying numbers of households that fall into both categories and some that are not poor at all (Monde et al., 2000). The relatively large difference in mean household income between the villages is perhaps unsurprising and undoubtedly reflects the higher educational standards at Koloni and its relatively close proximity to King William's Town and Bisho. These are major centres of employment in local government and industry and are within daily commuting distance.

It is also important in the context of this discussion to consider the origins of household income. Using data from ARDRI's survey, Van Averbeke (1999) has demonstrated that only 10% of household income is generated within the village at Guquka, compared to nearly 29% at Koloni. Moreover, on average agriculture accounts for nearly 12% of total household income at Koloni (in both cash and kind) compared to just 4.4% at Guquka. To put this in a regional context, Rose and Williams (1988) found that 5.6% of income from households in the Ciskei and Transkei was derived from agriculture. In this respect Guquka may be considered as fairly typical whereas Koloni is somewhat exceptional. Indeed, at the broad level a picture emerges of Koloni as a comparatively self-sustaining settlement within which a relatively large sector of the population maintain an active interest in agricultural (particularly livestock) production. Guquka by contrast emerges as a settlement with a very limited local production base, maintained essentially by state transfers and remittances.
4.2.2) ARABLE LAND

The number of people from the sample interviewed at each village who have access to arable land is summarised in Table 4.3.

Table 4.3: Number of households at Guquka and Koloni with access to one or more fields.

<table>
<thead>
<tr>
<th>ACCESS TO FIELD</th>
<th>GUQUKA</th>
<th>KOLONI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>Percent</td>
</tr>
<tr>
<td>Yes</td>
<td>29</td>
<td>37.2</td>
</tr>
<tr>
<td>No</td>
<td>49</td>
<td>62.8</td>
</tr>
<tr>
<td>Total sample size</td>
<td>78</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Source: ARDRI, unpublished survey data

It is immediately apparent that access to arable land is far more problematic at Guquka since only 37% of households had access to a field compared to over 83% at Koloni. This is not surprising given that there are 127 households at Guquka and just 41 fields compared with 97 households at Koloni and 112 fields (refer to Section 2.2). Almost all of the respondents from Koloni without access to arable land were from the new section of the village where title includes only a residential site and access to rangeland. That these households have not managed to gain access to arable land might appear strange given that there are only 73 houses in the village with quitrent title and 112 fields. However, the situation is complicated by the fact that many quitrent households have access to more than one field and that many fields are owned by people who do not reside in the village (see Section 4.3 for more details).

The sample data on how households at Guquka and Koloni have gained access to the fields they make use of is summarised in Table 4.4.

Table 4.4: Ways in which households at get access to arable land.

<table>
<thead>
<tr>
<th>ACCESS TO ARABLE LAND</th>
<th>GUQUKA</th>
<th>KOLONI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>Percent</td>
</tr>
<tr>
<td>Purchased privately (title deed)</td>
<td>1</td>
<td>2.9</td>
</tr>
<tr>
<td>Inherited through parents</td>
<td>25</td>
<td>73.6</td>
</tr>
<tr>
<td>Application to tribal authority</td>
<td>4</td>
<td>11.8</td>
</tr>
<tr>
<td>Renting</td>
<td>3</td>
<td>8.8</td>
</tr>
<tr>
<td>Sharecropping</td>
<td>1</td>
<td>2.9</td>
</tr>
<tr>
<td>Total</td>
<td>34</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Source: ARDRI, unpublished survey data
The most obvious difference between the two villages is that almost all arable land at Guquka is inherited whereas at Koloni there is also a significant amount of private purchase taking place. This is symptomatic of the different tenure systems in place at the villages. Communal tenure officially precludes sale or renting of land - it can only be obtained through application to the tribal authority or through inheritance. Quitrent on the other hand is more flexible and land can be bought or sold if the correct procedure is observed (refer to Appendix 1). Nevertheless, this process can be complicated by a number of factors as the case in Box 1 illustrates.

Box 1. The difficulties of land transfer under quitrent title: the case of Mrs G.

Mrs G. of Koloni has recently been widowed and inherited two fields from her deceased husband. One of them she has used for sharecropping with other village residents but the other field is located in an inaccessible part of the large arable land allocation and she wants to offer it for sale. However, despite having access to the field she cannot sell it because under the quitrent system she does not have official title to the land. She is only a guardian of the land until her death at which stage title theoretically passes to the nearest male kin from her husband’s family as she has no sons of her own. However, it is proving extremely difficult for her to get in contact with any of her inlaws they all live a considerable distance from Koloni in urban areas such as Bloemfontein. She has tried using a well-known radio programme to contact them, but is not hopeful of resolving the situation, as most of them have never been to Koloni and thus are unsure of where it is.

Taken together these findings have significant implications both for agricultural production and any recommendations that can be made with regard to changes in land use. The essentially stagnant land market at Guquka may act to prevent fields from being accessed by those who might use them more productively or being turned over to alternative land uses. Conversely, some form of land market is clearly in operation at Koloni, which allows land exchange to take place as long as owners are willing to sell. However, given the complicated quitrent system and the lack of institutional support it has been afforded since the disintegration of the Tribal Authorities system, it is unlikely that this is particularly active anymore. Indeed, the current quitrent system would seem to act as a disincentive to the formalised sale of land.

Inferential statistics were used to investigate any relationships that might exist between land access and the three social parameters outlined in Section 4.2.1. These
demonstrated that gender and access to arable land were not significantly related at either village, although the relationship was stronger at Guquka (see Table 1, Appendix 4.1). This may seem surprising given that land inheritance is generally patrilineal (Mills and Wilson, 1952). However, the fact that land goes first to the widow of the deceased and that many Xhosa men marry much younger women, means that there are a considerable number of widowed landowners at each village.

Similarly, there was no significant relationship between income and access to arable land at either village (see Table 2, Appendix 4.1). However, access was found to be positively and significantly related to age at both Guquka (p< 0.001) and Koloni (p< 0.05) [see Table 2, Appendix 4.1]. This is unsurprising given that most fields are inherited, particularly at Guquka. Even at Koloni where a limited land market exists, it is mainly older people who have access to arable land, as young people can only gain access to land in the new part of the village and this does not include access to a field.

The available data on cropping at Guquka and Koloni were also investigated to provide an indication of the level of productive land use and possible constraints to this. Data on whether or not households have cropped any of the fields to which they have access within the previous three seasons, are summarised in Table 4.5 below:

<table>
<thead>
<tr>
<th></th>
<th>GUQUKA</th>
<th>KOLONI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>19</td>
<td>9</td>
</tr>
<tr>
<td>Percent</td>
<td>65.5</td>
<td>20</td>
</tr>
<tr>
<td>Total</td>
<td>29</td>
<td>45</td>
</tr>
<tr>
<td>Frequency</td>
<td>10</td>
<td>36</td>
</tr>
<tr>
<td>Percent</td>
<td>34.5</td>
<td>80</td>
</tr>
</tbody>
</table>

Source, ARDRI unpublished survey data

The proportion of households who had cropped at Guquka (65.5 %) was more than three times greater than that at Koloni (20 %). This is undoubtedly a result of the much greater ecological cropping potential that exists at Guquka and also to some extent the differences in security of tenure that exist between the villages. Communal tenure can be revoked if a field lies idle for three successive seasons, which provides a strong incentive for the owner to cultivate on a regular basis. Quitrent fields however,
will remain secure even if they are unused as long as the owner continues to pay
quitrent dues. Moreover, these findings suggest that whilst access to land may act as a
constraint to crop production at Guquka, this does not seem to be the case at Koloni.

Relationships that might exist between ability to crop and social factors were also
investigated (refer to tables 3 and 4 in Appendix 4.1). The lack of a significant
relationship between income and cropping was surprising given that crop production
frequently involves a considerable amount of initial financial outlay (Mbuti,
unpublished MSc data). However, the relationship between male-headed households
and ability to crop was found to be significant at the 0.05 level at Guquka. This
strong gender-bias at Guquka is probably a result of male control over vital inputs
such as ploughs, tractors and oxen. Although crop production in Xhosa society has
historically been undertaken mainly by women (Bundy, 1988), in the former Ciskei
they are now largely relegated to involvement in weeding and harvesting (pers.
observ.). Why the same relationship is not evident at Koloni is not easy to account
for, although it probably reflects the greater level of community spirit at Koloni.
Certainly, it would appear that one or two widows at Koloni have been able to
produce crops in recent years by engaging in reciprocal ploughing arrangements with
men. An interesting example of such an arrangement is provided in Box 2.

### Box 2. A reciprocal arrangement for crop production: the case of Mrs N. and Mr M.

Mrs N. is a widow of some considerable standing within Koloni. Upon the death of her husband,
a keen farmer, she inherited a herd of 22 cattle and access to a fenced field in one of the small
arable land allocations at the village. Since his death she has been able to continue producing
crops most years through an arrangement she has with a close friend Mr M. During the 1996/97
growing season he used the oxen from her herd to plough her field and plant it to maize. They
shared the costs of seeds and other inputs and the labour expended in weeding and harvesting the
crop. The entire maize harvest was shared between them through the fact that Mrs N. prepares all
of Mr M’s meals. Thus, although the two live separately they have what it is effectively a
marriage of convenience whereby Mrs N. does the cooking and provides the land and oxen which
enable Mr M. to produce crops for their mutual benefit.

In summary therefore, access to arable land at both Guquka and Koloni seems to be
the preserve of old people but largely unrelated to gender or wealth. Crop production
on the other hand is unrelated to any of these factors at Koloni but is biased almost
exclusively towards male-headed households at Guquka. Taken together these findings suggest that the overriding constraints to crop production at Koloni are not social but ecological, whereas at Guquka social factors do play a significant part. This has significant implications for development interventions based around arable land and its use at both villages.

Interventions focused on production of field crops would have to acknowledge from the outset that they were facing different sets of constraints at each village. At Guquka, culture and inheritance patterns discriminate against women and younger people in crop production, and thus it is likely under current circumstances that old men would be the most direct beneficiaries of such projects. Moreover, given the compounding factors of archaic land tenure arrangements and a shortage of available land it is unlikely that this scenario will change in the near future. If the egalitarian aims of current government development policy are to be achieved then such projects could only be justified if schemes for alleviating poverty amongst other sectors of the community were also introduced. At Koloni, crop production does not suffer from the same social biases, land is abundant and there is a limited land market. The scenario would therefore appear ideal for encouraging crop production. However, the low rainfall the site experiences, is a major constraint. Few people continue to show interest in what is an essentially risky venture, particularly when livestock production offers a more reliable (and frequently more productive) alternative. This would suggest that interventions focused on increasing crop production would not be the most pragmatic means of enhancing rural livelihoods at either village.
4.2.3) **LIVESTOCK**

In assessing the effectiveness of cattle production as a strategy for uplifting rural livelihoods, it is important to have some idea of which social groups within the village would benefit most from such an intervention. In this section, data from ARDRI's socio-economic survey relating to ownership of cattle, sheep and goats is presented and related to key social factors at Guquka and Koloni. Table 4.6 provides an overview of stock ownership statistics at both villages.

**Table 4.6: Descriptive statistics for ownership of livestock amongst households at Guquka and Koloni.**

<table>
<thead>
<tr>
<th>STATISTIC</th>
<th>GUQUKA</th>
<th></th>
<th>KOLONI</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ownership (%)</td>
<td>33.3</td>
<td>14.1</td>
<td>14.1</td>
<td>55.6</td>
</tr>
<tr>
<td>Min. no. of animals</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Max. no. of animals</td>
<td>20</td>
<td>50</td>
<td>18</td>
<td>25</td>
</tr>
<tr>
<td>Mean no. of animals</td>
<td>6.0</td>
<td>19.0</td>
<td>5.4</td>
<td>9.5</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>4.9</td>
<td>16.3</td>
<td>4.7</td>
<td>7.3</td>
</tr>
</tbody>
</table>

Source: ARDRI, unpublished survey data

It is immediately apparent that a far greater proportion of the households interviewed at Koloni owned livestock than those Guquka. This applies to all major livestock species. Consideration of mean herd sizes amongst livestock owners also shows that they are consistently greater at Koloni for all livestock species. These differences undoubtedly reflect the greater ecological suitability of the region in which Koloni is situated to livestock production. Moreover, they have important implications for interventions based on cattle production at the two villages. That Koloni has a much greater proportion of households with cattle, means that a larger sector of the population are likely to benefit directly from such interventions (at least in the shorter term). Furthermore, according to Bembridge (1979), the minimum herd size necessary to generate a sustainable livelihood solely from cattle production is nine animals per household. This suggests that the majority of cattle owning households at Koloni could subsist from their herds alone if the need arose, and demonstrates their importance as a form of security. It also suggests that any development initiatives focused on increasing cattle production would have a better chance of yielding
tangible and sustainable livelihood improvements at Koloni than they would at Guquka.

Statistical tests were employed to investigate relationships that might exist between livestock holdings and the three social parameters. This was investigated at two levels: ownership and size of stock holding. For gender it was hypothesised that both ownership and size of holding would be biased towards male-headed households for cattle and female-headed households for goats.

A significant overall bias in stock holding towards male-headed households existed at both Guquka (p< 0.01) and Koloni (p< 0.05). However, at the species level differences in ownership between the villages were evident. At Guquka there was a significant male bias in the ownership of cattle (p< 0.01), but not of goats or sheep. At Koloni the relationship between male-headed households and ownership of both goats and sheep was found to be significant (p< 0.05), but no significant relationship could be found for cattle (See Table 5, Appendix 4.1). The significant male bias in cattle ownership at Guquka was expected. This is because ownership of cattle in Xhosa society is viewed as a male prerogative, whereas women's focus is traditionally on goats and poultry (Coertze, 1986). The lack of a significant bias at Koloni is more difficult to explain and possibly results from the considerable number of widows at Koloni who have inherited cattle from their deceased husbands.

With regard to relationships that exist between gender and size of livestock holdings, there were insufficient numbers of female-headed households at both Guquka and Koloni to provide realistic mean herd sizes for each species that could be compared with male headed households by t-tests. Nevertheless, the results from the ownership data alone suggest that a much greater level of gender bias existed at Guquka than Koloni with regard to cattle. This has strong implications for interventions focused on cattle production at the two villages. The direct benefits of such interventions are likely to be realised by both male and female-headed households at Koloni whereas they will be skewed far more towards male-headed households at Guquka.

Any relationships that might exist between age of household head and ownership of livestock were also investigated. The strongest relationship was for sheep at Guquka,
although even this was not significant at p< 0.05 (see Table 6, Appendix 4.1). This suggests that ownership of livestock is fairly evenly distributed across the full age spectrum for household heads at both villages. With regard to age of household head and size of livestock holding no significant relationships could be found for any livestock species at Koloni. However, relationships at Guquka were much stronger being significant for both goats (p< 0.01) and sheep (p< 0.01) [see Table 7, Appendix 4.1].

Once again no straightforward explanation can be offered for the differences between the villages. One possibility lies in the greater mean household income at Koloni, which may allow younger household heads to invest in livestock without waiting for natural increases in numbers. The significant correlation between age of household head and the size of both goat and sheep holdings at Guquka suggests that households tend to concentrate on building up flocks of small-stock (sheep and goats), as they are better suited to the ecological conditions prevailing in the area. The absence of a significant relationship between age of household head and both cattle ownership and herd size is surprising given that one of the primary objectives of cattle ownership amongst black peoples in Southern Africa is to increase herd size (Düvel and Afful, 1996). Nevertheless, this has positive implications for interventions focused on cattle production, suggesting that they would be likely to benefit a broad cross section of age groups amongst cattle owners at both villages.

Likewise, an investigation into household income and ownership of livestock was also undertaken (see Table 8, Appendix 4.1). The only significant relationship was for cattle at Guquka (p< 0.05). This would appear to reflect the acknowledged use of cattle by the Xhosa as a store of wealth (Schmidt, 1992).

Correlation analysis was used to relate income to the numbers of cattle, sheep and goats owned by households at both villages (see Table 9, Appendix 4.1). Unexpectedly, the only significant relationship was for sheep numbers at Koloni, where the correlation was strong (p<0.01). This would seem to suggest that ownership of large flocks of sheep at Koloni was the preserve of those with the highest incomes. Why this was not the case at Guquka, and why the size of cattle holdings at both Guquka and Koloni did not show any strong relationship with income
as expected, is far from obvious. Nevertheless, taken together these findings have implications for any cattle-based development initiatives at the two villages. The polarisation of cattle ownership towards higher income families at Guquka suggests that such initiatives would be of direct benefit only to the more wealthy households.

By way of contrast, the fact that there is actually a slightly negative relationship between income and the number of cattle owned at Koloni, suggests a far more even distribution of benefits here and one that is far more in keeping with the objectives of current development policy.

In summary, ownership of cattle at Guquka was restricted to about one-third of the households interviewed as part of the socio-economic survey undertaken by ARDRI during 1997. This immediately limits the impact any development intervention based on cattle production can have on improving rural livelihoods. Moreover, the significant social biases within cattle production at Guquka mean production is skewed towards wealthier, male-headed households. Thus, not only would the number of direct beneficiaries of a cattle production project at Guquka be small, those who did benefit would primarily be the "haves" rather than the "have nots". Given the emphasis in current development policy on targeting the most needy, such a project would be difficult to justify.

By way of contrast, cattle ownership is not only far more widespread at Koloni but without significant social bias with regard to gender, age or income. This suggests that a project with a focus on increasing cattle production could benefit a large sector of the village population and be in keeping with the poverty focus of current policy to improve rural livelihoods.
4.3) **LAND OWNERSHIP AND ACCESS DETAILS**

The objective of the second phase of the social investigation was as follows:

*To characterise within each village current arrangements for access to the fields on the arable land allocations and their recent cultivation history.*

An overview of land access and utilisation at Guquka and Koloni has been provided in Section 4.2. So too has an analysis of key social factors that might be constraining access to and utilisation of land for crop production. Whilst, this provides some broad indication of the social factors constraining land use at each village, it was apparent that this did not account for all the constraints, particularly at Guquka. Thus, the purpose of this section is to investigate any additional factors that might be constraining the effective use of available land at the villages. To this end, key findings from the comprehensive data set on land ownership and utilisation collected at each village (see Section 3.2.2) are presented below and discussed with regard to two potentially important constraints to the effective use of land at both Guquka and Koloni. The data are also used to inform management recommendations for the arable land allocations at both villages.

4.3.1) **WHEREABOUTS OF LANDOWNERS**

During the data collection process it became apparent at both villages that several of the fields belonged to individuals who did not reside there. Moreover, in almost every case fields belonging to outsiders showed no recent signs of cultivation (Bennett, 1998). It was thus possible that ownership of the land by outsiders might be constraining its more effective use by village residents. This is investigated in Table 4.7 below. Data are divided into four categories based on the current proximity of the field owner to each village. The first category deals with those who are resident in the village. The second category “resident in nearby location” refers to those individuals living in close proximity (taken to be < 5 km) to the village. This seemingly arbitrary distinction is intended to include all the surrounding villages belonging to the same
tribal authority, since it was quite common for arable land to be allocated to people residing in neighbouring villages if it was surplus. The third category "resident in distant location" includes those individuals who currently reside more than 5 km from the village. The fourth category accounts for those field owners whose whereabouts are unknown.

Table 4.7: Proportion of arable land at Guquka and Koloni belonging to people who reside within the village and those who reside elsewhere.

<table>
<thead>
<tr>
<th>Category of owner</th>
<th>GUQUKA</th>
<th>KOLONI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of fields</td>
<td>Approx. area (ha)</td>
</tr>
<tr>
<td>Resident in village</td>
<td>28</td>
<td>100.3</td>
</tr>
<tr>
<td>Resident in nearby location</td>
<td>9</td>
<td>30.6</td>
</tr>
<tr>
<td>Resident in distant location</td>
<td>4</td>
<td>11.4</td>
</tr>
<tr>
<td>Whereabouts unknown</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Totals</td>
<td>41</td>
<td>142.3</td>
</tr>
</tbody>
</table>

Source: Bennett, 1998

An interesting picture emerges from these results. It is immediately apparent that the individuals who own the vast majority of arable land at both Guquka (70.5%) and Koloni (70.5%) reside in the village. The situation with regard to ownership by individuals outside the village is, however, quite different. At Guquka 29.5% of arable land belongs to outsiders. Of this, 21.5% belongs to individuals residing in neighbouring villages and 8.0% to those who reside some distance from the village. No land is owned by individuals whose whereabouts are unknown. In contrast, nobody residing in nearby locations has access to land at Koloni. Rather, 6.3% of the land owned by individuals outside the village belongs to people who reside some distance from the village and the majority (23.2%) belongs to individuals whose current whereabouts are unknown. Indeed, of the 33 fields included in these two ownership categories, 18 belong to people who never even resided at Koloni. One of these individuals has access to three fields at the village. Others are known to have never even ploughed the fields they were allocated! (Chairman of Koloni, pers. comm.).

These findings have implications for the levels of land utilisation at both sites. Approximately 92% of the arable land at Guquka is owned by individuals within the immediate area (< 5 km), whereas at Koloni this figure is only 70.5% (only those who
actually reside in the location). Thus, whilst land ownership by outsiders is unlikely to be an important factor in restricting land access at Guquka, it does play a much more significant role in limiting the amount of land available to the current residents of Koloni for crop production. Moreover, the individual tenure type under which these fields are held at Koloni means that ownership remains secure as long as quitrent payments are maintained. Land can only be reallocated with the owner's permission and an appropriate level of compensation.

In light of this, it would be tempting to suggest that absenteeism amongst landowners is a major constraint to land access at Koloni and thus to potentially higher levels of crop production. However, given the huge amount of arable land still retained by residents at Koloni this appears unlikely. The vast majority of current residents at Koloni have access to a field through their family. Furthermore, several households at Koloni gain access to a field through share-cropping arrangements with a resident or by making temporary use of a field belonging to an absent landowner (Bennett, 1998). This applies not only to the "landless" minority, but also to those quitrent title holders whose fields are severely eroded or located in very inaccessible areas. Indeed, the use of fields belonging to absent landowners used to be widespread and is still preferred to sharecropping as there is no cost to the producer for the use of the land (informal interview with Mr M. 19/2/98). In light of this evidence it is highly unlikely that the 29.5% of arable land that belongs to outsiders is in anyway constraining crop production at the village.

4.3.2) MONOPOLISATION OF LAND

Land at both villages was originally allocated under the ubiquitous "one man, one lot" principle which evolved under colonial rule and was perpetuated under apartheid. Under this system each household received a residential site and access to an arable field (Mills and Wilson, 1952). However, given the very limited amount of arable land at Guquka and the fact that the communal tenure system forbade the subdivision of fields, landlessness appears to have been a problem at the village for several decades. Many of the households registered in the 1965 survey of allotments at the
village (see Appendix 2.1) belong to families\(^1\) that currently do not even have access to a single field (Bennett, 1998). By way of contrast landlessness at Koloni is a very limited and fairly recent phenomenon and, as outlined above, is more a symptom of the tortuous land tenure system than an actual dearth of available land. It was thus expected that at Koloni there would be a fairly strong relationship between family size (defined as number of households) and the number of fields they have access to, indicating fairly equitable land distribution between families. At Guquka, however, the relationship was expected to be far weaker given the degree of landlessness at the village.

For each village the relationship between family size and number of fields they owned was investigated. A list of all the households at each village was available from the 1997 ARDRI survey. These were grouped according to family name and the number of fields each family owned was obtained from Bennett (1998). The resulting data comparing family size and field number at both villages are presented in table form in Appendix 4.2 and diagrammatically in the scatter plots below.

![Fig 4.1: Scatter plot showing relationship between family size and number of fields owned at Guquka.](image)

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\(^1\) For the purposes of this study a family is defined as a group of households sharing the same surname.
Figure 4.2: Scatter plot showing relationship between family size and number of fields owned at Koloni.

It is immediately obvious that there is a more definite linear relationship between the size of a family and the number of fields they have access to at Koloni than at Guquka. This was predicted and reflects the "one man, one lot" ethos of land distribution which was effective at Koloni until relatively recently, but has long been impossible to practice at Guquka. What is also clear is the wide variation in family size at Guquka amongst those families that do not have access to arable land, which is not evident at Koloni. This is examined in more detail in Table 4.8.

Table 4.8: Family size amongst landless families at Guquka and Koloni.

<table>
<thead>
<tr>
<th>Family size (number of households)</th>
<th>GUQUKA</th>
<th>KOLONI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of families</td>
<td>Total number of households</td>
</tr>
<tr>
<td>1</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>Total</td>
<td>27</td>
<td>56</td>
</tr>
</tbody>
</table>

It must be emphasised that this data covers only those families that are completely landless i.e. where none of the households which comprise the family have access to a field. There are several other households without fields at both villages (particularly Guquka) but these belong to families where one or more of the households does have land.
These figures highlight the vast discrepancy between the two villages in access to arable land. At Guquka 27 families comprising a total of 56 households are completely landless, compared to just seven families comprising seven households at Koloni. The discrepancy in the size of landless families at both villages is even more striking. All the landless families at Koloni are relatively recent arrivals (in the communal tenure area of the village) consisting of single households. In contrast some of the landless families at Guquka are fairly large. Indeed, reference to Appendix 4.2 shows that the Mona and Tobi families are amongst the largest in the village consisting of six households each. By way of comparison, the Rubuxa family consists of only four households but they have access to four fields. This illustrates some of the striking disparities between families at the village with regard to land holdings and demonstrates that land is not linked to family size but rather to family history. A relatively small number of established families have access to the majority of the arable land at the village. This is summarised in Table 4.9.

Table 4.9: Size of land-owning families at Guquka in relation to arable holdings.

<table>
<thead>
<tr>
<th>FAMILY NAME</th>
<th>HOUSEHOLDS</th>
<th>%</th>
<th>FIELDS</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>NDONGENI</td>
<td>1</td>
<td>0.9</td>
<td>1</td>
<td>2.4</td>
</tr>
<tr>
<td>MANGQONGOZA</td>
<td>2</td>
<td>1.8</td>
<td>1</td>
<td>2.4</td>
</tr>
<tr>
<td>MZILIKHAZI</td>
<td>2</td>
<td>1.8</td>
<td>1</td>
<td>2.4</td>
</tr>
<tr>
<td>MAXELA</td>
<td>2</td>
<td>1.8</td>
<td>2</td>
<td>4.9</td>
</tr>
<tr>
<td>GOSHANA</td>
<td>3</td>
<td>2.7</td>
<td>1</td>
<td>2.4</td>
</tr>
<tr>
<td>MOOI</td>
<td>4</td>
<td>3.5</td>
<td>2</td>
<td>4.9</td>
</tr>
<tr>
<td>FUNJWA</td>
<td>4</td>
<td>3.5</td>
<td>3</td>
<td>7.3</td>
</tr>
<tr>
<td>RUBUXA</td>
<td>4</td>
<td>3.5</td>
<td>4</td>
<td>9.8</td>
</tr>
<tr>
<td>DLANGA</td>
<td>5</td>
<td>4.4</td>
<td>2</td>
<td>4.9</td>
</tr>
<tr>
<td>TIBINI</td>
<td>6</td>
<td>5.3</td>
<td>3</td>
<td>7.3</td>
</tr>
<tr>
<td>MSIZI</td>
<td>7</td>
<td>6.2</td>
<td>2</td>
<td>4.9</td>
</tr>
<tr>
<td>DIBELA</td>
<td>17</td>
<td>15.0</td>
<td>11</td>
<td>26.8</td>
</tr>
<tr>
<td><strong>TOTALS</strong></td>
<td><strong>57</strong></td>
<td><strong>50.4</strong></td>
<td><strong>33</strong></td>
<td><strong>80.4</strong></td>
</tr>
</tbody>
</table>

Just 12 established families at Guquka, consisting of 57 households, have ownership of more than 80% of all the arable fields in the village. The Dibela family alone own more than a quarter of all the arable fields. The remaining fields belong to families that no longer reside in the village (see Appendix 4.2). This suggests that access to arable land at Guquka is determined principally by family history. Fields are
inherited from generation to generation within a few of the more invested families, preventing the landless majority from getting access to them. This reinforces the finding of Holbrook (1998a), that these invested families have control over the majority of agricultural resources at the village.

This has important implications for agriculture at Guquka. It was suggested in section 4.2.2 that social factors probably constitute the main constraint to large-scale field crop production at Guquka, particularly age and gender. These findings corroborate this idea and suggest that family history is also a constraining factor as it prevents the newer families from owning arable fields. Indeed, not just ownership, but access of any kind to arable land seems to be a problem for landless families at Guquka. Just two households from landless families (the Mdashe and the Booi families) gained access to arable land for crop production during 1997/98 (Bennett, 1998). There seems to be a genuine aversion amongst landowners at Guquka to allowing non-family members access to their land. The insecure land tenure arrangements at the village encourage a belief amongst landowners that somebody may lay claim to their field if they are allowed to crop it, particularly if this continues over a prolonged period (Van Averbeke, 2000a). Furthermore, landowners who allow their fields to be borrowed generally do so as part of a sharecropping arrangement. These arrangements tend to be inherently biased in their favour, as they often do nothing more than provide the land and expect 50% of the harvest in return. This acts as a major disincentive to crop production amongst the landless (Van Averbeke, 2000a).

Together these findings suggest that only the more established families at Guquka can effectively gain access to arable land and engage in field crop production. Given that much of the crop production at the village has now devolved to home gardens (pers. observ.), focusing on smaller-scale garden production might provide a more egalitarian alternative.

The results also have implications with regard to recommendations that can be made on appropriate land uses at both villages. At Guquka almost all fields are owned by individuals who reside in or around the community. Moreover, arable land is in short supply and tends to be jealously guarded by those who have access to it. There is thus limited scope for the conversion of under-utilised fields to more productive land uses.
By contrast, outsiders who have either left the village or have never resided there hold a considerable portion of the arable land at Koloni. Many of these individuals have had no contact with the village for several decades and it can be assumed that a good proportion of them are now deceased and that their offspring have now unknowingly inherited their land. This provides a mechanism for the allocation of fields to the landless and for reallocation to those whose fields have become either too eroded to plough any longer or are situated in very inaccessible areas. It would also enable unused or unproductive sections of arable land to be converted to more appropriate uses such as livestock production.
4.4) CHARACTERISATION OF CURRENT LIVESTOCK MANAGEMENT PRACTICES

The specific objective of this third phase of the social investigation was as follows:

**To undertake a detailed characterisation of current livestock management strategies and how these differ between the villages, with particular emphasis on the use of the arable land allocations as a forage reserve.**

For each village the interview data from key informants (see Section 3.2.3) will be used to provide an overview of how the grazing management systems for livestock at each village should function in principal. Data from individual interviews with livestock owners will be used to develop a broad picture of what is happening in practice. This will be undertaken for each village in turn, beginning with Guquka. The way the systems operate at each village will then be compared and discussed to allow any constraints to the effective use of available forage (particularly on the arable land allocations) for communal livestock production to be identified.

4.4.1) GUQUKA

4.4.1.1) THE GRAZING MANAGEMENT SYSTEM

**CONTROL OF GRAZING MANAGEMENT**

The major management decisions at Guquka are officially under the control of the Resident's Association (RA). However, as outlined in Section 2.2.1, individuals from the more established land-owning families dominate the RA. Moreover, these families also exert a very strong influence over the committees that are constituted on an *ad hoc* basis to deal with resource management. This means that at a practical level committees such as the grazing committee are controlled by the established families who have a vested interest in the grazing management decisions taken at the village as they own the majority of livestock (Holbrook, 1998a).
RANGELAND GRAZING

The rangeland at Guquka is available to all livestock species at all times of the year. For reasons of safety small-stock tend to be grazed within relatively close proximity to the village. Cattle, however, can be found grazing throughout the most mountainous extent of the range during the summer months (Figure 4.3). They even gain access to the state forest plantations when fencing is inadequate. This leaves them vulnerable to loss, impoundment and theft, the latter having become a significant problem in recent years.

Figure 4.3: Cattle from the AmaKhuze villages grazing at the extreme limit of their mountainous range during summer.

The fencing that existed to divide the range into separate camps has long since been removed. All that remains is that which defines the upper limit of the range. Thus, the community can exercise no control over the intensity of utilisation of the range. Rather, seasonal parameters and not human decisions drive use of the range. With the approach of winter, cattle move down to the lower areas of the range and do not return to the higher pastures until springtime. Thus, management of rangeland resources for grazing purposes is negligible at Guquka.
GRAZING OF ARABLE LAND ALLOCATIONS

With regard to its grazing role, the bulk of the arable land allocation at Guquka officially functions as an exclusive forage reserve for the village’s livestock during the winter. However, several factors operate at the village that prevent it functioning in such a clear-cut manner. These are discussed below.

• The different roles of the upper and lower arable land allocations

Before any discussion begins of the role played by arable land in grazing it is important to outline the differing ways the upper and lower arable land allocations are utilised at Guquka.

The lower field allocation consists of fields 1-28 (Figure 4.4, overleaf). This is where the vast majority of cultivation still occurs each year. The general grazing management framework that restricts livestock from this area during the cropping period, and allows them access after harvesting, applies here. For this reason the majority of the discussion which follows will be restricted to the lower allocation.

The upper arable land allocation consists of fields 29 - 41 (Figure 4.4, overleaf). Arable cropping has largely been abandoned here, and the gates which previously separated it from the other sections of the village, have been removed. It has effectively become an extension of the range with grazing tolerated on a permanent basis. Fields that are not fenced are available to free-ranging livestock throughout the year, whereas those that retain fencing are utilised by their owners for grazing livestock whenever they please. Thus, individual grazing rights are retained here throughout the year in selected fields. The situation is further complicated by the fact that some limited cropping is still undertaken in this area. However, those cultivating crops must accept that they do so at their own risk, as the general grazing management framework that applies to the lower field allocation does not pertain here.
• **Duration of arable grazing**

The exact duration of arable grazing at Guquka is not easy to determine since the arable land allocations are being grazed at a largely unofficial level throughout the year (see below). However, the duration of officially sanctioned (through the RA) grazing can be taken as 3-4 months, with fields officially opening in early to late June and closing at the end of September.

Officially, the arable land allocations are opened to grazing once the harvesting of all crops has been completed. A meeting is held, which all field owners are encouraged to attend, and a decision to open the fields is taken by the chairman once there is complete agreement amongst participants. However, even this decision can be circumvented. Not everybody finishes cropping at the same time, and so the grazing of crop residues is frequently initiated before all harvesting is completed. In such
instances, livestock owners make an arrangement to put their animals on one field after another as harvesting is completed in each of them (Figure 4.5).

Figure 4.5: Cattle and sheep grazing crop residues in a fenced field at Guquka prior to the official opening of the entire arable land allocation for grazing.

In general, this is conducted in a fairly egalitarian manner with livestock belonging to landless households also given an opportunity to participate. The process is continued until harvesting is completed on all fields, at which point the entire arable allocation is opened to grazing. This is possible because cultivated fields at Guquka are always fenced. Thus, animals can be restricted to grazing one field and prevented from interfering with unharvested crops in nearby fields. Nevertheless, there is still a requirement for animals to be watched at this time to ensure there are no transgressions.

A meeting of the RA officially precedes the closing of the arable land allocations to winter grazing. The desire of individuals to begin cropping is the most important factor influencing the timing of the closure. However, prior to closure the majority of livestock have generally vacated the lands anyway and moved back to the range, due to lack of forage. Once it is decided to officially close the allocations, the gates allowing access to the fields are shut and all remaining livestock are officially excluded. However, this “closure” is far from clear cut since, for reasons outlined
below, livestock continue to be present on the arable land allocations at residual levels even during the cropping (summer) period.

- **Livestock involved in arable grazing**

Amongst key informants there was mixed opinion as to which livestock are officially sanctioned to be on the arable lands during the winter. Of the four individuals interviewed, two stated that all livestock are allowed on the fields, whereas the other two held that they should be reserved for cattle only, although they accepted that sheep and goats do get access because the gates to the main arable land allocation are left open. This divide in opinion was also reflected in the responses of livestock owners from the village when asked where their animals had been grazing during the winter. All those (13) individuals who owned cattle said that their animals had spent time on the arable lands. However, only three out of the eight individuals who owned sheep and two of the seven individuals who owned goats said their animals had utilised the arable lands during the winter. The remainder made a determined effort to restrict their small stock from grazing here. Thus, at a practical level it would appear that whilst the arable lands are officially reserved for cattle, the presence of small-stock is tolerated, particularly early in the season when crop residues are abundant.

- **Livestock movements**

During the winter period livestock from the village are essentially free to move between the range area and the arable lands. However, a number of factors can limit the use made of the available forage by livestock.

**Individual rights over fields.**

All land-owners must relinquish individual rights to fields during the winter, such that the entire land allocation reverts to a communal grazing resource for all. This enables those individuals who have livestock but do not have access to a field of their own to share in this forage reserve. All four key informants testified to this being the accepted situation.
The main exception is if the owner of the field grows a winter crop. They can then maintain individual rights to the field for as long as the crop remains, as reward for their individual endeavour. However, this practice is rare at Guquka. Semi-structured interviews revealed that only one individual regularly grows winter crops. He is the focus of the first case study (Box 3).

Two main points emerge from this case. The first is the lack of specific production objectives in the decision to plant forage. Rather the objective is maintenance of animal numbers, which reflects the multi-purpose nature of livestock holdings in Xhosa culture. The other is the difficulty facing livestock owners in communal areas in taking individual initiatives to try and improve their situation. In the face of high pressure on scarce resources, individuals have little alternative than to make best use of what resources are available to them privately. In Mr D.’s case, these are relatively good and this has engendered a sense of resentment amongst other livestock owners, particularly those who do not have access to arable land.

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**Box 3. Progress in the midst of adversity: the case of Mr D.**

Mr D. is one of the major stock-holders in the village, owning at the time of interview 17 cattle, 42 sheep and 15 goats. He is the last remaining land-owner who still regularly plants winter forage for his livestock. This is a practice that used to be fairly commonplace and was derived from the white livestock farmers in the area. In 1999 he grew barley on separate fenced sections of the two fields he has access to. This was planted in late summer time (March) just prior to the harvesting of his summer maize crop. Seed was purchased from Queenstown at R55 per 50kg bag and ploughing and planting was undertaken using his own tractor and family labour.

The barley crop is generally grazed from early May onwards and is reserved for his winter lambs, calves and older cattle (Figure 4.6). There are no specific production objectives in this exercise, but rather the focus is on giving the more vulnerable animals in his herd an increased chance of surviving the difficult winter months.

By perpetuating this practice and his regular visits to the white farming areas of Queenstown and Cathcart, Mr D. has engendered a certain amount of jealousy from sectors of the community. Several livestock owners have accused him of being selfish for not allowing their animals to graze his winter barley. Their behaviour is rarely overt and is generally restricted to gossip. However, there have been instances of individuals cutting the fences to his fields to allow their livestock onto his crop. This has left him feeling bitter and somewhat alienated within the village.
Amongst those livestock owners who were not involved in winter forage cultivation, two said that they had previously engaged in this practice and two others stated that they used to grow winter crops (wheat) for human consumption. The main constraints to continuing winter cropping were identified as lack of adequate fencing to keep out small stock, and no longer having access to a combine harvester for the wheat. Four interviewees stated that they would be keen to engage in winter forage production providing they could get access to an adequately fenced field. Interestingly, all of them stipulated that this endeavour should be undertaken on a communal basis.

The other situation in which individuals can maintain land rights during the winter is if a field is fenced. Interviews with livestock owners and livestock count data for winter 1999 (see Chapter 5) demonstrated that individual grazing rights to fields were retained during the winter in several fenced fields. Four of the livestock owners interviewed had not made their fields available for communal grazing the previous winter. Two of these had grazed livestock on their fields during the summer and wanted to give the grass sward a chance to recover. Two other individuals regularly maintained exclusive grazing rights over fields during the winter. One of these is the focus of the second case study (Box 4).
Box 4. Fenced fields allow flexibility in grazing: the case of Mr B.

Although the B. family does not officially own any fields, Mr B. has access to two fields (numbers 31 and 40) on the upper arable land allocation. Field 31 is effectively the property of the family as it was entrusted to Mr B.'s father many years before when its owner Mr T. moved away from Guquka. Field 40 belongs to Mr G. who is a relative of the B. family.

Mr B. works as a security guard and is frequently away from the village for several days at a time. When he is absent his cattle are enclosed in fields 31 and 40 for safe-keeping. This facilitates easy maintenance of the animals, particularly on field 31 where water is generally available in ditches. During 1999 his cattle were maintained on field 31 for almost the entire duration of the winter. Mr B.'s cattle have exclusive access to these fields for grazing at this time. This arrangement is strictly between Mr B. and the owners of the fields, and according to him there is no need to seek the permission of the rest of the community, as they have no jurisdiction over this land. However, he believes that his exclusive use of these fields during the winter does not engender animosity from the rest of the community as they empathise with the fact that there is nobody else to look after the cattle when he is away.

This case study serves to underline a number of points with regard to grazing management practices at the village. First, when owners are unable to supervise their animals directly, safety would appear to be accorded higher priority than forage availability in the grazing management decisions they make. This is understandable given the regular incidences of stock theft that occur in the area. More importantly, cattle owners who have access to fenced arable fields are able to maintain individual grazing rights over fields during the winter and thereby bypass the official communal grazing ethos at this time. Indeed, many individuals who have access to land feel that they are well within their rights to do this, as the field does not belong to the community.

Access to water.
Access to water is not a limiting factor to free-ranging livestock on the arable fields, as the Tyume River borders the arable land allocation and provides water throughout the year. However, those animals that are maintained in fenced fields must be taken to water at least once a day.
Grazing conflicts with neighbouring communities

Mention has been made of the high pressure on grazing resources in the area. This becomes particularly marked during the winter, when most of the available forage has been removed from the range area. More established villages such as Guquka have the advantage of a clearly defined area of arable land, which acts a winter forage reserve for village livestock at this time. However, the neighbouring township of Kayalethu has no such formal cropland and during the winter its livestock are forced to forage wherever they can. This invariably results in livestock from Kayalethu, particularly cattle, trespassing on Guquka’s arable fields. This takes place during both winter and, to a lesser extent, summer.

Such intrusions are largely ignored on the upper allocation, as the fields here function effectively as an extension of the range anyway. However, less tolerance is shown towards animals that encroach on the lower allocation, particularly during the summer months. Large sections of the fencing bordering the Tyume River were missing during the time the fieldwork was being undertaken. This allowed livestock to cross the river and make their way onto the arable lands at all times of the year. Indeed, during the course of the research, owners from Kayalethu were frequently seen driving their animals across the river early in the morning and then sending boys to go and collect them in the late afternoon.

This behaviour is an ongoing point of contention with many field owners at Guquka, especially those who regularly crop. Their crops are vulnerable to small-stock, despite being enclosed in fenced fields and sometimes suffer damage. On several occasions livestock from Kayalethu were rounded up by individuals from Guquka and driven back to their owners with the threat that they would be impounded the next time they were caught trespassing. This was generally effective in the short term but the animals inevitably trickled back with time. In August 1999, a group of the older men from Guquka organised themselves into a work team and, using abandoned perimeter fencing from another part of the village, repaired the entire stretch of missing fencing bordering Kayalethu. It remains to be seen how effective this will be.
solving the problem. Individuals from Kayalethu have cut the fence on several previous occasions, and one key informant suggested that he would be surprised if it was still intact by the following winter (field assistant, August 1999).

• **Grazing of arable lands at other times**

It is clear from what has been discussed above, that the upper arable land allocation is constantly utilised for grazing and that livestock from Kayalethu are also present on the lower allocation throughout the year, albeit at a low level. However, during the summer additional grazing pressure on the lower allocation comes from Guquka’s own livestock. Of the 14 livestock owners interviewed at Guquka, eight had maintained their cattle on the arable land allocations at some stage during the previous summer. The reasons provided for this were as follows:

1. The animals were sick or problematic (five owners)
2. It was easier (and safer) to look after them on a field (two owners)
3. The owner was frequently absent from the village (one owner).

In the majority (six) of cases cattle were held in securely fenced fields, generally belonging to the owner of the cattle or to family or friends. Duration of field use lasted anything from just a week or two, to almost the entire cropping period, depending on the circumstances of the cattle owner. In two cases, however, cattle had been maintained on unfenced areas of the lower allocation. In both cases there were some important provisos that had to be fulfilled for this to be sanctioned. Firstly, it was strictly limited to sickly animals. Furthermore, the permission of the grazing committee was required and the animals had to be closely supervised at all times to ensure they did not damage crops. Nevertheless, it appears that in reality these provisos are often ignored by livestock owners, as the third case study demonstrates (Box 5).
Box 5. Rules are open to interpretation: the case of Mr F.

Mr F. is one of the oldest active farmers at Guquka. Although he has access to his own fenced field he could not make use of this for grazing his cattle during the summer because he was growing maize there. Instead, during late summer (March and April) 1999 he sought permission for four of his cattle that were in poor condition to graze on the unfenced fields within the arable land allocation for a short period. He has engaged in this practice for many years. It is motivated by the fact that forage is perceived as being more abundant on the arable lands at this time compared to the range area. This gives animals in poor condition a chance to recover. If sufficient forage was available on the range area at this time, then he would be happy to leave them there for the entire summer period.

In order for this summer grazing to be approved he testified to the fact that he had first to inform the older men who comprise the grazing committee and then to ensure that the animals were supervised all the time. However, this was not entirely the case. Although, he most probably informed his contemporaries on the grazing committee as to his intentions, Figure 4.7 shows that at the end of March the herd being grazed was almost certainly not being supervised all of the time. In fact, the photograph was taken shortly before dusk so it was likely that they were allowed to free-range on the fields overnight. Moreover, the condition of the animals was far from poor and certainly no worse than most of the other cattle around the village.

Figure 4.7: Free ranging cattle from Guquka on unfenced arable fields in late summer (note well-developed maize crop in adjacent fenced field).

This case serves to underline not only the inherent flexibility of the arable land allocation at Guquka as a summer as well as a winter forage reserve, but also the
degree of interpretation the grazing management rules are open to. Mr F. was able to use his influence within the village to allow his animals to graze on the fields during the summer despite not meeting the specified criteria for doing so. Crucial to the grazing committee's decision to sanction this was undoubtedly his senior position within the village and his family background.

4.4.1.2) OTHER MANAGEMENT PRACTICES

- **Kraaling of livestock**

It would appear that small-stock at Guquka are kraaled on a nightly basis during both winter and summer. All 10 interviewees who held small-stock testified to this. They were also unanimous in citing animal safety as the main reason for this practice. Attack by jackals was identified as one problem, but more important was the danger of animals being stolen. Small-stock are easy to remove, particularly at night. Seemingly, even kraaling cannot guarantee their safety, as one interviewee related that she had recently had her entire flock of 30 sheep stolen at night from her kraal.

However, practices differed markedly between individuals with regard to the kraaling of cattle. During the summer months just four of the 12 cattle-owners interviewed stated that they kraaled their cattle on a nightly basis. All of these cited the threat of theft as the main reason for this. Indeed, two of these individuals had themselves been victims of cattle theft and were keen to emphasise how much of a problem it had become in recent years. This is illustrated by the final case study in Box 6.
Mr. D. is one of the major cattle owners in Guquka, having 21 animals at the time of interview. However, since the previous summer he has been missing two oxen and two cows and believes them to have been stolen whilst they were grazing on the mountain pastures. He is confident they were taken by the residents of two notorious villages located in the neighbouring district of Keiskammahoek. These villages have a case pending against them for theft of livestock from Guquka.

The problem is also being experienced by livestock owners from neighbouring villages. It has reached such a point that recently many of the major cattle owners from all four of the Amakhuzo villages came together and organised a group of men, backed up by local police officers, to visit the troublesome villages. The party was organised by Mr. G. from Gilton, who is a prominent livestock owner in the area and who works for the agricultural department in King William’s Town. The mission was a success, with several animals being recovered from kraals in the villages. However, many cattle, including those of Mr. D. were not found and they are believed to have been slaughtered or possibly sold.

Mr. D. testified that the problem of theft at this scale was only a fairly recent phenomenon. He attributed it to a general breakdown in law and order and the greater freedom people now enjoyed since the transition to democracy. Black people can now move without the need for passes so not only opportunist but organised theft is now rife, with syndicates working in the area and exporting animals through the major towns to places such as the Transkei.

The remaining eight cattle owners did not kraal their animals on a regular basis at this time despite the real danger of theft. Animals only tended to be kraaled if they came back to the homestead of their own accord or prior to a major event such as dipping. The main reason provided for not kraaling animals regularly during the summer, was that it inhibits the distance the animals can travel to obtain sufficient forage. However, the safety of their animals was still of paramount importance and several respondents mentioned that their animals were checked on regular basis (generally at least weekly) to ensure their well being.

In contrast, a greater proportion of owners kraaled their cattle during the winter. Eight out of the 12 cattle owners interviewed stated that they had kraaled their cattle on a nightly basis the previous winter. Four of these owners cited theft as the main
reason for this increased level of kraaling. The remainder cited a variety of other reasons including: -

1. The threat of impoundment if the animals stray from the fields onto the land of the nearby agricultural school (one owner).
2. The risk of animals being injured or killed if fire sweeps through the arable fields during the night (two owners). This in fact occurred in winter 1998 during the course of the fieldwork.
3. The desire to collect manure for summer crop cultivation (one owner).

Once again safety of the animals emerges as the single most important criterion in the decision to kraal animals on a nightly basis
4.4.2) KOLONI

4.4.2.1) THE GRAZING MANAGEMENT SYSTEM

CONTROL OF GRAZING MANAGEMENT

Under the apartheid administration, all grazing management decisions taken in the village were in the hands of the Grazing Committee. This was composed exclusively of the older male residents of the village (the amaxhego) and chaired by the headman of the village. With the election of the Government of National Unity in 1994, the powers of the Grazing Committee were subsumed into the all-purpose Residents Association (RA). The structure of the RA is described in section 2.2.2.

RANGELAND GRAZING

Extensive control of rangeland grazing is possible at Koloni because fencing divides the range area into four separate camps (see Figure 2.5, Chapter 2). Under the original plan for betterment of the village drawn up in 1961, it was envisaged that one grazing camp would be rested for a period of a year whilst the remainder were grazed (Bantu Affairs Commission, 1962). This involved a notice being issued from the Bantu Affairs Office at the beginning of each year as to which camp was to be rested. Indeed, rotational resting of the camps is still practised, although it is unclear whether the camp is now rested for the entire year in all cases or whether the original resting regime is still adhered to. Furthermore, it would appear that the rested camp functions as a sanctuary for elderly or sick animals, particularly during the winter (informal interview with Koloni Chairman, 17/10/97).

The separation of the range into camps allows the RA to control which animals graze where. During the summer this is of no importance, because mixed grazing is practised on all three grazed camps. However, during the winter months the arable land allocations are reserved as a grazing resource for cattle (see below). This is possible, because all small-stock are maintained within selected range camps at this...
time. This was observed during both 1998 and 1999, when most small-stock, particularly sheep, were restricted to camps one and two.

GRAZING OF ARABLE LAND ALLOCATIONS

The arable land allocation at Koloni functions as an additional forage reserve for livestock during the lean winter months, when the range camps are at their least productive. The management regime governing its use is fairly involved and is driven by a combination of environmental factors and human objectives.

- **Duration of grazing of arable lands**

The length of time the arable lands at Koloni are available for grazing can vary considerably between years. The arable lands are generally opened to grazing between mid-May and early June and closed at any time between early September and late October (Koloni Chairman, informal interview, 17/10/97). This gives a grazing duration of anything between three and five months. Both extremes were experienced during the course of the fieldwork. The arable allocations were available for grazing for just under four months in 1998 (mid-May to early September), whereas this increased to five months in 1999 (late May to late October).

The single most important factor governing the opening of the arable lands to grazing is the completion of harvesting. Every individual who has grown a crop must have finished reaping before the lands are opened. Once this has happened a meeting of the RA is called at the village. All individuals who own cattle, or have access to a field, are encouraged to attend. A decision is reached on an appropriate date for opening the arable lands and on this day (usually the day after the meeting) all the allocations are made available to grazing.

With regard to the closing of the lands a number of human and climatic factors influence the decision. In the late winter/early summer period individuals begin to
prepare for the next season of cropping. The desire of individuals to begin cultivating, combined with the state of the range camps, determines the exact timing of the closure. The single most important factor in this decision is the coming of the summer rains as this simultaneously heralds both the time of planting and the recovery of the range camps. After the first period of prolonged rain a meeting of the RA will be held in which the closure of the arable lands will be put forward. Given sufficient agreement amongst those owning livestock and those wishing to cultivate, the motion will be carried and the lands officially closed. At this point, livestock owners are obliged to remove all their animals to the appropriate camps. The only exception is those oxen involved in ploughing, which are sometimes maintained on the arable lands by their owners during the time of ploughing. They must, however, be removed as soon as their work is complete.

One other exception concerns those portions of the arable land allocations in which no cultivation occurs. Here grazing is possible throughout the cropping season. During the research period the small arable land allocation including fields 92-96 and 106-112 (see Figure 4.8, overleaf), was used in this way as no cultivation had taken place there for several years. It has effectively become a temporary extension of the range with the gate being left open throughout the year and livestock being allowed continuous access. However, under the current management system it would immediately become out of bounds to grazing at this time should the owner of a particular field decide to cultivate.

- Livestock involved

It was clear from all three key informants interviewed that the arable land allocations are reserved exclusively for cattle. This is because they are perceived as being the most valuable of the livestock species (culturally and economically) and at greatest risk from lack of forage during the lean winter months (checklist interviews with key informants, April 1998). Any small-stock that gain access to the arable lands do so as a result of inadequate perimeter fencing and are there illegally.
Figure 4.8: Plan of the arable land allocation at Koloni
Livestock movements
During the winter, small-stock are entirely restricted to the range and residential area. This is generally achieved by enclosing them in one or more allocated camps. By contrast, there was unanimous agreement amongst key informants, that cattle are free to move between the entirety of the arable land allocations and those range camps that remain open at this time. Of the 15 livestock owners interviewed, the majority (11) allowed their cattle to move around in this way. However, a number of factors were identified, which restricted how effectively cattle make use of the forage available to them at this time.

Access to water
All of the key informants mentioned water availability on the arable land allocations during the winter as being a problem for cattle. No dams are situated on the arable lands and this makes watering a problem, particularly on the large allocation (fields 1-88). Natural springs and rainwater collection points do provide some limited sources of water, but these are generally short lived or insufficient to meet demands. To overcome this problem, the gates linking the fields to the range camps must be left open throughout the winter to allow cattle access to the dams in the camps. In addition, a section of the fencing at the northern end of the arable allocation is frequently taken down to allow animals access to an adjacent dam (Figure 4.9).

Figure 4.9: Cattle resting by dam after watering during winter 1998. Note cattle-owner on horseback checking on whereabouts of animals.
There was a general consensus amongst key informants that the only reason for leaving any of the access points to the arable lands open during the winter is to allow cattle to get access to water. If sufficient water supplies were present, they would be happy to enclose the cattle solely on the arable lands for the duration of the winter. Forage availability is generally not considered to be a limiting factor. Indeed, it would appear that maintaining cattle on the fields is actively encouraged in order to try and graze the abundant tall grass down (the concept that this improved the grazing was expressed by one interviewee) and ease the pressure on the range camps.

During 1999, the months preceding the opening of the arable fields were very dry, causing the dam adjacent to the top of the large allocation to dry up. This left only one smaller dam to supply all the water needs of the cattle on the large allocation and prompted many owners to relocate their animals. Most chose the small arable allocation (comprising fields 97-105) on the far side of the Debe-Nek road, as this included a temporary pond sufficiently large to supply water throughout the winter. A period of heavy rain some weeks later led to the subsequent return of many cattle to the large allocation. Nevertheless, this demonstrates how the effective use of forage resources by cattle, can be restricted by scarce water resources at this time of year. It also illustrates that, through the selective closing of gates and active relocation of animals, larger scale foraging decisions are actually determined by owners rather than the cattle themselves.

**Individual rights over fields**
When the arable land allocations are opened to grazing, individual rights are effectively relinquished and the entire area becomes communal grazing. All cattle owners have rights to graze their cattle here even if they do not have access to their own field. Every field must be made available for grazing, even those which are fenced. The only exception to this is if an owner cultivates during this time. In this case they can retain exclusive rights over what they produce. However, such events are rare nowadays. Key informants related that previously, before attendance at school became compulsory, children were used to guard winter crops to ensure that cattle did not spoil them and winter cropping was commonplace. Now that this is no longer the case winter cropping is only possible in fenced fields. Very few fields at
Koloni are fenced and so few individuals have the opportunity. Only Mr M., one of the former headmen of the village, is known to have engaged in winter cropping over the past few years and he has access to two fenced fields. Thus, during most winters, there are few restrictions on cattle movements over the arable fields at Koloni from a land rights perspective.

Indeed, the majority of stockowners who had previously engaged in winter cropping (three out of four interviewees) cited lack of fencing as the major obstacle to their continued involvement in this practice. With regard to winter forage most owners stated that there was little point in growing it, as scarcity of forage was rarely a problem at Koloni during the winter. Two respondents pointed out that under drought conditions it made more sense these days to simply buy in supplementary feed for animals. This generally takes the form of bales of lucerne hay, which are purchased from King William’s Town or Middledrift and fed to animals around the homestead. However, this practice is expensive and only those few individuals with sufficient capital and motivation do so.

**Restriction of cattle to grazing camps by owners**

There were a limited number of owners (four out of 15 interviewed) who actively exclude all or part of their cattle herd from the arable land allocations throughout the winter. Greater safety on the camps was the main reason cited for this, as elderly and young animals had a tendency to injure themselves on the rough terrain of the arable lands. Lack of available water on the fields was also mentioned. One interviewee even had separate management strategies for cattle on the basis of age: older animals were maintained on camps in close proximity to water, as they were deemed not to be able to walk as far as younger animals, which were kept on the arable lands.
4.4.2.2) OTHER MANAGEMENT PRACTICES

- Kraaling of livestock

There are no defined rules governing the kraaling of livestock at Koloni, it is more a matter of common sense amongst owners. Nevertheless, there were broad similarities in the kraaling practices of the individual livestock owners interviewed.

All of the 12 interviewees who owned small-stock kraaled them every night during both summer and winter. Prevention of attack by wild dogs at night was the main reason given. Theft was not considered to be an important issue in this decision.

All 15 livestock owners interviewed stated that their cattle were not usually kraaled, regardless of whether they are on the arable allocations or range camps. The underlying rationale for this is essentially practical. Adult cattle are generally at minimal risk from attack and theft is very rare in this area. Thus, the effort of walking the extensive range camps and/or arable areas to find and collect them is not worthwhile. Furthermore, leaving the cattle out at night on the arable lands gives them greater opportunity to forage during the leaner winter months, and also encourages more even grazing pressure over the arable land allocations. The only situation in which owners regularly kraaled their cattle was if a cow had a young calf. Of the 11 owners whose herds included calves, eight stated that the calves and their mothers were kraaled every night. This served to ensure that the calves were safe from attack by wild dogs, and also allowed the owner to obtain milk from the mother each morning prior to the animals being released to graze.
4.4.3) DISCUSSION

From what has been outlined above, it is apparent that whilst broadly similar grazing management systems exist at each village, prevailing resource pressures and institutional issues at the local level have resulted in some fundamental differences. The general management framework that theoretically governs the grazing of the arable lands at both villages is summarised in Figure 4.10.

Figure 4.10: General management framework governing the use of the arable land allocations as a forage reserve for livestock.
To begin with the villages differ in the way in which the arable lands become available to grazing at the beginning of the winter. At Koloni the lands are opened only after every individual who has cropped has finished harvesting. By contrast at Guquka this process is frequently a stepwise affair, with crop residues being grazed as they come available until all harvesting is complete, at which point all the land becomes available to grazing. This can be viewed as a practical means of supplying hungry livestock with good quality forage at a critical time of the year without having to delay until all harvesting is completed (and the animals are in worse condition). It is a response to a severe shortage of forage, not generally experienced at Koloni, and is made possible by cropping at Guquka taking place in fenced fields.

A similar rationale underlies the grazing of the arable fields at Guquka throughout the cropping (summer) period, a practice strictly prohibited at Koloni. Lack of available grazing at Kayalethu encourages livestock owners to maintain their animals on Guquka’s arable lands. Furthermore, livestock from Guquka also make significant use of the fields for grazing at this time. This mostly takes the form of cattle grazing individually fenced fields because owners are absent from the village or because animals are sick or unruly. In this way their use can be viewed as analogous to that of the rested grazing camp at Koloni. However, towards the end of the summer, increasing numbers of cattle from Guquka can be found free-ranging on unfenced areas of the arable lands. Owners generally justify this behaviour to the grazing committee with an official excuse, but the underlying reason for their presence is invariably shortage of forage on the range area at this time. Moreover, the owners who are able to practice this tend to be those who are well connected with the grazing committee on the basis of social standing within the village.

Differences between the two villages also extend to the type of livestock allowed on the arable lands. This is essentially an issue of differing levels of resource control. Koloni has separate range camps with reasonably maintained fencing, which give it greater flexibility in controlling livestock movement. Thus, small-stock can be maintained on the camps during the winter and arable land allocations preserved for cattle. This control is not possible at Guquka. Here, several communities share the range but there is no collective responsibility for its upkeep. In this sense the range
can be considered as more typical of an open access than a common property resource, in that there is no control over user rights (Cousins, 1995). In such an environment control over livestock access to the grazing resource is almost impossible. Thus, at Guquka, the lower arable land allocation inevitably becomes accessible to all livestock (including some from outside the village) once the gates separating it from the range area are opened.

There is also the issue of maintenance of individual rights over fields during the winter period. The grazing management rules at both villages officially maintain that all fields become accessible by all livestock at this time, unless a winter crop is grown. At Koloni this is the only exception tolerated. At Guquka, however, several residents maintain individual rights over fields throughout the winter without growing crops. This may be for grazing their own livestock or simply for resting a field that was grazed during the summer months. In all cases these exceptions are possible because the field is fenced.

In summary, the key discrepancies outlined above between the grazing management systems at Guquka and Koloni are essentially a result of differing levels of resource demand, availability and control at each village, compounded at Guquka by the ever-present threat of livestock theft.

At Koloni local grazing pressure is relatively low and grazing resources are adequate and belong exclusively to the village. Moreover, the separation of arable land from grazing land and the division of the range into camps allows flexibility in control over grazing decisions at the communal level. In this environment, the RA is able to both make and enforce all grazing management decisions at the village level, and the system, with very few exceptions, follows the general model outlined in Figure 4.10. The only real constraint to the effective use of grazing resources is the lack of water on the arable lands during the winter. This necessitates grazing camps being made available when they might otherwise be rested. However, this does not require any deviation from the recognised grazing management system and is dealt with at a communal level. Thus, control and enforcement of communal grazing decisions remains very much with the whole community at Koloni and in this sense the ethos of communal grazing is still strong within the village.
At Guquka the situation is very different. The range is shared with several other communities and is essentially inadequate for the number of livestock it serves. The arable land allocations are the exclusive property of the village, but inadequate communal fencing in the face of this high resource pressure makes it difficult to retain grazing rights exclusively for the village. Theft has also become a real problem in recent years. This applies not only to small stock but also to cattle, which are easy targets when grazing on the isolated mountain pastures. These problems have led to some key deviations from the official grazing management system, at a day to day level. The maintenance of fencing around individual fields is an important feature, which facilitates many of these deviations. It enables livestock owners who have access to fenced fields to bypass many grazing management decisions to a greater or lesser extent, without overtly contravening the grazing management regulations. In this sense, decision-making power has devolved from the central to the individual level for members of this land-owning elite.

The situation is exacerbated by inherently weak institutional control at the local level, resulting from a succession of power struggles within the RA between 1996 and 1999 (see Chapter 2). This has resulted in control over communal grazing management decisions being assumed by a somewhat ad hoc grazing committee. Not only is this structure inadequately defined in terms of who constitutes it and when and where it meets, it is known to be dominated by old men from established (land-owning) families, who have a vested interest in assisting their contemporaries and relatives. However, some cause for hope lies in the emergence at the end of 1999 of a relatively young and popular chairman who comes from a landless family with a relatively recent history within the village (Smith, pers. comm.). This must be seen as an opportunity to reinvent the RA as an effective and more egalitarian decision-making body at the village level.
4.5) SUMMARY AND RECOMMENDATIONS

This chapter has highlighted some fundamental differences in social structure between the research villages with strong implications both for appropriate development strategies and for altering current land use patterns.

At Guquka the majority of households are landless and there is a distinct bias in land holdings towards established families and the elderly. Furthermore, crop production is centred almost entirely around males. Taken together, these factors suggest that land availability and social biases act as a significant constraint to more widespread crop production at Guquka. Moreover, given these constraints crop production from arable lands is unlikely to be effective as a strategy for improving livelihoods within the village, particularly with regard to targeting the most needy sections of the community. However, the climatic suitability of Guquka to crop production suggests that it offers considerable potential as a livelihood strategy, if ways can be found to overcome the severe social constraints to land access amongst the landless and lack of secure tenure amongst the landed.

The most immediate possibility is the upgrading of existing land rights from communal to private tenure. There are inherent dangers in this that have been well documented (De Wet, 1988). Most notable is that of poor households selling their residential land if a land market comes into existence. However, at Guquka ownership of arable land is not linked to residential sites through certificates. Thus, it would be possible for residential land to remain under communal tenure (and thus not open to purchase) while arable land became saleable under private tenure. In effect, a mentality of private ownership already exists amongst landowners at Guquka, evidenced by the number of fields that have been individually fenced and the limited rental market that already exists (see Table 4.4). The introduction of private tenure with separate ownership certificates for arable land, would seek to formalise and expand this and also make land available for private purchase. However, the social environment within the village is not suited to freehold in its strictest sense and the following provisos would be necessary:
• Land could only be used for agriculture
• Land could not be subdivided
• Land could only be held by individuals who are resident in the village

This would encourage all forms of forms of land lending, leasing and sale and at the same time ensure, as far as possible, that it does not become unproductive. The government would remain the ultimate owner of the land and would take possession of any fields that are not inherited upon death of the owner or not sold when somebody leaves the village. It would also be responsible for adequately compensating (at current market prices) those few individuals from outside the village who stand to lose their land. Land that became available in this way would be offered to households from landless families within the village on a case by case basis.

In contrast to Guquka, arable land at Koloni is abundant and there is little evidence of social bias within the village with regard to land ownership or crop production. However, in spite of this conducive social environment crop production at the village remains very low. It would appear that climatic factors act as the main constraint to increasing levels of crop production, as rainfall in the area is highly variable both with regard to amount and timing. This makes investment of both time and money in rainfed arable cropping a risky endeavour. Unless cost effective ways can be found of increasing water use efficiency (and thereby minimising risk) in these dry areas, rainfed cropping will continue to offer little potential as a mechanism for enhancing rural livelihoods.

Nevertheless, the somewhat archaic quitrent tenure system is constraining the effective utilisation of arable land at Koloni. Although a limited land market does exist it is stifled by the unnecessarily complicated process of land transfer (see Box 1, p121). This is might explain why so many quitrent landowners have not sold their fields prior to leaving the village. The quitrent system needs to be upgraded to allow for more efficient land transfer. Ownership of residential land also needs to be uncoupled from arable land in the quitrent section of the village. A system akin to the one envisaged for Guquka is required, whereby separate titles are issued for
residential and arable land to allow them to be acquired independently of each other but with the same provisos pertaining. This would enable the current “landless” sector of the village to buy into the land market by purchasing land from landed households. It would also enable current landholders to acquire additional fields without the need to acquire additional residential sites. Instead, these sites could be acquired by expanding families, which would delay the need to excise additional areas of rangeland for allocation of residential sites.

These tenure changes would provide a mechanism for the more effective distribution of land resources at the village. Whilst such a system would do little to address the main constraints to crop production, it would provide a mechanism for the more effective use of land for livestock production.

Indeed, cattle production appears to offer the greatest potential for livelihood interventions at Koloni. It is clear from the socio-economic analysis of the village that cattle ownership is widespread and that many households maintain herds that are sufficiently large to be economically viable. Moreover, there is no inherent social bias in cattle ownership at the village. Nor is there any bias with regard to grazing practices at the village. Grazing of the arable land allocations as a winter forage reserve is a genuinely communal endeavour, in which all animals have equal access to the available forage irrespective of whether their owner has their own field or not. Rather from a land use perspective the main constraints to improving cattle production at Koloni appear to be logistical and felt by all cattle-owners.

To begin with, the current land tenure system allows people to hold arable land without being resident in the village. From a crop production perspective this land is essentially redundant, as the owners never return to the village. The envisaged changes to the tenure system would eliminate this problem, as all redundant land would revert to government ownership. It could then be concentrated on one of the smaller arable land allocations and all of the productive land on the larger allocation (see Figure 4.8). This smaller allocation could then be operated as an additional range camp, which could be grazed throughout the year by livestock. An additional logistical problem is shortage of water on the main arable land allocation during the winter. This limits effective use of the available grazing resources. The provision of
permanent water sources on the large allocation would overcome this, as camps that are currently left open to provide access to water for the cattle could then be rested throughout the winter (see Chapter 5).

In contrast cattle production as a mechanism for enhancing rural livelihoods at Guquka is constrained by considerable social bias. To begin with, only a relatively small proportion of households own cattle and few have herds of sufficient size to be economically viable. Furthermore, ownership is biased towards wealthy, male-headed households. If consideration is made of the use of the arable land allocations as a forage reserve, it emerges that in many cases cattle production has devolved to the individual level. Several individuals who have access to fenced fields choose to retain individual grazing rights throughout the winter and do not open them to the rest of the community. Within this social environment the promotion of cattle production as a mechanism for enhancing rural livelihoods is only likely to impact on a very limited (and already relatively privileged) sector of the community. Nevertheless, if these constraints are accepted from the outset, then several options do present themselves.

At the communal level, one option might be the complete repair of the perimeter fencing around the lower arable land allocation. This would prevent livestock from Kayalethu from gaining access to this area and thereby ensure that it is maintained exclusively as a winter grazing reserve for livestock from Guquka. Large sections of fencing were replaced during winter 1999 and it is imperative that this activity be maintained, as incidences of fence cutting by livestock owners from Kayalethu have been frequent over previous years. Another alternative is to strictly control the summer grazing of unfenced fields on the lower land allocation by cattle from Guquka in order to improve the quality of the forage available during the subsequent winter. This is explored in more detail in the recommendations of Chapter 5 and in Chapter 6.

Another option with particular potential for addressing the generally accepted nutritional shortfall in the available forage during the winter, is the cultivation of winter forage crops. One avenue that seems especially worthy of investigation is the cultivation of winter forage at a communal level. This was mentioned by several of the livestock owners themselves, although widespread involvement in this by cattle
owners is unlikely. Initially, development interventions would be best focused on a small group of individuals and just one or two fields, in order to assess the feasibility of this.

For those who have access to their own fenced fields, the cultivation of winter forage crops on an individual basis would seem to offer the greatest chance of improving livestock condition, particularly if this was combined with the grazing of summer crop residues (see Chapter 5). However, interventions targeted at such small groups could only ever have a limited impact on rural poverty, and would need to be complemented by alternative interventions focussing on different sections of the community.
5) QUANTIFYING THE USE OF ARABLE LAND
ALLOCATIONS BY FREE-RANGING LIVESTOCK

5.1) INTRODUCTION

Having presented the social component of the research in the previous chapter, this
chapter will provide the results from the ecological section of the fieldwork
quantifying the use made of the arable land allocations by free-ranging cattle at each
village. To reiterate, the overall objective of this ecological component of the
fieldwork was: -

To determine the contribution of the arable land allocations to cattle as a forage
reserve by investigating, both qualitatively and quantitatively, the behaviour of
free-ranging cattle, the forage they consume during the winter and its nutritional
value.

This broad overall objective was divided into a number of more specific objectives in
order to give greater definition to the fieldwork undertaken, specifically: -
1. To subdivide the vegetation on the arable lands into a number of separate
categories.
2. To determine the number of livestock making use of the arable land allocations.
3. To characterise, both qualitatively and quantitatively, cattle feeding patterns
during the winter, at both the vegetation category and species level.
4. To quantify the level of forage removal by cattle during the winter months, at both
the community and species level and its nutritional quality.

The data resulting from each of these four specific objectives are presented below as a
separate sub-section for each village. Also included for each village is a fifth sub-
section, which draws together the preceding data to provide an overall picture of
nutritional intake at the animal level. Following this, the findings from the two
villages will be compared and contrasted and discussed with reference to the current
body of theory about animal behaviour and nutrition. Finally, on the basis of these
findings, a series of recommendations for making more effective utilisation of the arable land allocations for cattle production will be developed for each village.

5.2) QUANTIFYING ARABLE GRAZING AT GUQUKA

5.2.1) VEGETATION CATEGORIES

GIS vegetation maps for the arable land allocations at Guquka during winter 1998 and 1999 are presented in Figures 5.1 and 5.2, respectively (overleaf). Four distinct vegetation categories were available to grazing livestock on the arable land allocations at this time. These categories were identified visually on the basis of the presence of key plant groups and species, and their delineation was influenced by the previous work of Lo Presti (1996) on these fields. The categories represented the various stages of plant succession following cultivation by farmers. The key distinguishing features of each category are described below.

CROP RESIDUES: The key factor distinguishing this category from the others was the presence of maize residues resulting from crop production during the previous summer (see Figure 4.12). Mixed with the maize stalks were also a number of tall, largely unpalatable weed species, such as *Datura stramonium* Thunb., *Convolvulus sagittatus* Thunb. and *Tagetes minuta* Linn., which had been competing with the maize crop during the growing season. A basal covering of forb and annual grass species such as *Digitaria sanguinalis* (L.) Scop., *Eleusine coracana subsp. africana* (K.O’Byrne) Hilu & De Wet and *Chloris virgata* Swartz was also evident. The latter are common species on recently cultivated arable land and in South Africa are generically known as the *landsgrasses*.

RECENT FALLOW VEGETATION: The vegetation in this category was similar in composition to the previous one, but was characterised by the absence of maize stalks. Furthermore, a far denser covering of grass and particularly forb species with a prostrate growth habit was evident. Typical species included those above, as well as increasing amounts of perennial grasses such as *Cynodon dactylon* (L.) Pers. and
Figure 5.1: Proportion of different vegetation types on arable land allocations at Guquka during the dry season of 1998.
Figure 5.2: Proportion of different vegetation types on arable land allocations at Guquka during the dry season of 1999.
*Paspalum notatum* Fluegge and forbs such as *Richardia brasiliensis* Gomes and *Ipomoea purpurea* var. diversifolia (Lindl.) O’Donell. This species mix was generally representative of fields that had been fallow for 1-2 years.

**SPOROBOLUS-ERAGROSTIS GRASSLAND VEGETATION:** The species composition of this vegetation category represented a distinct shift away from dominance by forbs and annual grasses in favour of increased amounts of perennial grass species. These included *Sporobolus fimbriatus* (Trin.) Nees, *Sporobolus africanaus* (Poir.) Robyns & Tournay, *Cynodon dactylon* (L.) Pers. and *Eragrostis curvula* (Schrad.) Nees (Figure 5.3).

![Figure 5.3: Cattle grazing in a typical area of Sporobolus-Eragrostis grassland vegetation at Guquka during winter 1999.](image)

There was also varying levels of colonisation by the grass *Hyparrhenia hirta* (L.) Stapf. depending on the time since cultivation. This vegetation category was representative of fields which had not been cultivated for 3-5 years.

**HYPARRHENIA GRASSLAND VEGETATION:** The vegetation in this category was dominated almost entirely by *Hyparrhenia hirta*. This species is indicative of arable lands that have remained uncultivated and relatively undisturbed for long periods. It is able to suppress the invasion of other grass species for many years and thus form dense, mono-specific stands (Van Oudtshoorn, 1992). In *Hyparrhenia* grassland
vegetation areas, where grazing had reduced the dominance of *H. hirta*, other more grazing tolerant grass species such as *Sporobolus africanus*, *Cynodon dactylon* and *Aristida congesta* subsp. *barbicollis* (Trin. & Rupr.) De Winter, could also be found. Examples of this vegetation type can be found in the reference photographs in Appendix 3.3.1.

The areas and proportions of these different vegetation categories during winter 1998 are summarised in Table 5.1.

Table 5.1: Areas of different vegetation types found on arable land allocations at Guquka during winter 1998.

<table>
<thead>
<tr>
<th>VEGETATION TYPE</th>
<th>TOTAL AREA</th>
<th>FREE-RANGING AREA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AREA (ha)</td>
<td>%</td>
</tr>
<tr>
<td>Crop residues</td>
<td>13.72</td>
<td>9.6</td>
</tr>
<tr>
<td>Recent fallow vegetation</td>
<td>16.59</td>
<td>11.6</td>
</tr>
<tr>
<td><em>Sporobolus-Eragrostis</em> grassland</td>
<td>19.44</td>
<td>13.5</td>
</tr>
<tr>
<td><em>Hyparrhenia</em> grassland</td>
<td>93.76</td>
<td>65.3</td>
</tr>
<tr>
<td>TOTAL</td>
<td>143.51</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Figures for the entire arable land allocation are provided in columns one and two of Table 5.1, and cover an area of some 144 ha. However, behavioural and offtake measurements (see sections 5.2.3 and 5.2.4) were conducted only in the free-ranging areas of the lower arable land allocation so the areas used in this work had to be adjusted to eliminate the upper allocation. Fields 14, 15 and 16 from the lower allocation also had to be eliminated as these were closed to grazing during the winter (see Section 4.4.1). The result was a free-range area of just over 91 ha, as described in Table 5.1. The same data is presented for winter 1999 in Table 5.2.

Table 5.2: Areas of different vegetation types found on arable land allocations at Guquka during winter 1999.

<table>
<thead>
<tr>
<th>VEGETATION TYPE</th>
<th>TOTAL AREA</th>
<th>FREE-RANGING AREA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AREA (ha)</td>
<td>%</td>
</tr>
<tr>
<td>Crop residues</td>
<td>21.05</td>
<td>14.6</td>
</tr>
<tr>
<td>Recent fallow vegetation</td>
<td>13.89</td>
<td>9.7</td>
</tr>
<tr>
<td><em>Sporobolus-Eragrostis</em> grassland</td>
<td>17.18</td>
<td>12.0</td>
</tr>
<tr>
<td><em>Hyparrhenia</em> grassland</td>
<td>91.39</td>
<td>63.7</td>
</tr>
<tr>
<td>TOTAL</td>
<td>143.51</td>
<td>100.0</td>
</tr>
</tbody>
</table>
The change in proportion of vegetation types between 1998 and 1999 was entirely the result of additional land being cultivated during summer 1998/99. Interestingly, reference to figures 5.1 and 5.2 shows that almost all of the land cultivated during summer 1997/98 was cultivated again the following season. Moreover, of the additional land brought under cultivation during 1998/99, the majority had been cultivated in the very recent past. This suggests that the same land is constantly being used for crop production. This corroborates the idea put forward in Chapter 4, that only a small number of key farmers are able to persistently engage in crop production at Guquka. These individuals have access to fenced fields and can afford the financial outlay involved in tractor hire. There are also negative implications for the land itself, as persistent use of the same fields will lead to loss of topsoil and depletion of soil nutrients. The latter will result in lowered yields unless fertilisers or manure are used to replenish them.

5.2.2) MONITORING OF LIVESTOCK NUMBERS

Livestock monitoring at Guquka during the winter period also demonstrated that substantial numbers of sheep were found free ranging on the arable land allocations during this time. The weekly change in numbers of both cattle and sheep found free ranging on the lower arable land allocation during winter 1999, is summarised in Figure 5.4 (overleaf).

Not only does this show significant numbers of sheep on the lower allocation at this time; it also demonstrates how the numbers of both species decline throughout the winter. Indeed, sheep were only recorded sporadically on the lands after early August, and cattle numbers also tailed off sharply past the end of July. Interestingly, the decrease in the numbers of both species coincided with the exhaustion of crop residues. This also supports the finding in Section 4.4.1.1 that mixed grazing of crop residues is an accepted management strategy at the village.
The number of free-ranging cattle and sheep recorded in each vegetation category on the lower arable land allocation during both winter 1998 and winter 1999 is summarised in Table 5.3.

Table 5.3: Sum of weekly counts of free-ranging cattle and sheep recorded in each vegetation category on the lower land allocation at Guquka during winter 1998 and 1999

<table>
<thead>
<tr>
<th>VEGETATION CATEGORY</th>
<th>WINTER 1998</th>
<th>WINTER 1999</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CATTLE</td>
<td>CATTLE</td>
</tr>
<tr>
<td></td>
<td>NO.</td>
<td>%</td>
</tr>
<tr>
<td>Crop residues</td>
<td>201</td>
<td>18.4</td>
</tr>
<tr>
<td>Recent fallow vegetation</td>
<td>130</td>
<td>11.9</td>
</tr>
<tr>
<td><em>Sporobolus-Eragrostis grassland</em></td>
<td>177</td>
<td>16.2</td>
</tr>
<tr>
<td><em>Hyparrhenia</em> grassland</td>
<td>583</td>
<td>53.5</td>
</tr>
<tr>
<td>OVERALL TOTALS</td>
<td>1091</td>
<td>100.0</td>
</tr>
</tbody>
</table>

* No data collected for sheep during winter 1998.

If comparison is made between the cattle data from 1998 and that from 1999, one of the most immediate disparities is the much smaller proportion of animals found on crop residues during 1998. There are two main reasons for this. Firstly, the proportion of land containing crop residues was considerably smaller in 1998. More
importantly, livestock counts in 1998 were slightly sporadic, and did not start being undertaken on a weekly basis until late July. Thus, the actual number of cattle present on crop residues was under-recorded as the residues were largely exhausted by late July.

If the observed frequency count data for cattle is compared with the expected frequency count data for both years (Table 1, Appendix 5.1), then it is clear that animal distribution in each of the vegetation categories is not random. The strength of the departure from randomness can be determined using log ratio analysis (see equation1, Section 3.3.1.2). G-values for this analysis are summarised in Table 2 of Appendix 5.1. In every case animal distribution is very significantly different (p<0.001) from what would be expected by chance, indicating the expression of strong preferences during both years. Since, no behaviour data were collected for sheep, a simplistic assessment of the preference animals displayed for different vegetation categories during winter 1999, can be obtained from indices derived from the ratio of observed to expected animal frequencies in each category (Table 5.4).

Table 5.4: Preferences indices for sheep in different vegetation categories.

<table>
<thead>
<tr>
<th>VEGETATION CATEGORY</th>
<th>PREFERENCE INDEX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop residues</td>
<td>3.31</td>
</tr>
<tr>
<td>Recent fallow vegetation</td>
<td>3.87</td>
</tr>
<tr>
<td><em>Sporobolus-Eragrostis</em> grassland</td>
<td>0.19</td>
</tr>
<tr>
<td><em>Hyparrhenia</em> grassland</td>
<td>0.10</td>
</tr>
</tbody>
</table>

A very strong preference emerges amongst sheep for both crop residues and recent fallow vegetation. This would be expected if the feeding habitats of sheep are considered. They are essentially selective feeders, targeting more nutritious parts of crop residues and short swards of the type found in the recent fallow vegetation category (Hanley, 1982; Owen-Smith, 1982). They are not adapted to deal with tall, stemmy grass species of the type found in the *Sporobolus-Eragrostis* and *Hyparrhenia* vegetation categories which explains why these are strongly avoided.

For cattle, consideration of total numbers of animals in each category disguises a marked changed in preference over the course of the winter. This is demonstrated in Figure 5.5, overleaf.
<table>
<thead>
<tr>
<th>Date</th>
<th>Crop residues</th>
<th>Recent fallow</th>
<th>Sporobolus-Eragrostis</th>
<th>Hyparrhenia</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/6/99</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14/6/99</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>27/6/99</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12/7/99</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26/7/99</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12/8/99</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>27/8/99</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7/9/99</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 5.5: Weekly count data of the number of free-ranging cattle in the different vegetation categories on the lower arable land allocation at Guquka during winter 1999 (n =15).
During the first few weeks of the winter the vast majority of animals are found on crop residues but in the latter stages numbers in this category dwindle to a negligible level. By contrast there is relatively little fluctuation in numbers in the *Sporobolus-Eragrostis* and *Hyparrhenia* grassland vegetation categories, such that by the latter stages of the winter almost all the remaining animals are found here. The cut off point seems to be the mid-winter stage when crop residues are exhausted. This idea of a switch in feeding preference amongst cattle on the arable lands is developed in more detail in Section 5.2.3, using the animal behaviour data.

Table 5.5 summarises the mean number of cattle found on both the upper and lower arable land allocations at Guquka during winter 1998 and 1999. Separate figures are provided for those animals that were restricted by their owners to specific fields and those that were allowed to free-range during this period.

**Table 5.5: Mean number of cattle per week on arable land allocations at Guquka based on weekly count data collected during winter 1998 (n =15) and winter 1999 (n =15).**

<table>
<thead>
<tr>
<th>MOVEMENT</th>
<th>WINTER 1998</th>
<th></th>
<th>WINTER 1999</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LOWER</td>
<td>UPPER</td>
<td>TOTAL</td>
</tr>
<tr>
<td>Restricted</td>
<td>0</td>
<td>6.1</td>
<td>6.1</td>
</tr>
<tr>
<td>Free-ranging</td>
<td>72.7</td>
<td>13.5</td>
<td>86.2</td>
</tr>
<tr>
<td>TOTAL</td>
<td>72.7</td>
<td>19.6</td>
<td>92.3</td>
</tr>
</tbody>
</table>

The figures show considerable consistency between years for almost all categories. This is especially true of the number of free-ranging animals found on the lower arable land allocation, which showed very little change between 1998 and 1999. Of particular note is the fact that there were no animals restricted to specific fields on the lower allocation during either winter. This lends support to the idea developed in Chapter 4 that efforts are still made to apply the theory of communal grazing in this area during the winter, despite a few of the fenced fields being rested by their owners at this time. By contrast animals were restricted to specific fields on the upper allocation during both winters. This demonstrates that individual grazing rights can be maintained at all times in this area and suggests that the general grazing management rules no longer apply here.
Data on livestock numbers also provide some indication of the use intensity of the arable land allocations at Guquka over the summer period. The data for cattle is presented in Table 5.6.

**Table 5.6: Mean number of cattle per week on arable land allocations at Guquka based on weekly count data collected during summer 1998/99 (n =31).**

<table>
<thead>
<tr>
<th>MOVEMENT</th>
<th>ARABLE LAND ALLOCATION</th>
<th>LOWER</th>
<th>UPPER</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Restricted</td>
<td>4.9</td>
<td>8.1</td>
<td>13.0</td>
<td></td>
</tr>
<tr>
<td>Free-ranging</td>
<td>16.4</td>
<td>10.9</td>
<td>27.3</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>21.3</td>
<td>19.0</td>
<td>40.3</td>
<td></td>
</tr>
</tbody>
</table>

It is immediately obvious from these figures that the arable land allocations at Guquka are subject to considerable use even during the summer. An average of just over 40 cattle per week was recorded on the arable land allocations during this time. Comparison with the winter data in Table 5.5 shows that the major seasonal fluctuation in animal numbers occurs on the lower arable land allocation. The mean number of animals in this area drops substantially during the summer as a result of free-ranging animals becoming much less numerous. Those, that do persist, are largely from the neighbouring village of Kayalethu. By contrast, the mean number of animals on the upper allocation showed little seasonal fluctuation. In fact, there were more animals present during summer 1998/99 than there were during the subsequent winter. This corroborates the idea put forward in Chapter 4 that the upper allocation behaves essentially as a year-round forage reserve for livestock.

### 5.2.3) CATTLE BEHAVIOUR DATA

The proportion of time free-ranging cattle spent engaged in the three main activities recorded as part of the behavioural observations (section 3.3.1.2) is summarised for both winter 1998 and winter 1999 in Figure 5.6. In order to provide a representative overview of animal behaviour the data includes observations conducted on animals that had moved outside the official boundary of the arable land allocations.
Figure 5.6: Mean proportion of time (± S.E) spent by cattle feeding, resting, or walking on and around the arable land allocations during winter 1998 and winter 1999 (n values included on x-axis).

The figures indicate that throughout the winter periods in both years cattle devoted the vast majority of time they spent on the arable land allocations to feeding. Indeed, during winter 1998 the average animal spent approximately 75% of its time grazing, increasing to more than 85% during winter 1999. It is understandable that such a
large amount of time was devoted to feeding when it is considered that the majority of animals had only about 10 hours to free range during the winter (07:00-17:00 hours). Livestock have been shown to compensate for restricted grazing periods by increasing the length of foraging bouts and increasing intake rates during these bouts (Iason et al., 1999). Moreover, the available forage in sourveld areas is widely recognised as being very limited at this time both in terms of quantity and nutritional quality (Tainton, 1981a). This also dictates that animals consume more forage within a given period in order to satisfy minimum maintenance requirements for energy and crude protein.

Far less time was spent moving between feeding stations and resting/ruminating. This was expected from animals that had been kraaled overnight (Arnold and Dudzinski, 1978). Furthermore, the animals were fairly consistent in the amount of time they allocated to each of these activities during the course of both winters. The only clear exception to this was the amount of time the animals devoted to resting during 1998. This was surprisingly high during the middle and end of winter grazing periods and was clearly undertaken at the expense of feeding. At least part of the explanation for the increased proportion of time cattle spent resting during mid-winter 1998 can be attributed to the very wet weather conditions that occurred in July, when the observations were being undertaken. It is generally recognised that such weather conditions cause cattle to become listless and spend a considerable amount of time resting in areas where they would normally feed (Arnold and Dudzinski, 1978). For the end of winter observations the unexpectedly high proportion of time the animals spent resting was undoubtedly a result of the scarcity of forage on the arable lands at this stage. At the beginning of August 1998, a severe fire removed almost all the forage on the arable land allocations. By the time the end of winter observations were undertaken there had been only very limited regrowth of the grass sward, and the animals could find very little to eat on the arable lands. As a result they tended to be listless and spend a greater amount of time than usual walking and resting.

The data collected on feeding behaviour, together with that on areas of vegetation categories can be used to provide an indication of cattle feeding preferences during the course of both winters. The mean proportion of time cattle spent feeding in each vegetation category on the lower arable allocation during both winters is summarised
in Figure 5.7. Only data from animals feeding on the arable land allocations was used (hence the frequently smaller number of observations compared to Figure 5.6).

Figure 5.7: Mean proportion of time (± S.E.) spent feeding by cattle in the different vegetation categories at Guquka during winter 1998 and winter 1999 (n values included on x-axis).
The data reveal two distinct feeding patterns during both winters. The first is a decline in the amount of time spent feeding on crop residues during the course of the winter. The second is a gradual increase in the amount of time spent feeding on the Hyparrhenia grassland vegetation. The feeding times in Tables 5.9 and 5.10 can be compared with the area of each vegetation category (Tables 5.1 and 5.2) to derive preference indices (equation 2, Section 3.3.1.2). These provide a direct indication of the strength of preference for each vegetation category and how this changes during the course of each winter. Preference indices are summarised in Table 5.7.

Table 5.7: Hunter's preference indices (Pi) for each vegetation category during winter 1998 and 1999.

<table>
<thead>
<tr>
<th>VEGETATION CATEGORY</th>
<th>WINTER 1998</th>
<th>WINTER 1999</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial</td>
<td>Middle</td>
</tr>
<tr>
<td>Crop residues</td>
<td>8.76</td>
<td>1.16</td>
</tr>
<tr>
<td>Recent fallow vegetation</td>
<td>0.00</td>
<td>0.36</td>
</tr>
<tr>
<td><em>Sporobolus-Eragrostis</em> grassland</td>
<td>0.00</td>
<td>1.55</td>
</tr>
<tr>
<td><em>Hyparrhenia</em> grassland</td>
<td>0.21</td>
<td>1.13</td>
</tr>
</tbody>
</table>

Cattle displayed a strong preference for crop residues over all other vegetation categories at the beginning of both winters. Use of Hyparrhenia grassland vegetation at this stage probably reflects feeding by cattle on the way to and from fields containing crop residues. By the middle of winter 1998 cattle did not exhibit any particularly strong feeding preferences, but at the same stage in 1999 cattle continued to manifest a preference for crop residues and avoid all other vegetation categories. This difference between years results primarily from the more rapid exhaustion of crop residues during winter 1998, which resulted in a switch in feeding preference at an earlier stage in the winter (pers. observ.). At the end of both winters cattle avoided crop residues and showed a strong preference for Hyparrhenia grassland vegetation. This reflects the depletion of crop residues on the arable lands and the subsequent switch to more abundant, although less preferred Hyparrhenia grassland vegetation. This switch in feeding preference from crop residues to Hyparrhenia grassland vegetation is illustrated graphically for both winter 1998 and 1999 in Figure 5.8.
The combined reliance on crop residues and Hyparrhenia grassland vegetation can be seen to be very considerable during both winters, accounting for 80-100% of feeding time in both 1998 and 1999. Also clearly evident in Figure 5.8 is the more delayed
switch in feeding preference during 1999 owing to the greater amount of crop residues available during 1999.

Although this switch in feeding preference between crop residues and Hyparrhenia grassland vegetation is undeniable, it is debatable how definitive it is. During the mid-winter period cattle seem to divide their grazing much more evenly between the vegetation categories than at either the beginning or end of the season. Indeed, at this time the Sporobolus-Eragrostis grassland vegetation is actually marginally preferred over the Hyparrhenia grassland. Thus, it would appear that the Sporobolus-Eragrostis grassland helps to facilitate the switch from crop residues to Hyparrhenia grassland.

5.2.4) MEASUREMENT OF FORAGE REMOVAL BY CATTLE

The data from the quadrat-based fieldwork can be used to determine the change in standing biomass (and thus the level of forage removal by cattle) during the course of the winter in each of the vegetation categories studied. The change in biomass through time for each vegetation category is depicted graphically in Figure 5.9, overleaf.

It is important to recognise that the values presented in Figure 5.9 for the initial and end biomass in the Hyparrhenia grassland exclosure are not those that were actually measured. The actual measurements for the initial and final biomass in the Hyparrhenia grassland exclosure were 1278.4 kg/ha and 1576.4 kg/ha respectively. These figures are indicative of an increase in biomass during the measurement period of June-August, which seems highly unlikely given that these are the main winter months when plants are dormant. Moreover, the regression coefficients for the visual estimation of biomass were poor and non-significant (r = 0.56, p = 0.092; and r = 0.63, p = 0.052; for the initial and final measurements respectively) and so the values obtained were likely to be somewhat inaccurate. However, the mid-winter biomass estimation was reliable (r = 0.95, p = 0.00003) and the revised initial and end estimates were estimated by proportionally scaling this value using the data from the
exclusion in the *Sporobolus-Eragrostis* grassland. This explains why there are no error bars in Figure 5.9 for the exclusion biomass at these points.

**Figure 5.9:** Mean standing biomass (± S.E.) in grazed and exclosed areas of grassland vegetation during winter 1999 (n = 50).
One of the most striking aspects of the data is the relatively low level of initial biomass in both vegetation categories. This is indicative of the continuous level of grazing pressure the arable lands are subject to during the summer months. The initial difference between the exclosure and the grazed area in the *Sporobolus-Eragrostis* grassland sampling area provides some limited measure of this. When the exclosure was constructed in mid-April 1999, the standing biomass it contained was almost identical to that in the grazed area (data not shown). However, by the time winter sampling commenced at the end of May 1999 there was already a difference of more than 300 kg DM/ha. Also of note is the final biomass recorded in each category following the cessation of grazing. These figures are remarkably similar (450-550 kg DM/ha) and would seem to represent a level of standing biomass below which cattle are unable sustain minimum rates of intake.

Comparative data for change in the standing biomass of crop residues and recent fallow vegetation are not available. However, estimates of the initial biomass of maize residues can be derived from grain yields (Powell, 1990). Mbuti (unpublished MSc data) has reported a mean grain yield at Guquka of 891.8kg/ha during the 1998/99 growing season. Using the regression equations developed for maize crops by Powell (1990) based on work conducted in West Africa, the initial biomass of both the leaf and stalk component of the residues can be calculated (Table 5.8).

**Table 5.8: Estimate of mean initial standing biomass of maize residues on cultivated fields at Guquka during winter 1999.**

<table>
<thead>
<tr>
<th>PLANT COMPONENT</th>
<th>BIOMASS (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf</td>
<td>684</td>
</tr>
<tr>
<td>Stalk</td>
<td>1321</td>
</tr>
<tr>
<td>TOTAL</td>
<td>2005</td>
</tr>
</tbody>
</table>

The standing biomass data from Figure 5.9, combined with that from Table 5.8, can be used to calculate forage removal figures by cattle in the *Sporobolus-Eragrostis* and *Hyparrhenia* grassland vegetation categories and also to derive estimates of removal of crop residues by cattle. These values are summarised in Table 5.9. They provide the basis for the estimated cattle intake figures during the first and second halves of the winter (section 5.2.6).
Table 5.9: Forage removal by cattle from different vegetation categories during winter 1999†.

<table>
<thead>
<tr>
<th>Vegetation category</th>
<th>Forage removal (kg DM/ha)</th>
<th>Total forage removal (kg DM)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st half winter</td>
<td>2nd half winter</td>
</tr>
<tr>
<td>Maize residues (leaf)*</td>
<td>403.2</td>
<td>0</td>
</tr>
<tr>
<td>Maize residues (stalk)**</td>
<td>462.2</td>
<td>0</td>
</tr>
<tr>
<td><em>Sporobolus-Eragrostis</em> grassland</td>
<td>172.2</td>
<td>87.1</td>
</tr>
<tr>
<td>Hyparrhenia grassland</td>
<td>163.9</td>
<td>319.5</td>
</tr>
<tr>
<td>Total</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

† Assuming no grazing from recent fallow vegetation.
* Assuming 59% utilisation of available biomass (Crichton et al., 1998) and all utilisation concentrated in first half of winter.
** Assuming 35% utilisation of available biomass (Crichton et al., 1998) and all utilisation concentrated in first half of winter.

As well as forage removal at the vegetation category level, the quadrat data, through use of the Dry Weight Rank Method, also provide a direct measure of the change in the proportion of key species within each category. This can be used as an indication of cattle preference at the species level and how this changed during winter 1999. This is summarised for the *Hyparrhenia* grassland vegetation (includes only species that constituted >1% of sward biomass) in Figure 5.10.

![Figure 5.10: Proportion (± S.E.) of three key grass species in Hyparrhenia grassland at Guquka during winter 1999 (n = 50).](image-url)
It is apparent that *H. hirta* was by far the dominant species in the *Hyparrhenia* grassland vegetation category, accounting for > 90% of the standing biomass throughout the winter. This was expected as in areas which have not been cultivated for some considerable time, *H. hirta* is able to effectively out-compete other grass species once it has become established and form dense stands. This dominance of *H. hirta* also corroborates the findings of other studies of abandoned cropland (Theron, 1991; Lo Presti, 1996). The presence of low levels of *S. africanus* and *C. dactylon* is indicative of grazing pressure as these species, unlike *H. hirta*, can tolerate fairly intensive grazing.

Given that proportion data does not follow a normal distribution, changes in species proportions during winter 1999 were assessed non-parametrically. The Kruskal-Wallis Test was used to determine the overall change in each species and the Mann-Whitney Test to assess changes between the beginning and middle and the middle and end of the winter (see section 3.3.1.3). These tests revealed no significant change (p<0.05) for any of the above species at any stage of the winter. From this it can be implied that cattle exhibited no significant species preference when grazing in *Hyparrhenia* grassland vegetation. This seems realistic given the almost monospecific nature of the grass sward and the fact that cattle have relatively low levels of species resolution (Roguet *et al.*, 1998).

For the *Sporobolus-Eragrostis* grassland vegetation, the change in proportion of the four major species identified (>1 % by mass in sward) is summarised in Figure 5.11 (overleaf). It is clear that there is a greater distribution of biomass between different species in the *Sporobolus-Eragrostis* grassland than in the *Hyparrhenia* grassland. Nevertheless, the majority of the biomass is still dominated by one species; in this case *S. africanus*. There are also significant levels of *H. hirta*, indicating the early stages of colonisation by this *Hyparrhenia* species.
As with *Hyparrhenia* grassland, the Kruskal-Wallis and Mann Whitney Tests revealed no significant changes \( (p<0.05) \) in the proportions of any of these species during either the first or second halves of the winter. This suggests that cattle did not display any significant species preference in this vegetation category during winter 1999. This is understandable given the relative unpalatability of most of these species during the winter months. The low standing biomass of the available vegetation is also likely to have acted as a deterrent to selective grazing.
5.2.5) **THE NUTRITIONAL VALUE OF THE GRASS SWARD**

The proportion of dry and green plant material and the crude protein (CP), Neutral Detergent Fibre (NDF) and *In Vitro* Organic Matter Digestibility (IVOMD) values of these separate components were determined for the two grassland vegetation categories that occur at Guquka (see Section 3.3.1.3). These parameters provide sufficient information about the nutritional quality of grass swards for basic inferences to be made about the performance of livestock grazing them.

The change in the proportion of dry and green plant material in the *Sporobolus-Eragrostis* and *Hyparrhenia* grassland swards at Guquka was investigated using ANOVA on arcsine transformed proportion data (see Section 3.3.1.3). This revealed that there was no significant (p<0.05) differences between the swards at any stage of winter 1999 (Figure 5.12, overleaf). However, with regard to within sward changes there was a very significant (p<0.001) decrease in the proportion of green material and a concomitant increase in the proportion of dry material during the winter period in both *Hyparrhenia* and *Sporobolus-Eragrostis* grassland swards. This was expected and is probably a result both of the well documented preference of cattle for green material (Reppert, 1960; Arnold, 1964; Hodgson, 1982) and also of necrosis of live matter during the relatively cold winter months.

The change in the proportions of the green and dry fractions of both grassland swards was most marked and significant (p<0.05) between the beginning and middle of winter 1999. This undoubtedly reflects the greater ability of cattle to select green material at this time (since there is more of it available early in the winter) and the greater level of plant necrosis at this time. The latter point is supported by the sharp decrease in biomass registered in both the *Sporobolus-Eragrostis* and *Hyparrhenia* grassland grazing exclosures between the beginning and end of the winter (Figure 5.9). Indeed, the decrease in biomass in both of these grazing exclosures mirrors the decrease in the proportion of green material in the sward very closely, suggesting that this is probably the most likely explanation. No significant decrease occurred between the middle and end of the winter in the proportion of green plant material in the swards.
*Columns with different letters are significantly different from one another (p<0.05)

Figure 5.12: Mean proportion of dry and green material (± S.E.) in different grassland swards at Guquka during winter 1999 (n=5).
Crude protein levels in both the *Sporobolus-Eragrostis* and *Hyparrhenia* grassland categories demonstrated strong fluctuations during the winter. Comparison of crude protein levels in the dry fraction of each sward showed significant (p<0.005, ANOVA) overall differences between categories during winter 1999 (Figure 5.13).

![Figure 5.13: Mean crude protein levels (± S.E.) in the dry fraction of the *Sporobolus-Eragrostis* grassland and *Hyparrhenia* grassland sward at Guquka during winter 1999 (n = 3).](image)

The LSD value in Figure 5.13 demonstrates that whilst these differences in crude protein were not significant at the beginning of the winter, between category differences in the dry fraction of the sward were significant (p<0.05) during both the middle and end of winter. There was, however, no significant (p<0.05) within category changes in crude protein levels in the dry fraction of each sward at any stage of winter 1999.

With regard to the green fraction of the sward there were significant (p< 0.005, ANOVA) differences in mean crude protein levels both within and between vegetation categories during winter 1999 (Figure 5.14, overleaf). Reference to the LSD value in Figure 5.14 shows that between category differences paralleled those in the dry fraction of the sward being significantly (p<0.05) higher in the *Sporobolus-*
Eragrostis grassland during the middle and end of winter 1999 but not at the beginning. The LSD value also demonstrates that within the green fraction of the Sporobolus-Eragrostis grassland sward there was no significant (p<0.05) change in the mean crude protein level between the beginning and middle of the winter although it increased significantly (p<0.05) between the middle and end of the winter. However, in the green fraction of the Hyparrhenia grassland sward there was a significant (p<0.05) decrease in mean crude protein between the beginning and middle of the winter and a significant increase between the middle and end of the winter.

![Figure 5.14: Mean crude protein values (± S.E.) of the green fraction of Sporobolus-Eragrostis grassland and Hyparrhenia grassland sward at Guquka during winter 1999 (n = 3).](image)

This suggests that the Sporobolus-Eragrostis vegetation retains a significantly higher mean protein level in both sward fractions than the Hyparrhenia grassland through most of the winter period. This, combined with the fact mean crude protein levels in the Hyparrhenia sward remained below 5% throughout the winter in both fractions, has important implications for feeding preferences and cattle performance since protein values below 6-8% tend to depress intake rates in ruminants (Minson, 1982).
With regard to the fibre content of the two grassland swards, mean fibre values in the dry fraction showed no significant (p<0.05, ANOVA) change through time in either the *Sporobolus-Eragrostis* or *Hyparrhenia* grassland vegetation categories. However, differences in mean fibre content between the dry fractions of these categories were significant (p<0.001, ANOVA) during winter 1999 (Figure 5.15).

![Figure 5.15: Mean fibre value (± S.E.) of the dry fraction of the *Sporobolus-Eragrostis* and *Hyparrhenia* grassland sward during winter 1999 (n = 3).](image)

Indeed, the LSD value in Figure 5.15, indicates that the mean fibre content of the dry fraction of *Sporobolus-Eragrostis* sward was significantly (p<0.05) higher than that of the dry fraction of the *Hyparrhenia* sward at all stages (beginning, middle and end) of winter 1999.

There was a significant (p<0.05, ANOVA) difference in mean fibre content of the green fraction during winter 1999 both within and between vegetation categories (Figure 5.16, overleaf). Mean fibre content in the green fraction of the *Hyparrhenia* grassland increased, although not significantly (p>0.05), between the beginning and middle of the winter whereas it decreased significantly (p<0.05) between the middle and end of the winter. The mean fibre content of the green fraction of the *Sporobolus-Eragrostis* grassland sward decreased throughout the winter, although the only
significant (p<0.05) decrease was between the beginning and end of the winter. Comparisons of mean fibre content between vegetation categories show that the only significant (p<0.05) difference was at the beginning of the winter.

![Graph showing fibre content changes](image)

**Figure 5.16:** Mean fibre value (± S.E.) of the green fraction of the *Sporobolus-Eragrostis* and *Hyparrhenia* grassland sward during winter 1999 (n = 3).

With regard to the mean *in vitro* digestibility of the *Sporobolus-Eragrostis* and *Hyparrhenia* grassland vegetation categories, values for the dry fraction of the sward are summarised in Figure 5.17.

![Graph showing digestibility changes](image)

**Figure 5.17:** Mean *in-vitro* digestibility (± S.E.) of the dry fraction of the *Sporobolus-Eragrostis* and *Hyparrhenia* sward during winter 1999 (n = 3).
During winter 1999, there was a significant (p<0.005, ANOVA) overall difference in the mean digestibility of the dry fraction of the sward between vegetation categories. Specifically the LSD revealed the digestibility to be significantly (p<0.05) higher in the *Hyparrhenia* sward compared to the *Sporobolus-Eragrostis* sward at both the beginning and the end of the winter. There was also a significant (p<0.05) overall change in digestibility within the two vegetation categories during the course of the winter. In both vegetation categories there was a significant (p<0.05) decrease in mean digestibility between the beginning and middle of the winter. There was also a significant (p<0.05) increase in mean digestibility between the middle and end of the winter in the *Hyparrhenia* grassland vegetation.

The mean *in vitro* digestibility values for the green fraction of the two grassland swards are summarised in Figure 5.18.

![Figure 5.18: Mean in vitro digestibility (± S.E.) of the green fraction of the Sporobolus-Eragrostis and Hyparrhenia grassland sward at Guquka during winter 1999 (n = 3).](image)

Overall there was no significant (p<0.05, ANOVA) difference between the two grassland swards with regard to the mean *in vitro* digestibility of the green fraction during winter 1999. However, the LSD value in Figure 5.18 suggests that this
difference was significant (p<0.05) during the middle of the winter. Considerably
greater fluctuations in \textit{in vitro} digestibility were found within the green fraction of
each grassland sward during the course of the winter. These were highly significant
(p<0.001, ANOVA) when taken over the whole winter. Specifically the LSD showed
that both grassland swards demonstrated a significant (p<0.05) decrease in mean \textit{in-
vitro} digestibility between the beginning and middle of the winter and a significant
(p<0.05) increase between the middle and end of the winter.

The very low digestibility of dry fraction of both sward types during the mid-winter
period has implications for cattle intake rates at this time. Forage of low digestibility
is retained in the reticulo-rumen for longer, meaning that the throughput of plant
material is slowed and that intake rates must consequently be lowered to compensate
for this (Poppi et al., 1981; Illius and Gordon, 1991). Given that approximately 80%
of both swards consisted of dry material by this stage (see Figure 5.12), the low
quality of the available grassland forage might therefore act as a constraint on animal
production at this time.

Taken together these findings have important implications for foraging cattle over the
winter. Throughout the winter each sward type consisted largely of dry material.
Thus, preference for either \textit{Hyparrhenia} or \textit{Sporobolus-Eragrostis} grassland at the
beginning and end of the winter would appear to be a careful trade-off between the
higher crude protein found in the dry fraction of the \textit{Sporobolus-Eragrostis} sward and
the significantly greater digestibility of the dry fraction of the \textit{Hyparrhenia} sward at
this time. However, during the middle period of the winter the significantly higher
crude protein level in both the green and dry fractions of the \textit{Sporobolus-Eragrostis}
grassland, combined with the significantly higher digestibility of the green fraction at
this time, suggest that it would make greater nutritional sense for cattle to feed
preferentially in the \textit{Sporobolus-Eragrostis} grassland rather than the \textit{Hyparrhenia}
grassland vegetation at this time. This is corroborated by the preference data
presented in Table 5.11. In both 1998 and 1999, cattle expressed a preference for
\textit{Sporobolus-Eragrostis} grassland over \textit{Hyparrhenia} grassland in the middle of the
winter.
5.2.6) **ESTIMATING THE NUTRITIONAL INTAKE OF CATTLE DURING THE WINTER**

Using the data from Figure 5.9 and Figures 5.12-5.18, estimates of the mean daily intake of biomass, energy and crude protein per animal during winter 1999 can be derived, as described in Appendix 5.2. These are summarised for both the first and second halves of the winter in Table 5.10.

**Table 5.10: Estimated mean daily intake of biomass, energy and crude protein for grazing cattle during winter 1999.**

<table>
<thead>
<tr>
<th>COMPONENT OF VEGETATION CATEGORY</th>
<th>1st HALF OF WINTER</th>
<th>2nd HALF OF WINTER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dry Matter (kg)</td>
<td>Energy (MJ)</td>
</tr>
<tr>
<td>Crop residues (stalk)</td>
<td>1.4</td>
<td>14.5</td>
</tr>
<tr>
<td>Crop residues (leaf)</td>
<td>1.2</td>
<td>12.7</td>
</tr>
<tr>
<td><em>Sporobolus-Eragrostis</em> (green)</td>
<td>0.6</td>
<td>1.7</td>
</tr>
<tr>
<td><em>Sporobolus-Eragrostis</em> (dry)</td>
<td>0.0</td>
<td>2.7</td>
</tr>
<tr>
<td><em>Hyparrhenia</em> (green)</td>
<td>1.7</td>
<td>5.1</td>
</tr>
<tr>
<td><em>Hyparrhenia</em> (dry)</td>
<td>0.0</td>
<td>9.1</td>
</tr>
<tr>
<td>TOTAL</td>
<td>4.9</td>
<td>45.8</td>
</tr>
</tbody>
</table>

These estimates are somewhat crude and make a number of fundamental assumptions with regard to the foraging behaviour of cattle. The first of these was that animals distributed themselves entirely randomly throughout the expanse of the lower land allocation, making the measured levels of forage intake from each sampling area representative of the entire vegetation category in each case. The second was that animals fed in a manner that was entirely non-selective, such that dry and green material was incorporated into the diet in proportion to its level of occurrence in the sward. This is improbable as although cattle are essentially bulk grazers (Hanley, 1982) they are capable of selectively feeding on green material to some extent even in swards that are largely moribund (Reppert, 1960; O’Reagain, 1994). For this reason, levels of crude protein intake are likely to have been underestimated during both halves of the winter.

Despite these shortcomings, the figures provide a reasonable indication of how intake changes through the winter. Possibly the most striking result is the very substantial
increase in dry matter intake between the first and second halves of the winter. Although, the scale of the increase may have been overestimated, such an increase was not unexpected. During the first half of the winter cattle feed preferentially on crop residues, which although higher in crude protein, have a tough and fibrous composition that does not permit high levels of intake. Thus, intake rates are relatively low at this time. During the second half of the winter intake rates are elevated as crop residues are exhausted and animals are forced to consume larger amounts of forage of relatively low nutritional quality, in order to try and satisfy their intake requirements.

Some idea of the impact that such intake rates are likely to have on animal condition can be obtained by comparing them with standard values derived for cattle in developing countries (Kearl, 1982). The mean mass of a typical adult animal in the central Eastern Cape region can be assumed to be about 350 kg (T.D. De Bruyn, unpublished PhD data). According to Kearl (1982) an animal of this mass would require a minimum daily intake rate of 6.1 kg of dry matter, 340 g of crude protein and 40.9 MJ of energy simply to maintain body condition. From Table 5.10 it can be seen that the estimated rate of intake of dry matter and energy is approximately sufficient for maintenance during both halves of the winter. However, estimated levels of crude protein intake at Guquka fall well below the required minimum for maintenance during both halves of the winter. Two separate sets of constraints on protein intake would appear to have been in operation during each half of the winter. During the first half of the winter, although feeding focused largely on crop residues, which were of relatively high nutritional quality, they were simply not abundant enough to satisfy demand throughout this period. Conversely, during the second half of the winter there was a switch to feeding on grassland vegetation, which although relatively abundant was of such low nutritional quality that it could not be consumed in sufficient quantities to satisfy protein intake requirements. Under conditions of such low protein intake it would be expected that cattle should lose condition for the entire duration of the winter. This was indeed the case during winter 1999. Although no formal measurements of condition were undertaken, some fairly severe declines in body condition were observed in animals used for behavioural observations, such that by the end of August many of them were decidedly thin in appearance.
5.3) QUANTIFYING ARABLE GRAZING AT KOLONI

5.3.1) VEGETATION CATEGORIES

GIS vegetation maps for the arable land allocations at Koloni during winter 1998 and 1999 are presented in Figures 5.19 and 5.20, respectively. Five distinct vegetation categories were available to grazing livestock on the arable land allocations at this time, as described in the map legends. These included all of the four vegetation categories identified at Guquka. The species composition of the crop residues, recent fallow and Sporobolus-Eragrostis grassland vegetation categories was almost identical to that at Guquka (Section 5.2.1). However, there were some notable differences with regard to the Hyparrhenia grassland vegetation and also an additional category not found at Guquka. These are described below.

HYPARRHENIA GRASSLAND VEGETATION: As with Guquka, this vegetation category was dominated almost entirely by Hyparrhenia hirta. However, at Koloni the category was also characterised by substantial levels of bush intrusion, particularly on fields that had remained uncultivated for a long time (Figure 5.21).

Figure 5.21: Hyparrhenia grassland vegetation category at Koloni, showing dense stands of H. hirta and substantial levels of bush intrusion.
Figure 5.19: Proportion of vegetation types on arable land allocations at Koloni during dry season 1999.
Figure 5.20: Proportion of different vegetation types on arable land allocations at Koloni during dry season 1999.
By far the most common bush species found in the *Hyparrhenia* grassland vegetation was *Acacia karroo*. This establishes easily on uncultivated lands in sweetveld areas and can grow to from dense stands, particularly in low-lying areas.

Another distinguishing feature of the *Hyparrhenia* grassland vegetation at Koloni was its patchiness. It could be divided into distinct patches of high and low biomass. The former consisted almost entirely of tall swathes of *H. hirta* as exemplified by Figure 5.21. The low biomass patches were characterised by a variety of largely grazing-tolerant species of low mean sward height (Figure 5.22).

![Figure 5.22: Typical low biomass patch in the *Hyparrhenia* grassland at Koloni.](image)

Common species included *Sporobolus africanus*, *Eragrostis capensis* (Thunb.) Trin. and *Digitaria eriantha* Steud. The low biomass patches accounted for approximately 30% of the total area of the *Hyparrhenia* grassland vegetation on the main arable land allocation (see Appendix 5.3).

**COMMONAGE VEGETATION:** There were several open areas within the fenced boundaries of the arable land allocations at Koloni that were never delineated as fields and therefore never cultivated. These were designated as grazing (commonage) areas for cattle involved in ploughing and in this respect they can be viewed as analogous to the grazing camps at the village. The vegetation they contained was very similar to that found on the veld in this area (Goqwana, 1998) and included valuable grazing
grasses such as *Themeda triandra* Forssk. and *Heteropogon contortus* (L.) Roem. & Schult. Figure 5.23 depicts a typical commonage area.

![Figure 5.23: View of one of the commonage areas at Koloni during winter 1999.](image)

Commonage vegetation was relatively widespread at Koloni, being found not only on the discrete parcels of land designated for cattle grazing but also in the corridors of land that separated blocks of arable fields from one another and along the many erosion bunds that traversed the majority of fields.

The areas and proportions of the different vegetation categories identified at Koloni are summarised, for winter 1998, in Table 5.11.

**Table 5.11: Areas of different vegetation types found on arable land allocations at Koloni during winter 1998.**

<table>
<thead>
<tr>
<th>VEGETATION TYPE</th>
<th>TOTAL AREA</th>
<th>FREE-RANGING AREA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AREA (ha)</td>
<td>%</td>
</tr>
<tr>
<td>Crop residues</td>
<td>17.13</td>
<td>4.4</td>
</tr>
<tr>
<td>Recent fallow vegetation</td>
<td>4.15</td>
<td>1.1</td>
</tr>
<tr>
<td><em>Sporobolus-Eragrostis</em> grassland</td>
<td>27.11</td>
<td>7.0</td>
</tr>
<tr>
<td><em>Hyparrhenia</em> (low biomass)</td>
<td>70.50</td>
<td>18.2</td>
</tr>
<tr>
<td><em>Hyparrhenia</em> (high biomass)</td>
<td>164.49</td>
<td>42.6</td>
</tr>
<tr>
<td>Commonage</td>
<td>103.17</td>
<td>26.7</td>
</tr>
<tr>
<td>TOTAL</td>
<td>386.55</td>
<td>100.0</td>
</tr>
</tbody>
</table>
Figures for the entire arable land allocation are provided in the first two columns of Table 5.11. The total area of vegetation available for grazing during the winter amounts to some 386 ha. However, as with Guquka, quantitative ecological field measurements were only conducted on the larger of the arable land allocations. Thus, the smaller areas of arable land (encompassing fields 89-112) had to be eliminated for the purpose of calculating the appropriate proportions of each vegetation type. The result was a free-ranging area of just over 300 ha, as described in the third column of Table 5.12. The same data are presented for winter 1999 in Table 5.12.

Table 5.12: Areas of different vegetation types found on arable land allocations at Koloni during winter 1999.

<table>
<thead>
<tr>
<th>VEGETATION TYPE</th>
<th>TOTAL AREA</th>
<th>FREE-RANGING AREA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AREA (ha)</td>
<td>%</td>
</tr>
<tr>
<td>Crop residues</td>
<td>44.64</td>
<td>11.5</td>
</tr>
<tr>
<td>Recent fallow vegetation</td>
<td>0.54</td>
<td>0.1</td>
</tr>
<tr>
<td><em>Sporobolus-Eragrostis</em> grassland</td>
<td>17.99</td>
<td>4.7</td>
</tr>
<tr>
<td><em>Hyparrhenia</em> (low biomass)</td>
<td>66.07</td>
<td>17.1</td>
</tr>
<tr>
<td><em>Hyparrhenia</em> (high biomass)</td>
<td>154.15</td>
<td>39.9</td>
</tr>
<tr>
<td>Commonage</td>
<td>103.17</td>
<td>26.7</td>
</tr>
<tr>
<td>TOTAL</td>
<td>386.56</td>
<td>100.0</td>
</tr>
</tbody>
</table>

The change in proportion of vegetation types between 1998 and 1999 was entirely the result of additional land being cultivated during summer 1998/99.

5.3.2) MONITORING OF LIVESTOCK NUMBERS

Cattle numbers were monitored on the arable land allocations at Koloni during both winters 1998 and 1999. Separate data is presented for the mean number of animals on both the large and small allocations, in Table 5.13.

Table 5.13: Mean number of cattle per week recorded on the arable land allocations at Koloni during winter 1998 (n=9) and winter 1999 (n=23).

<table>
<thead>
<tr>
<th>ARABLE AREA</th>
<th>WINTER 1998</th>
<th>WINTER 1999</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large allocation</td>
<td>163.2</td>
<td>119.4</td>
</tr>
<tr>
<td>Small allocation</td>
<td>NA†</td>
<td>28.2</td>
</tr>
<tr>
<td>TOTAL</td>
<td>163.2</td>
<td>147.6</td>
</tr>
</tbody>
</table>

† Data unavailable.
Although there was no substantial difference in the total mean number of animals per week found on the entire arable land allocation between winter 1998 and 1999 the difference in mean numbers found on the large allocation was considerable between years. This was a reflection not of a difference in cattle numbers between years but rather of different management practices. The severe shortage of water during the early part of winter 1999 led many owners to move their cattle onto the smaller arable land allocation and others to return them to range camps, where permanent water supplies were available. This is reflected in the decline in animal numbers on the main allocation and the concomitant increase in numbers on the small allocation between mid-June and late July 1999 (Figure 5.24).

![Weekly count data of the total number of cattle on the large and small arable land allocations at Koloni during winter 1999 (n = 23).](image)

Figure 5.24: Weekly count data of the total number of cattle on the large and small arable land allocations at Koloni during winter 1999 (n = 23).

From the beginning of August onwards there was a sharp decrease in the number of animals on the smaller allocation, and an increase in the number on the main allocation. This coincided with a period of very wet weather at the end of July 1999, after which many cattle owners decided to actively move their animals back to the main arable land allocation.
The total number of free-ranging cattle recorded in each vegetation category during both winter 1998 and 1999, is summarised in Table 5.14. The most noticeable difference between the two sets of data is the vastly smaller proportion of cattle found on crop residues during 1998 than in 1999. However, this is unlikely to reflect a real difference in preference between years, as recording of animal numbers during winter 1998 did not commence until the beginning of July, almost six weeks after the allocations had first been opened for grazing. By contrast, recording of animal numbers in 1999 began within a week of the arable allocations being opened to grazing, and thus can be taken as being a more realistic reflection of cattle preference.

Table 5.14: Sum of weekly counts of numbers of cattle recorded in each vegetation category on the larger arable land allocation at Koloni during winter 1998 and winter 1999.

<table>
<thead>
<tr>
<th>VEGETATION CATEGORY</th>
<th>WINTER 1998</th>
<th></th>
<th>WINTER 1999</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NUMBER</td>
<td>%</td>
<td>NUMBER</td>
<td>%</td>
</tr>
<tr>
<td>Crop residues</td>
<td>5.3</td>
<td></td>
<td>32.0</td>
<td></td>
</tr>
<tr>
<td>Recent fallow vegetation</td>
<td>0.1</td>
<td></td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td><em>Sporobolus-Eragrostis</em> grassland</td>
<td>6.9</td>
<td></td>
<td>1.9</td>
<td></td>
</tr>
<tr>
<td><em>Hyparrhenia</em> grassland</td>
<td>51.1</td>
<td></td>
<td>24.2</td>
<td></td>
</tr>
<tr>
<td>Commonage</td>
<td>36.6</td>
<td></td>
<td>41.4</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>100.0</td>
<td></td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

If the observed frequency count data is compared with the expected frequency count data for both years, then it is clear that animal distribution in each of the vegetation categories is not random (Table 1, Appendix 5.4). The strength of the departure from randomness can be determined using log ratio analysis (see equation 1, Section 3.3.1.2). This demonstrates that during both 1998 and 1999, cattle distribution was very significantly different (p<0.001) from what would be expected by chance, indicating the expression of strong levels of preference (Table 2, Appendix 5.4). Moreover, consideration of the change in cattle numbers in different vegetation categories (Figure 5.25, overleaf) suggests that there was no marked change in preference for particular vegetation categories during the course of the winter. The only noticeable change is a sharp decline during the last few weeks of arable grazing in the number of animals found on crop residues (probably corresponding with their exhaustion) and a simultaneous increase in the number in the *Sporobolus-Eragrostis* grassland. This would seem to suggest that, with the exception of crop residues, there
Figure 5.25: Weekly count data of the number of free-ranging cattle in different vegetation categories on the large arable land allocation at Koloni during winter 1999 (n =23).
was enough available forage for animals to continue expressing preference at the vegetation category level throughout the winter. Cattle feeding preference is investigated in more detail in the following section, using the behaviour data.

5.3.3) CATTLE BEHAVIOUR DATA

Data on the mean proportion of time cattle spent feeding, resting and walking during both winter 1998 and winter 1999 is summarised in Figure 5.26 (overleaf). As for Guquka, the data set includes observations of animals that moved outside the boundaries of the arable land allocation.

The amount of time cattle allocated to all three activities remained fairly consistent throughout both winters. The only exception to this was the behaviour of cattle observed in the middle of winter 1998. These animals spent substantially more time feeding at the expense of resting than other herds observed during both 1998 and 1999. This can be explained by the fact that the herd selected for observation in mid-1998, consisted largely of lactating cows with very young calves. These animals followed a quite different grazing pattern than the others observed. Rather than resting extensively during the middle of the day these animals continued to graze intensively for most of the day. Then towards dusk they moved back towards the village and watered, before resting near their respective homesteads ready to be kraaled and reunited with their calves. This demonstrates the difficulties of generalising about livestock behaviour over time, without taking adequate account of the age, sex and physiological state of the animals being observed at each stage.

Feeding was the most important animal activity accounting for around 55%-75% of the active daylight period during winter 1999. Accepting that there are around 12 hours of daylight during the day at this time, this equates to an average of 7-9 hours of grazing each day over the whole winter. For the majority of animals observed, feeding during the day was divided into two distinct phases. The first commenced in the early morning and lasted until around midday. The second commenced around mid-afternoon and lasted until dusk. This pattern has been observed in other studies of the behaviour of free-ranging cattle (Arnold and Dudzinski, 1978). The proportion
of time spent feeding during winter 1999, seems to have shown a steady increase during the course of the season. This may reflect a decrease in the amount of available forage and a need for animals to compensate for this by increasing the amount of time they spent grazing (Chacon and Stobbs, 1976; Gibb et al., 1999). Nevertheless, this hypothesised decrease in forage does not seem to have been sufficient to affect daily intake rates over the course of the winter (Section 5.3.6).

Figure 5.26: Mean proportion of time (± S.E.) spent by cattle feeding, resting, or walking on the arable lands at Koloni during winter 1998 and winter 1999.
Resting also accounted for a considerable portion of the mean daily time the animals spent free-ranging. This was consistently concentrated around the middle of the day, generally commencing around late morning and lasting until mid-afternoon. During 1998, it also tended to be associated with watering points. Animals grazing on the main arable land allocation would generally exit the area to drink at one of the dams in the adjacent range camps. They would then remain by the dam resting and ruminating until mid-afternoon, at which point they would return to the arable land to begin feeding again.

The amount of time animals spent walking was also consistently higher during 1998 compared to 1999. This is almost entirely a reflection of differences in the availability of water between years and the effect this had on animal drinking patterns. During 1998, watering was undertaken at dams during the middle of the day and animals often walked relatively long distances (1-2km) to get there. In particular, the top dam above fields 111 and 112 (see Figure 4.9) was a favourite watering point for the majority of animals on the main land allocation. However, at the beginning of winter 1999 this dam dried up forcing animals to find alternative sources of water. The majority of animals responded by either by altering their main watering time to early evening (after animal observations had already ceased), or watering from rain-filled depressions on the fields following the unseasonally heavy rains of July 1999 (see Appendix 2.2.4). The amount of time spent walking in search of water during daylight hours was thus greatly reduced.

The amount of time cattle spent feeding in the different vegetation categories at Koloni is summarised for winter 1998 and winter 1999 in Figure 5.27 (overleaf). As for Guquka, only data from animals observed feeding exclusively on the arable land allocations is included.
Figure 5.27: Proportion of time (± S.E.) spent feeding by cattle in the different vegetation categories at Koloni during winter 1998 and winter 1999.

The immediate disparity when comparing the 1998 and 1999 data, is the complete lack of feeding on crop residues during 1998. Even though only a relatively small
proportion of land contained crop residues during 1998, this result is somewhat unexpected given the recognised preference cattle have for crop residues. In fact, this result is unrealistic, as due to delays in getting fieldwork underway during 1998, animal observations did not begin until the end of June whereas animals had been present on the arable lands since mid-May. Thus, by the time observations began the crop residues were already completely exhausted. The 1998 data is also compromised by a lack of consistency that prevents any clear changes in preference from emerging. It was realised from the offset that the main arable land allocation was too big for cattle to range over its entirety in the course of one day. Thus, in order to generate a complete picture of animal feeding preference, observations were undertaken on herds in widely different areas of the allocation. This explains the somewhat erratic fluctuations in time spent feeding in different categories at different stages of the winter. Thus, although the resulting data provides a realistic assessment of the average level of preference expressed by cattle over the whole winter, it can say nothing about how this changes with time. It is also testament to the adoption of specific home range areas amongst different groups of cattle, when the feeding area is sufficiently large and forage plentiful enough to allow for this. Consistent home range behaviour in cattle has been reported by other researchers (Bailey et al., 1998).

Subsequent discussion of preference will thus make use of the 1998 data averaged over the whole winter period and the 1999 data in its entirety. Indices of preference for the different vegetation categories can be derived for both years (equation 2, section 3.3.1.2). These values are summarised in Table 5.15.

**Table 5.15: Cattle preference indices (Pi) for each vegetation category at Koloni during winter 1998 and winter 1999.**

<table>
<thead>
<tr>
<th>VEG. CATEGORY</th>
<th>WINTER 1998</th>
<th>WINTER 1999</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial</td>
<td>Middle</td>
</tr>
<tr>
<td>Crop residues</td>
<td>0.00</td>
<td>2.50</td>
</tr>
<tr>
<td>Recent fallow vegetation</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td><em>Sporobolus-Eragrostis</em> grassland</td>
<td>0.70</td>
<td>0.02</td>
</tr>
<tr>
<td><em>Hyparrhenia</em> (low biomass)</td>
<td>1.44</td>
<td>0.79</td>
</tr>
<tr>
<td><em>Hyparrhenia</em> (high biomass)</td>
<td>0.70</td>
<td>0.34</td>
</tr>
<tr>
<td>Commonage</td>
<td>1.51</td>
<td>1.65</td>
</tr>
</tbody>
</table>
Considering first the complete data set from 1999, it is clear that at the beginning of the winter cattle showed a distinct preference for crop residues. This was followed by the highly palatable vegetation found on the commonage area and then the low biomass and high biomass patches of the *Hyparrhenia* grassland vegetation. The *Sporobolus-Eragrostis* grassland was largely avoided at this stage and the recent fallow completely ignored. By the middle of the winter, crop residues remained the most preferred food source, but low biomass patches of the *Hyparrhenia* grassland had become preferred over commonage vegetation. This switch in preference appears to have been prompted by a decline in the quality of the commonage sward at this time (see section 5.3.5). *Sporobolus-Eragrostis* grassland continued to be avoided, although less so than initially, whilst the recent fallow was again completely ignored. By the end of the winter the most obvious change was the lack of preference for crop residues due to their total depletion by this stage. Instead, at this stage cattle expressed strongest preference for commonage vegetation. This appears to have been mediated by an extensive recovery of the commonage vegetation, with regard to both its quantity and quality, by the late winter/early spring period (see sections 5.3.4 & 5.3.5) following the heavy rains of late July (see Appendix 2.2.4). *Sporobolus-Eragrostis* grassland continued to be the least preferred of those vegetation categories selected, and the low biomass patches of *Hyparrhenia* grassland vegetation continued to be preferred over high biomass patches. The consistent preference expressed by cattle for low biomass over the high biomass areas of *Hyparrhenia* grassland vegetation is supported by studies conducted on cattle grazing in heterogeneous fescue pastures in Argentina (Cid and Brizuela, 1998).

Although the 1998 data provide no indication of changes in preference through time, they do provide an overall indication of preference when forage availability is not a restricting factor. This is remarkably similar to the data for the end of the winter 1999, when crop residues had been exhausted. The only real discrepancy between the 1998 and the 1999 data is the order of preference for the *Sporobolus-Eragrostis* grassland and the high biomass patches of the *Hyparrhenia* grassland. In the combined 1998 data, *Sporobolus-Eragrostis* grassland is equally preferred to the high biomass patches, but the 1999 data shows it to be consistently less preferred. However, the 1999 animal observation data was collected exclusively from the area encompassing fields 19-88 on the western side of the main donga, (Figure 5.19).
was almost entirely devoid of *Sporobolus-Eragrostis* grassland. Thus, the true level of preference being expressed for *Sporobolus-Eragrostis* grassland at this time was likely to have been somewhat higher. Accepting this, and the high preference accorded to crop residues during 1999, the overall preference hierarchy that emerges for the six vegetation categories at Koloni is as follows (highest = 1, lowest = 6): -

1. Crop residues
2. Commonage grassland vegetation
3. *Hyparrhenia* grassland vegetation (low biomass patches)
4. *Sporobolus-Eragrostis* grassland vegetation
5. *Hyparrhenia* grassland vegetation (high biomass patches)
6. Recent fallow vegetation.

5.3.4) **MEASUREMENT OF FORAGE REMOVAL BY CATTLE**

Figure 5.28 summarises the amount of forage removed from the high and low patches of the *Hyparrhenia* grassland vegetation during winter 1999.

Figure 5.28: Standing biomass (± S.E.) in grazed and exclosed areas of the low (n = 40) and high (n = 60) biomass patches of the *Hyparrhenia* grassland vegetation at Koloni during winter 1999.
The difference in standing biomass throughout the winter between the different patches in the *Hyparrhenia* grassland is clearly demonstrated by the data.

If the exclosure data for the different patch areas are compared, then it can be seen that the swards behaved in quite different ways over the course of the winter. The high biomass patches showed a marked decrease in standing biomass during the first half of the winter, whereas this was almost negligible in the low biomass patches. Conversely, the high biomass patches showed very little natural change in standing biomass during the second half of the winter, whereas there was a much more pronounced increase in the low biomass patches. This might be expected if the species composition of each sward is considered. The high biomass patches are almost mono-specific, being dominated by *Hyparrhenia hirta*. Grasses of this genus, although fairly hardy, undergo considerable necrosis becoming tough and fibrous during the early winter and mature stands are relatively slow to produce new growth the following spring (Smith, 1961a, Van Oudtshoorn, 1992). By contrast, the low biomass patches are dominated by a variety of species such as *Eragrostis capensis*, which die back rapidly before the onset of winter but recover rapidly as soon as the growing season begins (Gibbs-Russell *et al*., 1990).

The change in the standing biomass in both exclosed and grazed areas of the *Sporobolus-Eragrostis* and commonage grassland is summarised in Figure 5.29 (overleaf). Figures for the standing biomass in the commonage exclosure during the middle and end of winter 1999 were estimated (hence the lack of standard error bars on the mean values). This is because after the initial sampling in the exclosure some of the fencing was removed by individuals from neighbouring villages allowing it to be grazed by cattle and rendering it effectively useless. Values were derived by extrapolating from the initial value using the change in biomass observed in the *Hyparrhenia* grassland (high biomass) exclosure, as both vegetation types contained considerable levels of *H. hirta*. 
Standing biomass (± S.E.) in grazed and exclosed areas of the *Sporobolus-Eragrostis* (n = 50) and commonage (n = 50) grassland vegetation at Koloni during winter 1999.

The natural change in the standing biomass in *Sporobolus-Eragrostis* and commonage grass swards parallels that in the low and high biomass patches (respectively) of the *Hyparrhenia* grassland sward and for broadly similar reasons. Also of note, is the fact that in the low biomass patches of the *Hyparrhenia* grassland and the commonage vegetation, both of which were heavily grazed during the winter, the final values for standing biomass at the end of the winter were similar, ranging roughly between 500 and 600 kg.

Comparative data for change in the standing biomass of crop residues and recent fallow vegetation during winter 1999 are not available. However, as with Guquka, estimates of the initial biomass of maize residues can be derived from grain yields (Powell, 1990). Mbuti (unpublished MSc data) reported a mean grain yield at Koloni of 1199.8 kg/ha during the 1998/99 growing season. Again the regression equations developed by Powell (1990) can be used to calculate the initial biomass of both the leaf and stalk components of the residues (Table 5.16).
Table 5.16: Estimate of mean initial standing biomass of maize residues on cultivated fields at Guquka during winter 1999.

<table>
<thead>
<tr>
<th>PLANT COMPONENT</th>
<th>BIOMASS (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf</td>
<td>770.5</td>
</tr>
<tr>
<td>Stalk</td>
<td>1535.3</td>
</tr>
<tr>
<td>TOTAL</td>
<td>2305.8</td>
</tr>
</tbody>
</table>

The data on change in standing biomass for the vegetation categories in Figures 5.28 and 5.29, together with the estimated data for maize residues in Table 5.16, can be used to calculate the amount of forage removed by grazing cattle (Table 5.17). The figures in Table 5.17 will provide the basis for deriving estimates of cattle forage intake during both the first and second halves of winter 1999 (section 5.3.6).

Table 5.17: Forage removal by cattle from different vegetation categories during winter 1999†.

<table>
<thead>
<tr>
<th>Vegetation category</th>
<th>Forage removal (kg DM/ha)</th>
<th>Total forage removal (kg DM)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st half</td>
<td>2nd half</td>
</tr>
<tr>
<td>Maize residues (leaf)</td>
<td>454.6</td>
<td>0</td>
</tr>
<tr>
<td>Maize residues (stall)</td>
<td>537.4</td>
<td>0</td>
</tr>
<tr>
<td>Sporobolus-Eragrostis</td>
<td>608.2</td>
<td>291.7</td>
</tr>
<tr>
<td>grassland</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commonage grassland</td>
<td>442.8</td>
<td>898.2</td>
</tr>
<tr>
<td>Hyparrhenia (low biomass)</td>
<td>410.6</td>
<td>668.9</td>
</tr>
<tr>
<td>Hyparrhenia (high biomass)</td>
<td>47.6</td>
<td>392.0</td>
</tr>
<tr>
<td>Total</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

† Assuming no grazing from recent fallow vegetation.

* Assuming 59% utilisation of available biomass (Crichton et al., 1998) and all utilisation concentrated in first half of winter.

** Assuming 35% utilisation of available biomass (Crichton et al., 1998) and all utilisation concentrated in first half of winter.

As well as forage removal at the vegetation category level the quadrat data also provide a direct measure of the change in the proportion of key species within each category and thus an indication of cattle preference at the species level and how this changed during winter 1999. This is summarised for the Sporobolus-Eragrostis grassland vegetation category in Figure 5.30. Species included are those that constituted >1% of sward biomass throughout the winter grazing period.
There was a very significant (p<0.001, Kruskal-Wallis Test) increase in the proportion of *Sporobolus africanus* in the sward during the winter period. This was particularly significant (p<0.001, Mann-Whitney Test) between the beginning and middle of the winter suggesting that this species was strongly avoided by cattle at this time. This was not unexpected as *S. africanus* becomes tough and fibrous during the winter and is thus difficult for animals to digest (Gibbs-Russell *et al.*, 1990). Concomitant with the increase in the proportion of *S. africanus* there was, during the winter, a significant (p<0.05, Kruskal-Wallis Test) change in the proportion of *Helictotrichon turgidulum*. This decreased very significantly (p<0.005, Mann-Whitney Test) between the middle and end of the winter, suggesting that cattle were showing preference for it at this stage. This is understandable as *H. turgidulum* remains green well into the winter and thus is still relatively palatable when other species are not (Van Oudtshoorn, 1992). There was no significant (p<0.05, Kruskal-Wallis Test) change in the proportion of any of the other species in the sward at any stage of the winter, suggesting that these were neither preferred nor avoided. For the commonage grassland the change in the proportion by mass of the six main species in the sward is summarised in Figure 5.31.
Figure 5.31: Proportion (± S.E.) of key grass species in Commonage grassland during winter 1999 (n = 50).

The most obvious and important change was the very significant (p<0.005, Kruskal-Wallis Test) decrease in the proportion of *Themeda triandra* in the sward during the course of winter 1999. This was significant (p<0.05, Mann-Whitney Test) between both the beginning and middle, and the middle and end of the winter. The apparent strong selection demonstrated by cattle throughout the winter for *T. triandra* can be reconciled with its status as one of the most desirable pasture species in South Africa due to its high palatability and leaf production (Gibbs-Russell *et al.*, 1990). Indeed, in grazing studies conducted in sweetveld areas, *T. triandra* has consistently been found to be the pasture species most preferred by cattle (Danckwerts *et al.*, 1983). The proportion of *Heteropogon contortus* in the commonage sward also showed a significant (p<0.05, Kruskal-Wallis Test) decrease over the course of the winter. Again this inferred level of grazing preference is consistent with the relatively high palatability of this species (Van Oudtshoorn, 1992). There was no significant change in the proportion of *Hyparrhenia hirta*, in the sward at this time (p = 0.310, Kruskal-Wallis Test). However, it could well be that the considerable degree of error in the measurement of *H. hirta* biomass, (due to its highly clumped distribution in the sward) was obscuring any significant changes. Certainly the woody nature of this
species during the winter would make it the primary candidate for being avoided by foraging cattle. There was no significant (p>0.05, Kruskal-Wallis Test) fluctuation in the proportion of any of the other species in the sward during the course of the winter.

For the _Hyparrhenia_ grassland, the change in the proportion by mass of the main species in the low biomass patches of the sward is summarised in Figure 5.32. Data for the high biomass patches are not presented, as _Hyparrhenia hirta_ dominated so much (> 90%) of the standing biomass that changes in other species were barely detectable.

![Figure 5.32: Proportion (± S.E.) of key grass species in low biomass Hyparrhenia grassland patches during winter 1999 (n = 26, initial; n = 30, middle; n =34, end).](image)

With regard to the four major grass species in the sward, quite different changes were found in their proportions during the course of the winter. The proportions of both _Eragrostis capensis_ and _Sporobolus fimbriatus_ changed significantly (p<0.01, Kruskal-Wallis Test) during the winter. During the first half of the winter there was a very significant (p<0.005, Mann-Whitney Test) decrease in the proportion of both species. This suggests a high level of selection for these species and undoubtedly reflects their relatively high palatability at this time. The proportion of _Digitaria eriantha_ and _Sporobolus africanus_ in the sward demonstrated no significant change.
during the first half of the winter (p > 0.05, Mann-Whitney Test). However, it is possible that the considerable degree of error in biomass measurement for these two species may have obscured any significant changes that did occur. Certainly some degree of avoidance of these species would be expected. *S. africanus* becomes tough and unpalatable during the winter whilst *D. eriantha*, although it is generally considered to be palatable, exhibited a prostrate growth form that may have made it less accessible to grazing than other palatable species. Indeed, the work of Danckwerts *et al.*, (1983) in sweetveld areas of the Eastern Cape suggests that, where there is no strong physical or chemical deterrent to grazing, species preference is quite strongly related to plant height.

During the second half of the winter there was no significant change in the proportion of any of these species (p > 0.05, Mann-Whitney Test). However, this does not appear to reflect a lack of cattle feeding preference at this time. Rather, these changes would seem to result from the depletion of *E. capensis* and *S. fimbriatus* in the sward by the end of the winter and an enforced switch to largely non-selective feeding by cattle.

These findings lend support to the idea that cattle are able to feed selectively at the species level under appropriate conditions. Moreover, they also support the general hierarchy of species selection in sweetveld areas identified by other researchers (Danckwerts *et al.*, 1983). However, in all cases care must taken to emphasise that none of the inferences with regard to cattle feeding preferences are absolute. Changes in the proportion of species as a result of selective feeding are confounded by those resulting from the natural dieback and regrowth of the vegetation. It is not possible to separate the relative extent of these two phenomena as proportional contribution of species to biomass in the exclosure samples from each of the vegetation categories was not determined as it was in the grazed areas. Thus, the findings with regard to cattle preference at the species level are largely speculative.
5.3.5) **THE NUTRITIONAL VALUE OF THE GRASS SWARD**

Analysis of key nutritional parameters allowed inferences to be made about the potential of the available forage for livestock production during the winter. The proportion of dry and green plant material, and the crude protein (CP), Neutral Detergent Fibre (NDF) and *In Vitro* Organic Matter Digestibility (IVOMD) values of these dry and green fractions were determined for the four grassland vegetation categories that occur at Koloni (see Section 3.3.1.3).

The proportion of dry and green plant material in the sward is summarised for each vegetation category in Figure 5.33, overleaf. As with the data from Guquka, changes in proportions were investigated using ANOVA on arcsine transformed data. There was a very significant (p<0.001) overall change in the proportion of green and dry material in all vegetation categories during the course of winter 1999. Between the beginning and middle of the winter, there was a very significant (p<0.05) decrease in the proportion of green material in all four of the different grassland swards and an equally significant increase in dry material. This undoubtedly reflects sustained selection for green plant material by foraging cattle at this time. Conversely, during the second half of the winter the situation was reversed with an increase in the proportion of green material in the sward and a decrease in the proportion of dry material for all of the grassland vegetation categories (see Figure 5.33). These changes were significant (p<0.05) for the commonage and low biomass patches of the *Hyparrhenia* grassland but not the *Sporobolus-Eragrostis* and high biomass patches of the *Hyparrhenia* grassland. The increase in the proportion of green material in the commonage and low biomass patches during this period, reflects the substantial level of sward recovery that had occurred in these vegetation categories by the time the final set of biomass samples were taken in early October.

With regard to differences between vegetation categories, there was no significant (p<0.05) difference in the proportion of dry material in the sward in the *Sporobolus-Eragrostis*, commonage or low biomass patches of the *Hyparrhenia* grassland at the beginning of winter 1999. However, the proportion of dry material in the high biomass patches was significantly (p<0.05) greater than that in all the other vegetation categories at this stage. This can be explained by the dominance of *Hyparrhenia hirta*
Figure 5.33: Mean proportion of dry and green material (±S.E.) in different grassland swards at Koloni during winter 1999.

*Columns with different letters are significantly different from one another (p<0.05)
in the high biomass patches. In the absence of fire, *Hyparrhenia* sward has a tendency to become woody and retain substantial quantities of dead material from the previous dry season (Garnier and Dajoz, 2001). By the middle of the winter however there was no significant (p<0.05) difference in the proportion of green or dry material in any of these swards. This was undoubtedly a reflection of the combined effects of sward dieback and strong selection for green material by foraging cattle during the first half of the winter. The significantly (p<0.05) greater proportion of green material in the commonage and low biomass patches of the *Hyparrhenia* grassland at the end of the winter compared to the high biomass patches, is undoubtedly a reflection of the much greater ability of these swards to produce new growth at this time. These swards are dominated by species such as *E.capensis* and *T.triandra*, which retain relatively little dead material in the sward and are able to rapidly produce new growth at the onset of the growing season (Van Oudtshoorn, 1992). By contrast, the *H.hirta* sward that dominates the high biomass patches, produces relatively little new growth at his time in proportion to the high level of dead material it retains.

Crude protein values in the dry and green fractions of the various vegetation categories showed relatively fluctuation until the latter stages of winter 1999. Those for the dry fraction of the sward are summarised in Figure 5.34.

![Figure 5.34: Mean crude protein values (± S.E.) in the dry fraction of the four grassland vegetation swards at Koloni during winter 1999 (n = 3).](image-url)
In the dry fraction of the sward mean crude values fell within the 2-3% range for all vegetation categories for the majority of the winter. There was a highly significant (p<0.005, ANOVA) overall difference in mean crude protein levels between vegetation categories at the different stages of the winter. However, reference to the LSD value in Figure 5.34 shows that there were no significant (p<0.05) differences between mean crude protein levels in the dry fraction of the four grassland vegetation categories during either the beginning or middle of the winter. Rather these were restricted to the end of the winter, when the mean crude protein value in the high biomass patches of the Hyparrhenia grassland was significantly (p<0.05) lower than that in both the commonage grassland and low biomass patches of the Hyparrhenia grassland. There was also a significant (p<0.05, ANOVA) overall change in mean crude protein levels within vegetation categories during the course of winter 1999. However, the only category to manifest such a change was the commonage vegetation. Here the mean crude protein level in the dry fraction of the sward increased significantly (p<0.05) between the middle and end of the winter.

The mean crude protein in the green fraction of the four vegetation categories during winter 1999, is summarised in Figure 5.35.

![Diagram](image)

**Figure 5.35:** Mean crude protein values (± S.E.) in the green fraction of the four grassland vegetation swards at Koloni during winter 1999 (n = 3).
There was a significant (p<0.05, ANOVA) difference between vegetation categories in the mean level of crude protein in the green fraction of the sward. However, as with the dry fraction of the sward none of these differences were evident until the end of the winter. At this stage mean crude protein in the green fraction of the commonage sward was significantly (p<0.05) higher than that in the green fraction of the other three vegetation categories. This would appear to reflect the high proportion of *T.triandra* in the commonage sward (see Figure 5.31). The nutritional value of this grass tends to be low during the winter although with the onset of the growing season it becomes very palatable in the young stage (Van Oudtshoorn, 1992). In addition, the mean level of the crude protein in the green fraction of the low biomass patches of the *Hyparrhenia* grassland was significantly (p<0.05) higher than that in the high biomass patches at this stage. This is likely to reflect the much greater proportion of regrowth that was occurring in the low biomass patches compared to the high biomass patches, particularly amongst grasses such as *E.capensis*. Furthermore, there was a significant (p<0.001, ANOVA) overall change in crude protein within the green fraction of vegetation categories although this was also restricted to the latter half of the winter. Between the middle and end of the winter there was a significant (p<0.05) increase in mean crude protein levels in the green fractions of all the vegetation categories apart from the high biomass patches of the *Hyparrhenia* grassland.

Mean fibre values are summarised for the dry fraction of the different vegetation categories in Figure 5.36, overleaf. There was a very significant (p<0.001, ANOVA) overall difference between vegetation categories in mean fibre in the dry fraction of the sward during winter 1999. Reference to the LSD value in Figure 5.36 shows that the mean fibre content of the dry fraction of the *Sporobolus-Eragrostis* grassland was significantly (p<0.05) higher than that of the commonage grassland at all stages of the winter. Indeed, during the middle of the winter it was significantly (p<0.05) higher than the fibre content in the dry fraction of all the other vegetation categories. This can be explained by the dominance of *S.africanus* in the *Sporobolus-Eragrostis* sward (see Figure 5.30). This species has a tendency to become very tough and fibrous as it dies back during the winter (Van Oudtshoorn, 1992). There was no significant (p>0.05, ANOVA) change in mean fibre content within the dry fraction of the different vegetation categories during the course of the winter.
Figure 5.36: Mean fibre values (± S.E.) of the dry fraction of the four grassland vegetation swards at Koloni during winter 1999 (n = 3).

The mean fibre content in the green fraction of the sward for the four different grassland vegetation categories at Koloni is summarised in Figure 5.37.

Figure 5.37: Mean fibre values (± S.E.) of the green fraction of the four grassland vegetation swards at Koloni during winter 1999 (n = 3).
ANOVA revealed there to be no significant (p>0.05) overall difference between the four vegetation categories in the fibre content of the green fraction of the sward. Changes in the fibre content within the green fraction of the different vegetation categories during the course of winter 1999 were found to be significant overall (p<0.05, ANOVA). Specifically this could be attributed to a significant (p<0.05) increase in fibre in the green fraction of the commonage grassland between the beginning and middle of the winter, and a significant (p<0.05) decrease in the same fraction between the middle and end of the winter.

Finally, the mean digestibility of the dry and green fractions of the four different grassland vegetation categories at Koloni was also determined for winter 1999. The results from the dry fraction are summarised in Figure 5.38.

![Figure 5.38: Mean in vitro digestibility values (± S.E.) of dry fraction of four grassland vegetation swards at Koloni during winter 1999 (n = 3).](image-url)

ANOVA revealed that there was no significant (p>0.05) overall difference between vegetation categories in the mean digestibility of the dry fraction of the sward, during the winter. In contrast, the overall change in mean digestibility within the dry fraction of each sward during the course of winter 1999 was found to be significant (p<0.05, ANOVA). However, this was limited to a significant (p<0.05) increase in the mean
digestibility of the dry fraction of the high biomass patches of the *Hyparrhenia* sward between the middle and end of the winter.

For the green fraction of the sward the mean digestibility values for the different vegetation categories during winter 1999 are presented in Figure 5.39.

![Figure 5.39: Mean in vitro digestibility values (± S.E.) of green fraction of four grassland vegetation swards at Koloni during winter 1999 (n =3).](image)

ANOVA revealed that there was no overall significant (p<0.05) difference in the mean digestibility of the green fractions of the different sward types during winter 1999. In contrast, ANOVA revealed a very significant (p<0.001) overall change in mean digestibility within the green fraction of each sward during the course of winter 1999. There was a significant (p<0.05) decrease in the mean digestibility of the green fraction of all swards apart from the *Sporobolus-Eragrostis* grassland between the beginning and middle of the winter. Conversely, between the middle and end of the winter there was a significant (p<0.05) increase in the mean digestibility of all the swards.

Together, these findings have important implications for cattle foraging strategies on the arable lands, both within and between the different vegetation categories. To
begin with the significant decrease in the proportion of green plant material in all vegetation categories during the first half of the winter suggests that cattle expressed a strong preference for the green fraction of the sward at this time. However, it is difficult to be conclusive about the role of cattle in altering the proportion of green plant material in the sward, as separation of green and dry components was not undertaken on quadrat samples from exclosures. Thus, during the first half of the winter, it was impossible to distinguish any preference for green plant material being expressed by foraging cattle from the natural die-back that was taking place in this fraction of the sward. Likewise, during the second half of the winter it would appear that sward recovery served to confound continued selection by cattle for green material in each vegetation category. There was an overall increase in the proportion of green material in all grassland swards at this time and this gave the impression that cattle were actually expressing preference for dry plant material. However, exclosure measurements at this time did show an overall increase in biomass, which is consistent with sward re-growth occurring. Furthermore, the consistently higher crude protein and in vitro digestibility levels found in the green, compared to the dry fraction of all sward types throughout the winter, suggests that a foraging strategy on the arable land allocations based on selection of green plant material would have been nutritionally beneficial to cattle. This is supported by a number of empirical grazing studies (e.g. Reppert, 1960; Stobbs, 1973; Hodgson, 1982).

The nutritional data also go some way towards explaining preferences shown by cattle for the different grassland vegetation categories during winter 1999, particularly with regard to the marked fluctuation in preference shown for the commonage vegetation. Certainly, the significant (p<0.05) increase in the level of fibre in the green fraction of the commonage grassland between the beginning and middle of the winter, combined with the substantial decrease in mean digestibility, explains the sudden decrease in preference shown by cattle for commonage vegetation at this time and the switch to other grassland vegetation types. However, by the end of the winter the commonage grassland was once more the most preferred vegetation category. This was consistent with the mean crude protein content of the green fraction of this sward being significantly (p<0.05) higher than that in the equivalent fraction of the other three grassland swards and the mean digestibility of this fraction being significantly (p<0.05) higher than that of the high biomass patches of the Hyparrhenia grassland.
5.3.6) **ESTIMATING THE NUTRITIONAL INTAKE OF CATTLE DURING THE WINTER**

Using the offtake and nutrition data, estimates of the mean daily intake of biomass and crude protein per animal during winter 1999 can be derived as described in Appendix 5.5. These are summarised in Table 5.18.

**Table 5.18: Estimated mean daily intake of biomass, energy and crude protein for grazing cattle during winter 1999.**

<table>
<thead>
<tr>
<th>COMPONENT OF VEGETATION CATEGORY</th>
<th>1st HALF OF WINTER</th>
<th>2nd HALF OF WINTER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dry Matter (kg)</td>
<td>Energy (MJ)</td>
</tr>
<tr>
<td>Crop residues (stalk)</td>
<td>2.5</td>
<td>25.9</td>
</tr>
<tr>
<td>Crop residues (leaf)</td>
<td>2.1</td>
<td>21.9</td>
</tr>
<tr>
<td><em>Sporobolus-Eragrostis</em> (green)</td>
<td>0.4</td>
<td>3.4</td>
</tr>
<tr>
<td><em>Sporobolus-Eragrostis</em> (dry)</td>
<td>0.8</td>
<td>5.2</td>
</tr>
<tr>
<td>Low biomass (green)</td>
<td>1.0</td>
<td>8.9</td>
</tr>
<tr>
<td>Low biomass (dry)</td>
<td>1.7</td>
<td>11.8</td>
</tr>
<tr>
<td>High biomass (green)</td>
<td>0.2</td>
<td>1.6</td>
</tr>
<tr>
<td>High biomass (dry)</td>
<td>0.5</td>
<td>3.5</td>
</tr>
<tr>
<td>Commonage (green)</td>
<td>1.4</td>
<td>13.2</td>
</tr>
<tr>
<td>Commonage(dry)</td>
<td>2.8</td>
<td>18.2</td>
</tr>
<tr>
<td>TOTAL</td>
<td>13.4</td>
<td>113.6</td>
</tr>
</tbody>
</table>

The same major assumptions apply to these estimates of intake as applied to the Guquka estimates. However, at Koloní the assumption that the level of biomass removal in the different vegetation sampling areas was representative of that experienced on the large arable land allocation as a whole, does not seem to have been valid. The behaviour data (section 5.3.3) revealed that foraging cattle exhibited home range behaviour and this seems to have resulted in the majority of animals foraging in the area west of the main donga (erosion channel), which runs down the length of the large allocation (see Figure 5.19). The fact that the sampling sites for all the grassland vegetation categories were located in this area suggests that they were probably overutilised relative to areas east of the donga. This is likely to have been exacerbated by the fact that almost all of the forage east of the donga was burnt during a severe fire which occurred at the beginning of September. This meant that for the last four weeks prior to the final set of biomass samples being taken from the different vegetation categories, cattle were feeding exclusively in the area west of the main
donga. In light of this, the biomass intake values presented in Table 5.18 are likely to be overestimates. This is supported by theory regarding maximum intake rates in ruminant livestock. At the crudest level, 2-3% of body mass is generally accepted as providing a rough guide to maximum intake rates for free-ranging cattle (Stobbs, 1973). Under these conditions maximum intake for a typical adult animal of 350 kg would be 7-10.5 kg per day. This is considerably below the estimated values in Table 5.18. A more accurate assessment of maximum daily forage intake is provided by the guidelines of Kearl (1982). These predict a maximum intake of 8.5 kg/day for a 350 kg animal. Thus, there seems little doubt that the values for biomass intake in Table 5.18 have been overestimated by as much as twofold.

Despite this limitation, the data still have relevance in terms of their implications for animal performance during the winter. According to Kearl (1982) the estimated daily intake rates for energy and crude protein summarised in Table 5.18 are sufficient to result in a substantial increase in mass amongst cattle throughout the winter period. Even halving them to account for possible overestimation still results in mean crude protein values that are approximately sufficient for maintenance of animal condition during both halves of the winter. There is little doubt then that the available forage on the arable land allocations at Koloni during winter 1999 was sufficient both in quantity and quality to maintain condition in cattle throughout this period.
5.4) DISCUSSION

Despite the generally greater heterogeneity of the vegetation on the arable land allocations at Koloni, similar vegetation types were found at both villages. The crop residue, recent fallow vegetation and *Sporobolus-Eragrostis* grassland vegetation categories were common to both villages. These categories shared not only the majority of the same species, but were also indicative in each case of similar periods of fallowing. Indeed, at both villages all three categories were representative of the fairly rapid change in plant composition during the first five years of fallowing. After this stage the vegetation at the two villages appeared to diversify considerably. Thus, the *Hyparrhenia* grassland vegetation found on the arable land allocations showed a considerable degree of variability between the villages. This was undoubtedly a reflection of the quite different environmental conditions (and thus veld types) found at each site. Regardless of the form it took, *Hyparrhenia* grassland was the dominant vegetation type at both villages, reflecting the large number of fields that have been left fallow in the long term. This is representative of the situation throughout former homeland areas of central Eastern Cape (Rose and Williams, 1988; ARDRI, 1996).

At Guquka the *Hyparrhenia* grassland was dominated almost entirely by *Hyparrhenia hirta* (thatching grass) with residual levels of more grazing tolerant grass species such as *Sporobolus africanus* and *Cynodon dactylon*. A broadly similar range of species characterised the mature stands (high biomass patches) of the *Hyparrhenia* grassland at Koloni. However, these were also characterised by the presence of varying levels of bush intrusion depending on the period of time the land had been left fallow. Substantial levels of bush intrusion were also found by Lo Presti (1996), on land that had been fallowed in the long term in sweetveld areas. The dominant species in all cases was *Acacia karroo*. By contrast no *A. karroo* was found on the arable lands at Guquka. Indeed, the only bush/tree species found at Guquka was *Acacia mearnsii* (black wattle), which tended to be confined to low-lying areas adjacent to the Tyume River. Another distinguishing feature of the mature stands of the *Hyparrhenia* grassland at Koloni was the presence of a woody herbaceous plant of the genus *Helichrysum*, which did not occur on fallowed fields at Guquka. This was a highly unpalatable aromatic plant and appeared to be one of the few species that could
compete effectively with the established *H. hirta* swards. It was most abundant on the fields lying on the eastern side of the central donga on the main arable land allocation, where in some areas it formed fairly dense stands. Its abundance in this area seemed to be connected with the relatively large number of fields, which had not been cultivated in the long term.

A further distinguishing feature of the *Hyparrhenia* grassland vegetation at Koloni was the presence of distinct patch areas of relatively low biomass. These were characterised by a much wider variety of species than the high biomass patches and considerably lower overall mean sward height. They are hypothesised to have resulted from continuous, heavy grazing pressure during the winter months. The creation and maintenance of patch areas in tall swards by high concentrations of grazing cattle, has been documented in a number of other studies (e.g. Cid and Brizuela, 1998). Furthermore, the presence of substantial amounts of *Digitaria eriantha* with a largely stoloniferous growth form within these patches also lends support to this idea, as *D. eriantha* with this growth from tends to be synonymous with heavily grazed range areas (O'Connor, 1991; Goqwana, 1998). What is more difficult to account for is why such patch areas were not also identified at Guquka, given the constant and relatively high grazing pressure the arable lands here were subject to. Certainly, in fields on Guquka’s upper arable land allocation, which were subject to heavy grazing pressure throughout the year, *H. hirta* had largely been replaced by grazing tolerant species such as *Sporobolus africanus*, *Cynodon dactylon*, *Aristida congesta* and a dense layer of the basal forb species *Richardia brasiliensis* (pers. observ.). Why this was not so on the lower arable land allocation is not immediately clear. However, it may be that grazing pressure on this allocation has historically been too low during the summer, and too short-lived and focussed on crop residues during the winter, to allow such patch areas to develop.

The other vegetation type that occurred at Guquka, but not Koloni, was the commonage grassland. This can be considered analogous to the vegetation found on the range camps and is an important forage reserve containing several species that are generally recognised to be of high nutritional quality. Most notable amongst these is *Themeda triandra*. At the beginning of the winter *T. triandra* accounted for more than 60% of the sward biomass in the sampling area compared to just 30% by cover
on the range camps (Goqwana, 1998). In contrast the less desirable Hyparrhenia hirta accounted for approximately 13% of the sward in both the commonage areas and the range camps. This would suggest that the current grazing management system for the arable lands is responsible for the retention of high levels of favourable decreaser species such as T. triandra in the commonage sward. This is corroborated by Augustine and McNaughton (1998), who suggest that the migration of animals to summer range areas is one of the most important factors alleviating deleterious effects on palatable plant species in winter range areas, as the animals are absent for most of the growing season. However, it is inappropriate to generalise on the basis of findings from a single sampling site, which is unlikely to be representative of all the commonage vegetation at Koloni. Indeed, although no formal sward measurements were made in other areas, it was clear at a visual level that other heavily grazed sections of the commonage vegetation contained considerably greater levels of H. hirta at the expense of decreaser species such as T. triandra. This would suggest that high intensity grazing even over the short winter period was sufficient to produce an unfavourable shift in species composition in the commonage vegetation, despite complete rest from grazing during the summer. Ensuring more even distribution of grazing pressure throughout the entirety of the 300 ha large arable land allocation at Koloni would therefore appear to be an important management challenge.

Data on livestock numbers demonstrated clear differences between Koloni and Guquka with regard to the use of the arable land allocations by livestock. During the winter period almost twice as many cattle were present on the arable land allocations at Koloni than at Guquka. However, there are substantially more cattle held at Koloni and more than twice the area of arable land, so this was not unexpected. Considerable numbers of sheep were also found on the lands at Guquka but not Koloni. This reflects the more lenient interpretation of the grazing management rules at Guquka resulting from the greater resource pressure at the village. Moreover, changes in cattle numbers on the main arable land allocation at each village would seem to reflect quite different sets of resource pressures. A Guquka the relatively rapid reduction in cattle numbers from mid-July onwards during 1999 mirrors the depletion of available

1 Decreaser species are those that dominate in veld that is in good condition but decrease when veld is mismanaged (Trollope, 1986; Van Oudtshoorn, 1992).
forage, particularly crop residues. By contrast, cattle numbers on the main arable land allocation at Koloni remained relatively stable for the majority of winter 1999, only registering a steady decline following the widespread fire which occurred in early September. Up until this stage the only notable decline in numbers was a direct result of a period of water shortage. This is indicative of the fact that water availability is a more pressing resource requirement than forage during the winter at Koloni.

Animal observation data showed that during winter 1999 cattle at Guquka allocated a considerably greater proportion of their available foraging time to feeding than those at Koloni did. The main reason for this seems to be that the majority of cattle at Guquka were kraaled overnight between 17:00 and 07:00 hours during the winter period. They were thus obliged to spend most of the time available to them feeding in order to try and satisfy their nutritional intake requirements. This is one of the main mechanisms used by livestock to compensate for restricted grazing periods (Iason et al., 1999). In contrast, the majority of cattle at Koloni were left permanently on the arable allocations throughout the winter period. This allowed the animals to begin grazing at first light (around 06:00) and continue until dusk (around 18:00) as well as engaging in limited night grazing (personal observations based on one-off night observation work conducted during both 1998 and 1999). Cattle at Koloni could thus afford to allocate a considerably smaller proportion of the time they spent on the arable lands to grazing. Moreover, it is clear that by adjusting the proportion of time spent grazing, animals at both villages were able to spend approximately similar lengths of time each day (around 8-9 hours) grazing. This compares well other studies of daily grazing times in cattle, which show modal grazing times of 8-9 hours for dairy cattle and 9-10 hours for beef cattle (Arnold and Dudzinski, 1978).

Conversely, when comparing the data on the time spent resting for animals at both villages, it is immediately clear that at all stages of the winter the animals at Guquka spent a far smaller proportion of the time they were being observed resting than those at Koloni did. Indeed, there seems to have been a strong inverse relationship between time spent feeding and that spent resting at both villages, whereas the time the animals spent walking appears to have remained relatively constant at both villages. This suggests that resting was the main activity compromised in order to achieve increased grazing times. This seems rational, given that walking is inextricably linked to
foraging, whereas resting and ruminating can be undertaken at separate times of the day (Arnold and Dudzinski, 1978).

With regard to cattle feeding preferences, behavioural observations demonstrated some similar patterns of preference between villages. The strongest preference in both cases was for crop residues. This might be expected given the relatively high levels of predicted crude protein in crop residues (particularly the stalk component) during the winter (see Appendices 5.2 and 5.5). At Guquka preference for crop residues was particularly marked during the early part of the winter but diminished rapidly. Scoones (1995) has documented a similar level of preference amongst cattle for crop residues, during the early part of the dry season in southern Zimbabwe. At Koloni preference was less strong but showed greater continuity during the winter period. The greater level of preference exhibited by cattle at Guquka for crop residues is unsurprising given the lack of heterogeneity in the vegetation compared to Koloni. This resulted in cattle feeding almost exclusively on crop residues until they were exhausted. Conversely, the greater diversity of preferred vegetation types at Koloni, allowed cattle more flexibility in their expression of preference. Indeed, at all stages of winter 1999 cattle at Koloni were able to express preference ($P_i > 1$) for at least two vegetation categories simultaneously.

At Koloni, strong preferences were also evident for much of the winter in the commonage vegetation and the low biomass patches of the *Hyparrhenia* grassland, neither of which occurred in the study area at Guquka. Again this appears to be closely tied to nutritional parameters, particularly crude protein levels in the green fraction of the sward. There was for example, a sudden expression of preference for the low biomass patches during the middle of winter 1999, which coincided with these having the highest crude protein levels of the grassland vegetation categories. Conversely, the mean crude protein content of the commonage vegetation, which was relatively high at the beginning of winter 1999, declined sharply towards the middle of the winter before increasingly significantly ($p<0.05$) towards the spring. This mirrored exactly the change in preference for the commonage vegetation shown by cattle at this time. Furthermore, this fluctuation in preference would appear to be closely related to key grazing species in the sward. In the case of the commonage vegetation, cattle showed a strong preference for *Themeda triandra* throughout the
winter period. The nutritional quality of *T. triandra* is known to decrease substantially during the winter but to recover rapidly during the early part of the growing season (Van Oudtshoorn, 1992). Likewise, the high level of preference shown for low biomass patches of the *Hyparrhenia* grassland towards the end of the winter coincided with the rapid regrowth of *Eragrostis capensis*, which was one of the most preferred species in the sward. Thus, fluctuations in preference for both the commonage grassland and the low biomass patches of the *Hyparrhenia* grassland would appear to be closely linked to short term changes in the nutritional quality of key grazing species during the course of the winter.

However, chemical parameters alone cannot entirely explain all aspects of preference. For example, at the beginning of the winter there were no significant (p<0.05) differences in mean crude protein, mean fibre or digestibility between any of the grassland vegetation categories and yet cattle exhibited a markedly higher preference for commonage vegetation than the high biomass patches of the *Hyparrhenia* grassland. This suggests that other factors such as the actual physical structure of the sward also had an important role to play in cattle preferences. Certainly both the low biomass patches and the commonage vegetation consisted of species with high leaf:stem ratios and relatively high bulk density. These species also tended to retain a good proportion of green material in the sward throughout the winter. These characteristics are widely recognised as being conducive to animals maintaining high levels of forage intake (Illius *et al.*, 1987; Laca *et al.*, 1992). In contrast, the sward in the high biomass patches of the *Hyparrhenia* grassland was dominated by *H. hirta*, a species which becomes woody and stemmy during the winter, retaining relatively little green material in the sward. These attributes are associated with depressed levels of forage intake (Ruyle *et al.*, 1987; O’Reagain, 1994; Ginnett *et al.*, 1999). This suggests that at the sward level physical characteristics as well as chemical parameters were both important factors influencing cattle foraging decisions on the arable land allocations during the winter.

The complex interaction of these sward based parameters with animal characteristics such as spatial recognition and social interaction, is the basis of an elegant body of theory explaining animal feeding preferences known optimal foraging theory (OFT), which has developed over the past few decades (e.g Emlen, 1966; Westoby, 1978;
Stephens and Krebs, 1986; Senft et al., 1987; Bailey et al., 1996). Current OFT models predict a diet that maximises the net rate of energy gain. This involves a balance between maximising intake rate and maximising intake quality (Roguet et al., 1998). When OFT theory is applied to the vegetation available on the arable land allocations at both villages, it largely verifies the observed hierarchy of preference at the vegetation category level. In almost all cases the trade off between intake rate and intake quality can be used to explain observed preferences. For example, the commonage vegetation, which has a sward structure amenable to high rates of intake, and which is of high nutritional quality for much the winter would be expected to rank highly. In contrast, the high biomass patches of the Hyparrhenia grassland would be expected to have a very low ranking, owing to a sward structure that does not favour high intake rates and is of continuously poor nutritional quality. This low level of preference is corroborated by the work of Wallis de Vries and Daleboudt (1994), who found that cattle selected mature feeding sites only when the exclusive use of short vegetative patches did not allow them to fulfil their daily intake requirements.

However, the relative placement of the recent fallow vegetation is less easily explained by OFT. Although no nutritional measurements were made of sward quality, it contained several annual grass and forb species recognised to be of relatively high quality. Moreover, the sward structure was quite low with a high leaf component that stayed relatively green for much of the winter. In light of these characteristics it might be expected that cattle would show a considerably greater level of preference for recent fallow vegetation than was actually observed. However, the actual vegetation cover was quite sparse with a relatively high proportion of bare earth. This resulted in a vegetation horizon with a bulk density so low that it is unlikely that bulk grazers such as cattle were able to maintain sufficient rates of forage intake (Laca et al., 1992). This might explain, at least partially, why cattle chose to ignore the recent fallow vegetation throughout the winter.

Finally, consideration must be given to the crude intake levels calculated for the average foraging animal during winter 1999 at both villages. Calculations of intake suggested that the amount of forage ingested (kg DM/ha), was generally sufficient to meet nutritional requirements at both villages. In simplistic terms foraging cattle can achieve a maximum daily intake of 2-3% of body mass (Stobbs, 1973). For an
average adult animal in a communal range area with an assumed mass of 350 kg (T.D. De Bruyn, unpublished PhD data) this equates to an intake of 7-10.5 kg/DM/day. The total intake rates from grassland vegetation categories at the two villages more than satisfy this requirement for all but the first half of the winter at Guquka. However, consideration of intake in isolation provides a distorted picture of cattle performance at each village. Sward quality was considerably higher at Koloni during winter 1999 than at Guquka. Crucially, all of the crude protein values at Guquka fell below the critical 6-8% level required to maintain animal performance (Minson, 1982). Bransby (1981) has demonstrated that where energy intake is sufficient to sustain growth in herbivores, crude protein levels provide the main limiting factor to maintenance of body condition. Thus, despite satisfaction of daily dry matter intake and energy requirements, cattle performance at Guquka appears to have been adversely affected by sub-maintenance crude protein levels. Certainly, in the absence of objective measurements of animal performance such as weight gain, simple visual assessment of animal condition at the end of the winter in both 1998 and 1999, suggested that cattle were in substantially better condition at Koloni than Guquka.

Although valid for the purposes of comparison, the two crude sets of calculations of intake are undoubtedly highly inaccurate and do not provide any foundation for making management recommendations. They appear, particularly in the case of Koloni, to be gross overestimates and probably reflect a strong element of bias in the sampling sites selected. However, a more realistic assessment of intake levels can be obtained if the maximum dry matter intake rate for a 350 kg heifer is taken as 8.5 kg/day (Kearl, 1982) and the values for intake of energy and crude protein are adjusted proportionally. These revised intake levels are summarised for both villages in Table 5.19.

**Table 5.19: Estimated mean daily intake of metabolisable energy and crude protein for grazing cattle during winter 1999, based on a maximum dry matter intake of 8.5 kg/animal/day.**

<table>
<thead>
<tr>
<th>STAGE OF WINTER</th>
<th>GUQUKA</th>
<th>KOLONI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dry Matter (kg)</td>
<td>Crude Protein (g)</td>
</tr>
<tr>
<td>1(^{st}) HALF</td>
<td>4.9</td>
<td>195.7</td>
</tr>
<tr>
<td>2(^{nd}) HALF</td>
<td>8.5</td>
<td>189.6</td>
</tr>
</tbody>
</table>
If these intake figures are compared with standard values then the implications for animal production can be assessed. Accepting that the primary objective of cattle owners in communal areas of central Eastern Cape during the winter is simply the survival of their animals, the standard intake levels appropriate to this objective are those for maintenance of body weight (zero weight gain). According to Kearl (1982), minimum intake levels for an average heifer of 350 kg mass 340 g/day for protein and 40.9 MJ/day for energy. Assuming that the figures in Table 5.19 are representative of a typical winter at each village, the general implications for cattle production at this time are particularly bad at Guquka. Here crude protein levels fall well below those required for maintenance of body weight for the entire duration of the winter. Under these conditions cattle at Guquka would be expected to lose body weight throughout the winter. This was indeed observed to occur during both winter 1998 and 1999. At Koloni however, the situation is somewhat better with crude protein intake sufficient to maintain animal condition during the first half of the winter. Furthermore, although protein intake fell to sub-maintenance levels during the second half of the winter, the inevitable level of underestimation of protein intake levels in assuming non-selective feeding by cattle means that the degree of shortfall is unlikely to be as large as is projected in Table 5.19.

Nevertheless, even these revised figures can at best only be considered rough guides as to the true level of intake from the arable land allocations over the winter. This is because there are a number of fundamental assumptions inherent in their calculation. For these reasons projections and recommendations based on these revised figures must continue to be viewed with an appropriate degree of caution.
5.5) CONCLUSIONS AND RECOMMENDATIONS

From the data that has been presented on the use of the arable land allocations by foraging cattle, it is apparent that two quite different sets of constraints to effective cattle production during the winter are in operation at the villages. At Koloni, a sweetveld site where forage quantity and quality are not considered as problematic, the primary constraint is the effective utilisation of the available forage resources. Relatively good grazing is available even during the winter, but current management practices restrict how efficiently it can be utilised. In contrast, production constraints at Guquka are more fundamental and concerned primarily with an inherent shortfall in the nutritional quality, and to some extent quantity, of forage available on the arable land allocations during the winter.

Forage quality in sourveld areas is widely recognised to be the major constraint to animal production from natural grazing during the winter (Tainton, 1981a). In commercial farming systems, a number of alternatives have been adopted for overcoming this constraint focussed mainly on the provision of mineral licks and feed supplements generally in the form of concentrates (feed pellets), hay or silage. Cost and availability have prohibited the general use of feed supplements amongst communal livestock farmers. However, given the relatively high rainfall in sourveld areas potential does exist for the cultivation of winter forage crops such as oats and barley, providing the livestock owner has access to a fenced field and sufficient overheads to engage in crop production. At Guquka it has been demonstrated that crop production is constrained by a number of socio-economic factors such that relatively few individuals are still able to persist in the summer production of maize. Under these circumstances the cultivation of winter forage for livestock is even more unlikely. Nevertheless, for those individuals where the potential does exist, this probably represents one of the most effective solutions to overcoming the nutritional constraint to cattle production at Guquka during the winter. The cost effectiveness of this operation would be increased if it could be undertaken on a group basis. Furthermore, the selective use of feed supplements would enhance the effectiveness of winter forage crops in overcoming the nutritional shortfall in protein. Although feed supplements are generally prohibitively expensive for communal livestock
farmers, urea is a low cost and widely available nitrogen supplement in most developing countries (Kearl, 1982). When properly used this can provide a safe and economical source of non-protein nitrogen (NPN). Urea supplementation is particularly effective when used in conjunction with diets where the nitrogen content is low but the energy content is high such as occurs with cereal crops and crop residues. However, if excess amounts of urea are provided to livestock, ammonia is produced as a by-product of digestion and can lead to poisoning of animals (Kearl, 1982). Considerable care is thus required in formulating diets containing urea and training would need to be provided to smallscale livestock farmers if this was to be a credible management recommendation for sourveld areas of the central Eastern Cape region.

In a similar vein, another solution to this problem would be to increase the amount of summer crop production taking place. This would lead to an increased amount of crop residues during the subsequent winter, which is clearly the most valuable forage type on the arable lands. At a simplistic level the amount of crop residues available on the arable lands during winter 1999 was sufficient to last foraging cattle for about 20 days, assuming a minimum intake rate of 6 kg/day sufficient to satisfy the maintenance requirements of a 350 kg animal (Kearl, 1982), and that cattle consumed only crop residues. Thus, if the area of land under summer cultivation could be increased from the 17% of 1999 to around 50%, there would be a trebling in the mass of available crop residues. This would be able to support foraging cattle for 60 days or approximately two-thirds of the duration of the winter. Once again however, this recommendation is constrained by the limited ability of the majority of individuals at Koloni to engage in crop production. Indeed, at a general level there is a need for much closer integration of many aspects of crop and livestock production at Guquka. However, it is difficult to assess the extent to which improvements might be made, as relatively little baseline information is presently available. For example, a considerable amount of crop production now takes place in home gardens rather than fields. Thus during the winter it is likely that a fairly large amount of crop residues are available to livestock in these areas although this has yet to be quantified. Although smallstock generally make greatest use of these residues, cattle have been observed utilising those in the larger gardens (pers. observ.). Furthermore, given their
proximity to the homestead these home gardens would also seem to offer greater potential for winter forage production.

With regard to the actual grassland vegetation found on the arable land allocations one standard recommendation for commercial farms in sourveld areas is the burning of the sward at the end of the winter (Tainton et al., 1977). This does sometimes occur accidentally at Guquka, but if it could be undertaken in a controlled manner each year once the cattle had moved back to the range camps, it would undoubtedly benefit subsequent grazing activity. By removing moribund material and encouraging vegetative regrowth in the sward cover, particularly that dominated by *H. hirta*, a sward would be generated which would be more conducive to grazing (Smith, 1961a; Tainton et al., 1977). This could be most effectively utilised during the summer months (before it once again became moribund) and thus would be of greatest benefit to those animals which are allowed to persist on the arable lands at this time. Indeed, it might even be worth allowing greater numbers of animals onto the lower arable land allocation for short periods of the summer to take advantage of the improved sward. A regime might be envisaged as set out in Table 5.20:

Table 5.20: Management regime for the lower arable land allocation at Guquka.

<table>
<thead>
<tr>
<th>TIME OF YEAR</th>
<th>MANAGEMENT PRACTICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Late August/early September</td>
<td>Remaining animals removed from lower arable land allocation and sward burnt.</td>
</tr>
<tr>
<td>September-November</td>
<td>Animals grazed on mountain pastures and burnt sward allowed to recover with spring and early summer rains.</td>
</tr>
<tr>
<td>December-January</td>
<td>During mid-summer, cattle allowed onto uncultivated fields on the lower arable land allocation to take advantage of sward regrowth, before it begins to become moribund later in the season.</td>
</tr>
<tr>
<td>February-May</td>
<td>Cattle excluded from lower allocation in order that the late summer rains can allow the sward to recover before winter.</td>
</tr>
<tr>
<td>June-early September</td>
<td>All fields opened to winter grazing by cattle.</td>
</tr>
</tbody>
</table>

The recommended management regime for the grazing of the lower arable land allocation by cattle is not that different from what is currently occurring. The only difference is that the timing and frequency of burning would be controlled as would both the duration of summer grazing and the number of cattle involved. However, the adoption of such a regime would raise a number of important considerations. For example, the benefits realised from burning would have to be balanced against the
fact that many of the fields on the lower arable land allocation are fenced. Fires can lead both to the charring and weakening of fence posts and the melting of barbed wire and thus it may be prudent to limit the frequency with which burning is undertaken to a biennial basis. This would also be beneficial from the perspective of carrying capacity. Winter burning is known to destroy the growing points of the grass tillers and thereby reduce grass yield during the subsequent growing season (Tainton, 1981b; Tainton and Mentis, 1984). However, by the following season the sward is able to recover and biomass yields are considerably improved. Burning on an annual basis would therefore be inappropriate, as it prevents this improvement in yield during the second year from being realised. It is also vital to consider how these management recommendations would be implemented and enforced at a day to day level. In order to be effective the implementation of such a management regime would require the involvement of a central village body such as the RA. However, effective central decision making and enforcement at Guquka is currently limited and may still be some considerable way off.

At Koloni the major challenge to cattle production is the efficient utilisation of grazing resources. With regard to the vegetation present on the arable land allocations at Koloni, a number of alternative management options present themselves. The Hyparrhenia grassland on many sections of the arable lands supports a dense cover of bush, particularly *A. karroo*. High levels of *A. karroo* intrusion are known to have a negative effect on the level of production in the grass sward (Stuart-Hill and Tainton, 1988). This is particularly true of taller, well-established trees. If the primary use of the arable lands during the winter is as a grazing reserve for cattle then it would seem sensible to control the invasion of *A. karroo*. An approach is suggested based on the selective felling of larger trees for use as firewood, timber and material for kraal construction followed by the intensive browsing of the coppiced trees by goats (P.F. Scogings, pers. comm). Where trees have already been felled or burnt, browsing by goats has been demonstrated to be an effective means of controlling bush encroachment, particularly in areas that are not natural savannas (Trollope, 1980). It is therefore recommended that goats be introduced onto the arable land allocations about a month after they are first opened for grazing. This will give cattle an opportunity to consume the bulk of the available crop residues and thus prevent goats competing with them for this valuable forage reserve. The goats can then spend the
remaining two to three months of the winter focussing on the bush material as well as crop residue material that the cattle are unable to make use of. The large-scale movement of goats onto the arable lands at this time will have the additional effect of relieving the pressure on the range camps for the remainder of the winter.

Another way in which the Hyparrhenia grassland at Koloni could be made more attractive to grazing cattle is by burning it periodically (Augustine and McNaughton, 1998; Bailey et al., 1998). The use of fire as a management tool is not generally recommended in sweetveld areas (Tainton, 1981b). However, the arable land allocations at Koloni are something of an exception as they have a quite different species composition from the normal veld and are not grazed during the growing season. Under these circumstances burning would serve not only to remove moribund vegetation accumulated from previous seasons, but also to reduce the level of unpalatable, chemically defended plant species. At Koloni these include the herbaceous species Helichrysum argyrophyllum and the turpentine grasses of the genus Cymbopogon, both of which are fairly abundant in the Hyparrhenia grassland east of the central donga on the main arable land allocation. These species are generally unable to recover as rapidly from the effects of fire as undefended species (Augustine and McNaughton, 1998). A single burn timed to coincide with the onset of the spring rains (around early September) would be sufficient to control these species (Tainton, 1981b). Burning is particularly effective at reducing the level of unpalatable species when combined with increased concentrations of herbivores (see below). This serves to increase both the level of grazing pressure in the area and the level of disturbance through trampling, neither of which are tolerated particularly well by chemically defended plants (Augustine and McNaughton, 1998). However, since the objective of burning is to improve the quality of the H. hirta sward that dominates the Hyparrhenia grassland, the frequency as well as the timing of burning would be important. Work in West Africa has demonstrated that the population growth rate of the closely related species H. diplandra is negatively affected by annual fires by (Garnier and Dajoz, 2001). However, less frequent fires improve growth by allowing new seedlings time to establish in the intervals between fires. Similarly, in South Africa there appears to be considerable empirical support for the infrequent application of fire in semi-arid grassland areas. Burning on an annual basis has been demonstrated to lead to a reduction in cover of palatable species such as T.triandra,
whereas it can be beneficial in preventing the invasion of unpalatable species when applied over longer time intervals (Tainton and Mentis, 1984). It would therefore seem reasonable to recommend burning of the *Hyparrhenia* grass sward at sweetveld sites every three years. It might also be advisable to factor in the amount and timing of rainfall in deciding when and how frequently this burning should be undertaken.

The other major tool for improving the utilisation of the forage on the main arable land allocation at Koloni is the provision of water. It has long been recognised that the proper location of water can lead to a more efficient utilisation of pasture (Reppert, 1960). In particular it can be an effective tool in increasing grazing in underutilised feeding sites (Bailey *et al*., 1998). Water availability on the large arable land allocation was identified as being problematic during the winter. Animals were forced to move to alternative grazing areas when water resources were exhausted early in winter 1999. The construction of one or more dams on the large land allocation would eliminate the need for animals to make use of adjacent grazing camps. Thus, all the gates allowing access to the lands could be closed and animals could then be maintained solely on the large arable land allocation for the duration of the winter. This would relieve the pressure on the range camps at this crucial time and give them some chance to recover before summer.

The current grazing management system at Koloni involves three out of the four range camps being grazed simultaneously on a mixed basis during the summer whilst one is rested. This situation continues into the winter, albeit with a reduced number of livestock once the arable lands are also made available for grazing. An alternative regime is envisaged whereby the only camp to be grazed during the winter is that which was rested during the summer. The camp would be reserved for the small stock and cattle most at risk from injury or death if grazed on the rough terrain of the arable lands (cows with young calves and elderly or sick animals). This would inevitably result in the large arable land allocation having to support considerably greater numbers of cattle during the winter. However, it is apparent when the levels of forage intake determined in section 5.3 are compared with the projected maximum levels of intake summarised in Table 5.19, that the large arable land allocation can actually support two to three times the number of cattle it was supporting during winter 1999. Thus, if the level of utilisation recorded in the sampling areas during
winter 1999 can be expanded to all areas of the allocation there should be sufficient forage available to cope with the increased number of cattle. However, the long-term affects of this increased grazing pressure on species composition might provide more cause for concern.

The siting of the dam would also have to be given careful consideration. The most practical place to site the dam would probably be on the more remote east-side of the main donga where the forage tends to be underutilised. However, if the dam was constructed here, consideration would have to be given to the additional level of grazing pressure this would generate in the area and its likely impact on the vegetation there. Many of these impacts are likely to be beneficial. For example, it might help to relieve the grazing pressure around the southern part of the large allocation, which is posited to be having a deleterious effect on the more valuable grass species in the commonage vegetation in this area. Furthermore, when combined with a regular regime of burning, this grazing pressure may also serve to reduce the levels of unpalatable, chemically defended plant species in the *Hyparrhenia* vegetation (see above). It is also likely to lead to an increase in the area of low biomass patches in the *Hyparrhenia* grassland, which have been demonstrated to have a higher grazing value than the mature forage.

However, it would not be prudent to allow excessive amounts of the high biomass *Hyparrhenia* grassland to be converted into low biomass patches for two reasons. Firstly, although it is of relatively low nutritional quality the high biomass *Hyparrhenia* grassland constitutes an important forage reserve, which grazing cattle utilise as a source of bulk and energy when other vegetation categories of lower biomass have been largely exhausted. If too much of it is lost then there may be a shortfall in available forage on the arable lands, particularly towards the end of the winter. Secondly, from a broader ecological perspective, the tall *Hyparrhenia hirta* sward, which constitutes the bulk of the high biomass *Hyparrhenia* grassland, provides an important refuge for local wildlife species. It supports a very considerable population of small rodents, which in turn act as food for a variety of snake species and a wide assortment of birds of prey. The latter include a number of hawk and falcon species and notably the grass owl. This rare and elusive bird roosts in the tall grass during the day, emerging at dusk to hunt for small rodents. Other
notable species observed on the arable lands at Koloni included wild tortoises, chameleons and secretary birds. Such an abundance of wildlife in a densely populated communal grazing area seems unusual, and could only have been facilitated by the widescale abandonment of cropland that has taken place and the subsequent development of a dense *Hyparrhenia* vegetation cover over a large area. The maintenance of as much of the mature *Hyparrhenia* grassland vegetation as possible should be encouraged. Not only is this important from the perspective of maintaining ecological diversity, but also for enriching the lives of local people. Indigenous plants and animals have an important cultural role in Xhosa beliefs and customs. Many animal species are associated with ancestors and plant species are used in a number of important rituals. For example, the woody forb species of the genus *Helichrysum argyrophyllum* are dried and burnt as incense in houses to ward away evil spirits. Furthermore, several plant species also have an important economic role. *Hyparrhenia hirta* for example still has considerable importance for the thatching of roofs, both at the local level and for sale.

Finally, where appropriate it would seem sensible that the above management recommendations be tested as thoroughly as possible prior to their full-scale implementation at either village. It is envisaged that, with the permission and full participation of the communities in each case, this might involve the implementation of some of the recommendations on just a limited area of the arable land allocations to begin with on a trial basis. At Koloni for example, it might be wise initially to experiment with burning of the *Hyparrhenia* dominated grassland and the felling and browsing of bush species, on one of the smaller sections of the arable land allocation. Successful results from this trial might then encourage the community to apply these techniques at a wider scale. However, other interventions such as the construction of a watering dam for livestock on the main arable land allocation would not have the opportunity of a test period. It must therefore be ensured that the dam is situated in the correct place. This process would require careful consultation with both the community and with relevant specialists such as hydrologists who would need to be involved in its construction.
6.1) INTRODUCTION

Animal production in South Africa is constrained by the widely recognised shortfall in the nutritional quality of the veld during the winter months. This is particularly true of sourveld areas (Tainton, 1981a). The accepted means of combating this shortfall in commercial production systems is to provide supplements in the form of feed concentrates and mineral licks. However, in communal production systems these are still largely unavailable or too expensive, and other avenues must be considered. Sward improvement is one alternative. This is practised in commercial systems in South Africa through the mowing and burning of veld in sourveld areas, but its application is currently limited to the late winter months as a means of improving the subsequent summer sward (Tainton et al., 1977). One cost-effective option with considerable potential in communal areas is the intensive grazing of the sward in the late summer period. This is particularly relevant for the arable land allocations, which are generally covered in large swathes of unproductive Hyparrhenia sward by the late summer period.

Trials to overcome the acknowledged nutritional shortfall in Hyparrhenia-dominated veld during the winter months, through a variety of regimes involving mowing and fertiliser application during the summer, have been documented in Zambia (Smith, 1961a & 1961b). Even mowing alone was shown to produce significant improvements in the nutritional quality of the sward during the subsequent winter. The experimental grazing trials undertaken at Koloni were informed to a considerable extent by the results of this early work. Furthermore, they also aimed to investigate ways of improving the sward from the perspective of animal intake. Since animal nutrition is a function both of the quality and quantity of forage ingested, improvements in intake rate will benefit animal production. This is particularly relevant for Hyparrhenia hirta, which as a result of its tall, stemmy morphology when mature, is one of the regularly grazed species in South Africa upon which cattle attain lowest rates of intake (O’Reagain and Goetsch, 1996). This aspect of the experiment took as its starting point the forage maturation hypothesis, which predicts that daily
forage intake should be maximised at intermediate levels of plant biomass (Fryxell, 1991). Empirical support for this concept has come from the work of O’Reagain (1994) in sourveld areas of South Africa. On the basis of this work, he has hypothesised that cattle maximise intake rates at a sward height of 20-25cm. Thus, by intensively grazing the *Hyparrhenia hirta* sward during the summer and allowing it to recover to approximately this height prior to the winter, the experiment aimed to investigate if there was an improvement both in the quality of the subsequent sward and the rate at which cattle were able to ingest it. To reiterate from chapter 3, the specific hypotheses that the experimental work aimed to test were as follows: -

1. The lower mean height and stemminess of the sward on the treatment plot would enable cattle to achieve greater mean intake rates compared to the control plot.
2. The nutritional quality of the sward in the treatment plot would be greater (in terms of a higher proportion of green material, higher crude protein content, lower fibre and greater *in vitro* digestibility) than that in the control plot.

However, as a result of the lack of replication in the experiment alluded to in section 3.3.2, the data cannot be used as a definitive test of the defined hypotheses. The lack of replication of the control and treatment plots means it is impossible to differentiate treatment effects from the natural level of variation in the vegetation (Stroup et al., 1986). Furthermore, the lack of replication between years made it impossible to account for variation that might result from large differences in environmental parameters such as rainfall, between years. This precludes the application of inferential statistics without which no adequate testing of the hypotheses can be conducted. Sub-sampling and comparison of multiple quadrat samples have been attempted in several studies as a means of overcoming this problem, but this is simply pseudo-replication and is not an adequate substitute for true replication (Hurlbert, 1984). No such attempt was made with the sample data from this experiment. However, the fact that multiple samples were taken in each control and treatment plot, provided an estimate of the variation in the data. This variation at least provides some broad indication of the extent to which the hypotheses were fulfilled.

The other shortcoming of the experimental work was the lack of duplication between the research sites. Given the very different ecological conditions pertaining at the two
sites, it might be reasonable to expect that extrapolation of the findings from one site to the other would be unrealistic. However, the fact that the experiment focused on just one grass species rather than different grassland communities and that this species demonstrates little difference in morphology and response to grazing between different environments (Gibbs-Russell et al., 1990), suggests that the data from one site would be broadly representative.

In spite of these shortcomings, it is nevertheless believed that the experimental data below provide a valuable insight into a management option that has been hitherto ignored in communal areas of South Africa. It is thus hoped that the results of this investigation will form the basis of more rigorous experimental work in the future, which will provide a more definitive test of the main hypotheses.

6.2) **SUMMER GRAZING WORK ON TREATMENT PLOT**

Summer grazing of the treatment plot at Koloni was initiated on 8/3/99 and continued on a daily basis until 14/3/99. Although one day was lost due to dipping of all the livestock at the village, this regime nevertheless provided six full grazing days for the 20 adult cattle (20 AU) being maintained on the plot. This was sufficient to remove a considerable portion of the herbage from the plot as illustrated in Figure 6.1.

![Figure 6.1: Treatment plot following intensive summer grazing.](image-url)
Before and after grazing measurements were also made of the mean sward height, the mean leaf table height and the standing biomass on the plot (see section 3.3.2). The resulting data is summarised in Table 6.1.

**Table 6.1: Sward parameters in treatment plot before and after grazing (± S.E.).**

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>Pre-grazing</th>
<th>Post-grazing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean sward height (cm)</td>
<td>66.4 (± 2.6)</td>
<td>31.0 ± (1.7)</td>
</tr>
<tr>
<td>Mean leaf table height (cm)</td>
<td>35.6 (± 1.4)</td>
<td>18.1 ± (1.1)</td>
</tr>
<tr>
<td>Mean biomass (kg/ha)</td>
<td>3811 (± 346)</td>
<td>2594 ± (264)</td>
</tr>
</tbody>
</table>

It is clear that this intensive period of grazing produced a substantial reduction in both sward height and leaf table height. The standing biomass on the plot was also reduced by some 1217 kg/ha, which represents almost a third of the initial overall biomass. Importantly, the cessation of grazing was timed to coincide with the second peak in the bi-modal summer rainfall regime experienced in Eastern Cape, in order to give the sward the maximum opportunity to recover prior to the winter. Late summer rainfall was good, the village receiving nearly 200 mm during the six weeks following grazing, which allowed a considerable amount of vegetative regrowth to occur on the plot (see Appendix 2.2.4). This provided the foundation for the three sets of subsequent comparative measurements undertaken in both the control and treatment plots at approximately the beginning, middle and end of winter 1999.
6.3) **COMPARATIVE SWARD STRUCTURE AND BIOMASS DATA**

Following recovery of the sward in the late summer period, the winter grazing work commenced in mid-June 1999 as outlined in section 3.3.2. The contrast in the sward on the control and treatment plots by this stage is illustrated in Figure 6.2.

![Comparison of the grass sward on the treatment plot (top) and control plot (bottom) prior to winter grazing commencing.](image)

Comparison with Figure 6.1 also illustrates the level of sward recovery on the treatment plot between March and June 1999.
The difference in the grass sward between the plots is clearly visible at a superficial level. A more objective assessment of the differences in the sward on the plots is provided by the sward measurements conducted before each of the three grazing periods. These are summarised in Figure 6.3, overleaf.

In both the control and treatment plots mean sward height and mean leaf table height decreased steadily throughout the winter. This was expected given that biomass was being removed by cattle during each grazing period, and that little or no re-growth was occurring at this time (see Figure 6.4). However, the majority of these decreases were relatively small, the only pronounced decreases being in mean sward height between the first and second grazing periods on both plots. This was logical, as tall individual grass culms, present on each plot at the beginning of the winter, contributed disproportionately to the overall mean sward height measured on each plot at this time (pers. observ.). These were removed by cattle during the first grazing period resulting in a strong overall decrease in mean sward height being subsequently recorded on both plots.

Changes in both the stemminess and degree of greeness of the sward also followed similar patterns on both plots. There was a substantial increase in mean sward stemminess on both plots between the first and second grazing periods. This is likely to be a result of cattle preferentially selecting leaf material during the first grazing period. Strong preference for leaf material has been documented in other studies of cattle grazing behaviour (Stobbs, 1974; O’Reagain and Mentis, 1988). In contrast, between the second and third grazing periods there was a decrease in stemminess on both plots. In the case of the treatment plot this would appear to have resulted from an increase in the proportion of green leaf material. This is corroborated by the data from the separation of sward samples (Figure 6.6), and appears to have resulted from the early spring recovery of the sward which was occurring around the time of the time of the third period grazing period (mid-September). Mean sward greenness showed a substantial decrease on both plots between the first and second grazing periods, particularly on the treatment plot. This most probably reflected not only selection for green sward material by foraging cattle, but also sward necrosis.
Figure 6.3: Mean sward parameters (± S.E.) on control and treatment experimental grazing plots at Koloni during winter 1999 (n =100).
Between the second and third grazing periods there was little change in mean sward greenness on either plot.

Between plot differences were considerable for all sward parameters at all stages of the winter. Mean sward height, mean leaf table height and mean stemminess were much higher on the control plot than on the treatment plot during winter 1999. In contrast mean greenness was markedly lower on the control plot throughout the winter period. These results are in keeping with those predicted and the subjective assessment of stemminess and greenness presented here is also supported by the results from the separation of the grassland sward into individual fractions (Figure 6.6). The fundamental differences in sward structure between the plots would appear to have had an important bearing on both dry matter and nutritional intake rates in foraging cattle. This will be investigated in more detail in section 6.6.

Measurement of the standing biomass on the plots before and after each grazing period was also undertaken in order to allow cattle intake rates to be determined at different stages of the winter. Assessment of standing biomass made use of the same visual estimation method employed in the free-ranging animal work (see section 3.3.1.3). Again 100 quadrats were assessed with every tenth one being harvested as both a running check on the accuracy of estimation and to allow for the investigation of the nutritional quality of the sward (section 6.4). However, despite all the regressions from the harvested quadrats being significant (p<0.02), suggesting that assessment of biomass was consistently accurate, this method resulted in biomass estimates that appeared unrealistic. For example, differences between standing biomass before and after grazing were far too large to have resulted from forage removal by cattle and there were also considerable increases in biomass between grazing periods, which would appear highly unlikely at this time of the year (see Appendix 6.1). The reason for these unrealistic results would seem to lie in the fact that some of the regressions were based on a very limited spread of biomass ratings. These tended to be bunched around the mid-range rather than making use of the entire 1-5 scale of assessment. This caused some of the regressions to have a strong element of bias in them. It was therefore decided to use the results from the Type 1 method of biomass estimation, in which all quadrats are visually assessed against the original
biomass standards established at the beginning of winter, with no adjustment for observer error (Haydock and Shaw, 1975). These are summarised in Figure 6.4.

![Figure 6.4: Mean standing biomass (kg/ha) on control and treatment plots before and after each grazing period in winter 1999 (± S.E., n = 100).](image)

Figure 6.4: Mean standing biomass (kg/ha) on control and treatment plots before and after each grazing period in winter 1999 (± S.E., n = 100).
A steady decline in biomass on each plot is clearly visible throughout the winter, resulting mostly from forage removal by cattle during each three-day grazing period. Between each grazing period, declines in standing biomass are also noticeable as a result of the natural dieback of the climax sward at this time of the year. These were most pronounced between the second and third grazing periods for both the control and treatment plots. In contrast, between the first and second grazing periods biomass declined only very marginally in the control plot and actually increased incrementally by some 41 kg/ha on the treatment plot. This would appear to be a result of the unseasonally heavy rains experienced at the end of July 1999, just prior to the second grazing period (Appendix 2.2.4). Such a limited increase in biomass is possible even at this time of the year under the appropriate environmental conditions (P.F. Scogings, pers. comm.). These estimates of standing biomass on each plot can be used to assess the amount of biomass removed during each grazing period. This is displayed graphically in Figure 6.5.

![Figure 6.5: Mean removal of standing biomass (kg/ha) from control and treatment plots at different stages of winter 1999.](image)

What is most immediately obvious from the data is the relatively constant level of biomass removal from the treatment plot throughout winter 1999. In contrast, biomass removal from the control plot was somewhat more erratic. It was particularly low during the first grazing period at the beginning of the winter, becoming more
consistent in the latter stages of winter 1999. This is probably a reflection of the relatively small proportion of time cattle on the control plot devoted to grazing at this time compared to later in the winter (see section 6.5). Furthermore, the amount of forage removed during the second and third grazing periods seems somewhat high to be accounted for solely by intake from grazing cattle. It would appear that much of the standing biomass being removed at this time was actually being transformed into litter, as a result of trampling and partial harvesting by foraging cattle, rather than actually being consumed by them. The biomass harvesting method employed by the researcher involved cutting to stubble height only the vegetation that was still rooted in each quadrat and ignoring litter material. Thus, the difference in measured biomass between the start and finish of each grazing period did not represent what was actually being consumed by cattle. This has important implications for the calculations of intake derived in section 6.6.

6.4) COMPARATIVE NUTRITIONAL DATA

In addition to measurement of the amount of biomass removed from the control and treatment plots, analysis was also undertaken of the nutritional quality of the sward available on each plot at different stages of winter 1999. The most straightforward of the nutritional parameters assessed was the proportion of green and dead stem, and green and dead leaf material in the sward. This was undertaken on quadrat samples harvested immediately prior to each grazing period. The data are summarised in Figure 6.6, overleaf. It is clear from the graphs in Figure 6.6, that during the first grazing period, at the beginning of the winter, there was more dead leaf material on the control plot than on the treatment plot. Furthermore, there was also a considerably greater amount of green leaf material on the treatment than the control plot. This was expected given the substantial opportunity the sward on the treatment plot had for recovery following intensive grazing in March 1999. The considerable precipitation the village experienced at this time must also have played an important role in facilitating the extensive re-growth achieved.
Figure 6.6: Proportion (± S.E.) of dry and green sward fractions on control and treatment experimental grazing plots during winter 1999 (n =4, initial; n =5, middle and end).
The lack of any notable differences in the proportion of the different sward fractions between the plots, during the second period of grazing (mid-winter) was also unsurprising. It is speculated that during the first grazing period, cattle on the treatment plot focused on the more nutritious green fraction of the sward, which was not only more accessible to grazing than on the control plot but also more abundant. Strong levels of selection by cattle for green material in the sward have been widely reported when swards are relatively undiluted by senescent material (Reppert, 1960; Arnold, 1964; Chacon and Stobbs, 1976). This selective feeding resulted in a substantial decrease in the proportion of green leaf and a concomitant increase in the proportion of dead stems and dead leaves by the beginning of the second grazing period. In contrast, foraging in the mature, rank swards on the control plot was, because of the inaccessibility of the available green material, almost entirely non-selective. This lack of selectivity on rank swards has been demonstrated in other studies of arable grazing (O’Reagain, 1994). This resulted in the proportion of each sward fraction remaining relatively unchanged between the first and second grazing periods.

By the time the final period of grazing was due to get underway, at the end of the winter, some fairly substantial differences between the plots in the proportion of the four sward fractions were once again apparent. There was a considerably higher proportion of dead stem material on the control plot and of dead leaves and green leaves on the treatment plot. This might suggest that cattle on the treatment plot were actually selecting dead stem material in their diet at the expense of green stem and particularly green leaf material. However, this would appear highly unlikely and it is speculated that the high variability in the samples and the confounding effects of sward regrowth at this time were largely responsible for the observed changes. The relative contribution of sward regrowth at this stage was impossible to determine. Separation of biomass samples from exclosed areas into separate sward components was not undertaken and thus the effects of sward dieback and re-growth could not be isolated from that of selective feeding by cattle. However, some limited level of sward regrowth at this stage would appear to have been inevitable and would certainly have accounted for the small increase in the proportion of green material in the treatment plot by the third grazing period. Interestingly, there seemed to be little evidence of regrowth in the mature stands of sward in the control plot by this point. It
may be that the shorter sward on the treatment plot was able to respond both more rapidly and more vigorously to the onset of spring.

As well as determining the proportions of the different sward fractions in the control and treatment plots, analysis was also undertaken of the crude protein, fibre and in vitro digestibility of the different fractions. This data is presented overleaf in Figures 6.7, 6.8 and 6.9 respectively.

What is immediately clear from the crude protein data, is that there was very little difference between equivalent sward fractions from control and treatment plots at each stage of the winter. However, crude protein values did tend to be slightly higher in the control plots, particularly when comparing the green leaf fraction of the sward. This was unexpected considering the very different sward structures of the two plots. The taller sward on the control plot had developed over the course of the entire grazing season and contained leaves at a variety of ages and stages of development, distributed throughout the profile of the sward. In contrast, the grass sward on the treatment plot had a considerable lower mean leaf table height (see Figure 6.3) and thus contained mainly leaves of relatively low insertion point on the tiller. It is recognised that leaves of lower insertion point on the tiller have both a higher crude protein content and digestibility (Wilson, 1976). It might therefore have been expected that the mean crude protein would be higher amongst green leaves on the treatment plot. In fact it would seem likely that this was indeed the case at one stage but that this was masked by the differing influence of seasonal change on the plots. Wilson (1976) has shown that leaves of low insertion point on grass tillers actually have a higher rate of senescence, including protein degradation as a result of having a relatively low lignin content in their cell walls. Thus, by the beginning of the winter, with sward dieback well underway by this stage, it is likely that leaves on the treatment plot would have experienced a greater overall level of protein degradation than those on the control plot. This increased rate of senescence amongst leaves of low insertion point might also help to explain why there was a steady increase in the proportion of dead leaf material on the treatment plot following the first grazing period (see Figure 6.6).
Figure 6.7: Mean protein values (± S.E.) of different sward fractions from control and treatment grazing plots at Koloni during winter 1999 (n =3).
Figure 6.8: Mean fibre values (± S.E.) of different sward fractions from control and treatment grazing plots at Kolon during winter 1999 (n = 3).
Figure 6.9: Mean *in vitro* digestibility values (± S.E.) of different sward fractions from control and treatment grazing plots at Koloni during winter 1999 (n =3).
Fibre values were almost identical for equivalent sward fractions from the plots throughout the winter. This is surprising given that leaves of low insertion point on the tiller are recognised to have a lower lignin content (Wilson, 1976). However, these differences were apparent in the digestibility values. With the exception of the dry stem fraction of the sward, digestibility values from the treatment plot were consistently higher than those from the control plot throughout winter 1999. For the leaf fraction of the sward this undoubtedly reflects the greater overall cell wall content of leaves on the control plot as a result of many of them having a much higher level of insertion on the grass tiller (Wilson, 1976).

Having discussed the impact that summer grazing had on the physical structure and nutritional value of the grass sward during the subsequent winter, an overview of the way in which these differences influenced the grazing behaviour of cattle will now be provided.

6.5) COMPARATIVE ANIMAL BEHAVIOUR DATA

Behaviour observations were conducted on the second day of each three-period the cattle occupied the grazing plots during winter 1999 (see Section 3.3.3.2). These revealed some quite distinctive differences in behaviour between animals on each plot. The mean proportion of time the animals allocated to feeding, resting and walking during winter 1999 is summarised in Figure 6.10, overleaf.

The most immediate difference in behaviour was in the amount of time animals allocated to feeding and resting during the winter, both within and between plots. Animals on the treatment plot were remarkably consistent in the amount of time they allocated to both feeding and resting throughout the winter. In contrast the animals on the control plot showed considerable variation in the amount of time they allocated to these activities. There was a steady increase in the amount of time spent feeding during the course of the winter and a concomitant decrease in the amount of time spent resting. Indeed, during both the beginning and middle of the winter, cattle on the control plot spent much less time feeding than those on the treatment plot and a
much greater proportion of their time resting. This was particularly true for the observations undertaken at the beginning of the winter (Figure 6.11, overleaf).

Figure 6.10: Mean proportion of time (± S.E.) cattle on control and treatment plots allocated to feeding, resting and walking during winter 1999 (n values indicated on x-axis of each graph).
Why the animals on the control plot spent such a relatively small proportion of their time feeding compared to the treatment plot at the beginning of the winter but not the end of the winter is difficult to explain. O’Reagain (1994) has shown there to be a significant negative correlation between sward height and time spent grazing and a significant positive correlation between grazing time and sward greeness. This would certainly support the considerable difference in grazing times between the plots during the beginning and middle of the winter but does not explain the results from the end of the winter. At this stage, mean sward height was still very much lower and the sward considerably greener on the treatment plot than on the control plot, but there was little difference in the proportion of time cattle spent feeding. Alternatively, it may be that the animals gradually became habituated to the tall, stemmy sward on the control plot.

Figure 6.11: Comparison of cattle behaviour on grazing plots at the beginning of winter 1999. Note the majority of animals resting on the control plot (foreground) and grazing on the treatment plot (background).

At the beginning of the winter, the cattle used in the experiment had previously been feeding on crop residues and grassland vegetation with a fairly low sward height. It may, therefore, have been difficult for the cattle in the control plot to suddenly adjust to the radically different type of forage available. Certainly for the first day or two
they were in the control plot, the animals appeared somewhat confused by their new
surroundings and reticent to feed. Conversely, the cattle on the treatment plot seemed
completely unaffected by their change in surroundings and continued to feed as
normal. This was probably a reflection of their familiarity with this type of sward.
By the end of the winter, however, it is speculated that cattle were more familiar with
the tall, stemmy sward found on the control plot, as they were forced to spend more
time grazing high biomass patches of climax grassland when free-ranging on the
arable lands (see section 5.2). This habituation may have allowed their feeding
behaviour to be unaffected when introduced onto the control plot at this stage of the
winter.

Another interesting aspect of feeding behaviour, which reflects the greater desirability
of the *Hyparrhenia hirta* sward in the treatment compared with the control plot, is the
level of preference animals showed for low biomass patches on the plots. The amount
of time cattle spent feeding in both the low biomass and high biomass areas of each
plot during the winter, is summarised in Table 6.2. The number of observations used
in deriving the means and standard errors presented in Table 6.2 is often smaller than
that for the activity data (Figure 6.10) as observations in which no feeding occurred
were excluded.

**Table 6.2: Mean proportion of time (± S.E.) animals spent feeding in low biomass
and high biomass patches on control and treatment plots during winter 1999.**

<table>
<thead>
<tr>
<th>PATCH AREA</th>
<th>CONTROL PLOT</th>
<th>TREATMENT PLOT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial (n =7)</td>
<td>Middle (n =7)</td>
</tr>
<tr>
<td>Low biomass</td>
<td>10.2% (± 7.6%)</td>
<td>23.3% (± 14.3%)</td>
</tr>
<tr>
<td>High biomass</td>
<td>89.8% (± 7.6%)</td>
<td>76.7% (± 14.3%)</td>
</tr>
<tr>
<td>TOTALS</td>
<td>100.0%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

If the proportion of time spent feeding in each patch type is compared with the area
occupied by each patch type (see Appendix 6.1) in the plots then a series of
preference indices can be derived for each plot. These are presented in Table 6.3,
overleaf.
Table 6.3: Preference indices for low and high biomass patches.

<table>
<thead>
<tr>
<th>PATCH AREA</th>
<th>CONTROL PLOT</th>
<th>TREATMENT PLOT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial</td>
<td>Middle</td>
</tr>
<tr>
<td>Low biomass</td>
<td>0.52</td>
<td>1.19</td>
</tr>
<tr>
<td>High biomass</td>
<td>1.12</td>
<td>0.95</td>
</tr>
</tbody>
</table>

It is clear in both plots that there was a general increase during the course of the winter in the level of preference shown by foraging cattle for low biomass patch areas. Moreover, preference for patch areas was consistently higher in the control plot than the treatment plot. Indeed, by the middle of the winter animals in the control plot were already displaying a greater preference for the low biomass patches than the high biomass patches (Table 6.3 and Figure 6.12). This was probably a result of the recovery of the sward that was taking place in the low biomass patch areas at this time with the approach of spring (see sections 5.3.4 and 5.3.5). Furthermore, the continually higher level of preference expressed by cattle for patch areas on the control plot would appear to have been a response to the poor quality of the mature stands of *Hyparrhenia hirta* on the control plot compared with those on the treatment plot. This emphasises the fact that the altered physical characteristics of the high biomass sward on the treatment plot compared with that on the control plot made it more acceptable to foraging cattle.

![Cow grazing in a low biomass patch on the control plot during the latter half of winter 1999.](image)

Figure 6.12: Cow grazing in a low biomass patch on the control plot during the latter half of winter 1999.
Animal observation data also provided an indication of the mean bite rate achieved by grazing cattle on each plot (bites/min), which was important in the calculation of approximate intake rates (see section 6.6). This is summarised in Figure 6.13.

**Figure 6.13:** Mean bite rate (± S.E.) of cattle grazing control and treatment plots during winter 1999 (n values are indicated within each bar and represent the total number of recorded grazing bouts during each day of animal observations).

Mean bite rate on the control plot was remarkably consistent through the winter, there being very little difference between data collected at the start, middle and end of the winter. This lack of variation seems quite realistic given the sward remained very tall and stemmy for the duration of the winter (see Figure 6.3). In contrast, on the treatment plot there was a considerably greater level of variation in mean bite rate during winter 1999. Mean bite rate increased substantially between the start and middle of the winter. This was expected and would appear to reflect the considerable decrease in the proportion of green leaf material in the sward that occurred at this stage (see Figure 6.6). Under conditions where preferred food becomes more difficult to harvest, cattle feed more selectively and generally compensate for the resulting decrease in bite size by increasing bite rate in order to maintain intake rate (Stobbs, 1974, Chacon and Stobbs, 1976). Strangely, between the middle and end of the
winter mean bite rate on the treatment plot actually decreased. This was unexpected and is not easy to account for. One explanation may be that the residual stems in the sward had a more pronounced negative impact on mean bite rate than previously, given that the animals were feeding at a lower height by the end of the winter. Certainly residual stems have been demonstrated to impact negatively on bite rates in both *Eragrostis lehmanniana* (Ruyle et al., 1987) and *Hyparrhenia hirta* (O’Reagain, 1994). Alternatively, the slight increase in the proportion of leaf material in the sward may have caused animals to feed less selectively and thereby decrease bite rate.

Importantly, mean bite rate was substantially higher on the treatment plot than on the control plot throughout winter 1999. This was undoubtedly a reflection of the lower sward height, leaf table height and stemminess and substantially greater level of greenness on the treatment plot compared to the control (see Figure 6.3). Negative correlations between bite rate and sward height, leaf table height and stemminess have been demonstrated in similar sward types on old lands in South Africa (O’Reagain and Goetsch, 1996). These researchers also reported a mean bite rate of 28.55 (± 5.25) bites/minute when cattle grazed pure stands of *Hyparrhenia hirta* presented to them in pots, which compares reasonably well with the bite rates obtained from the control plot at Koloni.

### 6.6) COMPARATIVE CATTLE INTAKE DATA

One the main hypotheses to be investigated by the experimental grazing work was that cattle would be able to attain higher rates of intake on the treatment plot as a result of the more conducive physical structure of the sward. Investigation of this required some way of estimating cattle intake rates from each plot during the three winter grazing periods and was achieved by combining the data on biomass removal from section 6.3, with that on rate of biting derived in section 6.5. The results of this are summarised in Table 6.4, overleaf. A more detailed explanation of how these figures are derived is provided in Appendix 6.2.
Table 6.4: Feeding parameters for cattle on control and treatment plots during winter 1999, based on measured biomass removal and bite rate data.

<table>
<thead>
<tr>
<th>FEEDING PARAMETER</th>
<th>CONTROL PLOT</th>
<th>1&lt;sup&gt;st&lt;/sup&gt;</th>
<th>2&lt;sup&gt;nd&lt;/sup&gt;</th>
<th>3&lt;sup&gt;rd&lt;/sup&gt;</th>
<th>TREATMENT PLOT</th>
<th>1&lt;sup&gt;st&lt;/sup&gt;</th>
<th>2&lt;sup&gt;nd&lt;/sup&gt;</th>
<th>3&lt;sup&gt;rd&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bite rate (bites/min)</td>
<td>22.29</td>
<td>22.85</td>
<td>22.42</td>
<td>32.45</td>
<td>39.17</td>
<td>34.76</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bite size (g/bite)</td>
<td>0.79</td>
<td>2.29</td>
<td>2.13</td>
<td>0.65</td>
<td>0.73</td>
<td>0.63</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total intake/animal/day (kg)</td>
<td>2.97</td>
<td>15.09</td>
<td>18.43</td>
<td>6.88</td>
<td>10.16</td>
<td>8.21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intake rate (g/min)</td>
<td>17.70</td>
<td>52.23</td>
<td>47.82</td>
<td>21.17</td>
<td>28.41</td>
<td>21.79</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The figures are broadly in line with what was expected apart from those from the control plot for the second and third grazing periods. Daily forage intakes of 15-18 kg are unfeasibly large under the conditions of the experiment. For a standard adult animal of mass 350 kg, maximum intake is in the range of 7-10.5 kg of forage per day (Stobbs, 1973). It would appear that the vast overestimation of intake on the control plot during these two grazing periods results from the problem alluded to in section 6.3, of accurately relating data on removal of standing biomass to that on animal intake. Over very short grazing periods it might seem realistic to assume that the difference between the initial standing biomass before grazing and that remaining afterwards provides an accurate reflection of what has been ingested by grazing cattle. However, after the first grazing period trampling of the tall sward on the control plot started to become a real problem in accurately estimating residual biomass in each quadrat. As a result, only standing biomass in quadrats was assessed and litter and trampled biomass that had become separated from the parent plant was ignored. This resulted in considerable overestimation of the amount of standing biomass removed from the control plot during the second and third grazing periods, and hence to the calculation of excessively high rates of daily forage intake for these periods.

Likewise the resulting calculations of intake rate per minute and bite size during these grazing periods are also excessive. Intake rates of around 16-33 g/min, with a mean of 24.3 g/min, were recorded on cultivated stands of *Hyparrhenia hirta* grazed by cattle (O’Reagain and Goetsch, 1996). The same experiment produced bite sizes of 0.6-1.16 g with a mean of 0.87 g. This would suggest that both intake rates and bite sizes calculated from all three grazing periods on the treatment plot, and from the first grazing period on the control plot, are fairly realistic whereas those obtained from the control plot during the second and third grazing periods are excessively high. Indeed, at 2.1-2.3 g per bite, the bite sizes obtained during the second and third grazing
periods were approximately twice the maximum values obtained under controlled conditions by O’Reagain and Goetsch (1996). In light of this and the fact that the bite rates recorded from the control plot are within the expected range for this type of sward, it would seem reasonable to adjust bite size during the second and third grazing periods on the control plot in order to derive a more realistic estimation of forage intake rates. A more realistic value for bite size is the 0.79g /bite obtained during the first grazing period, before the sward became severely trampled. The revised intake figures incorporating this bite size during the second and third grazing periods are presented in Table 6.5.

Table 6.5: Feeding parameters for cattle on control and treatment plots during winter 1999.

<table>
<thead>
<tr>
<th>FEEDING PARAMETER</th>
<th>CONTROL PLOT</th>
<th>TREATMENT PLOT</th>
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<tbody>
<tr>
<td></td>
<td>1st</td>
<td>2nd</td>
</tr>
<tr>
<td>Bite rate (bites/min)</td>
<td>22.29</td>
<td>22.85</td>
</tr>
<tr>
<td>Bite size (g/bite)</td>
<td>0.79</td>
<td>0.79</td>
</tr>
<tr>
<td>Total intake/animal/day (kg)</td>
<td>2.97</td>
<td>5.24</td>
</tr>
<tr>
<td>Intake rate (g/min)</td>
<td>17.70</td>
<td>18.14</td>
</tr>
</tbody>
</table>

These revised intake values undoubtedly provide a more accurate reflection of the true rate of forage intake by grazing cattle. What is clear, is that intake rate (g/min) is consistently higher on the treatment plot than the control plot when the assumed values for bite size are used during the middle and end of the winter. This was one the hypothesised outcomes of summer grazing. Furthermore, if the intake rates in Table 6.5 are combined with nutritional data from section 6.4 estimates of daily intake of energy and crude protein from the control and treatment plots at each grazing stage can be derived (Figure 6.14, overleaf). These values are inherently crude, not only because they are derived from figures that are themselves relatively inaccurate, but also because there are a number of critical assumptions involved in their calculation. Most prominent of these is the imposed limitation on bite size during the second and third grazing periods on the control plot. Furthermore, as with the intake calculations in Chapter 5, it has been assumed that cattle foraging on the plots showed no preference for different fractions of the sward, but rather included these fractions in their diet in the same proportion in which they occurred in the sward (see Appendix 6.3 for a more detailed breakdown of these intake calculations).
Figure 6.14: Estimated daily intake of crude protein and energy by cattle on control and treatment plots during winter 1999.

Whilst it is clear that under appropriate circumstances cattle are able to select strongly for both leaf material (Stobbs, 1974; O’Reagain and Mentis, 1988) and green sward (Reppert, 1960) in their diets, it has also been shown that on tall, stemmy swards such as those found on arable lands, this selectivity is greatly decreased (O’Reagain, 1994). For this reason the assumption of non-selective feeding would appear justified, particularly for the control plot. For the treatment plot, however, the initial estimates
of both crude protein and energy are likely to be too low as the relatively high proportion of green leaf material on the plot at this time would almost certainly have enabled cattle to feed selectively.

Despite their relatively crude nature, the estimates presented in Figure 6.14 do have considerable value from a comparative perspective. They clearly demonstrate that intake of both crude protein and energy was greater on the treatment than the control plot for the duration of winter 1999. This difference was particularly pronounced during the first grazing period, early in the winter. However, these differences became less pronounced during each successive grazing period such that by the end of the winter there was little difference particularly in crude protein levels. This suggests that any benefit the summer-grazed sward had over the standard sward in increasing the nutritional intake of grazing cattle was relatively short lived. Moreover, if these values are compared with standard nutritional requirements for the maintenance and growth of cattle in developing countries (Kearl, 1982) then the implication of these elevated intake rates for animal performance can be evaluated. For a standard 350 kg animal, daily intake rates of 340 g of crude protein and 40.9 MJ of energy are required just for maintenance (Kearl, 1982). This suggests that animals on the treatment plot are able to consistently satisfy energy requirements whereas those on the control plot are not. In contrast, it would appear that the crude protein intake rate of cattle on both plots was considerably below that required for maintenance throughout the winter, although this shortfall was consistently greater on the control plot compared to the treatment plot. However, this shortfall in crude protein on the treatment plot can be seen to result largely from the assumed inability of cattle to feed selectively at any stage of the winter. Alternatively, it might also be justifiably assumed that during the first grazing period on the control plot cattle were able to feed exclusively on green leaf material given that their total biomass intake at this time was only just over 200 kg/ha and more than 650 kg/ha of green leaf material was available (see Appendix 6.3). Under these circumstances a crude protein intake of some 400 g/animal/day could be achieved, which is more than sufficient to meet cattle maintenance requirements. Clearly, a realistic value for crude protein intake on the treatment plot at this stage lies somewhere between these two extremes, although probably closer to the value assuming exclusive feeding on green leaf material.
The inherent variation in these estimates of intake also underlines the problems of producing realistic assessments of nutritional intake when diet composition cannot be accurately determined. The use of oesophageally fistulated animals is a commonly used technique in assessing the plant part composition of herbivore diets (O’Reagain, 1994) and would have helped considerably to solve this problem. However, this was not a realistic option given that the experiment required the use of cattle belonging to villagers from Koloni.
6.7) DISCUSSION

In light of the shortcomings of the experimental design outlined in the introduction, it is impossible for any firm conclusions to be drawn from the data regarding the potential of summer grazing for improving the grass sward on old lands for cattle production during the subsequent winter. The results can be viewed as providing nothing more than a crude insight into an alternative grazing management regime. They do, nevertheless, have considerable value in this respect as little or no research has previously been conducted in this field in communal areas of South Africa. Moreover, their validity is reinforced by the fact that in most respects they are in general agreement with what has been published elsewhere.

With regard to the two major hypotheses that the experiment aimed to test, the lack of plot replication and the resulting inability to apply inferential statistics, means that the data does not offer definitive support for either hypothesis. However, as a first step in assessing the potential of summer grazing as a management tool for improving cattle production from *H. hirta* sward, the data do provide a broad, albeit inconclusive, insight at the “look-see” level. Intake rate data were consistently higher on the treatment plot than on the control plot at all three stages of sampling during winter 1999. However, intake data from the second and third grazing periods on the control plot were estimated rather than measured, which may lead to questions over the validity of the conclusions. Nevertheless, the premise upon which these predictions have been made, namely that measured bite size on the control plot during the first grazing period is unlikely to be exceeded on a sward of lower biomass during subsequent grazing periods, is sound. O’Reagain (1994) has demonstrated that on tall swards, where bite depth is not limited at any stage, animals tend to maintain maximum bite size and intake is a function of bite rate. Rather questions should be raised regarding the actual method of assessing the removal of standing biomass. Visual estimation of standing biomass using the comparative yield technique was clearly unsuitable for the type of sward involved, and problems of accurate assessment were exacerbated by the amount of trampling that occurred. Indeed, it is not generally recommended that the technique be applied in tall, stemmy swards (Haydock and Shaw, 1975), and only severe constraints on time forced its adoption.
for the experimental work. Given the accuracy to which change in biomass needed to be measured for the calculation of realistic intake rates, it would undoubtedly have been advisable to harvest the biomass from all the quadrats sampled and also to include in this vegetation which had been trampled. This is particularly true for the control plot, where trampling was a real problem. Nevertheless, accepting the limitations of the method, the data obtained does suggest a clear difference in intake rates between the plots. The inability to apply inferential statistics to the data does however make it impossible to determine if this difference was a result merely of natural variation in the sward or of the experimental manipulation of sward characteristics.

Assuming that the difference in intake rates can actually be attributed to effects of summer grazing on the treatment plot, then hypothetically there are a number of important implications. Firstly, given that bite size did not appear to be a restricting factor on either plot, the elevated intake rates on the treatment plot would seem primarily to be a function of the increased rate of biting cattle attained throughout the winter. This would appear to be a reflection both of the lower overall sward height on the treatment plot and decreased level of stems in the grazing horizon. This negative relationship between bite rate and both sward height and stemminess is also corroborated by the findings of O’Reagain (1994). Furthermore, these findings would also suggest that on tall, stemmy swards such as that found on the control plot, there might actually be a quadratic relationship between intake and sward height, determined initially by bite size and then by bite rate above a critical sward height. This contradicts the accepted Type II curvilinear response mechanism found in other studies of grazing ungulates (Allden and Whittaker, 1970; Spalinger and Hobbs, 1992). Here, intake increases linearly to a certain critical sward height and thereafter remains at a constant level, being constrained by the time required to process each bite (Spalinger and Hobbs, 1992). Other studies also offer support for a quadratic response for forage intake on tall swards of low quality (Hodgson and Wilkinson, 1968; O’Reagain, 1994).

The other hypothesis that the experiment aimed to test was that summer grazing would produce a sward of higher nutritional quality during the subsequent winter. Although, the overall nutritional quality of the summer-grazed sward was higher than
that of the control, the limitations in the experimental design meant that it was again impossible to separate the effects of the experiment from the natural variation in the vegetation. Nevertheless, there were some substantial differences between the plots. Perhaps the most striking was in the proportion of green material in the sward. This was considerably higher on the treatment plot than on the control during the first grazing period at the beginning of the winter. However, this disparity was very short-lived, there being relatively little difference between the proportion of green sward in either plot by the middle of the winter. With regard to differences in crude protein it was surprising to find consistently higher values for almost all sward fractions on the control plot, contradicting the expected findings. However, for reasons outlined above, crude protein levels were probably higher in the treatment sward immediately prior to the winter, but were disproportionately diminished by the time of the first grazing period due to the more severe impact of the winter on this sward type. The clearest chemical improvement in the treatment plot was in the level of digestibility, which was considerably higher in the green fraction of the sward. This was expected and would appear to reflect the fact that the bulk of the green material on the treatment plot had regrown quite rapidly and thus had a decreased cell wall content (Wilson, 1976). Strangely, however, this was not reflected in a decreased level of fibre in this fraction.

If it is accepted that there is a genuine difference between the two plots as a result of experimental manipulation, the implications of summer grazing for animal production are clearly positive. However, the actual extent to which nutritional intake and thus animal performance is increased is debatable. Accepting the assumptions made in the various calculations of nutritional intake, the data suggest that differences in nutritional intake were most pronounced during the first grazing period at the beginning of winter 1999. However, the main parameter facilitating the considerably elevated level of daily nutritional intake in the treatment plot would appear to have been the much greater proportion of time cattle on the treatment plot spent grazing at this stage. The extent to which the actual characteristics of the plot (sward height, stemminess) were responsible for this variation in grazing times is debatable. O’Reagain (1994) has shown that an inverse relationship exists between grazing time and both height and stemminess of grass swards. On this basis, it might be concluded that sward parameters, by influencing the different times cattle spent grazing on the
plots, were entirely responsible for the differences in daily nutritional intake between the plots. However, the difference in grazing time between the two plots was so considerable early in the winter that it is speculated that animal based factors such as habituation were also responsible to a large extent for these differences.

Consideration of nutritional intake rates in the shorter term eliminates this problem of variable grazing times between plots and allows the influence of other parameters to be investigated. This is summarised for crude protein in Table 6.6.

**Table 6.6: Mean rate of crude protein intake by cattle foraging on control and treatment plots at three stages during winter 1999.**

<table>
<thead>
<tr>
<th>PLOT</th>
<th>RATE OF CRUDE PROTEIN INTAKE (g/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial</td>
</tr>
<tr>
<td>Control</td>
<td>0.51</td>
</tr>
<tr>
<td>Treatment</td>
<td>0.62</td>
</tr>
</tbody>
</table>

The nutritional advantage of grazing on the control plot, although less pronounced than with daily intake levels is still evident, suggesting that it was not just differences in grazing time that resulted in the marked disparity in nutritional intake during the first grazing period. Furthermore, if it is assumed that during the initial grazing period cattle on the treatment plot were able to feed almost exclusively on the green leaf fraction of the sward, then the rate of crude protein intake at this stage doubles to 1.24g/minute. On this basis it is speculated that the single most important parameter facilitating the increased nutritional intake on the treatment sward was the increased proportion of green material in sward in the treatment plot. The greater rate of forage intake on the treatment plot also undoubtedly had a role to play in the increased level of nutritional intake. However, this would seem to be less important as demonstrated by the much smaller differences in the rate of crude protein intake later in the winter despite equally large or greater differences in intake. The research of O’Reagain (1994), also suggests that the proportion of green material in the sward is one of the key factors in cattle nutrition in South Africa.
6.8) CONCLUSIONS AND RECOMMENDATIONS

In view of the shortcomings of the experimental design, the findings cannot be taken as providing definitive support for the adoption of summer grazing as a management strategy for improving cattle production on cropland that has been fallowed in the long term. Taken on face value, the data suggest that summer grazing is able to increase both the quality of the sward and its rate of ingestion by grazing cattle. Moreover, it would appear that it is the improvement of sward quality that is likely to result in the greatest increase in animal nutrition, although this improvement would appear to be only relatively short-lived. However, before any of these findings can be corroborated there is a need for more conclusive data. It is, therefore, recommended that a more comprehensive investigation of the effect of the summer grazing of arable lands on cattle production be undertaken, which would allow for proper testing of the defined hypotheses. Specifically the following weaknesses in the existing experimental design and sampling procedure would have to be addressed:

- Both the control and treatment plots would need to be replicated to separate treatment effects from the natural variation in the grass sward.
- Summer grazing on the treatment plot(s) should be undertaken at an earlier stage (late January/early February) to guarantee substantial sward recovery, as the late summer rains are not always reliable.
- All quadrats involved in biomass sampling should be harvested rather than estimated visually to provide a more accurate estimate of standing biomass, particularly on the control plot.
- All biomass falling within a quadrat should be harvested regardless of whether it is actually rooted within the quadrat.

If these weaknesses could be addressed, the data set would be sufficiently robust for genuine statistical inferences to be made regarding the effectiveness of summer grazing as a management technique for improving cattle production from arable land allocations.
CHAPTER 7: OVERALL SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

7.1) INTRODUCTION

The starting point for this thesis has been that agriculture has a vital role to play in the alleviation of rural poverty in South Africa. Following years of debilitating colonial and apartheid policies, the new democratic government of South Africa is keen to rebuild a limited African peasantry, which can compete effectively with the larger commercial farms and provide a livelihood for many black smallholders. This is particularly true in former homeland areas, where the lack of industrialisation means that agriculture is one of the few areas with potential for improving rural livelihoods. This desire has been explicitly acknowledged by the South African government in its policy statements (ANC, 1994; Government of South Africa, 1997a). The central Eastern Cape region has specifically been identified as an area in which agriculture, and livestock production in particular, have considerable potential for uplifting rural livelihoods (Government of South Africa, 1997a). From an ecological perspective, many of the lower lying areas of the region are dominated by sweetveld which supports livestock production throughout the year. Furthermore, the Xhosa people of rural Eastern Cape have always had a strong cultural affinity with livestock, particularly cattle, which have traditionally played an important part in their lives. However, although the ecological and socio-political environment in the region is favourably oriented towards development interventions with a livestock production focus, very little baseline information exists on the way cattle production systems currently operate in communal areas and the potential they have for making sustainable improvements to rural livelihoods.

To this end, the research focused on providing a holistic characterisation of cattle production systems in communal areas of the central Eastern Cape region, and in particular of the role played by arable land allocations in these. These arable land allocations are the areas specifically designated for crop production and are of particular interest because a combination of ecological and social factors have led to
crop production being largely abandoned in recent years. Thus, the majority of the land in these areas lies fallow from year to year. In many communal areas this represents a considerable amount of unproductive land which might better be utilised as permanent grazing for livestock. The overall goal of the research was thus to assess current levels and patterns of utilisation of these areas for cattle production and how these might be improved. In so doing, it investigated in considerable depth both the social and ecological aspects of cattle production from the arable land allocations at two villages in the former homeland of Ciskei. These villages were selected for being broadly representative of much of the social and ecological diversity that exists in what is now the central Eastern Cape region. Such a comprehensive investigation of the production systems at each village was necessary in order to develop a meaningful and realistic set of recommendations for improving them. The holistic nature of the project was embodied in a comprehensive set of social and ecological objectives for the research work that was undertaken at each village.

7.2) SUMMARY OF FINDINGS IN RELATION TO STATED OBJECTIVES

To begin with, the research aimed to provide an indication of the potential of agriculture for poverty alleviation in each village by investigating patterns of social differentiation. At the broadest level, this involved using data from a baseline socio-economic survey undertaken by ARDRI in each village, to identify any significant relationships that existed at the household level between access to land and livestock, and the age and gender of each household head and total household income. Interestingly, this showed some quite marked disparities between the two villages. At Guquka, relatively few households had access to arable land and of those that did ownership was significantly (p<0.05) skewed towards the elderly. Furthermore, crop production was biased almost entirely towards males. Ownership of cattle also showed considerable bias at Guquka. Only a relatively small proportion of households owned cattle and of those that did very few had herds of sufficient size to be economically viable. Ownership was also (significantly p<0.05) biased towards wealthier, male-headed households. In contrast, at Koloni there was no significant
social bias in either access to land or ownership of cattle. Moreover, cattle ownership was quite widespread in the village and many households owned herds of sufficient size to be economically viable.

This social disparity between the villages was further underlined by the amount of arable land held by different sectors of each community. At Guquka, land ownership was severely polarised towards the established families, who settled when the village was formalised and the land allocations were made. These established families had access to nearly all of the arable fields at the village, such that very few were available to the more recently settled families despite the fact that some of them were actually larger in terms of the number of households occupied than the established families. By contrast, land access at Koloni was far less biased. With the exception of the very recent settlers in the new section of the residential area, land ownership at the village was very much in proportion to family size. Moreover, even those families without an official allocation of arable land could get access to one of the many fields held by people who no longer resided at the village.

Taken together, these findings suggest that under current social conditions development interventions with an agricultural focus are likely to have a far more widespread impact on poverty alleviation at Koloni than they are at Guquka. However, it would appear that only cattle production offers any real potential for improving livelihoods at Koloni. Despite the lack of strong social bias with regard to land holdings and ability to crop within the village, relatively few households engage in crop production on a regular basis. It would appear that high variability in rainfall, with regard to both timing and amount, and the high initial investment required, combine to make rainfed cropping an unpopular livelihood option at the village. Cattle production by contrast is far less affected by these factors.

The second major objective of the work was also of a social nature. This aimed to determine the current extent of agricultural use of the arable land allocations at each village, and in particular how they are managed as a grazing resource for cattle. It was clear from the research conducted that crop production at both villages was very low and far below potential. Indeed, less than 20% of the available land area was cultivated at the villages during either the 1997/98 or 1998/99 growing seasons. This
finding served to substantiate one of the initial premises of the research, namely that annual crop production in communal areas of the former Ciskei is very low and that large areas of the arable land allocations are lying fallow in the medium and long term. However, perhaps more importantly, the research also demonstrated the very different ways in which the arable land allocations in these areas can be utilised as a grazing resource for livestock. Conventional wisdom has held that all livestock are grazed on the range camps during the summer months. Cattle are moved to the arable lands only after harvesting has taken place in order that they might take advantage of the crop residues and reserves of grass that have accumulated during the summer (refer to Figure 4.10). Furthermore, it is generally believed that this grazing is undertaken on an entirely communal basis. Not only did the research serve to further elucidate some of the more detailed aspects of this grazing management system but it also demonstrated that where pressure on local resources is severe, there can be some quite marked deviations from the generally accepted grazing management paradigm.

Specifically, at Guquka there were two main areas in which differences were identified. Firstly, livestock were found on the arable lands during the summer period as well as the winter. This summer grazing involved animals from both Guquka and neighbouring settlements. Secondly, during the winter period several landowners did not make their fields available for grazing by animals from the rest of the community. These individuals included not only those who had grown winter forage crops but also some of those whose fields were fallow. This was very unexpected and clearly contradicts the ethic of communal grazing that was generally accepted to underpin these communal grazing systems. Both of these exceptions to the general paradigm have come about through a combination of high pressure on local grazing resources and the fact that the majority of the fields at Guquka are fenced. Indeed, it would appear that the individual fencing of fields has been a direct response to the increased pressure on available grazing resources, and there is no doubt that this has facilitated the considerable diversity in the grazing management system in operation at Guquka. Fencing has allowed animals to roam on the arable lands during the growing season without too much fear of crops being damaged, and has also enabled landowners to control the way in which their fields are used as a forage reserve during the winter months.
By way of contrast, the grazing management system at Koloni was found to follow the generally accepted paradigm with very few exceptions. This adherence to the recognised system would appear to reflect the relatively large amount of individual grazing land that both Koloni and the surrounding villages have available to them compared to villages such as Guquka. This means that the pressure on these grazing resources is not too great. Under these circumstances there is little incentive for livestock production to devolve to the individual level, and this allows grazing management decisions to take place effectively at the communal level. The community can thus afford to entirely exclude animals from the arable land allocations during the summer and manage them strictly as winter grazing reserves.

In documenting the quite different ways in which the grazing management systems at each village have adapted to varying levels of pressure on grazing resources, the research has undoubtedly added much to current knowledge about livestock production practices in communal farming areas of South Africa. Importantly, it has also served to clearly define the social parameters within which recommendations for improving the arable grazing systems at each village could be made.

Having characterised the major social contrasts between the villages, the remaining objectives sought to complete the picture by elucidating the main aspects of the system at the livestock and pasture level. The most ambitious of these aimed to document the behaviour of free-ranging cattle on the arable land allocations at each village, and to estimate the amount of forage they consumed and its nutritional quality. Animal behaviour data were collected during both winter 1998 and 1999, and demonstrated that the behaviour of free-ranging cattle on the arable land allocations differed markedly between villages with regard to the amount of time they allocated to different activities. Animals at Guquka allocated far more time to grazing at the expense of resting than their counterparts at Koloni. This was unsurprising and reflected the very different circumstances under which the animals at each village were able to forage. At Guquka the very real threat of stock theft meant that the majority of owners kraaled their cattle at night for security reasons. This meant that the animals were only able to forage between dawn and dusk, and thus spent the vast majority of the time available to them feeding in order to try and satisfy their intake requirements. In contrast, the greater security at Koloni meant that most animals were
left on the arable land allocations overnight allowing them to feed at all times. Consequently, they were able to allocate a greater proportion of their time to resting during the daytime. The large amount of relatively high quality forage available at Koloni, particularly at the beginning of the winter, would also appear to have had a role to play in this, by allowing cattle to maximise intake rates and thus spend the shortest possible time feeding. This is evidenced by the steady increase in the mean proportion of time which cattle at Koloni allocated to feeding during the course of winter 1999 as the amount of available forage decreased.

Observation data on the time spent feeding in each of the different vegetation categories at each village were also combined with GIS data on the area of each category to calculate a series of preference indices. A preference hierarchy was thus established which was remarkably similar at both villages. Cattle at Koloni expressed greatest preference for crop residues, followed by the commonage grassland vegetation, the low biomass patches of the *Hyparrhenia* grassland, the *Sporobolus-Eragrostis* grassland, the high biomass patches of the *Hyparrhenia* grassland and finally the recent fallow vegetation, which was completely ignored. At Guquka, there was no commonage grassland or low biomass patches of the *Hyparrhenia* grassland on the arable land allocations, but exactly the same order of preference was expressed by cattle with regard to the four remaining vegetation categories. This emphasises the important role played by crop residues in communal areas in cattle maintenance during the winter, and also that some of the recently established vegetation on fallow arable land is of little value in this respect.

Weekly records of the number of livestock present on the arable land allocations also provided some vital insights into the way in which the arable land allocations are utilised at each village. At Guquka, considerable numbers of cattle were recorded free-ranging on the arable land allocations during the summer months. This served to corroborate that the arable lands were indeed being utilised as a forage reserve for cattle throughout the year and provided some indication of the level of utilisation that was occurring. At Koloni, large numbers of cattle were recorded on the main arable land allocation at the beginning of winter 1999. However, by the third week in June the number of animals present in this area had declined sharply. This decline was precipitated by an adjacent watering hole drying up and the subsequent decision by
many cattle owners to move their animals to one of the smaller arable allocations where permanent water was available. This highlighted how the lack of a permanent water source on the main arable land allocation is acting as constraint to its effective utilisation as a grazing resource during the winter.

Estimates of the quantity and nutritional quality of forage ingested by grazing cattle also revealed substantial differences between the villages. Standing biomass and forage quality were higher for almost all vegetation categories at Koloni. This meant that animals at Koloni were able to attain considerably higher rates of intake of dry matter, energy and crude protein than those at Guquka. If these estimated intake values are compared with standard values for animal maintenance then the disparity in cattle intake between the villages becomes clearer. Even when it is assumed that animals had a maximum intake rate of 8.5kg/day, and fed in a completely non-selective manner, intake rates at Koloni were above those required for maintenance during the first half of the winter, although during the second half of the winter there was a shortfall in the requirement for crude protein. By contrast, at Guquka there was a severe shortfall in the requirement for crude protein throughout winter 1999 according to the estimated intake values. These differences were expected and are largely a reflection of the fact that Guquka lies in a sourveld area and Koloni in sweetveld. Importantly, they serve to underline that whilst the major natural constraint to cattle production at Guquka during the winter months is the shortfall in the nutritional quality of the available forage, this was considerably less problematic at Koloni. This has vital implications for the recommendations for improving livestock production from the arable land allocations at each village.

The final objective of the ecological investigation was to assess the potential of summer grazing as a management tool for improving cattle production from the Hyparrhenia grassland that dominated the arable land allocations at each village. It was hypothesised that during the winter cattle grazing summer-grazed sward would be able to attain higher rates of intake than those on ungrazed sward, and also that the sward they consumed would be of a higher nutritional quality than that which had not been summer-grazed. An experiment was undertaken at Koloni during winter 1999 in an attempt to test this. However, the lack of replication of the plots used in the experiment meant that the resulting data could not be used as a definitive test of the
experimental hypotheses. Nevertheless, accepting the inherent weakness of the experimental design, the results from the unreplicated plots were as predicted and are also corroborated by the literature. During winter 1999, cattle grazing the summer grazed plot did at least in the short term appear to attain higher rates of intake of both dry matter and crude protein than those on the ungrazed plot. Thus, although the experiment failed to provide conclusive support for the defined hypotheses, the results do suggest that summer grazing of the arable lands at Koloni is an avenue worthy of further investigation.

Taken together, the findings outlined above have important implications for the final objective of the research. This aimed to develop a series of recommendations for improving cattle production from the arable land allocations at each village, based on the comprehensive overview of the cattle production systems provided by the first four research objectives and augmented by the literature. These are discussed below, beginning with Guquka.

7.3) RECOMMENDED INTERVENTIONS AT GUQUKA

In developing recommendations for Guquka, it is vital that adequate regard is given to the fundamental social inequalities identified at the village. These are likely to impose severe limitations on the effectiveness of development interventions with an agricultural focus in alleviating poverty amongst a broad section of the community. This is particularly true of cattle production which, as outlined above, is focused on a small number of relatively wealthy male-headed households within the village. It must therefore be appreciated that within the current social environment many of the recommendations outlined below are only likely to have a direct impact on the livelihoods of a relatively small section of the community. Other complementary interventions would appear necessary if a genuine improvement in livelihoods is envisaged for the majority of households.

- **Upgrading of the existing system of tenure over arable land.** Given the favourable climate, crop production at Guquka offers potential for uplifting
livedhhoods both through the production of crops such as maize for human consumption and the production of winter forage for cattle. However, it is currently constrained by the highly skewed distribution of land and the lack of secure rights for those who do have access to arable fields. Landless households who might engage in crop production are often unable to get access to land because landowners are unwilling to enter into rental agreements for fear of losing their land. Current informal ownership rights over arable land must be formalised under a recognised tenure system. An adapted form of freehold is envisaged, which will hopefully stimulate a land market and encourage land lending, leasing and sale and allow arable land to find its way into the most productive hands. However, existing forms of freehold (see Appendix 1.1) are not well suited to maintaining agricultural productivity in a communal environment, and it would be necessary to impose several restrictive clauses such that land could only be utilised for agriculture, could not be sub-divided and could only be held by people resident in the village. The ethos of private ownership is already in existence at Guquka, as exemplified by the individual fencing of most fields and the exercising of individual grazing rights within them. The new adapted freehold system would seek to formalise and strengthen this.

The remainder of the recommendations are concerned with overcoming the nutritional shortfall in the forage available to cattle during the winter months and are summarised below.

- **Increased cultivation of summer crops.** If the changes in tenure suggested above are successful in increasing production levels of crops for human consumption then this will also be of considerable benefit to cattle production. Maize residues were the most nutritionally valuable food source available to cattle on the arable lands at Guquka during winter 1999. Moreover, they were the only food type that could allow cattle to meet their requirement for crude protein at this time. The crude calculations in section 5.5 have demonstrated that if the area of land under cultivation at Guquka was increased by threefold over 1999 levels to around 50%, then cattle could theoretically be sustained on the arable land allocations for up to 60 days. Importantly, this would allow cattle to endure the majority of the winter period without loss of condition. This highlights the need
for closer integration of crop and livestock production at Guquka on a communal basis. It is particularly important that this integration attempts to embrace those livestock owners who currently do not have access to arable land.

• **Cultivation of winter forage.** Closer integration of crop and livestock production should also be extended to the cultivation of winter forage crops. For those individuals who do have access to a fenced field and the ability to engage in crop production, the cultivation of winter forage offers one solution to meeting the nutritional shortfall of the natural veld at this time. However, very few individuals currently engage in this activity, due to the general overheads associated with crop production and the increased risk of crop failure due to cultivation taking place much later in the season. It would be more effective if villagers engaged in this undertaking on a group basis. This would allow a far greater area of forage to be cultivated and serve both to minimise costs and share risks between the group. Such a scheme would appear to have popular support, as it was raised independently by several individuals who were interviewed as part of the fieldwork.

• **Use of feed supplements.** Another alternative for meeting the winter deficit in the crude protein intake of cattle at Guquka would be to provide feed supplements. Urea is one cost-effective source of non-protein nitrogen (NPN) available in most developing countries. It is particularly effective when used in conjunction with feed stuffs that are low in nitrogen but high in energy. These include cereal crops, and so there is considerable potential for urea to be used in conjunction with winter forage crops and maize residues. However, the lack of familiarity of communal livestock farmers with feed supplements would require that they were thoroughly trained in their application, as the improper use of urea can result in animals being poisoned as outlined in section 5.5. Thus, realistically this would be an option to be considered in the longer term.

• **Management of grassland on arable land allocations as a winter forage reserve.** In light of the sustained use of the arable land allocations at Guquka by livestock during the summer period, one management alternative with real
potential for improving the available grassland forage during the winter is to control the level of grazing it is subject to. This would require the complete repair of the perimeter fencing surrounding the lower arable land allocation to allow strict control over livestock movements to and from the area. In particular, this would prevent livestock from adjacent communities from trespassing on this area and reducing the winter forage available to animals from Guquka. It would also be advisable to augment this controlled grazing with a periodic regime of burning. In sourveld areas, grazing alone is generally acknowledged to be insufficient to prevent a decline in the quality of natural grassland and burning is a recommended management tool. A regime is thus envisaged in which the sward is burnt at the end of winter and then grazed intensively in the summer once it has recovered (see Figure 5.20). This should be undertaken on a biannual basis to allow the sward to recover to its full productive potential, although during years when it is not burnt it can still be grazed during the subsequent summer to improve quality. Such a regime has considerable potential for improving both the quantity and quality of grassland forage available on the arable lands during the winter. However, it would require co-operation by livestock owners at Guquka and for management responsibility to be taken on board and strictly enforced by a central village body such as the RA. The RA would need to ensure that burning was undertaken at the correct time and that animals were only grazed during the appropriate period. Furthermore, a change in mindset would be required amongst those livestock owners who currently allow their cattle to free-range on the lower arable land allocation during late summer when forage on the range becomes scarce.

7.4) RECOMMENDED INTERVENTIONS AT KOLONI

At Koloni the considerable social bias in holdings of land and livestock that exists at Guquka is not apparent and agriculture thus has greater potential for improving the livelihoods of a broader cross-section of the community. This is particularly true of livestock production, which is not constrained by the same ecological barriers as crop production. Investigating ways of improving the use of the of the arable land allocations as a forage reserve for cattle can thus be justified from both an ecological
and social perspective as a means of promoting improvements in livelihoods at Koloni.

From what has been outlined above it is apparent that the main constraint in improving cattle production from the arable land allocations at Koloni is not so much the shortfall in the nutritional quality of the forage available in these areas during the winter as their inefficient use and management as a winter grazing resource. To this end the following recommendations offer a number of alternatives for addressing this constraint.

- **Upgrading of existing tenure rights over arable land.** An arable tenure system akin to that recommended for Guquka should also be adopted at Koloni. However, given that crop production at Koloni has fairly limited potential for livelihood improvements, the purpose of this change in tenure would not be to try and improve current levels of cultivation. Rather, its envisaged role is essentially twofold. First, and perhaps most importantly, the adoption of adapted freehold would allow for the conversion of unproductive arable land to other uses. There are many fields at Koloni that are held by households who no longer reside at the village. Indeed, some of these fields have not been cultivated for several decades. Under the adapted freehold system, these fields would become the property of the state and would become available for reallocation through the RA. This would enable all remaining land ownership on the small arable land allocation encompassing fields 92-96 and 106-112 (see Figure 4.8) to be transferred to the main arable land allocation. This small allocation could then be used as a permanent extension of the adjacent range camp and thus as a means of improving livestock production at the village.

The second major goal of these tenure changes would be to make land rights more secure for households with communal title. Although the majority of landowners at Koloni have access to their fields through secure quitrent title, residents from the new section of the village only have communal title. Several of these households do, however have access to arable land on an informal basis, either by a sharecropping or rental agreement with a quitrent household, or by utilising a field belonging to a household that is no longer resident in the village. There are
sufficient unutilised fields on the main arable land allocation for most residents in the communal section of the village to have secure access to arable land under adapted freehold even after the title of several fields from the smaller allocation had been transferred. However, given the intense bureaucracy that currently plagues land claims in communal areas of South Africa, these envisaged changes in land use and field ownership patterns can only realistically be considered as long-term alternatives.

In the shorter term, there are also a number of management options that are likely to have a more immediate impact on cattle production from the arable land allocations.

- **Construction of a watering hole on the main arable land allocation.** The lack of a permanent source of water on the main arable land allocation was identified as one of the key factors preventing the effective use of available grazing resources at Koloni during the winter. At present, during the winter the majority of free-ranging cattle drink at the pond to north of the arable lands, adjacent to the main road. This is prone to drying up at this time and many owners actively relocate their animals either to the range camps or to one of the smaller arable land allocations where permanent water is available. This results in uneven pressure on the available grazing resources. The construction of a stock dam within the boundaries of the main arable land allocation would overcome this problem. Not only would it enable cattle to make continuous use of the considerable amount of forage available on the main arable land allocation during the winter, but it would also allow access to the range camps to be restricted at this time. A single camp could be left open during the winter for small-stock and sickly or vulnerable cattle and the remaining camps could be closed. The closure of these camps would provide them with an important respite from grazing during the winter months and put them in a better position to recover rapidly during the following spring. The most important factor in the construction of the dam would be to ensure that it was sited in a position that would allow it to receive an adequate supply of surface water run off and thus prevent it from drying out during the winter. Efforts must also be made to try and site the dam in one of the less accessible areas of the main allocation, in order to try and encourage more uniform utilisation of the available forage.
• **Control of invasive weed and bush species.** The *Hyparrhenia* grassland to the east of the central erosion donga on the main arable land allocation supports substantial quantities of unpalatable forb and grass species. These include the woody, aromatic herb *Helichrysum argyrophyllum* and turpentine grasses of the genus *Cymbopogon*. It is speculated that the widespread occurrence of these species in this area of the *Hyparrhenia* grassland has been facilitated by the relative lack of grazing pressure in this area. One way of reducing the level of these species would be to increase the grazing pressure within this area. The siting of the watering dam here would achieve this both by encouraging more cattle to graze around the dam and by increasing the total number of cattle that could be maintained exclusively on the main arable land allocation during the winter. The periodic burning of the vegetation on the main arable land allocation would also help to control the spread of these unpalatable species, as they tend to recover less quickly from the effects of fire than palatable species. Although burning is not recommended as a management tool in sweetveld areas, the fact that the arable lands are not currently grazed during the summer period and thus accumulate moribund material makes this justifiable. However, it should only be undertaken infrequently to allow palatable species sufficient time to recover. It is thus recommended that burning be undertaken every three years at the end of the winter. Burning might also assist in controlling the large amounts of bush which are found in the *Hyparrhenia* grassland. These bush species have a tendency to suppress the growth of the grass sward around them, which has negative implications for production from grazing livestock such as cattle. It would thus be beneficial to control the level of bush invasion. Burning has been shown to be most effective in this respect when it is undertaken in conjunction with the intensive browsing of regrowth by goats and particularly when augmented by the selective felling of larger trees. These can then be used as firewood and kraal material. A management programme is thus recommended involving the annual felling of bushes above 1.8m in height at the beginning of the winter, followed by the intensive grazing of the regrowth by all goats available at the village.
• **Summer grazing.** Another alternative for reducing the amount of moribund material in the high biomass patches of the *Hyparrhaenia* grassland is summer grazing. At a sweetveld site such as Koloni, summer grazing might prove an effective alternative to burning if it can be undertaken in a sufficiently controlled manner and with the correct timing and intensity. However, due to the inconclusive nature of the preliminary assessment of summer grazing at Koloni it cannot currently be recommended as an effective management option. Rather, it is recommended that a more thorough investigation is undertaken regarding the effectiveness of summer grazing in this role.

### 7.5) **RECOMMENDATIONS FOR FURTHER WORK AT THE RESEARCH VILLAGES**

The desire to make more effective use of available arable land for livestock production was expressed by villagers at both research sites through a series of rural appraisal sessions conducted by ARDRI staff members during 1995. Given the current dearth of knowledge in this area, the research was initiated to provide baseline information about the use livestock currently make of the arable land allocations at each village. This information was to then act as the foundation for the development of a series of interventions for improving interactions between livestock and arable land. It was hoped that these would not only to be site-specific, but also to act as a foundation for agricultural-based development interventions the central Eastern Cape region as a whole. In doing this, the research has effectively fulfilled the objectives outlined in Section 1.5.3.

However, part of the longer-term commitment to the development process on the part of ARDRI must be to encourage the implementation of at least some of the management recommendations that the research has developed. The next stage would therefore be for ARDRI to present the recommendations in their entirety to each village and allow the villagers to identify which of them they would most like to see implemented. Efforts could then be made to gradually incorporate the required changes into the livestock production systems at each village. It must, however, be
accepted that where recommendations involve changes in tenure and the reallocation of sections of arable land, the process will require careful consultation with local government and will inevitably be long term. In contrast, the introduction of management techniques for improving the available forage on the arable lands could take place in the shorter term provided adequate technical support and guidance is made available to each community. However, it might be advisable for some of the less proven management options to be adopted on a trial basis at first. For example, at Koloni one of the smaller sections of arable land could be used to investigate the effectiveness of fire in reducing the level of unpalatable forb and grass species in the sward before introducing this as a standard technique for management of the grassland on the main arable land allocation. The use of fire for grassland management in sweetveld areas is not a proven management technique and an appropriate degree of caution must therefore be recommended before its general adoption. Likewise, the summer grazing of the Hyparrhenia sward as a technique for improving the quality of the winter sward at Koloni also requires more thorough testing before it can be adopted as a standard management tool at the village.

For these management recommendations to have any chance of being effectively implemented at each village there will need to be a long-term commitment by a coordinating body such as ARDRI in each village, and the close co-operation of local government and possibly non-governmental organisations. Only under these conditions will it be possible to achieve a sustainable improvement in rural livelihoods that might serve as an example of what can be achieved in the central Eastern Cape region as a whole.
7.6) **THE BROADER PICTURE: IMPLICATIONS OF THE WORK FOR RESEARCH METHODS AND POLICY DEVELOPMENT**

In addition to the specific recommendations developed for each village, the research has a number of important wider implications for development researchers, practitioners and policy makers both within South Africa and beyond.

7.6.1) **IMPLICATIONS FOR RESEARCH METHODOLOGY**

First, at a research level, the methodology adopted for the PhD has served to underline the need for an holistic approach to development research. Too often in academia there is a lack of communication between researchers from different disciplines. This can compromise the effectiveness of the recommendations resulting from research projects. In the case of this research, the method adopted was unusual in that the researcher was simultaneously obliged to be both social and natural scientist throughout the fieldwork period. The combination of natural and social science allowed realistic and meaningful recommendations for improving the management of the arable land allocations as a forage reserve to be derived for each of the villages. The message for research work of this nature is clear. A multi-disciplinary approach, be it by a single individual or a group of individuals from different disciplines, is vital if development needs are to be adequately identified and met.

The research also holds some valuable lessons for development practitioners both at the regional and national level. Possibly the most important is that interventions must be carefully tailored to the ecological and social realities of the local environment if they are to be effective in alleviating poverty. Indeed, the lack of an adequate poverty focus within livestock-based development projects has been highlighted as a major failing worldwide (Livestock in Development, 1998). One of the key lessons from the case studies at Guquka and Koloni is that considerable differences in social structure exist between villages particularly with regard to access to arable land and ownership of livestock. Thus, the actual livelihood benefits that might result from the implementation of these management recommendations will differ greatly between
villages according to the degree of bias in holdings of stock and land. An initial
indication of the extent of such biases can be achieved through a simple analysis of
the relationship between social variables such as gender, age and household income
and access to resources such as land and livestock, as was undertaken at both Guquka
and Koloni. This will allow those social groupings most likely to be benefit from a
particular set of interventions to be identified and thus a realistic assessment made of
whether the interventions are likely to have an effective pro-poor focus as current
development policy recommends. It is therefore important that these management
recommendations are not viewed by regional development planners as a panacea for
improving rural livelihoods in the central Eastern Cape, despite the general suitability
of the region to interventions of this nature. Rather the potential of such interventions
will have to be assessed on a village by village basis to ensure that they benefit as
broad a cross section of the community as possible. These considerations apply not
only to villages in the Eastern Cape but also to other areas of South Africa where
development interventions with a cattle-focus are being attempted.

7.6.2) IMPLICATIONS FOR DEVELOPMENT POLICY

AGRICULTURE AS A LIVELIHOOD

The research work also has some important broader implications for development
policy in South Africa. The national government has committed itself to rebuilding a
limited African peasantry centred particularly on former homeland areas with the dual
objectives both of making these areas less reliant on food imports from outside and
alleviating the frequently desperate poverty that afflicts them. However, in light of
the research findings it is important to question if this commitment is realistic. Is the
government’s vision of small-scale agriculture compatible with what emerges from
the two case studies? Can a substantial peasant farming class ever remerge in former
homeland areas and compete effectively under current market conditions? Whilst it is
unlikely that the halcyon days of peasant production in the late nineteenth and early
twentieth century are ever likely to remerge, the case studies suggest that agriculture,
and livestock production in particular, does have potential in the central Eastern Cape
region for making a greater contribution to rural livelihoods. The management
recommendations developed for Guquka and Koloni are intended to be generic and have the potential for fairly widespread application in communal cattle production systems in the central Eastern Cape region. However, the livelihood improvements these recommendations are intended to produce, are premised on using available grazing resources more effectively to support a limited number of additional animals. Thus, in isolation such interventions can only ever be considered as a short-term solution to poverty alleviation. Ultimately there is a need to look beyond just facilitating increases in cattle numbers as a mechanism for uplifting rural livelihoods. Such livelihood improvements will also depend on a number of vital reforms being enacted at the broader level. Many of these have been highlighted by the case studies themselves. They are discussed in turn below.

- **Livestock extension services.**
Since the amalgamation of the former homelands with the South African Republic, the quality of livestock extension services provided by the local agricultural departments has generally deteriorated. This seems particularly true of the former Ciskei. At Koloni, for example, many residents no longer have a positive perception of the Agricultural Department. Until relatively recently Agricultural Technicians (ATs) from the Department used to visit the village regularly but this no longer occurs. Indeed, the villagers do not even know the name of the AT assigned to Koloni. This deterioration in service is largely a result of shortages in trained personnel illustrated by the fact that in Middledrift District there are only seven available ATs to provide extension services to 58 villages. Such shortages are symptomatic of the general lack of priority accorded to extension by the local Agricultural Department. These problems are widespread in the former homelands and need to be urgently addressed. Livestock extension provides an important platform from which villagers can express their needs and also learn how to manage their animals more effectively. Furthermore, it provides many of the services crucial to promoting the health and productivity of livestock, including dipping and vaccination programmes. In recent years the residents of Koloni have been forced to organise their own livestock dipping programme, involving each livestock owner contributing towards the cost of the exercise. However, if there is to be an effective
commitment to uplifting rural livelihoods in the region, the responsibility for such activities must, in the longer term, lie with local government.

- **Market linkages.**

In communal areas, livestock, particularly cattle, function as a store of wealth, which can be accessed at times of need. However, the monetary potential of these animals cannot be realised unless there is a market for them. It appears that in many cases the lack of effective market linkages is compromising the potential of cattle for improving rural livelihoods. Certainly, with regard to the two case studies, the market for cattle at the village level seems to be limited. This would suggest that effective linkages would need to be established with markets in urban areas such as East London if cattle are to realise their cash potential. Koloni provides an interesting example of how this might occur. During the course of the fieldwork, white farmers sporadically visited the village and purchased small-stock from some of the key livestock owners in the village. Such an arrangement could be formalised into a series of regular visits, which included purchase of cattle as well. Alternatively, given sufficient demand, it might be more beneficial for the government to provide transport to local markets as this would cut out the middle-men and allow livestock owners to realise greater prices for their animals. Perhaps in the longer term consideration might even be given to a roving livestock market, which periodically visits areas with good potential for sales, thereby eliminating transportation costs altogether.

The Koloni example highlights two important points. First, that a market for livestock of sufficient quality does exist in communal areas. Second, that more research is required on current levels of cash sales of livestock by owners in communal areas and if these could be improved by more effective linkages with local markets. This would provide an empirical basis for assessing the demand amongst communal livestock owners for improved market linkages and the most effective way of providing these. Koloni provides an excellent example of a village in which to undertake a baseline survey of this nature.
• **Institutions and governance structures.**
The reform of institutions associated with resource management and control will also be essential if poverty is to be effectively tackled in rural South Africa. At the community level institutional bias can compromise the ability of many sectors of the community to engage effectively in agriculture. At Guquka, for example, the ability to distribute and manage resources in an egalitarian manner is severely compromised by political control lying with individuals from invested, land owning families. This allows landowners to bypass many of the grazing management decisions taken on a communal basis and graze their livestock wherever they wish. They are keen to maintain the current situation, which is to their advantage, but to the detriment of the landless majority who also tend to be the poorest members of the community. If these poor individuals are to stand any chance of improving their livelihoods through agriculture, then such institutional shortcomings must be addressed. A more democratic system of resource management and allocation is required. However, institutional reform will be difficult in an environment where there are such conflicting demands over scarce land resources and protectionist interests are strong. Nevertheless, the potential for change at Guquka certainly exists given that the RA now has a democratically elected chairman who is both proactive and part of the landless majority at the village. It is vital that he reorganises the committees concerned with resource allocation and control to ensure that their dealings are transparent and that their membership adequately represents the full cross-section of social differentiation found at the village. This may help to restore the faith of the landless majority in the structures of governance at the village. This case is indicative of the general requirement in rural South Africa for the reform of local governance structures – what Bernstein (1997) has termed a ‘national democratic revolution’. Without this the effectiveness of local poverty alleviation initiatives will continue to be handicapped by the vested interests of established institutions.

Indeed, the requirement for the reform of institutions associated with land and agriculture in South Africa traverses just the local level. If a commitment to pro-poor development is to be effectively expressed at a national level, then the reform of such institutions at the state level will also be essential. The merging of the Departments of Agriculture and Land Affairs in the late 1990s was a step forward in this respect. The Department of Agriculture had historically been oriented entirely towards large-scale,
commercial farming and its amalgamation with Land Affairs acknowledged the government’s commitment to land reform and the emergence of a number of smaller scale farmers. However, more specific reforms have been less forthcoming. The Rural Development Framework of 1997, despite a strong commitment to poverty reduction in rural areas, was generally devoid of targets or timescales for achieving this. Likewise, the shelving of the proposed Land Rights Bill in 1999 and the subsequent failure to provide an adequate alternative also reflects the lack of cohesion and direction in recent government policy on land reform and development. The lack of co-ordination in pro-poor thinking within government institutions needs to be urgently dealt with. In so doing it is important to recognise that institutional reform is not just the responsibility of the South African government itself but also of the international community. Donor countries have a vital role to play in providing expertise and implementing programmes in which institutional constraints are addressed. In this regard it promising to see that a considerable portion of the money allocated by the UK to programmes in South Africa has been earmarked for the development and restructuring of institutional capacity (DFID, 1998).

- **Security and reform of land tenure.**
Reform of common property institutions at the local level will be of little meaning if the grazing resources they govern cannot be defined and controlled effectively. One of the premises of effective communal livestock production is strict control over the grazing resource and the individuals whose animals have access to it. Without this the resource tends to be utilised more on an ‘open access’ than a communal basis and in such an environment there is a tendency for any attempts at effective livestock production to devolve to the individual level. This is exemplified by the situation at Guquka. Here rangeland is officially shared with the neighbouring village of Gilton, and unofficially with the adjacent township of Kayalethu. This puts considerable pressure on a resource that is neither extensive nor particularly productive under the best circumstances. Furthermore, Guquka’s arable land, which functions as an extension to the range during the winter, is persistently grazed by livestock from Kayalethu. In such a competitive environment effective control over the community’s grazing resources is very difficult and many livestock owners from Guquka choose to maintain their livestock within fenced fields for all or part of the year. For those
livestock owners without access to fenced fields, animal productivity from such an intensively grazed commons is minimal even during the summer months. Defining and controlling grazing resources is very difficult in such an environment. Steps in the right direction were taken in winter 1999, when the community repaired the fence between Kayalethu and Guquka’s lower arable land allocation. This will at least secure exclusive community grazing rights on one area of land at the village. However, in the longer term, the only effective solution to the problem will be access to a formalised area of grazing land for livestock from Kayalethu (see below).

The reform of the type of tenure under which land is held in former homelands is also an issue, which must be addressed. There are several different systems in place, most of which, in their current mode of operation, appear to act as a disincentive to effective land use. This is underlined by examples from both case study villages. At Koloni the complicated quitrent system seems to be acting as a barrier to effective land exchange. At Guquka the communal tenure system in place does not adequately define ownership rights for the arable fields. This lack of security makes current owners unwilling to engage in sharecropping or rental activities thereby discouraging agricultural production. Clearly, there is a requirement for a simplified system of tenure in these areas, which provides unambiguous user rights and, perhaps more importantly, allows the exchange of arable land to take place independently of residential land. The South African government must heed the message provided by these examples and develop a modern, flexible system of land tenure for these former homeland areas, which provides security and allows land exchange to proceed in a swift and effective manner. The adapted freehold system proposed for the two case villages, might provide a useful starting point.

- **Access to additional grazing land.**
Proponents of both equilibrial and non-equilibrial grazing dynamics must accept that ultimately there is a limit to the number of free-ranging livestock that can be maintained on a limited amount of grazing land. Given that for black South Africans livelihood improvements derived from livestock (particularly cattle) are related above all to increase in numbers, the availability of grazing land must ultimately be considered as the single most important factor limiting the potential of cattle
production for improving livelihoods. This is particularly true of former homeland areas. The number of people in these areas has increased dramatically during the past few decades both through forced removals and natural increases, but in the majority of cases grazing land has remained at a premium. This is a trend that is unlikely to be reversed in the near future. In the shorter term more effective use of grazing resources, particularly the arable land allocations, as well as improving livestock support services, linkages with markets and institutional structures may create additional livelihoods and/or improve existing livelihoods through cattle production. However, it must be accepted that under conditions of increasing population, these improvements will not be sustainable in the longer term unless more land becomes available. In instances where it is possible for communities to appropriate additional land, as part of viable strategy of livestock production, then this should be encouraged. The mechanisms of Land Restitution and Redistribution, introduced through the Land Reform Programme, have opened many avenues in this respect. However, in former homeland areas there is often no additional land to appropriate and simply subdividing that which already exists would inevitably compromise livestock productivity. It must therefore be accepted that for the majority of communities in already over-crowded areas such as the former Ciskei, access to additional grazing land is unlikely to ever be a possibility. It is vital that this limitation be recognised in regional and national development policy. Under constraints of limited grazing resources not all households within a community will be able to make an effective livelihood from cattle production or even be able to depend on it as part of their livelihood stream. Rather, a government policy that both recognises and encourages social stratification must be embraced in former homeland areas. This will depend fundamentally on providing livelihood alternatives beyond just cattle production and agriculture in general, and is discussed in more detail below.

ALTERNATIVE LIVELIHOODS

In considering some of the wider implications of this research for South African development policy, is also essential to step back from land reform and agriculture and consider the potential of other livelihood alternatives. Although agriculture will inevitably play an important role in improving rural livelihoods it must be recognised
that not everybody in rural areas can be, or indeed wants to be, a farmer. Given the
generally very limited amount of land available to blacks in former homeland areas it
is not possible for all members of a community to make an effective living out of
agriculture. The widespread proletarianisation that has occurred in the former
homelands, particularly Ciskei, must be acknowledged and used as the basis of a
cohesive policy of job creation, at the local level, for rural blacks.

The reconstruction of the small towns will have a crucial role to play in this. In
particular, the revitalisation of manufacturing in the local urban economy will provide
an opportunity for job creation as well as meeting the consumption demands of
inhabitants both within these settlements and surrounding rural areas. Considerable
potential exists within these towns for the substitution of imports by local alternatives
and many of these possibilities lend themselves to small business activities (Dewar,
1994). One development model that would seem to have particular potential in this
respect is that of Local Economic Development (LED). Although the concept of
LED defies rigid definition, it encompasses a range of strategies founded in
endogenous or bottom-up development (Nel, 2000). In South Africa initiatives of this
type within rural areas have tended to be community-based. For example, in Kei
Road, a small town in the Eastern Cape, a church-led initiative in the community
resulted in a number of self-employment opportunities being developed through
brick-making, bulk buying and house construction. Likewise, in the coastal town of
Stillbaai in the Western Cape, the formation of a partnership between the local
business community, tourism authorities and local government has resulted in an
effective tourism-based development strategy, which has virtually eliminated
unemployment in the town (Nel, 2000). However, despite these successes application
of the LED concept is limited in many localities by fundamental constraints such as a
shortage of skills amongst local people. This emphasises the need for adequate social
as well as economic reconstruction amongst communities in rural areas. Many black
people in these areas have little education or formal training. This is particularly true
of those who schooled during the 1970s and 1980s, the so-called ‘lost generation’,
whose education was badly disrupted by the political upheaval during this period.
Training programmes that develop marketable skills as well as encourage
entrepreneurial qualities will be vital if these people are to contribute to the local
economy. It is only through the effective integration of social and economic
reconstruction in rural areas of South Africa, that black people will be provided with sustainable livelihood options at the local level, beyond just subsistence agriculture.

Indeed, it is likely that the provision of employment opportunities at the local level will also lead indirectly to an improvement in the potential of communal agriculture for providing sustainable livelihoods in former homeland areas. As more people from rural villages find employment opportunities in the local area, their interest in traditional pursuits such as cattle production is likely to decrease. This is particularly true for those with higher incomes. At Koloni for example, there were several relatively young teachers who had no interest or time for agriculture of any kind, although they did envisage investing in cattle at a later stage as security for their retirement. A movement away from agriculture by those with gainful employment would leave the remainder of the population (typically the elderly and those with no marketable skills) to engage in full-time agriculture. The potential of these individuals for making a decent livelihood from agriculture will be enhanced by the greater amount of land now available to them. This is particularly true of livestock production, as there would be less pressure on available grazing land, which would allow individuals to increase herd sizes and animal productivity. Thus, a scenario is envisaged in which the provision of jobs at the local level allows the emergence of full-time class of peasant farmers in former homeland areas. These farmers will be able to meet much of the local demand for agricultural produce as well as providing for themselves. In essence this is reminiscent of the social scenario that existed in the late nineteenth century, which ‘betterment’ in its original form sought at least partially to recreate, before it was compromised by the political ideals of apartheid.

In sum, therefore, there is clearly a role for small-scale agriculture in uplifting rural livelihoods in South Africa. Cattle production has been highlighted as one agricultural pursuit with particular potential for improving livelihoods in the central Eastern Cape region. However, it is vital that the South African Government does not view small-scale agriculture as a panacea in this respect. There is neither the land nor the necessary skills for all poor blacks to engage in agriculture. If there is to be a widespread and effective approach to tackling rural poverty in South Africa, agricultural initiatives must be complemented by the development of a variety of local employment opportunities.
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APPENDICES
APPENDIX 1: THE DIFFERENT TENURE TYPES IN THE FORMER CISKEI

In the former Ciskei four main types of land tenure were allocated to Africans, namely freehold tenure, quitrent tenure, communal tenure and trust tenure (De Wet, 1987b). The following provides an overview of the key features of each tenure type as they were originally laid down and perpetuated under minority government rule.

MAIN FEATURES OF DIFFERENT TENURE TYPES

Freehold tenure: Grants of freehold land to Africans in the former Ciskei began in the 1850s. They were however, fairly limited and mostly concentrated in the magisterial district of Keiskammahoek (Cokwana, 1988). Under freehold an individual owned the land they had title to. The owner had considerable security of tenure in that they did not have to occupy or use the land in order to retain it. Furthermore, the local authority had no jurisdiction over how the land was utilised and owners were free to establish houses, fields and grazing areas as they liked (De Wet, 1987b). However, nobody other than the grantee and his immediate family were allowed to reside on the land without government permission which made non-agricultural use or development of the land very difficult. If this occurred without ministerial permission then the land could be subject to forfeiture (Cokwana, 1988).

Freehold land was acquired through purchase or inheritance. However, unlike freehold held by Europeans, that held by Africans could not be alienated by sale, lease or any other manner without state approval (Cokwana, 1988). Furthermore, even if approved by the state, sale was only possible to another African (De Wet, 1987b). In practice very little land changed hands through purchase, as in most areas no new lots became available after initial freehold allocations were made (Mills and Wilson, 1952). Thus, inheritance was effectively the only means by which transfer of freehold land took place. This occurred either by an owner willing it to a person of their choice or more commonly through customary inheritance procedures. Customary inheritance was patrilineal in nature and was the more accepted form of inheritance.
Land passed from the deceased to the eldest son or where there were no male sons, to the highest-ranking collateral male kinsman. The practical effect of this was that land was not sub-divided and women were excluded altogether from inheritance (Mills and Wilson, 1952).

Since democracy in 1994, legislation has been enacted which lifts the previous restrictions on African freehold land in terms of how it is used and to whom it can be sold such that it is now on a par with European freehold (Republic of South Africa, 1997b). Thus, in relation to other tenure types pertaining in the former Ciskei (see below) freehold offers a great deal of flexibility and security.

**Quitrent tenure:** Like freehold, quitrent was a form of individual tenure. However, land was not held outright, but held subject to an annual quitrent payment to the local authority. In the former Ciskei this amounted to one Rand per arable allotment and twenty-five cents per residential site (De Wet, 1987b). Quitrent is common in surveyed locations in certain districts of the former Ciskei. Original titles were issued between 1849 and 1879 and incorporated few restrictions. However, with the issue of new titles restrictions became more extensive and the situation became confused. This was due both to lack of uniformity of title conditions and the failure in many cases to register transfers of land. The conditions under which all quitrent titles in the former Ciskei were held until democracy, were governed by the Bantu Areas Land Regulations Act of 1969 (Cokwana, 1988).

Under quitrent individuals had access to land demarcated for residential, arable and grazing purposes. It was possible to sell land to another individual, although officially an individual could hold only one lot. Nevertheless, it was possible for an individual to purchase additional lots of land on behalf of their minor sons (those who did not stand to inherit their father's field upon his death) and historically this often occurred (Mills and Wilson, 1952). However, all purchases of quitrent land had to be sanctioned by the local magistrate (De Wet, 1987b). The more usual method of land transfer was through inheritance. Quitrent allotments could not be sub-divided and had to be transferred through the male line. On the death of a landowner his widow was entitled to occupy the land, although no official transfer took place until her
death, at which point it passed to the eldest son. Where there were no sons it passes to the nearest male kin (Mills and Wilson, 1952).

By law, tenure could be revoked if an individual failed to pay quitrent dues or if the land had been used to secure a debt or mortgage owing to the government (Mills and Wilson, 1952). However, in practice tenure was fairly secure, as the case had first to be referred to the local authority and then to the relevant minister. This was a messy and protracted process and occurred only rarely. In fact like freehold, quitrent tenure could be maintained even when individuals had left an area for extended periods as long as payments were continued throughout this time (De Wet, 1987b).

Officially, the conditions of quitrent title still pertain in those areas of the Ciskei where it was introduced and dues should still be paid. However, many owners have defaulted on these conditions, including payment in recent years (particularly since democratic rule) due to lack of enforcement. The system is generally seen as outdated and unwieldy and the Upgrading of Land Tenure Rights Act of 1991, made provision for holders of quitrent title to convert to freehold without charge (Government of South Africa, 1991).

Communal tenure: Communal tenure or Permission To Occupy (PTO) is the most ubiquitous type of tenure found in the former Ciskei. Indeed, from the latter part of the nineteenth century onwards PTO was the only system under which new allotments were allocated. It functioned under the general principal that a member of a community has rights to residential, arable and grazing land in an area by virtue of being a member of the community (De Wet, 1987b). As with quitrent individuals (men) could only have rights to one residential and arable allotment. Furthermore, they did not legally own their residential or arable allotments but rather they were the property of the state. Individuals thus had rights of occupation rather than ownership (De Wet, 1987b).

PTO allotments could not be acquired through purchase. However, transfer of allotments was possible between villagers. This was only possible whilst the occupier was still alive and had to be approved both by the village headman and the local
magistrate. Transfer was effected by an endorsement on the registration certificate, indicating that the land had been voluntarily and finally surrendered to the recipient who themselves had to be initially landless (Cokwana, 1988). In law an occupier's rights to the arable and residential sites were forfeited on their death i.e. the land reverted to commonage that was reallocated by the headman and his council (Mills and Wilson, 1952). However, in practice reallocation only occurred when a family left the village altogether or an owner died without leaving a direct heir (Mills and Wilson, 1952). The more usual method of land transfer was through family inheritance. This occurred in a patrilineal manner as with quitrent title. A widow was allowed to retain use of her dead husband's field during her lifetime and it then passed to the eldest son upon her death. Rights to grazing upon the commonage were also inherited in this way (Mills and Wilson, 1952).

Under the traditional form of tenure land rights were forfeited if the holder left the village voluntarily or was driven out (Mills and Wilson, 1952). Under colonial rule additional circumstances of forfeiture were introduced such as non-cultivation of arable land for three successive seasons, the non-payment of local taxes and stock theft (Mills and Wilson, 1952; De Wet, 1987a).

Since democracy in 1994, the system has partially disintegrated. At this time land functions were allocated to the national Department of Land Affairs, but officials responsible for the administration of land in former homeland areas remained in the provinces. Thus, the PTO system effectively operated outside the law for a short period. Land functions have since been allocated back to the provinces but there has been considerable disruption in many areas (McIntosh and Vaughan, 1999).

At a national level the government has expressed it's commitment to upholding communal tenure in rural areas (Republic of South Africa, 1997b). However, until recently, little has been forthcoming with regard to the exact conditions of tenure and whether these will continue to be so gender-biased and relatively insecure as the previous system. The Draft Land Rights Bill of 1998 aimed to recognise and protect underlying rights in land and, where constitutional, existing community practices regarding land management and allocation (McIntosh and Vaughan, 1999). However, the government’s change of heart in implementing this legislation means that the
situation with regard to communal tenure remains largely unchanged (Claasens, 2000).

**Trust tenure:** Under the terms of the Native Trust and Land Act of 1936, land owned by whites that fell in the proclaimed "reserve" areas was purchased by the South African Development Trust. Trust land was divided into residential areas, arable plots and the remainder was designated as communal grazing. Legally there is no inheritance in relation to allocations held under Trust tenure but in practice land and residential sites passed from men via their widows to their sons in the same way as PTO allotments (De Wet, 1987b).

The main difference between Trust and communal tenure was the stringent restrictions were originally imposed on holders of Trust land. Individuals were not allowed more than one field and no portion of this could not be share-cropped, subdivided, rented or lent out. If any of these rules were transgressed fields could be forfeited. Forfeiture was also possible if a field lay uncultivated over two successive years or if an allotment holder was more than two years in arrears with payment of tax (Mills and Wilson, 1952). Thus, Trust tenure was the least secure of all the tenure types found in the former Ciskei. It appears that the threat of forfeiture of an allotment was used as a sanction against the misuse of fields and several cases did occur in which people were evicted for non-compliance with regulations regarding cultivation (Mills and Wilson, 1952).

Legislation allowing for upgrading of tenure, means that all land currently held under Trust tenure is eligible to be converted to communal tenure which will hopefully provide owners with more security (Government of South Africa, 1991).
APPENDIX 2.1: LAND TENURE AT GUQUKA

Allotment of residential sites took place under proclamation 116 of 1949. All sites were allotted under the Permission to Occupy (P.T.O) type of tenure. Chief Mqalo of the AmaKhuze Tribal Authority, within which Guquka falls, sanctioned all allotments and certificates were issued from Alice Magistrate's Office from the mid 1960s onwards.

The table below summarises all the certificates that were allocated, including the full name of the individual, the date of the allocation, the size of the allotment and the allotment number.

<table>
<thead>
<tr>
<th>LIST NO.</th>
<th>NAME</th>
<th>DATE OF ALLOCATION</th>
<th>SIZE (morgen)</th>
<th>ALLOTMENT NUMBER</th>
</tr>
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<td>GOSHANE, Jane</td>
<td>2/1/65</td>
<td>1/8</td>
<td>3</td>
</tr>
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APPENDIX 2.2: RAINFALL DATA

APPENDIX 2.2.1: RELIABLE RAINFALL RECORDS FOR PLEASANT VIEW (1930-1968)

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### Reliable Yearly Rainfall Data for Pleasant View (1937-1968)

![Rainfall Data Graph](chart.png)

- The rainfall values range from 405.7 mm to 977.8 mm.
- The graph shows a variation in rainfall across the years, with some years experiencing significantly higher rainfall than others.
- The rainfall data is presented in a line graph, with years on the x-axis and rainfall in mm on the y-axis.
APPENDIX 2.2.2: MONTHLY RECORDED RAINFALL AT GUQUKA (1998-1999)

TOTAL RAINFALL RECORD (1998-99): -

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RAINFALL DURING SUMMER 1998/99: -

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## APPENDIX 2.2.3: RELIABLE RAINFALL DATA FROM MIDDLEDRIFFT (1934-1976)

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<td>438.4</td>
<td></td>
</tr>
<tr>
<td>1967</td>
<td>375.9</td>
<td>467.7</td>
</tr>
<tr>
<td>1968</td>
<td>583</td>
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</tr>
<tr>
<td>1969</td>
<td>367.3</td>
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<td>1970</td>
<td>486.5</td>
<td>479.8</td>
</tr>
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<td>1971</td>
<td>586.7</td>
<td>429.4</td>
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</tr>
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<td>1976</td>
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### STATISTICS FOR YEARLY TOTAL

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<tr>
<td>Standard Error</td>
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</tr>
<tr>
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<tr>
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<tr>
<td>Minimum</td>
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<td>Confidence Level (95%)</td>
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### RELIABLE YEARLY RAINFALL DATA FOR MIDDLEDRIFT (1934-1976)

![Rainfall Data Graph](image-url)
# APPENDIX 2.2.4: MONTHLY RECORDED RAINFALL AT KOLONI (1998-99)

## TOTAL RECORDED RAINFALL (1998-99): -

<table>
<thead>
<tr>
<th>YEAR</th>
<th>MONTH</th>
<th>RAINFALL (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>June</td>
<td>0</td>
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<tr>
<td></td>
<td>July</td>
<td>18</td>
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<tr>
<td></td>
<td>August</td>
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<td></td>
<td>September</td>
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<td>October</td>
<td>53</td>
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<td></td>
<td>November</td>
<td>112</td>
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<tr>
<td></td>
<td>December</td>
<td>125</td>
</tr>
<tr>
<td>1999</td>
<td>January</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td>February</td>
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<tr>
<td></td>
<td>March</td>
<td>114</td>
</tr>
<tr>
<td></td>
<td>April</td>
<td>83</td>
</tr>
<tr>
<td></td>
<td>May</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>June</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>July</td>
<td>96</td>
</tr>
<tr>
<td></td>
<td>August</td>
<td>6</td>
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<tr>
<td></td>
<td>September</td>
<td>30</td>
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<tr>
<td></td>
<td>October</td>
<td>52</td>
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<tr>
<td></td>
<td>November</td>
<td>85</td>
</tr>
<tr>
<td></td>
<td>December</td>
<td>62</td>
</tr>
</tbody>
</table>

## TOTAL RAINFALL DURING 1999: -

<table>
<thead>
<tr>
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<th>MONTH</th>
<th>RAINFALL (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>January</td>
<td>46</td>
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<tr>
<td></td>
<td>February</td>
<td>62</td>
</tr>
<tr>
<td></td>
<td>March</td>
<td>114</td>
</tr>
<tr>
<td></td>
<td>April</td>
<td>83</td>
</tr>
<tr>
<td></td>
<td>May</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>June</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>July</td>
<td>96</td>
</tr>
<tr>
<td></td>
<td>August</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>September</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>October</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td>November</td>
<td>85</td>
</tr>
<tr>
<td></td>
<td>December</td>
<td>62</td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td>661</td>
</tr>
</tbody>
</table>
### SUMMER RAINFALL 1998/99:

<table>
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<tr>
<th>YEAR</th>
<th>MONTH</th>
<th>RAINFALL (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>October</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>November</td>
<td>112</td>
</tr>
<tr>
<td></td>
<td>December</td>
<td>125</td>
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<td></td>
<td>January</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td>February</td>
<td>62</td>
</tr>
<tr>
<td></td>
<td>March</td>
<td>114</td>
</tr>
<tr>
<td></td>
<td>April</td>
<td>83</td>
</tr>
<tr>
<td></td>
<td>May</td>
<td>15</td>
</tr>
<tr>
<td>1999</td>
<td>TOTAL</td>
<td>610</td>
</tr>
</tbody>
</table>
APPENDIX 3.1: CHECKLIST SURVEY REGARDING THE GRAZING AND MANAGEMENT OF LIVESTOCK

1). **Access to arable land.**
Must determine if livestock owner:
- has access to their own piece of arable land
  if it is individually fenced and, if so, the main reason(s) for this.

2). **Individual grazing rights.**
Important to identify if individual field owners exercise control over the livestock which graze on their fields particularly during the winter.
Do they reserve their fields for their own livestock?
How are the field owners able to control when and which animals move onto their fields and prevent any others from being there?
Is this effective? Is encroachment of unwanted animals a problem?

3). **The commencement of grazing on arable land.**
Need to identify:
- when livestock are likely to begin grazing on arable land;
  if this is the same every season;
  why livestock were grazing on fields earlier this season (particularly at Guquka).

4). **Criteria involved in commencement of arable grazing.**
Need to identify:
- the factors of importance in the decision to begin grazing arable land;
  the individuals involved in this decision making process.

5). **Livestock involved in arable grazing.**
Need to identify:
- if all species are found grazing on arable lands;
  if there is a propensity for one particular species to spend more time on arable land than the others.
  approximate numbers or proportions of animals found on arable land during the winter

6). **Kraaling of livestock.**
It will be important to identify:
- if the livestock are kraaled during the evening;
  if so, the approximate timing of the animals being led from and back to the kraal;
  if this is the same for all livestock and at all times of the year.
7). Livestock movements.  
Important to determine: - 
if livestock are free to move between the range camps and arable fields during the 
winter period or if their movements the result of active management decisions on the 
part of the owners; 
if this is the same at all times of the winter and for all livestock species; 
Must identify all access points to arable lands particularly those linking arable land 
and rangeland.

8). Livestock grazing preferences.  
if the livestock tend to have a preference for arable or range areas during the winter 
i.e. where do they spend the bulk of their time?; 
if livestock tend to graze in any particular areas of the arable land e.g. along fence 
lines, pathways or in low-lying riverine/donga areas; 
if owners know of any preference livestock show for particular types of fallow e.g.: - 
fresh crop residues (explain if necessary) 
fields dominated by weeds 
fields dominated by grasses 
fields containing plenty of bushes 
Try to relate these preferences to different livestock species.

9). Natural limitations on livestock grazing.  
Are there any natural restrictions on the ability of livestock to graze e.g. :- 
distance to water being too great to allow grazing of certain fields - is this a problem 
in the winter months? 
topography -dongas or steep inclines preventing certain livestock from gaining access 
to some fields? 
Need to identify position of water dams. Are there any in the arable areas?

10). Supervision of livestock during grazing.  
Must determine if anybody watches over animals whilst they are grazing. 
What are the duties involved? Try to relate this to the responses from question 9.
APPENDIX 3.2: SEMI-STRUCTURED INTERVIEW SCHEDULE
FOR CHARACTERISATION OF LIVESTOCK PRODUCTION
PRACTICES AT KOLONI AND GUQUKA

Begin by establishing exactly how many cattle, sheep, goats and horses the individual currently owns.

Then, for each species owned ask the following questions :-

1. Where did your animals spend the majority of the winter period (June - September) last year?
   
   I) Range camps  
   ii) Arable fields  
   iii) Within village boundaries

Then for each area identified must establish :-

• when exactly they were put there

• if they spent the whole of the winter period in that one place or were they free to move (e.g. between arable lands and camps)

• if the animals spent the majority of their time on the range camps what was the main factor underlying the decision to keep them here rather than on the arable fields as is the normal practice? Is this a regular practice? If not explore factors influencing the decision?

• if they spent time on the arable lands which particular allocation?
• if the individual grazed their livestock on arable fields whether this was part of the general communal grazing or if they were grazed exclusively on one particular field at any time

If individual practised exclusive grazing rights then consider using them as a case study (see checklist A)

2. Were any of your animals kralled on a regular basis over the winter period?
Identify:-
• which ones

• how regularly

• why

3. Did you lose any livestock during the winter months?
Identify:-
• where

• how (of particular concern here is death due to insufficient forage)

4. Did you grow a forage crop during last winter or do you intend to during winter 1999?
If yes, use as case study (refer to checklist B)
If no:-
Have they ever grown a forage crop?
If no establish main factors discouraging them.

If yes, why do they no longer plant?

Would they ever consider planting a forage crop again and under what circumstances?

5. Where have your animals spent the summer months?
For each species owned check with regard to :-
• Range camps (try to identify exactly where)

• Village area
• Arable fields

If it established that livestock have been actively maintained on arable land during summer then consider using individual as a case study (refer to checklist C).

6. Where any of your livestock kralled during the summer months?
Identify:-
• which ones

• how regularly

why [relate to responses from question 5 (especially if case study conducted)]

7. Responsibility for cattle production practices

Which individual is responsible for management decisions with regard to the following factors (if it is not the head of household who is making these decisions then must establish which individual is, their relationship to the head of the household and why they are making these decisions) :-

• where they are grazed and when

• when animals are slaughtered or sold

• how animal products are used i.e. within household or sold

• how income from the sale of meat or milk is spent

CASE STUDIES : CHECKLIST OF KEY POINTS WHICH MUST BE COVERED WITH REGARD TO UNUSUAL PRODUCTION PRACTICES
A: EXCLUSIVE WINTER GRAZING RIGHTS ON ARABLE FIELDS

Must identify the following factors :-

- which animals involved and why
- which field(s) was involved
- which individuals were involved in the practice i.e. was it exclusively the owner of a particular field reserving the field for his own animals or where others involved?
- age of fallow vegetation utilised
- how exclusive grazing rights were maintained e.g. by using a completely fenced field and limiting access to selected animals
- if exclusive grazing rights were maintained on field throughout winter
- when (at what stage of the winter) this was undertaken
- why this particular practice was undertaken
- if this is a regular practice - will the individual be involved with this again this year?

B: PLANTING OF WINTER FORAGE

Must establish following factors in course of interview : -

Practicalities:
- what was/is being planted
- time of planting
- where i.e. which fields
- how much (approximately) has been planted
- which animals forage will be used for
- when forage will be used for these animals

What are the most important factors underlying the decision to plant forage?
Must establish if their is a desire for increased production.

Does the individual feel the benefits of planting a winter crop outweigh the input costs?
If yes, how is this realised?

Identify input costs in terms of:-
- cost of seed
- cost of tractor hire
- cost of labour
- other input costs e.g. fertiliser and herbicide

Does the individual experience any trouble with attempted theft or other overt acts of jealousy from other village residents?
If yes, provide details
C: SUMMER GRAZING OF ARABLE FIELDS

Must establish following factors during the course of the interview:-

1. Which field(s) was utilised by the individual

2. If field is owned by individual. If not the access arrangements made
   • name of field owner and residency details
   • connection to individual being interviewed
   • if any form of remuneration in cash or kind was provided to field owner

3. Which animals were put to graze on the fields

4. Under what circumstances were these animals allowed to be kept on the fields during the summer period e.g.:
   • field was securely fenced
   • animals were actively looked after
   • animals ranged free with no supervision
   (question with regard to fields in both upper and lower field allocations)

5. How the grazing system employed operated:
   • continuous
   • periodic

6. The factors which affected this decision
   If grazing was periodic, the location of the animals when not in the arable fields.

7. The main factor(s) motivating the individual to maintain the animals on the arable fields during the winter
   • safety
   • close proximity of animals to village
   • lack of forage on range area

8. If the individual makes use of arable land for summer grazing on a regular basis. The factors influencing whether this is practised or not.

9. If it has always been the case that their livestock have made use of the arable land during the summer.
   If no establish factors which have caused this to come about.

10. If there would be any circumstances under which they would maintain their animals on range areas throughout the summer months.
APPENDIX 3.3: REFERENCE
PHOTOGRAPHS FOR BIOMASS
ASSESSMENT WORK ON ARABLE
LAND ALLOCATIONS
APPENDIX 3.3.1: BIOMASS STANDARDS FOR CLIMAX GRASSLAND AT GUQUKA

1.

2.
APPENDIX 3.3.2: BIOMASS STANDARDS FOR SUCCESSIONAL GRASSLAND AT GUQUKA

1.

2.

3.
APPENDIX 3.3.3: BIOMASS STANDARDS FOR CLIMAX GRASSLAND AT KOLONI

1.

2.

3.
4.

5.
APPENDIX 3.3.4: BIOMASS STANDARDS FOR SUCCESSIONAL GRASSLAND AT KOLONI

1.

2.

3.
4.

5.
APPENDIX 3.3.5: BIOMASS STANDARDS FOR COMMONAGE GRASSLAND AT KOLONI

1.

2.
APPENDIX 3.4: REFERENCE PHOTOGRAPHS FOR BIOMASS ASSESSMENT WORK ON EXPERIMENTAL PLOTS
APPENDIX 3.4.1: BIOMASS STANDARDS FOR CONTROL PLOT AT KOLONI

1.

2.

3.
APPENDIX 3.4.2: BIOMASS STANDARDS FOR TREATMENT PLOT AT KOLONI

1.

2.
# APPENDIX 4.1: INFERENTIAL STATISTICS FROM SECTION 4.2 OF CHAPTER 4

Table 1: values from Chi-squared tests relating gender to access to arable land.

<table>
<thead>
<tr>
<th></th>
<th>GUQUKA</th>
<th>KOLONI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi-square tests</td>
<td>Value df Asymp. Sig. (2-sided)</td>
<td>Value df Asymp. Sig. (2-sided)</td>
</tr>
<tr>
<td>Pearson Chi-square</td>
<td>1.158 1 0.282</td>
<td>0.140 1 0.708</td>
</tr>
<tr>
<td>Continuity correction</td>
<td>0.704 1 0.401</td>
<td>0.000 1 1.000</td>
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<tr>
<td>Likelihood ratio</td>
<td>1.170 1 0.279</td>
<td>0.139 1 0.710</td>
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<tr>
<td>Linear-by-linear association</td>
<td>1.143 1 0.285</td>
<td>0.138 1 0.711</td>
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<tr>
<td>No. of valid cases</td>
<td>78</td>
<td>54</td>
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</table>

Table 2: significance of t-tests relating age and income to access to arable land.

<table>
<thead>
<tr>
<th></th>
<th>GUQUKA AGE</th>
<th>INCOME</th>
<th>KOLONI AGE</th>
<th>INCOME</th>
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</thead>
<tbody>
<tr>
<td>Levene's Test for equality of variances</td>
<td>F</td>
<td>1.000</td>
<td>1.141</td>
<td>0.878</td>
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<td>Significance</td>
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<td>0.320</td>
<td>0.289</td>
<td>0.353</td>
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<td>T-test for equality of means†</td>
<td>t</td>
<td>3.669</td>
<td>1.164</td>
<td>2.097</td>
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<td>df</td>
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<td>76</td>
<td>76</td>
<td>52</td>
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<tr>
<td>Significance (2-tailed)</td>
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<td>0.000**</td>
<td>0.248</td>
<td>0.041*</td>
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†Equal variances assumed for all values
*Significant at the 0.05 level
**Significant at the 0.01 level

Table 3: values from Chi-squared tests relating gender to ability to crop.

<table>
<thead>
<tr>
<th></th>
<th>GUQUKA</th>
<th>KOLONI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi-square tests</td>
<td>Value df Asymp. Sig. (2-sided)</td>
<td>Value df Asymp. Sig. (2-sided)</td>
</tr>
<tr>
<td>Pearson Chi-square</td>
<td>4.399 1 0.036*</td>
<td>1.158 1 0.282</td>
</tr>
<tr>
<td>Continuity correction</td>
<td>2.844 1 0.092</td>
<td>0.479 1 0.489</td>
</tr>
<tr>
<td>Likelihood ratio</td>
<td>4.346 1 0.037*</td>
<td>1.230 1 0.267</td>
</tr>
<tr>
<td>Linear-by-linear association</td>
<td>4.247 1 0.039*</td>
<td>1.132 1 0.287</td>
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<tr>
<td>No. of valid cases</td>
<td>29</td>
<td>45</td>
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</table>

*Significant at the 0.05 level
Table 4: significance of t-tests relating age and income to ability to grow crops.

<table>
<thead>
<tr>
<th>STATISTICS</th>
<th>GUQUKA</th>
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<th>KOLONI</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AGE</td>
<td>INCOME</td>
<td>AGE</td>
<td>INCOME</td>
</tr>
<tr>
<td>Levene's Test for equality</td>
<td>F</td>
<td>1.122</td>
<td>1.026</td>
<td>1.177</td>
</tr>
<tr>
<td>of variances</td>
<td></td>
<td>0.299</td>
<td>0.320</td>
<td>0.284</td>
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<tr>
<td>T-test for equality of</td>
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<td>0.394</td>
<td>0.451</td>
<td>0.316</td>
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<tr>
<td>means †</td>
<td>df</td>
<td>27</td>
<td>27</td>
<td>43</td>
</tr>
<tr>
<td>Significance (2-tailed)</td>
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<td>0.696</td>
<td>0.655</td>
<td>0.753</td>
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</tbody>
</table>

†Equal variances assumed for all values

Table 5: Pearson Chi-squared values for significance of gender in ownership of different livestock species.

<table>
<thead>
<tr>
<th>LIVESTOCK SPECIES</th>
<th>GUQUKA</th>
<th></th>
<th>KOLONI</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Value</td>
<td>df</td>
<td>Asymp. Sig. (2-tailed)</td>
<td>Value</td>
</tr>
<tr>
<td>STOCK</td>
<td>7.191</td>
<td>1</td>
<td>0.007**</td>
<td>4.456</td>
</tr>
<tr>
<td>CATTLE</td>
<td>11.582</td>
<td>1</td>
<td>0.001**</td>
<td>2.244</td>
</tr>
<tr>
<td>SHEEP</td>
<td>3.054</td>
<td>1</td>
<td>0.081</td>
<td>5.610</td>
</tr>
<tr>
<td>GOATS</td>
<td>1.186</td>
<td>1</td>
<td>0.276</td>
<td>4.080</td>
</tr>
</tbody>
</table>

*Significant at the 0.05 level
**Significant at the 0.01 level

Table 6: significance of t-tests relating age of head of household to ownership of livestock.

<table>
<thead>
<tr>
<th>STATISTICS</th>
<th>GUQUKA</th>
<th></th>
<th>KOLONI</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stock</td>
<td>Cattle</td>
<td>Sheep</td>
<td>Goats</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>1.671</td>
<td>0.671</td>
<td>1.616</td>
</tr>
<tr>
<td></td>
<td>Sig.</td>
<td>0.200</td>
<td>0.415</td>
<td>0.208</td>
</tr>
<tr>
<td>T-test for equality of</td>
<td>t</td>
<td>0.517</td>
<td>0.135</td>
<td>1.825</td>
</tr>
<tr>
<td>means †</td>
<td>df</td>
<td>76</td>
<td>76</td>
<td>76</td>
</tr>
<tr>
<td>Sign. (2-tailed)</td>
<td></td>
<td>0.607</td>
<td>0.893</td>
<td>0.072</td>
</tr>
</tbody>
</table>
Table 7: relationship between age of head of household and number of livestock owned.

<table>
<thead>
<tr>
<th></th>
<th>GUQUKA</th>
<th>KOLONI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cattle</td>
<td>Sheep</td>
</tr>
<tr>
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<td>0.776</td>
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<tr>
<td>Significance (2-tailed)</td>
<td>0.135</td>
<td>0.005**</td>
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<tr>
<td>No. of households</td>
<td>26</td>
<td>11</td>
</tr>
</tbody>
</table>

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Table 8: significance of t-tests relating household income to ownership of livestock.

<table>
<thead>
<tr>
<th></th>
<th>GUQUKA</th>
<th>KOLONI</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Stock</td>
<td>Cattle</td>
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<tr>
<td>Levene's test for equality of variances</td>
<td>F</td>
<td>3.250</td>
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<tr>
<td>Sig.</td>
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<td>0.047</td>
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<tr>
<td>T-test for equality of means</td>
<td>t</td>
<td>1.881</td>
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<tr>
<td>df</td>
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<td>76</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>0.064</td>
<td>0.049</td>
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*Relationship significant at 0.05 level

Table 9: relationship between household income and number of livestock owned.

<table>
<thead>
<tr>
<th></th>
<th>GUQUKA</th>
<th>KOLONI</th>
</tr>
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<tbody>
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<td>Cattle</td>
<td>Sheep</td>
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<tr>
<td>Pearson correlation</td>
<td>0.277</td>
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<td>Significance (2-tailed)</td>
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<td>0.932</td>
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<tr>
<td>No. of households</td>
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</table>

** Correlation is significant at the 0.01 level (2-tailed).
APPENDIX 4.2: FAMILY SIZE AND LAND HOLDINGS AT GUQUKA AND KOLONI
**APPENDIX 4.2.1: NUMBER OF HOUSEHOLDS AND NUMBER OF FIELDS PER FAMILY AT GUQUKA**

<table>
<thead>
<tr>
<th>FAMILY NAME</th>
<th>NUMBER OF HOUSEHOLDS</th>
<th>NUMBER OF FIELDS</th>
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</tr>
<tr>
<td>MNONO</td>
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<td>1</td>
</tr>
<tr>
<td>NOBHULA</td>
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<td>1</td>
</tr>
<tr>
<td>TUTHELA</td>
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<td>ALFANI</td>
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<td>0</td>
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<tr>
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<td>0</td>
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<tr>
<td>MARI</td>
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<td>0</td>
</tr>
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<tr>
<td>TOM</td>
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APPENDIX 4.2.2: NUMBER OF HOUSEHOLDS AND NUMBER OF FIELDS PER FAMILY AT KOLONI

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<td>NUMBER OF FIELDS</td>
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<tr>
<td>MANDITHA</td>
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<tr>
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<td>112</td>
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</table>
### APPENDIX 5.1: DISTRIBUTION OF CATTLE IN VEGETATION CATEGORIES AT GUQUKA DURING WINTER 1998 AND 1999

#### Table 1: Observed and expected cattle frequencies in each vegetation category.

<table>
<thead>
<tr>
<th>VEGETATION CATEGORY</th>
<th>WINTER 1998</th>
<th></th>
<th>WINTER 1999</th>
<th></th>
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<tbody>
<tr>
<td></td>
<td>OBSERVED (f)</td>
<td>EXPECTED (f)</td>
<td>OBSERVED (f)</td>
<td>EXPECTED (f)</td>
</tr>
<tr>
<td>CROP RESIDUES</td>
<td>201</td>
<td>109.1</td>
<td>560</td>
<td>178.99</td>
</tr>
<tr>
<td>RECENT FALLOW</td>
<td>130</td>
<td>146.52</td>
<td>98</td>
<td>94.59</td>
</tr>
<tr>
<td><em>SPOROBOLUS-CYNODON</em> GRASSLAND</td>
<td>177</td>
<td>176.52</td>
<td>155</td>
<td>170.05</td>
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<tr>
<td><em>HYPARRHENIA</em> GRASSLAND</td>
<td>583</td>
<td>658.86</td>
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<td>607.37</td>
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<td>1091</td>
<td>1091</td>
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<td>1051</td>
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</table>

#### Table 2: Calculation of G-values from analysis of log ratios.

<table>
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<tr>
<th>VEGETATION CATEGORY</th>
<th>WINTER 1998</th>
<th></th>
<th>WINTER 1999</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RATIO (f/f)</td>
<td>f ln(f/f)</td>
<td>RATIO (f/f)</td>
<td>f ln(f/f)</td>
</tr>
<tr>
<td>CROP RESIDUES</td>
<td>1.84</td>
<td>122.82</td>
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<td>638.74</td>
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<td>RECENT FALLOW</td>
<td>0.89</td>
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<td>1.04</td>
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<tr>
<td><em>SPOROBOLUS-CYNODON</em> GRASSLAND</td>
<td>1.00</td>
<td>0.48</td>
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<tr>
<td><em>HYPARRHENIA</em> GRASSLAND</td>
<td>0.88</td>
<td>-71.31</td>
<td>0.39</td>
<td>-222.97</td>
</tr>
<tr>
<td>TOTAL (lnL)</td>
<td></td>
<td>36.43</td>
<td></td>
<td>404.87</td>
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<tr>
<td>G VALUE (2lnL)</td>
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<td>72.87*</td>
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<td>809.75*</td>
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* Value is highly significant (p<0.001)
APPENDIX 5.2: CALCULATION OF CATTLE INTAKE FIGURES AT GUQUKA DURING WINTER 1999
### INTAKE DATA FROM FIRST HALF OF WINTER 1999.

<table>
<thead>
<tr>
<th>VEGETATION CATEGORY</th>
<th>CODE</th>
<th>PARAMETER</th>
<th>Stalk</th>
<th>Leaf</th>
<th>Sporobolus-Cynodon grassland</th>
<th>Hyparrhenia grassland</th>
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<tr>
<td>A</td>
<td>Initial standing biomass (kg)</td>
<td>20482.51</td>
<td>10599.53</td>
<td>16785.90</td>
<td>72018.90</td>
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<tr>
<td>B</td>
<td>% green</td>
<td>0.00</td>
<td>0.00</td>
<td>32.83§</td>
<td>34.31§</td>
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<tr>
<td>C</td>
<td>% dry</td>
<td>100.00*</td>
<td>100.00*</td>
<td>67.17§</td>
<td>65.69§</td>
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<tr>
<td>D</td>
<td>Available green (kg)</td>
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<td>0.00</td>
<td>5510.81</td>
<td>24709.68</td>
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</tr>
<tr>
<td>E</td>
<td>Available dry (kg)</td>
<td>20482.51</td>
<td>10599.53</td>
<td>11275.09</td>
<td>47309.22</td>
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<tr>
<td>F</td>
<td>Forage removal (kg)</td>
<td>7168.70</td>
<td>6253.60</td>
<td>2786.20</td>
<td>8626.20</td>
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<tr>
<td>G</td>
<td>Utilised green (kg)†</td>
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<td>0.00</td>
<td>914.71</td>
<td>2959.65</td>
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<tr>
<td>H</td>
<td>Utilised dry (kg)§</td>
<td>7168.70</td>
<td>6253.60</td>
<td>1871.49</td>
<td>5666.55</td>
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<tr>
<td>I</td>
<td>Crude protein green (%)</td>
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<td>0.00</td>
<td>3.85§</td>
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<tr>
<td>J</td>
<td>Crude protein dry (%)</td>
<td>7.11*</td>
<td>3.66*</td>
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<td>1.88§</td>
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<tr>
<td>K</td>
<td>Mean number of cattle</td>
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<td>L</td>
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<td>47.00</td>
<td>47.00</td>
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</table>

**A** = [Initial standing biomass (kg/ha) * area of each vegetation category (ha)]  
**D** = [B*A]  
**E** = [C*A]  
**F** = Data from Table 5.11  
**G** = [F*B/100]  
**H** = [F*C/100]  
**K** = Data from Figure 5.4  
**L** = Period between initial and mid-winter sampling  
* Data derived from Powell (1990)  
† Assuming that cattle feed non-selectively i.e. that green and dry material is consumed in proportion to its occurrence in the sward.  
§ Mean of values from initial and mid-winter samples.

### INTAKE/ANIMAL/DAY

<table>
<thead>
<tr>
<th>VEGETATION FRACTION</th>
<th>Dry Matter (kg)†</th>
<th>Crude Protein (g)§</th>
<th>Energy (MJ)§</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residues (stalk)</td>
<td>1.41</td>
<td>100.14</td>
<td>14.55</td>
</tr>
<tr>
<td>Residues (leaf)</td>
<td>1.23</td>
<td>44.97</td>
<td>12.69</td>
</tr>
<tr>
<td><em>Sporobolus-Cynodon</em> (green)</td>
<td>0.18</td>
<td>6.92</td>
<td>1.65</td>
</tr>
<tr>
<td><em>Sporobolus-Cynodon</em> (dry)</td>
<td>0.37</td>
<td>8.68</td>
<td>2.75</td>
</tr>
<tr>
<td><em>Hyparrhenia</em> (green)</td>
<td>0.58</td>
<td>14.07</td>
<td>5.09</td>
</tr>
<tr>
<td><em>Hyparrhenia</em> (dry)</td>
<td>1.11</td>
<td>20.93</td>
<td>9.09</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>4.88</td>
<td>195.71</td>
<td>45.83</td>
</tr>
</tbody>
</table>

1 = (Total dry matter from each category)/K/L  
2 = (Total crude protein from each category)/K/L  
3. For each vegetation category digestible energy (DE) was calculated according to the following equation:  
\[ 1 \text{ kg Total Digestible Nutrients (TDN)} = 18.4096 \text{ MJ DE} \]  
where TDN = (Mass of forage consumed)*(Digestibility of forage consumed)  
[after Bergman et al., 2001]
INTAKE DATA FROM SECOND HALF OF WINTER 1999.

<table>
<thead>
<tr>
<th>CODE</th>
<th>PARAMETER</th>
<th>Stalk</th>
<th>Leaf</th>
<th>Sporobolus-Cynodon grassland</th>
<th>Hyparrhenia grassland</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Initial standing biomass (kg)</td>
<td>0.00</td>
<td>0.00</td>
<td>10394.70</td>
<td>46861.80</td>
</tr>
<tr>
<td>B</td>
<td>% green</td>
<td>0.00</td>
<td>0.00</td>
<td>19.33†</td>
<td>21.53†</td>
</tr>
<tr>
<td>C</td>
<td>% dry</td>
<td>100.00</td>
<td>100.00</td>
<td>80.67†</td>
<td>78.47†</td>
</tr>
<tr>
<td>D</td>
<td>Available green (kg)</td>
<td>0.00</td>
<td>0.00</td>
<td>2009.30</td>
<td>10089.35</td>
</tr>
<tr>
<td>E</td>
<td>Available dry (kg)</td>
<td>0.00</td>
<td>0.00</td>
<td>8385.40</td>
<td>36772.45</td>
</tr>
<tr>
<td>F</td>
<td>Forage removal (kg)</td>
<td>0.00</td>
<td>0.00</td>
<td>1409.30</td>
<td>16815.30</td>
</tr>
<tr>
<td>G</td>
<td>Utilised green (kg)†</td>
<td>0.00</td>
<td>0.00</td>
<td>272.42</td>
<td>3620.33</td>
</tr>
<tr>
<td>H</td>
<td>Utilised dry (kg)†</td>
<td>0.00</td>
<td>0.00</td>
<td>1136.88</td>
<td>13194.97</td>
</tr>
<tr>
<td>I</td>
<td>Crude protein green (%)</td>
<td>0.00</td>
<td>0.00</td>
<td>5.81§</td>
<td>3.22§</td>
</tr>
<tr>
<td>J</td>
<td>Crude protein dry (%)</td>
<td>0.00</td>
<td>0.00</td>
<td>2.56§</td>
<td>1.86§</td>
</tr>
<tr>
<td>K</td>
<td>Mean number of cattle</td>
<td>36.63</td>
<td>36.63</td>
<td>36.63</td>
<td>36.63</td>
</tr>
<tr>
<td>L</td>
<td>Number of days</td>
<td>47.00</td>
<td>47.00</td>
<td>47.00</td>
<td>47.00</td>
</tr>
</tbody>
</table>

A = [Initial standing biomass (kg/ha) * area of each vegetation category (ha)]
D = [B*A]
E = [C*A]
F = Data from Table 5.11
G = [F*B/100]
H = [F*C/100]
K = Data from Figure 5.4
L = Period between mid-winter and end of winter sampling
† Assuming that cattle feed non-selectively i.e. that green and dry material is consumed in proportion to its occurrence in the sward.
§ Mean of values from mid-winter and end of winter samples.

<table>
<thead>
<tr>
<th>VEGETATION FRACTION</th>
<th>Dry Matter (kg)</th>
<th>Crude Protein (g)</th>
<th>Energy (MJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residues (stalk)</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Residues (leaf)</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Sporobolus-Cynodon (green)</td>
<td>0.16</td>
<td>9.19</td>
<td>1.45</td>
</tr>
<tr>
<td>Sporobolus-Cynodon (dry)</td>
<td>0.66</td>
<td>16.91</td>
<td>4.84</td>
</tr>
<tr>
<td>Hyparrhenia (green)</td>
<td>2.10</td>
<td>67.71</td>
<td>17.99</td>
</tr>
<tr>
<td>Hyparrhenia (dry)</td>
<td>7.66</td>
<td>142.56</td>
<td>61.77</td>
</tr>
<tr>
<td>TOTAL</td>
<td>10.59</td>
<td>236.37</td>
<td>86.05</td>
</tr>
</tbody>
</table>

1 = (Total dry matter from each category)/K/L
2 = (Total crude protein from each category)/K/L
3. For each vegetation category digestible energy (DE) was calculated according to the following equation:
   1 kg Total Digestible Nutrients (TDN) = 18.4096 MJ DE
   where TDN = (Mass of forage consumed)*(Digestibility of forage consumed)
   [after Bergman et al., 2001]
APPENDIX 5.3: DETERMINATION OF PROPORTION
OF HIGH BIOMASS AND LOW BIOMASS PATCHES IN
HYPARRHENIA GRASSLAND AT KOLONI

The table below shows the occurrence of different species in the *Hyparrhenia*
grassland vegetation calculated from 32 random 100m transects each involving 100
point measurements. The ratio of high biomass (*Hyparrhenia hirta*) patches to low
biomass (all other species) can be seen to approximate to 70:30.

<table>
<thead>
<tr>
<th>SPECIES</th>
<th>TOTAL FREQUENCY OF OCCURRENCE</th>
<th>MEAN % OCCURRENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Hyparrhenia hirta</em></td>
<td>2210</td>
<td>69.06%</td>
</tr>
<tr>
<td><em>Eragrostis capensis</em></td>
<td>236</td>
<td>7.38%</td>
</tr>
<tr>
<td><em>Digitaria eriantha</em></td>
<td>162</td>
<td>5.06%</td>
</tr>
<tr>
<td><em>Sporobolus fimbriatus</em></td>
<td>104</td>
<td>3.25%</td>
</tr>
<tr>
<td><em>Sporobolus africanus</em></td>
<td>100</td>
<td>3.13%</td>
</tr>
<tr>
<td><em>Cynodon dactylon</em></td>
<td>174</td>
<td>5.44%</td>
</tr>
<tr>
<td><em>Helictotrichon turgidulum</em></td>
<td>32</td>
<td>1.00%</td>
</tr>
<tr>
<td><em>Panicum maximum</em></td>
<td>32</td>
<td>1.00%</td>
</tr>
<tr>
<td><em>Eragrostis curvula</em></td>
<td>16</td>
<td>0.50%</td>
</tr>
<tr>
<td><em>Microchloa caffra</em></td>
<td>8</td>
<td>0.25%</td>
</tr>
<tr>
<td><em>Setaria sphacelata</em></td>
<td>2</td>
<td>0.06%</td>
</tr>
<tr>
<td>Basal forb</td>
<td>108</td>
<td>3.38%</td>
</tr>
<tr>
<td><em>Acacia karroo</em> (basal)</td>
<td>6</td>
<td>0.19%</td>
</tr>
<tr>
<td><em>Heteropogon contortus</em></td>
<td>2</td>
<td>0.06%</td>
</tr>
<tr>
<td><em>Sedge</em></td>
<td>6</td>
<td>0.19%</td>
</tr>
<tr>
<td><em>Ehrata calycina</em></td>
<td>2</td>
<td>0.06%</td>
</tr>
<tr>
<td><strong>TOTALS</strong></td>
<td><strong>3200</strong></td>
<td><strong>100.00%</strong></td>
</tr>
</tbody>
</table>
APPENDIX 5.4: DISTRIBUTION OF CATTLE IN VEGETATION CATEGORIES AT KOLONI DURING WINTER 1998 AND 1999

Table 1: Observed and expected cattle frequencies in each vegetation category.

<table>
<thead>
<tr>
<th>VEGETATION CATEGORY</th>
<th>WINTER 1998</th>
<th>WINTER 1999</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OBSERVED (f)</td>
<td>EXPECTED (f)</td>
</tr>
<tr>
<td>CROP RESIDUES</td>
<td>77</td>
<td>80.45</td>
</tr>
<tr>
<td>RECENT FALLOW</td>
<td>1</td>
<td>10.42</td>
</tr>
<tr>
<td>SPOROBOLUS-CYNODON GRASSLAND</td>
<td>102</td>
<td>93.07</td>
</tr>
<tr>
<td>HYPPARRHENIA GRASSLAND</td>
<td>750</td>
<td>912.66</td>
</tr>
<tr>
<td>COMMONAGE</td>
<td>538</td>
<td>371.4</td>
</tr>
<tr>
<td>TOTALS</td>
<td>1468</td>
<td>1468</td>
</tr>
</tbody>
</table>

Table 2: Calculation of G-values from analysis of log ratios.

<table>
<thead>
<tr>
<th>VEGETATION CATEGORY</th>
<th>WINTER 1998</th>
<th>WINTER 1999</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RATIO (f/f)</td>
<td>f ln(f/f)</td>
</tr>
<tr>
<td>CROP RESIDUES</td>
<td>0.96</td>
<td>-3.37</td>
</tr>
<tr>
<td>RECENT FALLOW</td>
<td>0.10</td>
<td>-2.34</td>
</tr>
<tr>
<td>SPOROBOLUS-CYNODON GRASSLAND</td>
<td>1.10</td>
<td>9.35</td>
</tr>
<tr>
<td>HYPPARRHENIA GRASSLAND</td>
<td>0.82</td>
<td>-147.22</td>
</tr>
<tr>
<td>COMMONAGE</td>
<td>1.45</td>
<td>199.37</td>
</tr>
<tr>
<td>TOTAL (lnL)</td>
<td></td>
<td>55.78</td>
</tr>
<tr>
<td>G VALUE (2lnL)</td>
<td></td>
<td>111.56</td>
</tr>
</tbody>
</table>

* Value is highly significant (p<0.001)
APPENDIX 5.5: CALCULATION OF CATTLE INTAKE FIGURES AT KOLONI DURING WINTER 1999
### CALCULATION OF INTAKE DATA DURING FIRST HALF OF WINTER 1999.

<table>
<thead>
<tr>
<th>CODE</th>
<th>PARAMETER</th>
<th>Stalk fraction of crop residues</th>
<th>Leaf fraction of crop residues</th>
<th>Sporobolus-Cynodon grassland</th>
<th>Low biomass patches</th>
<th>High biomass patches</th>
<th>Commonage grassland</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Initial standing biomass (kg)</td>
<td>56990.34</td>
<td>28600.96</td>
<td>27911.07</td>
<td>71622.00</td>
<td>386287.09</td>
<td>187190.39</td>
</tr>
<tr>
<td>B</td>
<td>% green</td>
<td>0.00</td>
<td>0.00</td>
<td>33.19</td>
<td>35.81</td>
<td>25.67</td>
<td>33.92</td>
</tr>
<tr>
<td>C</td>
<td>% dry</td>
<td>100.00*</td>
<td>100.00*</td>
<td>66.81</td>
<td>64.19</td>
<td>74.33</td>
<td>66.08</td>
</tr>
<tr>
<td>D</td>
<td>Available green (kg)</td>
<td>0.00</td>
<td>0.00</td>
<td>9263.68</td>
<td>25647.84</td>
<td>99159.90</td>
<td>63494.98</td>
</tr>
<tr>
<td>E</td>
<td>Available dry (kg)</td>
<td>56990.34</td>
<td>28600.96</td>
<td>18647.39</td>
<td>45974.16</td>
<td>287127.19</td>
<td>123695.41</td>
</tr>
<tr>
<td>F</td>
<td>Forage removal (kg)</td>
<td>19948.30</td>
<td>16874.80</td>
<td>9025.70</td>
<td>21248.60</td>
<td>5748.20</td>
<td>33754.60</td>
</tr>
<tr>
<td>G</td>
<td>Utilised green (kg)†</td>
<td>19948.30</td>
<td>16874.80</td>
<td>6030.07</td>
<td>13639.48</td>
<td>4272.64</td>
<td>22305.04</td>
</tr>
<tr>
<td>I</td>
<td>Crude protein green (%)</td>
<td>0.00</td>
<td>0.00</td>
<td>5.55§</td>
<td>5.73§</td>
<td>4.21§</td>
<td>4.34§</td>
</tr>
<tr>
<td>J</td>
<td>Crude protein dry (%)</td>
<td>7.11†</td>
<td>3.66*</td>
<td>2.76†</td>
<td>2.67†</td>
<td>1.99†</td>
<td>2.26†</td>
</tr>
<tr>
<td>K</td>
<td>Mean number of cattle</td>
<td>132.80</td>
<td>132.80</td>
<td>132.80</td>
<td>132.80</td>
<td>132.80</td>
<td>132.80</td>
</tr>
<tr>
<td>L</td>
<td>Number of days</td>
<td>60.00</td>
<td>60.00</td>
<td>60.00</td>
<td>60.00</td>
<td>60.00</td>
<td>60.00</td>
</tr>
</tbody>
</table>

A = [Initial standing biomass (kg/ha) * area of each vegetation category (ha)]
D = [B*A]
E = [C*A]
F = Data from Table 5.20
G = [F*B/100]
H = [F*C/100]
K = Data from Figure 5.21
L = Period between initial and mid-winter sampling

* Data derived from Powell (1990)
† Assuming that cattle feed non-selectively i.e. that green and dry material is consumed in proportion to its occurrence in the sward.
§ Mean of values from initial and mid-winter samples.
<table>
<thead>
<tr>
<th>VEGETATION FRACTION</th>
<th>Dry Matter (kg) $^1$</th>
<th>Crude Protein (g) $^2$</th>
<th>Energy (MJ) $^3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residues (stalk)</td>
<td>2.50</td>
<td>178.00</td>
<td>25.86</td>
</tr>
<tr>
<td>Residues (leaf)</td>
<td>2.12</td>
<td>77.51</td>
<td>21.87</td>
</tr>
<tr>
<td><em>Sporobolus-Cynodon</em> (green)</td>
<td>0.38</td>
<td>20.87</td>
<td>3.40</td>
</tr>
<tr>
<td><em>Sporobolus-Cynodon</em> (dry)</td>
<td>0.76</td>
<td>20.89</td>
<td>5.19</td>
</tr>
<tr>
<td>Low biomass (green)</td>
<td>0.95</td>
<td>54.72</td>
<td>8.86</td>
</tr>
<tr>
<td>Low biomass (dry)</td>
<td>1.71</td>
<td>45.70</td>
<td>11.83</td>
</tr>
<tr>
<td>High biomass (green)</td>
<td>0.19</td>
<td>7.80</td>
<td>1.64</td>
</tr>
<tr>
<td>High biomass (dry)</td>
<td>0.54</td>
<td>10.67</td>
<td>3.52</td>
</tr>
<tr>
<td>Commonage (green)</td>
<td>1.44</td>
<td>62.36</td>
<td>13.22</td>
</tr>
<tr>
<td>Commonage (dry)</td>
<td>2.80</td>
<td>63.26</td>
<td>18.17</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>13.38</strong></td>
<td><strong>541.79</strong></td>
<td><strong>113.56</strong></td>
</tr>
</tbody>
</table>

$^1$ = (Total dry matter from each category)/K/L  
$^2$ = (Total crude protein from each category)/K/L  
$^3$ For each vegetation category digestible energy (DE) was calculated according to the following equation: 

$1$ kg Total Digestible Nutrients (TDN) = 18.4096 MJ DE

where TDN = (Mass of forage consumed)*(Digestibility of forage consumed) 
[after Bergman et al., 2001]
### CALCULATION OF INTAKE DATA DURING SECOND HALF OF WINTER 1999.

<table>
<thead>
<tr>
<th>CODE</th>
<th>PARAMETER</th>
<th>Vegetation Category</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Initial standing biomass (kg)</td>
</tr>
<tr>
<td>A</td>
<td>Initial standing biomass (kg)</td>
<td>0.00</td>
</tr>
<tr>
<td>B</td>
<td>% green</td>
<td>0.00</td>
</tr>
<tr>
<td>C</td>
<td>% dry</td>
<td>100.00</td>
</tr>
<tr>
<td>D</td>
<td>Available green (kg)</td>
<td>0.00</td>
</tr>
<tr>
<td>E</td>
<td>Available dry (kg)</td>
<td>0.00</td>
</tr>
<tr>
<td>F</td>
<td>Forage removal (kg)</td>
<td>0.00</td>
</tr>
<tr>
<td>G</td>
<td>Utilised green (kg)</td>
<td>0.00</td>
</tr>
<tr>
<td>H</td>
<td>Utilised dry (kg)</td>
<td>0.00</td>
</tr>
<tr>
<td>I</td>
<td>Crude protein green (%)</td>
<td>0.00</td>
</tr>
<tr>
<td>J</td>
<td>Crude protein dry (%)</td>
<td>7.11</td>
</tr>
<tr>
<td>K</td>
<td>Mean number of cattle</td>
<td>118.00</td>
</tr>
<tr>
<td>L</td>
<td>Number of days</td>
<td>68.00</td>
</tr>
</tbody>
</table>

A = [Initial standing biomass (kg/ha) * area of each vegetation category (ha)]  
D = [B*A]  
E = [C*A]  
F = Data from Table 5.20  
G = [F*B/100]  
H = [F*C/100]  
K = Data from Figure 5.21  
L = Period between mid-winter and end of winter sampling  
† Assuming that cattle feed non-selectively i.e. that green and dry material is consumed in proportion to its occurrence in the sward.  
§ Mean of values from mid-winter and end of winter samples.
<table>
<thead>
<tr>
<th>VEGETATION FRACTION</th>
<th>Dry Matter (kg)</th>
<th>Crude Protein (g)</th>
<th>Energy (MJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residues (stalk)</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Residues (leaf)</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Sporobolus-Cynodon (green)</td>
<td>0.12</td>
<td>7.36</td>
<td>1.11</td>
</tr>
<tr>
<td>Sporobolus-Cynodon (dry)</td>
<td>0.42</td>
<td>11.69</td>
<td>2.89</td>
</tr>
<tr>
<td>Low biomass (green)</td>
<td>1.12</td>
<td>74.39</td>
<td>11.19</td>
</tr>
<tr>
<td>Low biomass (dry)</td>
<td>3.20</td>
<td>90.16</td>
<td>21.69</td>
</tr>
<tr>
<td>High biomass (green)</td>
<td>1.10</td>
<td>49.48</td>
<td>9.85</td>
</tr>
<tr>
<td>High biomass (dry)</td>
<td>4.80</td>
<td>96.43</td>
<td>31.90</td>
</tr>
<tr>
<td>Commonage (green)</td>
<td>1.92</td>
<td>132.85</td>
<td>19.00</td>
</tr>
<tr>
<td>Commonage (dry)</td>
<td>6.61</td>
<td>182.45</td>
<td>41.84</td>
</tr>
<tr>
<td>TOTAL</td>
<td>19.29</td>
<td>644.80</td>
<td>139.47</td>
</tr>
</tbody>
</table>

1 = (Total dry matter from each category)/K/L
2 = (Total crude protein from each category)/K/L
3. For each vegetation category digestible energy (DE) was calculated according to the following equation: 
1 kg Total Digestible Nutrients (TDN) = 18.4096 MJ DE
where TDN = (Mass of forage consumed)*(Digestibility of forage consumed)
[after Bergman et al., 2001]
APPENDIX 6.1: PERCENTAGE FREQUENCY OF OCCURRENCE OF DIFFERENT SPECIES ON CONTROL PLOT AND TREATMENT GRAZING PLOTS AT KOLONI

The table below shows the occurrence of different species on the plots calculated from 9 random 100m transects on the control plot and 10 random 100m transects on the treatment plot, each involving 100 point measurements. For the control plot the proportional area of high biomass (*Hyparrhenia hirta*) patches was thus taken as 80.44% and that of low biomass patches (all other species) as 19.56%. For the treatment plot these percentages were 84.20% and 15.80% respectively.

<table>
<thead>
<tr>
<th>SPECIES</th>
<th>TOTAL COUNT</th>
<th>FREQUENCY OF OCCURRENCE (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hyparrhenia hirta</td>
<td>724</td>
<td>80.44%</td>
</tr>
<tr>
<td>Cynodon dactylon</td>
<td>60</td>
<td>6.67%</td>
</tr>
<tr>
<td>Sporobolus africanus</td>
<td>16</td>
<td>1.78%</td>
</tr>
<tr>
<td>Digitaria eriantha</td>
<td>30</td>
<td>3.33%</td>
</tr>
<tr>
<td>Panicum maximum</td>
<td>10</td>
<td>1.11%</td>
</tr>
<tr>
<td>Eragrostis capensis</td>
<td>16</td>
<td>1.78%</td>
</tr>
<tr>
<td>Eragrostis curvula</td>
<td>2</td>
<td>0.22%</td>
</tr>
<tr>
<td>Helictotrichon turgidulum</td>
<td>10</td>
<td>1.11%</td>
</tr>
<tr>
<td>Sporobolus fimbriatus</td>
<td>20</td>
<td>2.22%</td>
</tr>
<tr>
<td>Microchloa caffra</td>
<td>2</td>
<td>0.22%</td>
</tr>
<tr>
<td>Basal forb</td>
<td>10</td>
<td>1.11%</td>
</tr>
<tr>
<td><strong>TOTALS</strong></td>
<td>900</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SPECIES</th>
<th>TOTAL COUNT</th>
<th>FREQUENCY OF OCCURRENCE (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hyparrhenia hirta</td>
<td>842</td>
<td>84.20%</td>
</tr>
<tr>
<td>Basal forb</td>
<td>34</td>
<td>3.40%</td>
</tr>
<tr>
<td>Cynodon dactylon</td>
<td>50</td>
<td>5.00%</td>
</tr>
<tr>
<td>Sporobolus africanus</td>
<td>36</td>
<td>3.60%</td>
</tr>
<tr>
<td>Sporobolus fimbriatus</td>
<td>8</td>
<td>0.80%</td>
</tr>
<tr>
<td>Panicum maximum</td>
<td>12</td>
<td>1.20%</td>
</tr>
<tr>
<td>Eragrostis capensis</td>
<td>4</td>
<td>0.40%</td>
</tr>
<tr>
<td>Eragrostis curvula</td>
<td>2</td>
<td>0.20%</td>
</tr>
<tr>
<td>Ehrata calycina</td>
<td>2</td>
<td>0.20%</td>
</tr>
<tr>
<td>Digitaria eriantha</td>
<td>2</td>
<td>0.20%</td>
</tr>
<tr>
<td>Heteropogon contortus</td>
<td>2</td>
<td>0.20%</td>
</tr>
<tr>
<td>Sedge</td>
<td>6</td>
<td>0.60%</td>
</tr>
<tr>
<td><strong>TOTALS</strong></td>
<td>1000</td>
<td>100.00%</td>
</tr>
</tbody>
</table>
APPENDIX 6.2: CALCULATION OF INTAKE PARAMETERS FOR CATTLE FEEDING ON CONTROL AND TREATMENT PLOTS AT KOLONI
# CALCULATION OF DAILY FORAGE INTAKE, INTAKE RATE AND BITE WEIGHT

<table>
<thead>
<tr>
<th>CODE</th>
<th>PARAMETER</th>
<th>CONTROL PLOT</th>
<th>TREATMENT PLOT</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Offtake/quadrat (g/0.25m$^2$)</td>
<td>2.23</td>
<td>11.32</td>
</tr>
<tr>
<td>B</td>
<td>Area of plot (m$^2$)</td>
<td>5000</td>
<td>5000</td>
</tr>
<tr>
<td>C</td>
<td>Number of grazing days</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>D</td>
<td>Number of cattle</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>E</td>
<td>Total time grazing (mins)</td>
<td>504</td>
<td>867</td>
</tr>
<tr>
<td>F</td>
<td>Mean bite rate (bites/min)</td>
<td>22.29</td>
<td>22.85</td>
</tr>
<tr>
<td>G</td>
<td>Total offtake (g)</td>
<td>44600</td>
<td>226400</td>
</tr>
<tr>
<td>H</td>
<td>Total intake/animal/day (kg)</td>
<td>2.973333</td>
<td>15.09333</td>
</tr>
<tr>
<td>I</td>
<td>Intake rate (g/min)</td>
<td>17.69841</td>
<td>52.22607</td>
</tr>
<tr>
<td>J</td>
<td>Bite weight (g/bite)</td>
<td>0.794007</td>
<td>2.285605</td>
</tr>
</tbody>
</table>

\[
G = A \times 4 \times B \\
H = \frac{G}{(C \times D \times 1000)} \\
I = \frac{G}{E} \\
J = \frac{I}{F}
\]
### Adjusted Calculations of Daily Forage Intake and Intake Rate for Control Plot

<table>
<thead>
<tr>
<th>CODE</th>
<th>Parameter</th>
<th>Initial</th>
<th>Middle</th>
<th>End</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Number of grazing days</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>B</td>
<td>Total time grazing (mins)</td>
<td>504</td>
<td>867</td>
<td>1156</td>
</tr>
<tr>
<td>C</td>
<td>Mean bite rate (bites/min)</td>
<td>22.29</td>
<td>22.85</td>
<td>22.42</td>
</tr>
<tr>
<td>D</td>
<td>Total intake/animal/day (kg)</td>
<td>2.973333</td>
<td>5.243343</td>
<td>6.859563</td>
</tr>
<tr>
<td>E</td>
<td>Intake rate (g/min)</td>
<td>17.69841</td>
<td>18.14306</td>
<td>17.80163</td>
</tr>
<tr>
<td>F</td>
<td>Bite weight (g/bite) *</td>
<td>0.794007</td>
<td>0.794007</td>
<td>0.794007</td>
</tr>
</tbody>
</table>

\[ E = C \times F \]

\[ D = \frac{(E \times B)}{(A \times 1000)} \]

* Assumed maximum bite weight.
APPENDIX 6.3: ESTIMATED LEVELS OF INTAKE OF DRY
MATTER, CRUDE PROTEIN AND DIGESTIBLE ENERGY FOR
CATTLE GRAZING ON EXPERIMENTAL PLOTS
# CALCULATION OF NUTRITIONAL INTAKE ASSUMING NON-SELECTIVE FEEDING BY CATTLE

<table>
<thead>
<tr>
<th>CODE</th>
<th>PARAMETER</th>
<th>CONTROL</th>
<th>TREATMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>INITIAL</td>
<td>MIDDLE</td>
</tr>
<tr>
<td>A</td>
<td>Total biomass removal (kg)</td>
<td>44.60</td>
<td>78.65</td>
</tr>
<tr>
<td>B</td>
<td>Proportion dead stem (%)</td>
<td>22.78</td>
<td>21.6</td>
</tr>
<tr>
<td>C</td>
<td>Proportion green stem (%)</td>
<td>2.93</td>
<td>1.23</td>
</tr>
<tr>
<td>D</td>
<td>Proportion dead leaf (%)</td>
<td>66.02</td>
<td>71.66</td>
</tr>
<tr>
<td>E</td>
<td>Proportion green leaf (%)</td>
<td>8.27</td>
<td>5.51</td>
</tr>
<tr>
<td>F</td>
<td>Crude protein dead stem (%)</td>
<td>0.95</td>
<td>1.01</td>
</tr>
<tr>
<td>G</td>
<td>Crude protein green stem (%)</td>
<td>1.63</td>
<td>2.00</td>
</tr>
<tr>
<td>H</td>
<td>Crude protein dead leaf (%)</td>
<td>2.49</td>
<td>2.70</td>
</tr>
<tr>
<td>I</td>
<td>Crude protein green leaf (%)</td>
<td>6.07</td>
<td>6.75</td>
</tr>
<tr>
<td>J</td>
<td>Digestibility dead stem (%)</td>
<td>28.43</td>
<td>28.24</td>
</tr>
<tr>
<td>K</td>
<td>Digestibility green stem (%)</td>
<td>30.51</td>
<td>30.3</td>
</tr>
<tr>
<td>L</td>
<td>Digestibility dead leaf (%)</td>
<td>32.67</td>
<td>33.66</td>
</tr>
<tr>
<td>M</td>
<td>Digestibility green leaf (%)</td>
<td>52.52</td>
<td>51.85</td>
</tr>
<tr>
<td>N</td>
<td>Number of animals</td>
<td>5.00</td>
<td>5.00</td>
</tr>
<tr>
<td>O</td>
<td>Number of grazing days</td>
<td>3.00</td>
<td>3.00</td>
</tr>
</tbody>
</table>

## DRY MATTER INTAKE (KG/ANIMAL/DAY)

<table>
<thead>
<tr>
<th>CODE</th>
<th>PARAMETER</th>
<th>CONTROL</th>
<th>TREATMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>INITIAL</td>
<td>MIDDLE</td>
</tr>
<tr>
<td>P</td>
<td>Intake dead stem</td>
<td>0.68</td>
<td>1.13</td>
</tr>
<tr>
<td>Q</td>
<td>Intake green stem</td>
<td>0.09</td>
<td>0.06</td>
</tr>
<tr>
<td>R</td>
<td>Intake dead leaf</td>
<td>1.96</td>
<td>3.76</td>
</tr>
<tr>
<td>S</td>
<td>Intake green leaf</td>
<td>0.25</td>
<td>0.29</td>
</tr>
</tbody>
</table>

Total herbage intake: 2.97, 5.24, 6.86, 6.88, 10.16, 8.21

\[
P = \frac{(A \times B)}{100 \times (N \times O)}
\]

\[
Q = \frac{(A \times C)}{100 \times (N \times O)}
\]

\[
R = \frac{(A \times D)}{100 \times (N \times O)}
\]

\[
S = \frac{(A \times E)}{100 \times (N \times O)}
\]
### Intake of Crude Protein (g/Animal/Day)

<table>
<thead>
<tr>
<th>CODE</th>
<th>PARAMETER</th>
<th>CONTROL</th>
<th></th>
<th>CONTROL</th>
<th></th>
<th>CONTROL</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>Crude protein dead stem</td>
<td>INITIAL</td>
<td>6.41</td>
<td>MIDDLE</td>
<td>11.42</td>
<td>END</td>
<td>17.91</td>
</tr>
<tr>
<td>U</td>
<td>Crude protein green stem</td>
<td>INITIAL</td>
<td>1.42</td>
<td>MIDDLE</td>
<td>1.29</td>
<td>END</td>
<td>1.06</td>
</tr>
<tr>
<td>V</td>
<td>Crude protein dead leaf</td>
<td>INITIAL</td>
<td>48.95</td>
<td>MIDDLE</td>
<td>101.61</td>
<td>END</td>
<td>116.22</td>
</tr>
<tr>
<td>W</td>
<td>Crude protein green leaf</td>
<td>INITIAL</td>
<td>14.92</td>
<td>MIDDLE</td>
<td>19.51</td>
<td>END</td>
<td>25.76</td>
</tr>
<tr>
<td></td>
<td>Total crude protein intake</td>
<td></td>
<td>71.70</td>
<td>133.82</td>
<td>160.96</td>
<td></td>
<td>199.92</td>
</tr>
</tbody>
</table>

\[
T = (P*F/100)*1000 \\
U = (Q*G/100)*1000 \\
V = (R*H/100)*1000 \\
W = (S*I/100)*1000
\]

### Intake of Digestible Energy (MJ/Animal/Day)

<table>
<thead>
<tr>
<th>CODE</th>
<th>PARAMETER</th>
<th>CONTROL</th>
<th></th>
<th>CONTROL</th>
<th></th>
<th>CONTROL</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>Digestible energy dead stem</td>
<td>INITIAL</td>
<td>3.55</td>
<td>MIDDLE</td>
<td>5.89</td>
<td>END</td>
<td>9.92</td>
</tr>
<tr>
<td>Y</td>
<td>Digestible energy green stem</td>
<td>INITIAL</td>
<td>0.49</td>
<td>MIDDLE</td>
<td>0.36</td>
<td>END</td>
<td>0.39</td>
</tr>
<tr>
<td>Z</td>
<td>Digestible energy green leaf</td>
<td>INITIAL</td>
<td>2.38</td>
<td>MIDDLE</td>
<td>2.76</td>
<td>END</td>
<td>3.68</td>
</tr>
<tr>
<td>AB</td>
<td>Digestible energy dead leaf</td>
<td>INITIAL</td>
<td>11.81</td>
<td>MIDDLE</td>
<td>23.28</td>
<td>END</td>
<td>25.13</td>
</tr>
<tr>
<td></td>
<td>Total digestible energy intake</td>
<td></td>
<td>18.22</td>
<td>32.29</td>
<td>39.12</td>
<td></td>
<td>50.51</td>
</tr>
</tbody>
</table>

\[
X = (P*J/100)*18.4096 \\
Y = (Q*K/100)*18.4096 \\
Z = (R*L/100)*18.4096 \\
AB = (S*M/100)*18.4096
\]

†Digestible energy (DE) was calculated according to the following equation:

1 kg Total Digestible Nutrients (TDN) = 18.4096 MJ DE

where TDN = (Mass of forage consumed)*(Digestibility of forage consumed)

[after Bergman et al., 2001]
### DRY MATTER INTAKE (KG/ANIMAL/DAY)

<table>
<thead>
<tr>
<th>CODE</th>
<th>PARAMETER</th>
<th>CONTROL INITIAL</th>
<th>MIDDLE</th>
<th>END</th>
<th>TREATMENT INITIAL</th>
<th>MIDDLE</th>
<th>END</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>Intake dead stem</td>
<td>0.68</td>
<td>1.13</td>
<td>1.91</td>
<td>0.00</td>
<td>2.19</td>
<td>1.16</td>
</tr>
<tr>
<td>Q</td>
<td>Intake green stem</td>
<td>0.09</td>
<td>0.06</td>
<td>0.07</td>
<td>0.00</td>
<td>0.09</td>
<td>0.11</td>
</tr>
<tr>
<td>R</td>
<td>Intake dead leaf</td>
<td>1.96</td>
<td>3.76</td>
<td>4.50</td>
<td>0.00</td>
<td>7.03</td>
<td>6.06</td>
</tr>
<tr>
<td>S</td>
<td>Intake green leaf</td>
<td>0.25</td>
<td>0.29</td>
<td>0.39</td>
<td>6.88</td>
<td>0.86</td>
<td>0.88</td>
</tr>
<tr>
<td></td>
<td>Total herbage intake</td>
<td>2.97</td>
<td>5.24</td>
<td>6.86</td>
<td>6.88</td>
<td>10.16</td>
<td>8.21</td>
</tr>
</tbody>
</table>

Calculations as before except for initial grazing period on treatment plot where:

- \( P = (A*0)/100/(N*O) \)
- \( Q = (A*0)/100/(N*O) \)
- \( R = (A*0)/100/(N*O) \)
- \( S = (A*100)/100/(N*O) \)

### INTAKE OF CRUDE PROTEIN (g/ANIMAL/DAY)

<table>
<thead>
<tr>
<th>CODE</th>
<th>PARAMETER</th>
<th>CONTROL INITIAL</th>
<th>MIDDLE</th>
<th>END</th>
<th>TREATMENT INITIAL</th>
<th>MIDDLE</th>
<th>END</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>Crude protein dead stem</td>
<td>6.41</td>
<td>11.42</td>
<td>17.91</td>
<td>0.00</td>
<td>18.96</td>
<td>9.60</td>
</tr>
<tr>
<td>U</td>
<td>Crude protein green stem</td>
<td>1.42</td>
<td>1.29</td>
<td>1.06</td>
<td>0.00</td>
<td>1.44</td>
<td>1.46</td>
</tr>
<tr>
<td>V</td>
<td>Crude protein dead leaf</td>
<td>48.95</td>
<td>101.61</td>
<td>116.22</td>
<td>0.00</td>
<td>164.96</td>
<td>128.23</td>
</tr>
<tr>
<td>W</td>
<td>Crude protein green leaf</td>
<td>14.92</td>
<td>19.51</td>
<td>25.76</td>
<td>401.33</td>
<td>45.81</td>
<td>48.38</td>
</tr>
<tr>
<td></td>
<td>Total crude protein intake</td>
<td>71.70</td>
<td>133.82</td>
<td>160.96</td>
<td>401.33</td>
<td>231.16</td>
<td>187.67</td>
</tr>
</tbody>
</table>

Calculations as before:

- \( T = (P*F/100)*1000 \)
- \( U = (Q*G/100)*1000 \)
- \( V = (R*H/100)*1000 \)
- \( W = (S*I/100)*1000 \)
<table>
<thead>
<tr>
<th>CODE</th>
<th>PARAMETER</th>
<th>CONTROL</th>
<th>TREATMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>INITIAL</td>
<td>MIDDLE</td>
</tr>
<tr>
<td>X</td>
<td>Digestible energy dead stem</td>
<td>3.55</td>
<td>5.89</td>
</tr>
<tr>
<td>Y</td>
<td>Digestible energy green stem</td>
<td>0.49</td>
<td>0.36</td>
</tr>
<tr>
<td>Z</td>
<td>Digestible energy green leaf</td>
<td>2.38</td>
<td>2.76</td>
</tr>
<tr>
<td>AB</td>
<td>Digestible energy dead leaf</td>
<td>11.81</td>
<td>23.28</td>
</tr>
<tr>
<td></td>
<td>Total digestible energy intake</td>
<td>18.22</td>
<td>32.29</td>
</tr>
</tbody>
</table>

**CALCULATIONS AS BEFORE:**

- \[ X = (P \times J / 100) \times 18.4096 \]
- \[ Y = (Q \times K / 100) \times 18.4096 \]
- \[ Z = (R \times L / 100) \times 18.4096 \]
- \[ AB = (S \times M / 100) \times 18.4096 \]