LIVESTOCK POPULATIONS AND THE HOUSEHOLD ECONOMY:

A CASE STUDY FROM SOUTHERN ZIMBABWE

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Abstract

This study explores the consequences of the contrasting dynamics of different savanna environments for livestock production in southern Zimbabwe. It is based on an interdisciplinary analysis of agroecosystems at a regional and local level, drawing on historical data, discussions with local informants, household economic studies and focused ecological investigations.

The agropastoral economy, and the role of livestock within this, has changed dramatically during this century, resulting in changes in management strategies. Patterns of sales behaviour are examined for cattle populations in the region between 1923 and 1986. This is used, along with data on biological parameters, to develop an integrated understanding of the economic and ecological factors that affect stock population changes.

These factors combine to maintain stock at high population levels in line with farmers' economic objectives. The economic value of cattle, donkeys and goats is investigated with local level data on production and use values. This highlights the contrasting role of different stock species in the agropastoral economy. Household economic data is presented that investigates the implications of differences in domestic cycles, income and expenditure patterns, agricultural success and food security position on stock investment and disposal decisions.

Comparisons are made between different wealth groups and different ecological zones. These contrasts are also considered in relation to livestock survival strategies during two recent droughts. Questions of drought survival and 'carrying capacity' can be related to the foraging behaviour of stock species in different savanna types. The role of small 'key resource' grazing areas and the browse resource is emphasised. The consequences of high stocking rates on long term sustainability is also discussed. It is argued that the integration of economic and ecological interpretations provides a different perspective on a range of important livestock policy issues.

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Abbreviations and local terms

Agritex	Department of Agricultural and extension services, Ministry of Lands, Agriculture and Rural Resettlement
CAs	Communal Areas or Lands
CNC	Chief Native Commissioner
DA	District Administrator
DC	District Commissioner
EEC	European Economic Community
ENDA	Environment and Development Activities
FMD	Foot and Mouth Disease
Hurudza	Plough entrepreneur
ICA	Intensive Conservation area
Lobola	Bridewealth payment
LU/LSU	Livestock Unit
Majeke	River bank garden
NLHA	Native Land Husbandry Act
NRB	Natural Resources Board
PNC	Provincial Native Commissioner
Sabhuku	Kraal head
TTL	Tribal Trust Land
Veld	Grassland/range
VIDCO	Village Development Committee
Vlei	Valley bottomland (also dambo)
Z$	Zimbabwe dollar (LS1 = approx Z$3)

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1. INTRODUCTION

1.1 Livestock populations and household economy: investigating the interactions

Observers of the small scale livestock sector in Zimbabwe have asked of the communal area (1) herds: How and why do they keep on growing? (Jarvis and Erickson, 1986). This thesis is an attempt to answer this question for communal areas in the central-south of the country.

The question is asked because the communal area livestock populations have continued to increase throughout this century, despite drought, government interventions, marketing and pricing policies and predictions of imminent ecological collapse. In most areas stock populations far exceed official 'carrying capacity' levels and although populations are not stable, crashes are followed by swift recovery. The communal areas are assumed to be suffering serious environmental degradation (eg. Zimbabwe National Conservation Strategy, 1987; Whitlow, 1988) and this is thought to have been significant for at least 50 years, yet still livestock survive in most years and in good years apparently thrive. It appears therefore that the system is productive (in terms of animal densities) and although unstable, remarkably resilient. It is the aim of this study to explore this general contention.

Livestock population dynamics in the communal areas are influenced by an interaction of economic and ecological factors. This interaction will be one of the central themes of the coming Chapters. Economic decisions to buy, sell or retain animals are central to understanding changes in population sizes. These decisions will be affected by the objectives of the producers and their response to a range of factors internal and external to the farming system. Decision making criteria will change historically as the system is transformed (eg through increased migrant labour), interannually in relation to changes in climatic

conditions and between different groups in society.

The ecological dynamics of different savannas will also affect this interaction, as different savannas have different system properties in terms of productivity, stability and resilience. These will affect the nature of the local economy; for instance, in some areas crop production may be more successful. This will in turn influence opportunities for investment in and disposal of livestock and so affect overall population growth.

Savanna system properties also affect the biology of different stock species and so intrinsic population growth, responses to drought etc. This interaction between ecology and economy will be explored in this study by contrasting clay veld and sand veld savannas (2) found in southern Zimbabwe.

This study therefore takes an interdisciplinary approach; integrating socio-economic, historical and ecological understanding. The research attempts to explore linkages between economy and ecology at both local and regional levels. As the focus is on interactions, the treatment of any one area may be more restricted than in a single discipline thesis. However the advantage of interdisciplinarity is that new light is shed on issues by approaching questions from a different angle. Theoretical frameworks for interdisciplinary analysis are lacking in this field; effectively bridging the natural and social sciences is rare. This is despite the fact that many of the key issues surrounding questions of 'sustainable livelihoods' in debates about environment and development (WCED, 1987) are centred on this interface.

This study draws on a diverse range of research methodologies and analytical tools, but the framework of agroecosystems analysis (Conway, 1985; 1987) allows an integration of both economic and ecological issues. Agroecosystems analysis has been developed from systems

theory and focuses on the analysis of trade-offs between different systems properties (3). Central to the arguments developed in this thesis is an investigation of the trade-offs between productivity, stability and sustainability of clay and sand veld savannas. Ecological aspects of these trade-offs are introduced in Chapter 2 and explored further using historical and economic analysis at regional and local levels in later Chapters.

A range of different perspectives on the issues of livestock production in the CAs are presented in this thesis. Interpretation of complex interactions requires a diverse approach. For instance, on the recurrent theme of the meaning of 'carrying capacity', historical perspectives interact with socio-economic and technocratic views. It is important to be explicit about the nature of the particular perspective taken, and for this reason in particular a historical analysis of the development of ideas is critical (4). My background as an applied ecologist is also relevant in the evolution of the arguments of this thesis. I have also tried to give an impression of the views of local people in the study area on the various issues arising, through the quotation of interviews and analysis of attitudes. It was perhaps the interaction of an human ecological approach to understanding agroecosystems with the systems of local knowledge and interpretation that was central to the development of the themes presented here.

1.2 Agropastoral systems

This study concerns the agropastoral economies of the Communal Areas (CAs) of the southern part of Zimbabwe. Agropastoral systems are characterised by a close interaction between the cropping and livestock components (McCown et al, 1979). These are arranged in many different ways in different parts of Africa (Brandstrom et al, 1979). In the case of Zimbabwe, a unilocal system operates where livestock are owned by the same group that farm and are kept at the homestead, so restricting the potentials for

stock movement. Despite this, as with other transhumant livestock systems, the livestock management system is centred on a flexible use of range and arable land derived fodder resources. The literature on agropastoralism in Africa points to a number of general patterns. These can be assessed in relation to the actual practices exhibited in southern Zimbabwe documented in the following Chapters.

- Agropastoral systems include an inherent competition for the resources of land, labour and capital, where the trade-offs between investment in livestock production vs. farming are determined by the productivity and stability of each. This is complicated by the form of interaction and the degree of complementarity between agricultural and livestock production. For instance, successful plough-based farming requires a certain number of animals (capital), needing a minimum herding input and an amount of grazing land. The allocation of these factors of production will have a complex effect on agricultural production; by both increasing the potential (through draft, manure) and decreasing it (by allocating land, labour and capital to another activity).

- This trade-off will vary according to environmental factors. In wetter areas and years the returns on farming land may well exceed the returns from livestock production, but this may not be the case in drier areas and years. The nature of such allocation decisions will also be affected by wealth (availability of capital to invest in cattle), production relations (ability to cooperatively use animals/labour etc) and institutional factors (land-use and tenure).

- Surplus income generated from farming is often reinvested in stock. This results in the increase in stocking levels without a regulatory factor (Haaland, 1977). This dynamic of investment may be increased when access to remittance incomes is high. The implications for long term sustainability are unclear.

- In situations of high resource pressure, increased stocking rates will result in lower productivity per head of animal (in terms of milk, meat, manure and draft). But the increased overall availability of animals may be advantageous in terms of, for instance, allowing more people to plough. The trade-offs between aggregate and individual household production, equity and sustainability are complex in agropastoral systems.

1.3 The case study areas

Zimbabwe's economy is diversified with a well developed mining sector, considerable urban based secondary industry and a dual structured agricultural industry (5). The agricultural sector can be divided into the Large scale commercial farms, small scale commercial farms and the Communal Areas (6). Interactions between these sectors is essential to an understanding of the economies of the CAs, as labour migrancy and remittance flows are central factors in the rural economy.

The study areas are situated in the drier regions of the middle and low veld (7) of the country, where rain falls during the summer months between November and April. In terms of the standard agro-climatological classification used in Zimbabwe (Vincent and Thomas, 1961), the study areas are found within Natural Regions IV and V (8). Figures 1.1 and 1.2 show the position of the study area within the country and the distribution of agroecological zones.

Soils and vegetation types are variable, but range from poor, granitic sands associated with miombo (9) woodland on the plateau edge to heavier soils associated with mixed Mopane-Acacia woodland in the lowveld areas. These areas are typified by low and variable annual rainfall and are regarded as marginal for productive agriculture (10).

Figure 1.1: Agroecological natural regions in Zimbabwe

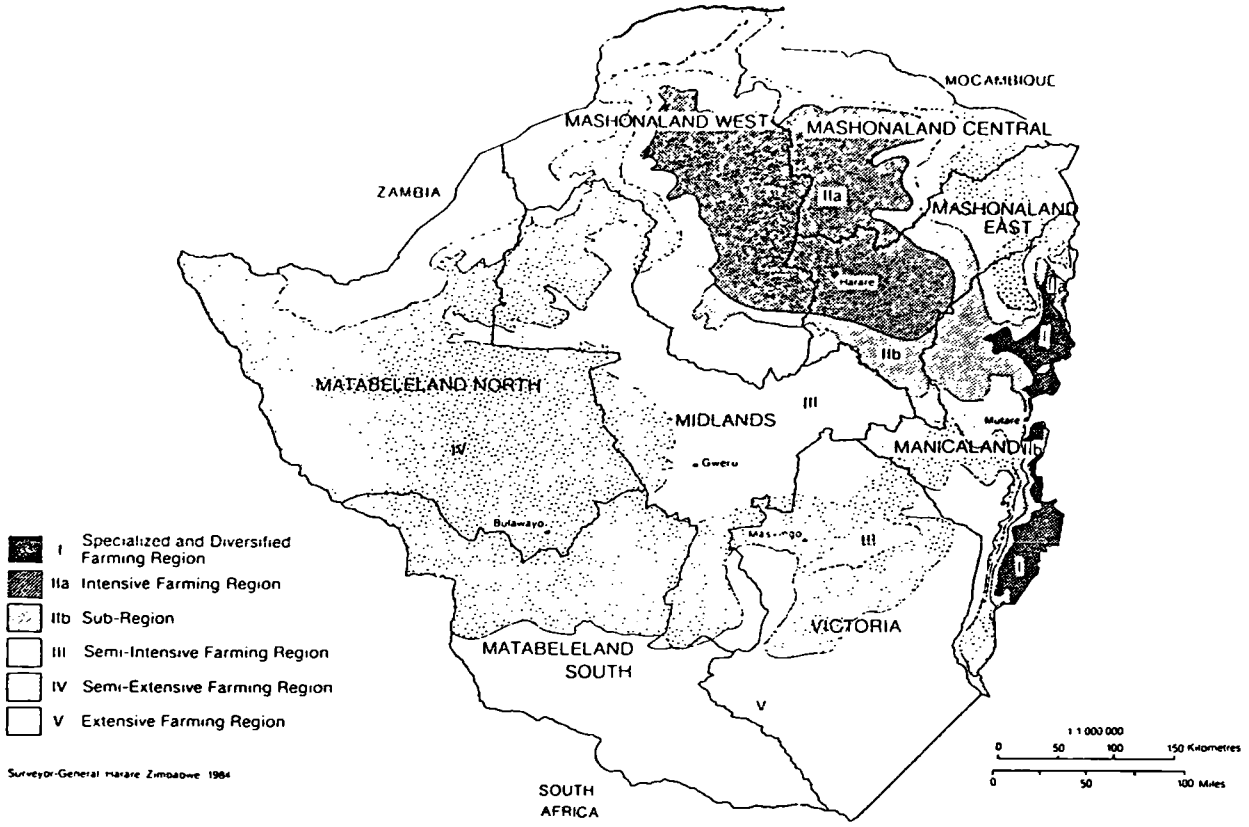
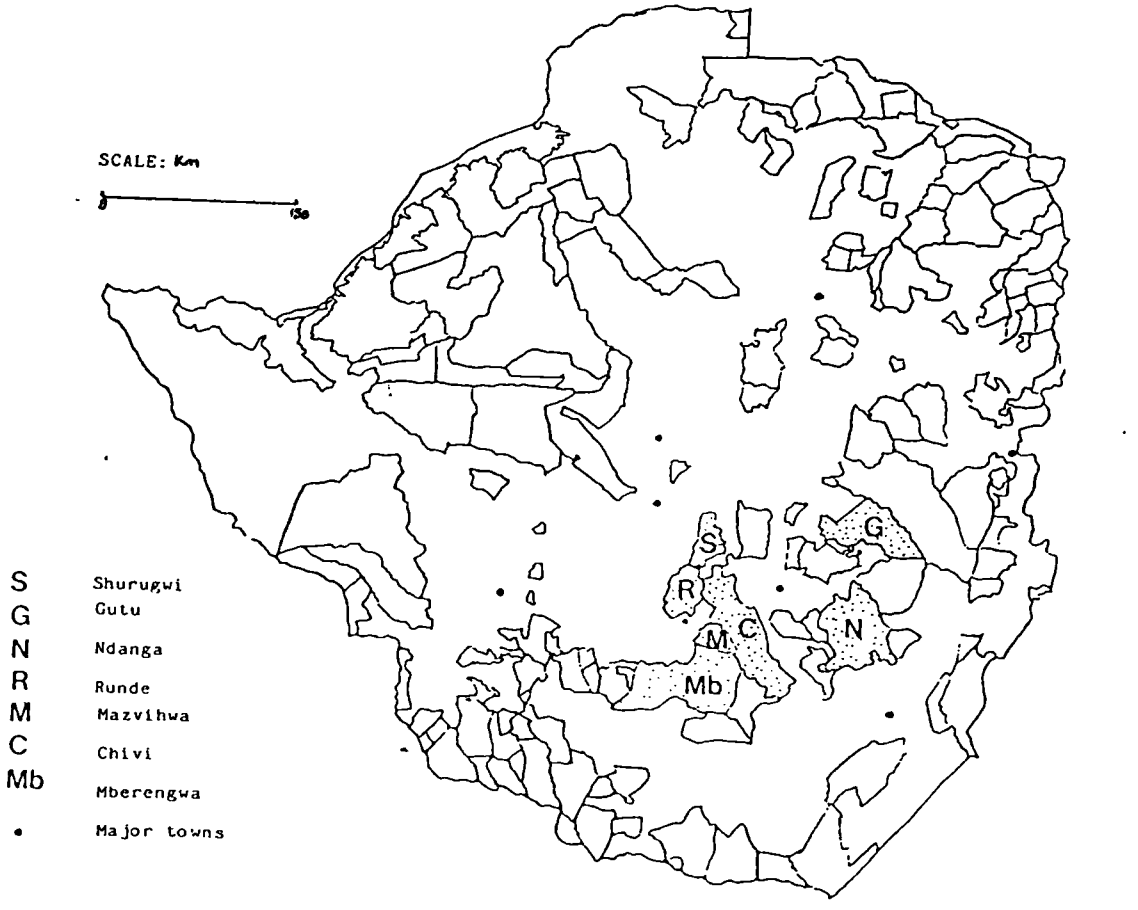


Figure 1.2: Position of study areas in Zimbabwe



Communal Areas make up 49% of the total land area of the country, but 74% of CA land is found in Natural Regions IV and V. In this respect, the study areas are typical of much of the CA sector (11). Despite some attempts at resettlement of communal area populations since Independence, human and stock densities are high (12). This results from the heritage of colonial land apportionment policies and high rates of population growth (see Chapter 3). Agricultural output tends to be low and variable, dependent on rainfall that has a high degree of interannual variability. Major crops include maize, bullrush and finger millet and groundnuts, but these are complemented by a range of minor crops (13). Yield levels and marketed output vary massively between years and different households. Although an increasing proportion of marketed grains are derived from the CA sector, this is largely from the higher potential regions. Livestock kept include cattle, donkeys, goats and chickens and again ownership and the output gained varies enormously.

Within a CA, adult men have rights over individual plots of land. Today these are allocated by government, but in the past different systems operated (14). Stock are individually owned, but are generally managed by a household or group of households. They are grazed on communal grazing land during the cropping season, but use the arable land following the harvest. Cattle, and increasingly donkeys, provide critical inputs to agricultural production in terms of ploughing, transport and manure. Draft animals owned by household members will be used to cultivate the arable areas of that home, but complex sharing and loaning relationships also influence the interaction between the pastoral and agricultural economies (see Chapter 6). Livestock products (meat, milk) are also important in the local economy, often providing a significant income source. However overall offtake rates of cattle to official markets are low (15).

In addition to agricultural and pastoral income, off-farm

sources are critical. The existence of a high rate of labour migrancy (to mines, urban industry or commercial farms) means that remittance income sources are highly significant in subsidising the rural economy, both in terms of supplying subsistence needs (including food, school fees) and in terms of investment (including farm implements, livestock). The position of important market and employment centres in relation to the position of the regional and local study areas is shown in Figure 1.2. The interaction between the agricultural, pastoral and urban wage labour sectors presents problems in the understanding of rural economies according to conventional paradigms (16).

This study draws on information from a regional and a local level. The breadth achieved by a regional focus is complemented by the depth of a detailed local case study. The regional study areas represent a group of CAs surrounding the local case study area of Mazvihwa CA (see Figure 1.3). The regional study areas can be divided into two groups. Some of the characteristics of these areas are given in Table 1.1. The grouping adopted differentiates between the 'wetter areas' situated on the middle veld (mostly Region IV) and the 'drier areas' which are further south (Regions IV to V). As Table 1.1 demonstrates, this is not a water tight classification, but because some general features are differentiated (notably rainfall and to some extent soils). This is illustrated in Figure 1.4 which gives a generalised geological map for the regional study area. Appendix 1 gives information on the national patterns of rainfall variation and data on rainfall patterns for each of the regional study areas.

The division into 'wetter' and 'drier' areas provides a basis for investigating the contrasts in savanna dynamics and the impact on livestock population at the regional level. This is pursued with more depth in the local level case study area (Mazvihwa CA), on the basis of contrasts in savanna type.

Figure 1.3: 'Wetter' and 'drier' regional study areas and sites of rainfall measurements. (1 = Shurugwi town; 2 = Gutu; 3 = Zaka; 4 = Zvishavane; 5 = Chivi office; 6 = Mberengwa)

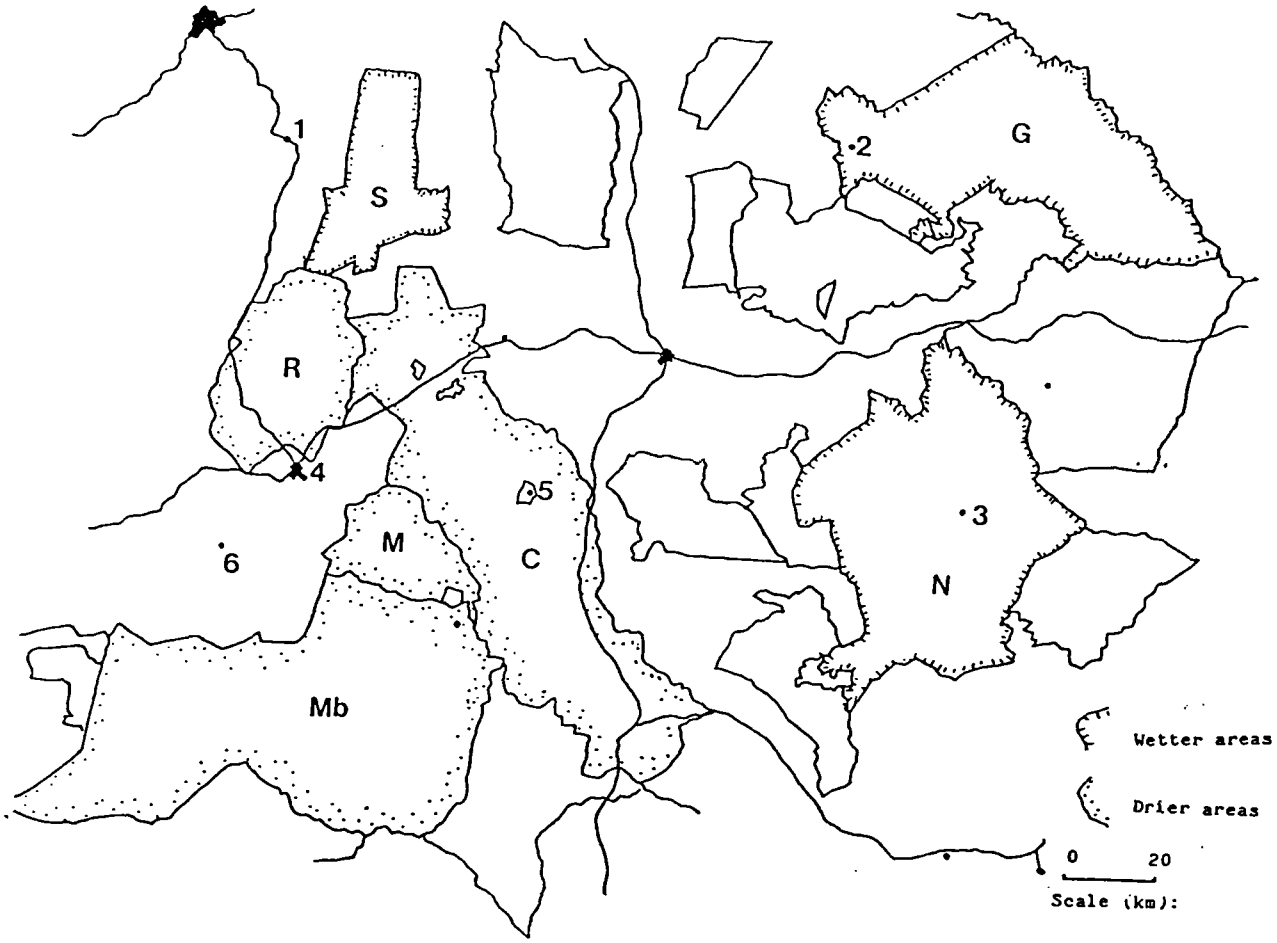


Figure 1.4: Geological map of study areas

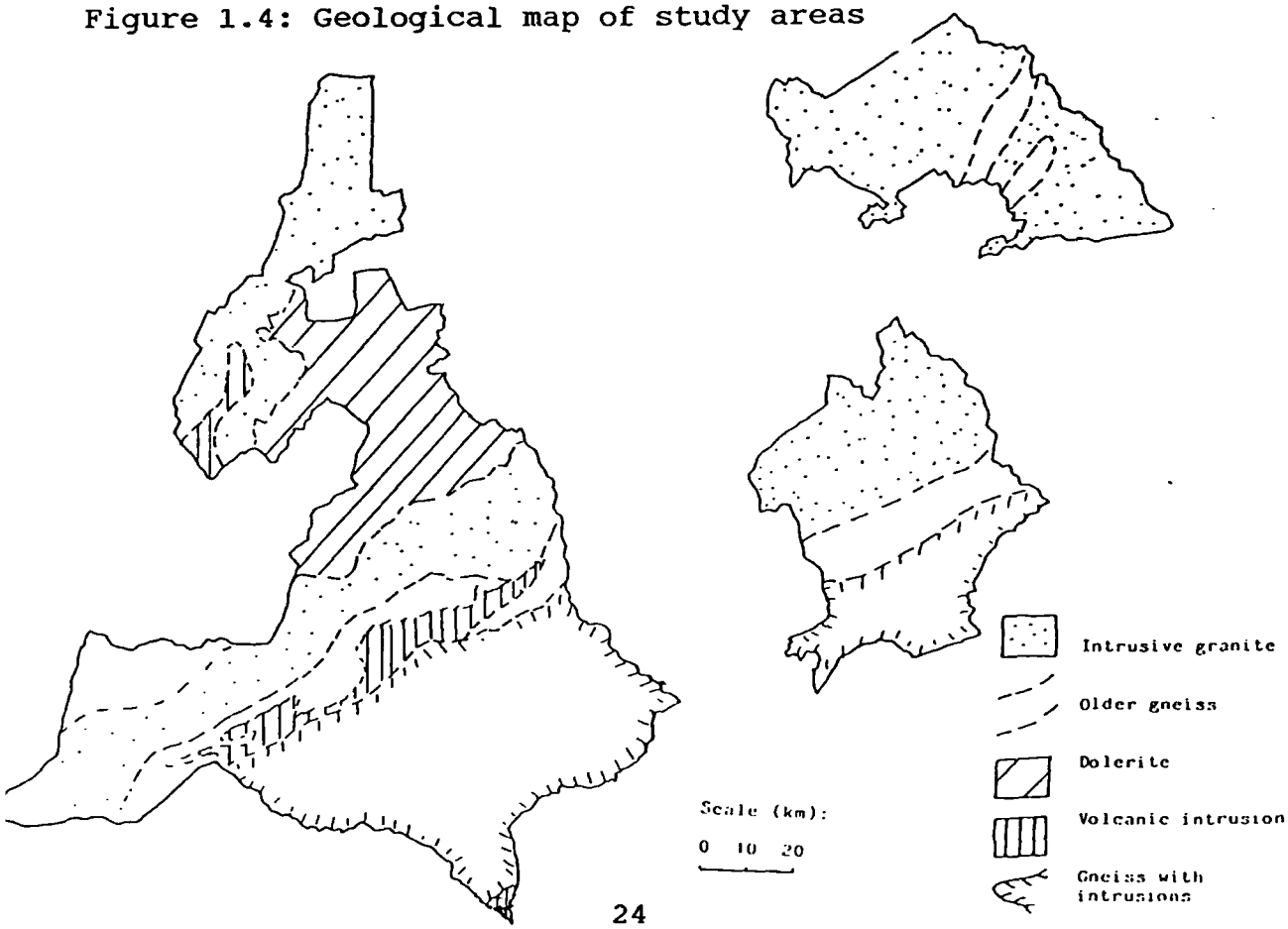


Table 1.1: Summary characterisations of regional study areas

Note: Rainfall averages and coefficient of variation (cv) values refer to the period 1923-1986 (see Appendix 1 for more detail), Human population figures are based on the 1982 census and areas refer to current sizes. Names used are current ones, these have changed over time (17).

Mberengwa District: includes only Mberengwa CA:

Mberengwa: Natural Region IV/V; Average rainfall: 516.8mm, cv = 0.33; Population 163585; Area: 375000ha; Soils derived mostly from gneiss with volcanic intrusions, although some areas have sandy soils derived from granite; vegetation is very varied and related to soil type. Most of the area is mixed dry Mopane-Acacia woodland, but dry miombo areas are found on sandier soils; Market/employment centres include Buchwa iron ore mine; surrounding areas are also CAs, but extensive cattle ranching occurs to the south and west.

Zvishavane District: includes Runde (Natural Region IV; Population: 38159; Area: 99900ha) and Mazvihwa CAs:

Average rainfall: 571.9mm, cv = 0.36; Soils in Runde are primarily sandy, granite derived soils, although an area in the south of volcanic intrusion results in heavier soils. In Mazvihwa soils are either heavy doleritic derived or sandy granite derived; two zones are identifiable. Vegetation is soil related with dry miombo complexes dominating the sandy soils and Acacia-mopane associations on the heavier soils. The major market/employment centre is Zvishavane town where a major asbestos mine is situated; other smaller gold mines exist in the area.

Chivi District: includes only Chivi CA (Natural Region IV/V; Population: 122497; Area 249100ha):

Average rainfall: 531.8mm, cv = 0.35; Soils are varied ranging from heavier soils derived from gneiss and volcanic intrusions in the south, through sandy granitic soils in central Chivi and doleritic/granite mixed soils in the northern part. Vegetation associations are equally complex. Market/employment centres include Chivi Office administrative and market centre situated within the CA, Mashava mining town close by and Masvingo, the provincial capital not far away.

Shurugwi District: includes only Shurugwi CA (Natural Region III (mostly); Population: 48575; Area: 74100ha):

Average rainfall: 1054.2mm, cv = 0.32; Soils are virtually all sandy derived from granite. The vegetation type is predominantly mixed miombo woodland. Market/employment centres include Shurugwi town (mining), nearby commercial farms, and Gweru, the provincial capital of Midlands Province.

Gutu District: includes Gutu, Chikwanda, Denhere and Serima CAs.

Gutu CA Natural region IV (mostly); Population 130916; Area: 227900ha; Gutu average rainfall: 785.5mm, cv = 0.34; Gutu CA soils are dominated by poor granitic sandy soils. Heavier soils are associated with schist belts and doleritic intrusions and occur in a a few parts of the area. Vegetation in most of the area can be characterised as miombo. Local market/employment centres include Masvingo. The area is surrounded by both large and small scale farming areas, as well as a local resettlement area.

Ndanga CA:

Average rainfall: 759.7, cv = 0.32; Soils vary from sandy granite derived soils in the north to heavier soils derived from gneisses with volcanic intrusions in the south. Vegetation is also very variable. Market/employment opportunities are centred on Masvingo.

Information on the regional study areas is centred on secondary sources complemented by short visits (see below). Detailed information was collected for the Mazvihwa case study area while resident there between September 1986 and November 1987 and during shorter visits in April and September 1988 and April 1989. For this opportunity I am indebted to the Mukamuri family who I lived with at Mototi Township Mazvihwa and provided invaluable support to the research. Ken Wilson initiated research in this area during 1986, and it was through his background work (with Billy Mukamuri and others) and the establishment of the household

sample in the area that this research study emerged. Ken Wilson and myself carried out parallel research studies in Mazvihwa during 1986-7, supported by a team of local researchers (see Acknowledgements). The debates generated by this field based working environment have been central to the development of the ideas presented in this thesis.

1.4 The Mazvihwa study area

The Mazvihwa study area is centred on Mototi Ward; one of four wards within the CA (18). Three zones can be defined within this area - the clay veld, edge zone and sand veld. The majority of the ward is on the clay veld plain, typical of the lowveld. However parts of the area are also found in the granitic sand veld area of the Bungowa hills, more typical of the middle veld. The area in between has a mixture of characteristics. The contrasts between these zones in terms of the dynamics of savanna ecology are explored fully in Chapter 2. A map of the local study area is shown in Figure 1.5.

The household sample

The household sample was initially established within the clay veld and edge zones. With the realisation that the edge zone was not truly representative of the sand veld situation this was extended to cover some households in the sand veld zone in November 1986. As a consequence the sand veld zone is underrepresented in the overall sample. The household sample included 71 households and was established in relation to two types of stratification during 1986 (see Appendix 7):

- Ecological zones: for the comparison of the dynamics of production in the clay veld, edge zone and sand veld.

- Household production characteristics: for the

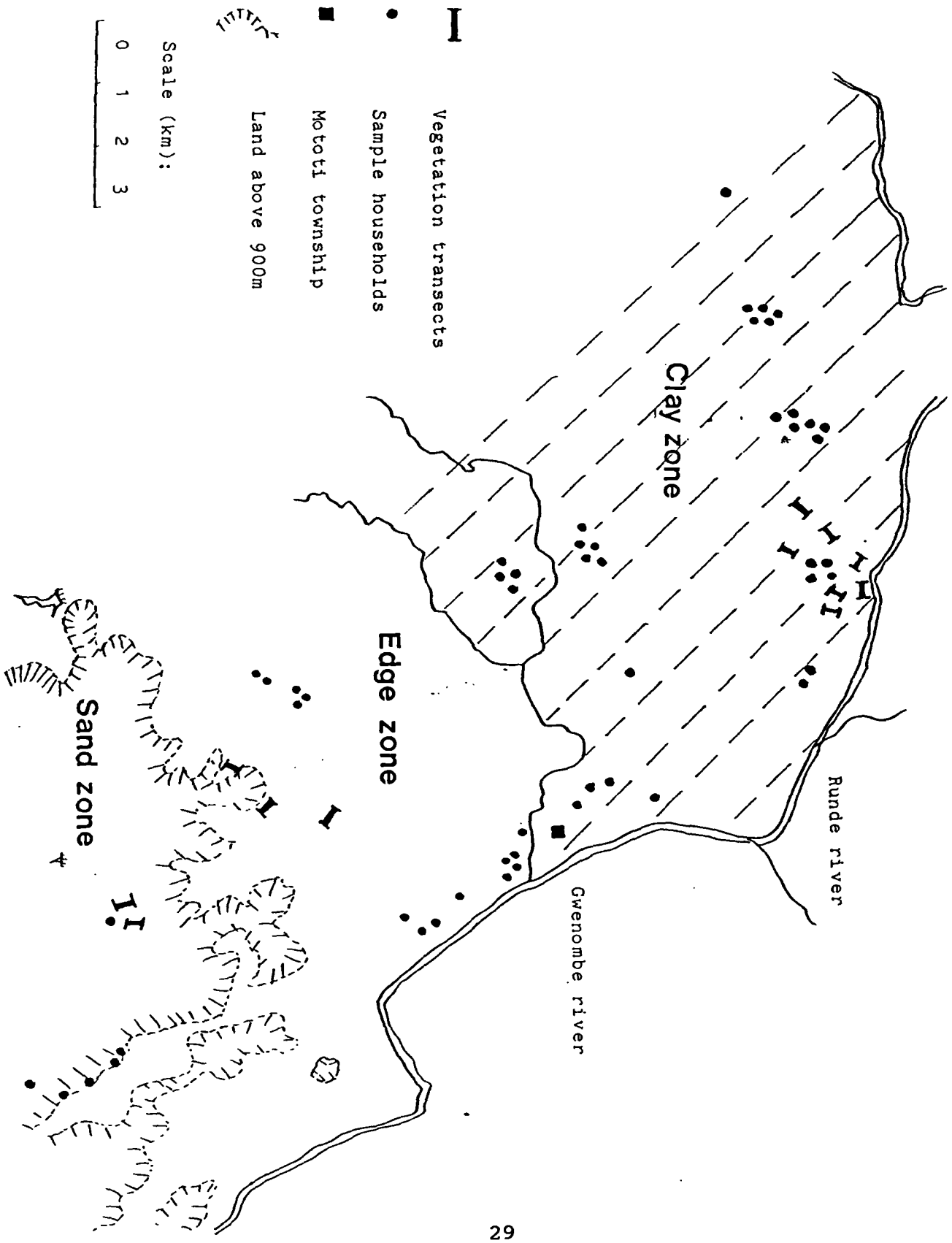
comparison of households in different forms of lineage production system and with different levels of income and asset holding (notably cattle).

The position of the sample households, the sites of livestock management investigations and the areas where vegetation sampling took place are shown in relation to savanna type in Figure 1.5.

The sample stratification according to household production characteristics requires some explanation. With no baseline data available the initial choice of households for detailed study was carried out by Ken Wilson on the basis of a purposive sampling approach using the insight of key local informants, notably Mr C. G. Mukamuri (Primary School Headmaster of Mototi School and our host). Clusters of cooperating households were identified. Such clusters are usually centred around a lineage (or shallow lineage (19)) head and his family. Sons and their families, as well as other more distant relatives and on occasions 'outsiders' who become attached to the group, are associated through sharing relationships often centred around the cooperative use of draft power, agricultural inputs and labour. These clusters are not static, but vary over time, but they are central to the organisation of local production (see Chapter 6; Appendix 9). Such clusters were identified in each zone, including both chiefly and immigrant lineage groups (20). Through extensive interviews with the 'cluster head' and others an impression of the pattern of organisation was worked out.

This allowed for the choice of a selection of households within a cluster, covering a range of ages, asset holdings, income sources etc. Not everyone works together as part of a lineage cluster; there are those whose production is relatively independent or perhaps only sporadically reliant on others. A selection of examples of this type of production organisation were also included in the sample.

Figure 1.5: Mazvihwa study area, Mototi ward: savanna ecological zones, sample household sites and vegetation study sites.



Again because no base line exists for this approach to sampling rural households, no indication of statistical representativity could be gained and local impressions were used as the guide.

Clusters and households

The sampling thus was focused at two levels of local organisation - the cluster and the household. The definition of these two terms is problematic, but critical. A cluster can be defined as a group of households who cooperate on a range of production activities. The definition of a household employed in this study refers to the local conception of a home being associated with a residential space, which is nominally 'owned' by a senior male belonging to that lineage group. Within this there may be a number of kitchens or granaries (especially in polygamous families or when newly married couples have not established a new home). Definitions used elsewhere were found not to be useful in the local context (21). Households can thus vary in size from 3 to more than 30. This definition of household is again not static and can result in dispute where boundaries are not clear. This applied to several households within the sample and an arbitrary decision had to be taken for the purpose of analysis (22). Patterns of intra-household organisation are also significant to the understanding of household economies and livestock production. Although qualitative insight was gained through the close interaction with all the members of the household sample, this important area is not fully explored in this thesis.

Livestock are individually owned but may be held in a common kraal where animals from a group of households are kept. Use and management of these animals may be on a group basis, involving sharing and loaning relationships. For a study of livestock and the household economy a sampling frame that accounts for both cluster and household differentiation is essential. A 'random sampling' (or

variant) approach based on the household level would produce a sample that would not be a good base for investigating the complexities of livestock management and the nature of inter-household interactions.

A more detailed exploration of differentiation within the household sample was carried out at a later stage using the technique of 'wealth ranking' (see Chapter 6). This allowed the effective stratification of the sample on a household basis according to local criteria of 'wealth'. This further stratification proved very useful for detailed comparative analysis of household strategies.

The representativity of the household sample could only be assessed post hoc. As data was collected this could be related to other studies with a larger sampling frame carried out in the area. Data on livestock holdings, arable areas, demographic patterns etc could be related to information collected as part of the Central Statistics Office National Household Survey and the work carried out by the Farming Systems Research Unit in neighbouring Chivi CA (23). At a more local level the nature of livestock sharing and the associated pattern of household clusters could be assessed with a follow-up to the Agritex livestock survey carried out in 1987 (24). Assessments of comparability are included as part of the text of subsequent Chapters when local data is presented. Comparisons of human demographic and livestock ownership patterns are presented in Appendix 2.

(* p. 36a-b)

1.5 Research approaches

This study encompasses historical investigations of changes in production systems and livestock policy, regional analysis of livestock populations and the influence of economic and ecological factors and a local level study of socio-economic processes and their interaction with ecological dynamics. This range requires a diversity of

research approaches. Details of different research methodologies are given as part of subsequent Chapters. At this stage only a brief introduction to the variety of research approaches employed and sources used is needed.

Historical investigations: An understanding of the changes in the production system and the influence of government policy was the major aim of the historical investigations. A combination of archival research and oral historical explorations were used (25), supplemented by published secondary sources.

Population dynamics: Changes in livestock and human populations were investigated for the period between 1923 and 1989. Data at a communal area level is available in archival sources between 1923 and 1986, while livestock population data by individual dip tank is available for the local study area of Mazvihwa from 1981. This data formed the basis for examining livestock population changes in terms of simple bioeconomic models.

Local livestock production: The herds and flocks of the Mazvihwa household sample were monitored closely. It took some time before an accurate picture of herd and flock size (including loaned animals) was gained. This involved recording all animals held and owned by name and meant repeated cross-checking. Production data was collected by compiling cow histories of all reproducing cows in the sample, by asking about pre- and post drought herds, by asking about sales and purchase patterns in the recent past, by monitoring milk production of selected cows and by recording monthly changes in births, deaths, sales, purchases and loans of all cattle, goats and donkeys in the sample. Data on chickens, pigs and sheep was not collected on a regular basis.

Household economy: An understanding of the nature of the local household economy was achieved through discussions with the household sample members between November 1986 and

April 1988. A semi-structured approach to this work was taken, using checklists of issues to discuss rather than questionnaires. Monthly discussion topics centred on a particular theme; the choice of which was heavily influenced by research experience during the previous month, as well as discussions with local people and the research team. Certain questions were asked regularly; these included the discussion of income and expenditure patterns and crop yield/sale levels (26).

Case studies, comparability assessments and thematic surveys: Where data could not be analysed in a quantitative frame, case studies are used to demonstrate particular points. Comparability assessments were carried out in neighbouring areas outside the sample to provide general comparisons of the different areas. These were carried out both within Mototi (Village Development Committee survey), elsewhere in Mazvihwa and in other regional study area Communal Lands (Runde, Chivi, Mwenezi, Shurugwi (27)). Thematic surveys were carried out on areas of particular interest. These included a study of local perceptions of different browse species, local grass classifications, livestock diseases, the nature of environmental degradation, and ceremonial and ritual aspects of livestock production in the area. These focused studies relied on key informants, largely from Mazvihwa.

Ecological studies: A basic characterisation of the local environment was achieved through the examination of the tree and grass layer in a series of belt transects within the Mazvihwa study area (see Figure 1.5). This complemented the investigation of livestock foraging behaviour aimed at investigating actual responses to variable and patchy resources.

Living and doing: Living locally, in close contact with daily events, was undoubtedly a valuable component of the research approach. Through our hosts, the Mukamuri family, the research team of local people and interaction with many

local people the depth of understanding of the farming system was increased. The initiation of two small community natural resource projects that emerged from the research effort and were run by members of the research team also inevitably had an impact (28). The transfer from research debate to practical action during 1987 meant that new sets of issues were brought up.

Discussion workshops: The establishment of the two NGO projects were in part the result of a series of community workshops on various issues. During 1987 two series focused on tree management and on wetland use. These were held in different parts of Mazvihwa, Runde and Chivi CAs (29). A later workshop at the close of the field research aimed at feedback and review of research results concentrated explicitly on issues of livestock production and management. These community workshops, attended by between 20 and 60 people and lasting several hours, were an important opportunity for the wider group discussion of research findings generated by the detailed household based study.

1.6 Structure and content of the study

So far the general aims and research approach of this study have been outlined. In this section the specific aims of each Chapter are briefly summarised to give an idea of the overall structure and content of the thesis.

The contrasts in ecological dynamics of different savanna types found in the study areas are explored in Chapter 2 within the framework of agroecosystems analysis. Differences in productivity, stability and sustainability properties of clay and sand veld savannas are discussed, providing a basis for the development of hypotheses about livestock production and management in different areas.

Changes in the local production system during this century are examined in Chapter 3. Transformations occurring at the

local level are related to wider land-use and livestock policy changes. Changes in the natural, economic and policy environment provide insight into the patterns of livestock population dynamics over time and the constraints imposed on opportunistic management strategies to cope with variable environmental and economic factors.

Cattle populations changes between 1923 and 1986 are investigated with quantitative data in Chapter 4. The interaction between economic and ecological factors is explored in relation to both changing sales responses and the impact on biological parameters of increasing cattle populations. The question of 'carrying capacity' is addressed and a series of models applied to assess possible levels for different savanna types.

Investigating livestock population changes requires a detailed understanding of the economic role of stock in the local production system. This is explored in Chapter 5 with an elementary assessment of economic value of cattle, donkeys and goats in terms of both their service and output functions. This provides an economic framework for understanding the reasons why people keep animals.

The economic role of livestock and the value of different functions is critical to understanding the investment and disposal decisions that affect population dynamics. This is investigated in detail in Chapter 6. Investment and disposal is not simply related to economic value, but is related to a complex of other factors. These include demographic factors, access to off-farm income sources and success in agriculture. These factors vary according to 'wealth' status as well as ecological zone. Differences in patterns of income and expenditure, asset ownership, household demography and food security position are related to differences in stock ownership, sales and expenditure.

Economic and ecological factors influencing population dynamics vary between years. In Chapter 7 the consequences

of drought on livestock production are investigated, with the cases of 1982-4 and 1987-8. The patterns of change of livestock populations in different savanna types of Mazvihwa are discussed and the consequences for biological parameters explored. The survival probabilities of cattle from the household sample are related to both management (herding and movement) and ecological factors, focusing on the contrasts between clay and sand veld areas.

The mechanisms of livestock survival under high stocking rates are investigated through a study of livestock foraging behaviour reported in Chapter 8. The seasonal use of different fodder resources is examined in different savanna types, and the 'key resources' that provide fodder at critical times of year are identified. This provides some answers to the question of how livestock populations persist and what resource components ultimately influence population patterns.

Chapter 9 investigates the possible implications of high stocking rates on the CA environment. Degradation (in terms of permanent changes in livestock production) is investigated using a number of indicators of secondary production (birth rates, extraction rates, 'equilibrium' densities). Changes in these are investigated for the cattle populations of the regional study areas over time, to investigate whether high stocking rates and apparently significant erosion levels are affecting the sustainability of livestock production.

Finally, Chapter 10 concludes with a summary of principal conclusions and a discussion of their implications for livestock policy and future research in Zimbabwe.

Resource ownership and decision-making (* insert)

Control over resources within the study area is affected by overlapping patterns of rights and obligations, ranging from the indiviudal through the household to the shallow lineage cluster. Wider social formations of the lineage, chiefdom and clan may also be significant. Patterns of decision-making are affected by interactions between these different levels of social organisation.

Assets are generally formally owned by an individual, however others may have claims over it. These are most likely to be other household members and close kin. For instance, arable land is allocated to the male household head, but the land may then get used by others within the household or loaned to relatives within the cluster. Since land is no longer allocated directly to women they must make claims on their husbands' allocated land in order to have direct access to cultivated land. Depending on who is holding the land, different decisions are likely to be made about its management. For land claimed by women the choice of crops for planting is likely to be decided by the woman. In the land formally owned by the husband, decision-making about cropping strategies will be dependant on the man's involvement in the agricultural process. In many households the husband is absent away at work and not directly engaged in agricultural production at the rural home; although he may be called upon to assist during vacations or contribute money for inputs at various stages. In such cases, it is the resident women and younger men who dominate factors of agricultural decision-making.

A distinction between use rights and disposal rights is relevant to discussion of control over livestock. Although animals are formally owned by individuals, claims can be made on their outputs by others. Draft or milk products may be widely shared through sharing or loaning arrangements between households, although primary access is maintained by the owner's household. Rights of sale are however

retained by the individual owner. These overlapping sets of rights thus affect patterns of management and sale of livestock. For instance, even if a household has sufficient cattle for their own use, cattle may be retained in the household herd and not sold if others within the lineage cluster have draft needs unfulfilled by their own animals. Under such a situation the household to whom the animals are lent may take over certain management tasks, such as herding (see Chapter 6).

Grazing areas are common property resources, but resource control involves a diffuse pattern of overlapping rights, including those of land spirits, chiefs, ward councillors, village development committee leaders, local patrilineage heads and individual homes. Rights at any one level never fully exclude rights at another. Because of the complexity of these competing claims, there are limited possibilities for evolving systems of exclusive tenure. However, there is often a sense of localised control around 'neighbourhood grazing territories', often associated with a particular patrilineal shallow lineage group, around which local management strategies may evolve (see Chapter 8; Scoones and Wilson, 1988).

Patterns of access to and control over resources is neither static over time or constant between households or areas. For this reason a disaggregated analysis of decision-making in the household economy is needed. This is attempted in Chapter 6.

Footnotes

1. Communal areas (CAs) represent the heritage of colonial land policy. These were the areas allocated for African residence as 'reserves' and later Tribal Trust Lands. The Communal Land Act (1982) formally recognised their status as land where in arable areas people can hold land, but where grazing land is held in common. All land in the CAs is owned by the state.

2. Veld is a southern African term for rangeland/grassland and will be regularly used in this thesis. Clay/sand veld refers to the differences in soil substrate of different savanna types.

3. The basis for the agroecosystems approach is explored fully in Chapter 2.

4. Drinkwater (1988) has provided a thorough analysis of the influence of different perspectives on the policies of rural development in Zimbabwe.

5. The mining industry in southern Zimbabwe includes substantial gold, asbestos and iron ore mines. The commercial agricultural sector in the area is dominated by ranching enterprises in the drier south (both individually owned and held by large corporations), but there are also significant maize cropping farms in wetter areas, as well as the large irrigated sugar estates in the low veld.

6. The division of land nationally according to different land tenure types is shown below:

	% Avail Agric	% Total land
Large scale commercial	39	33
Small scale commercial	4	4
Communal Areas	49	42
Resettlement	8	7

Source: GFA (1987: 20)

7. Middle veld refers to the area of the country on the edge of the central plateau. The low veld refers to the area off the plateau stretching down to the Limpopo.

8. Natural regions were assessed on the basis of a range of agro-ecological factors, primarily rainfall. The assessment is used as a land capability map where different 'ideal' production systems are delineated. The characteristics of the Natural Regions are outlined below:

Region I: Rainfall high and effective; specialised and diversified farming region. Suitable for afforestation, horticulture and intensive livestock production.
Region II: Rainfall c. 750-1000mm; stocking rates 3-4 ha/LSU; suitable for intensive crop and pasture production, including maize, cotton, tobacco.
Region III: Rainfall 650-800mm; stocking rates 5-6 ha/LSU; suitable for livestock production combined with growing short season crops.
Region IV: Rainfall c. 450-650mm; stocking rates 8 ha/LSU; suitable for drought resistant cropping combined with livestock ranching
Region V: Rainfall less than 450mm; stocking rates 12 ha/LSU; suitable only for extensive cattle or game ranching.
(Sources: National Conservation Strategy, 1987; Agritex, nd)

Most CA land, including the study areas, is found in the drier regions, deemed 'unsuitable' for mixed farming.

9. Miombo refers to a woodland association dominated by Julbernadia globiflora and Brachystegia spp., typical of much of central Africa.

10. Annual rainfall patterns (September - August) for stations within or close to each of the regional study areas for the period between 1923 and 1986 are shown in Appendix 1.

11. This study is concerned with the CAs in the central south of the country and does not relate to the high rainfall areas on the plateau and the Eastern Highlands, the situation in the lowveld and Matabeland or the Zambezi Valley.

12. Resettlement was initiated after Independence but has not achieved projected targets (Cliffe, 1986). There are four resettlement models, which by 1986 (Ministry of Agriculture data) had resettled under 350000 families:

Model A - Small scale farming units held individually with arable blocks and communal grazing (29670 families; 1834000ha)
Model B - Producer cooperatives (2400 families; 95000 ha)
Model C - Collective farms (515 families; 18000ha)
Model D - Group use of ranch grazing land (636 families; 23000ha)

In Masvingo Province c. 2.6ha/caput was available and in Midlands Province the population density was 3.5ha/caput (GFA, 1987: 25). The population growth rate in Masvingo CAs between 1969 and 1982 was 2.6% (CSO statistics).

13. According to the GFA survey the order of importance of crops in Mberengwa and Chivi CAs was: Maize, sorghum, groundnuts, finger millet, bullrush millet, beans (of different sorts), sunflowers. Other crops include a wide variety of cucurbits.

14. Today the District Council via the Ward Councillor and the Village Development Committee have rights to allocate land. In the past this right was given to the sabukhu (village headman) and the chiefs, except during the period of land reorganisation when the state took control of land allocation decisions.

15. Offtake rates according to official figures generally range between 2 and 5% for cattle populations.

16. The question of whether southern African rural people can be referred to as peasants, where reproduction occurs through rural based production, is ongoing. Some have suggested the term worker-farmers as more appropriate. This study will not be drawn into this discussion, except to acknowledge the importance of considering the wider economy in relation to rural production systems.

17. Previous names of the regional study areas are:
Mberengwa = Belingwe; Chivi = Chibi; Zvishavane = Shabani; Runde = Lundi; Mazvihwa = Mazvihwa-Bungowa; Shurugwi = Selukwe; Ndanga = Zaka.

18. Following the Prime Minister's Directive of 1984 a new administrative structure was established in the CAs. This involved the establishment of wards and within these a series of Village Development Committees (VIDCOs). Each

VIDCO is supposed to contain 100 households or approximately 600 people.

19. As lineages have grown and split, new clusters have formed around those who have moved away from the chiefly head. These can be referred to as shallow lineage clusters.

20. In Mazvihwa, the chiefly Ngowa group dominate part of the area. However there are other lineage groups who are 'immigrants' to the area.

21. Household definitions often focus on the use of a common hearth or characterise households as eating from the same pot (cf Moock, 1985). However, in rural Zimbabwe several kitchens may exist within one unit, especially in polygamous families. Just as Zimbabwean 'households' are not defined in terms of consumption units, they are not necessarily production units either. As discussed briefly in this Chapter, group forms of production within clusters are important in this respect. The definition of a social unit, such as a 'farm family' is also problematic due to the fluid nature of social relations. Although each of these definitions reflect elements of the Zimbabwean situation, the most useful definition for the current study focused on the residence unit as a means of classifying households. This was not without problems though (note 22).

22. This applied particularly to households in the process of formation. These included instances where younger sons had married but had not established a new home separate to the fathers'. By the end of the study period this had happened in one case.

23. The National Household Capability Survey includes regular survey work carried out in Mazvihwa. However this is aggregated and the comparable data refers to an average for several sites in Midlands Province. The FSRU studies carried out in 1982 and the ICRA study of 1987 provide comparable data for Chivi South (Collinson et al, 1982; ICRA, 1987).

24. Agritex extension workers were requested to carry out livestock surveys during 1987. These they carried out in three wards of Mazvihwa using information collected by village headmen. A selection of villages in Mototi Ward were visited later in the year as part of this research to cross-check the figures and investigate cooperative/sharing

cluster relationships in these areas not covered by the household sample. Very similar patterns were found throughout; the detailed results of this are not reported here.

25. The understanding of environmental history of the area was greatly assisted by the preliminary work carried out by Ken Wilson and Billy Mukamuri during 1986.

26. Crop production data was collected primarily by Ken Wilson.

27. Studies carried out in other areas were assisted greatly by the involvement of University of Zimbabwe students during vacations. The work carried out by Billy Mukamuri in Chivi, Marx Mahobele in Mwenezi and Frank Matose in Zaka was very important in allowing a wider perspective to be shed on the Mazvihwa research. Mr Z. Phiri assisted enormously in introducing me to Runde and many people there. The area of southern Chivi was visited during the ICRA course of 1987 at the invitation of Sam Jackson and team, this visit and the subsequent work with ENDA there allowed me to learn something of that area. The Commonwealth Science Council/Forestry Commission of Zimbabwe training course during 1988 provided me with some insight into the situation in Shurugwi. This was extended through discussions with Jo McGregor whose work on woodland management provides significant comparative insights. Finally, Mike Drinkwater, who was working further north in Chilimanzi and Chiwundura, also helped with setting the comparative context to the work with his wide knowledge of Midlands Province.

28. During 1987 the Zvishavane Water Project and the ENDA-Zimbabwe Community management of woodlands project were established. This was achieved with the support of Oxfam (UK) and the Ford Foundation. The projects initially operated in Mazvihwa, but have since expanded to work in Runde and Chivi CAs, working with many of the communities who supported this and other research so much.

29. Community workshops on woodland management issues were started in early 1987 (see Wilson, 1987, for two transcripts) and continued as part of the ENDA-Zimbabwe project. A series of workshops on the use of vleis were also held as part of the research of the Zvishavane Water Project.

2. THE PROPERTIES OF SAVANNA AGROECOSYSTEMS

2.1 Introduction

In this Chapter an interpretation of savanna structure and functioning will be presented that will form the basis of the examination of historical and contemporary livestock management strategies in southern Zimbabwe. Current understanding of savanna ecology will be examined by looking at the trade-offs between the agroecosytem properties of productivity, stability and sustainability. This provides the opportunity for examining the dynamics of different savanna systems in terms of the implications for livestock management and household economics. It is a central argument of this research that the ecological dynamics of savanna systems need to be understood in order to explain the interaction of economy and ecology within rural production systems. For it is the responses of different savanna types to changes in abiotic and biotic factors that form the backcloth on which the livelihood strategies of peasant producers are played out.

Savannas include a range of different types with the common characteristic that their vegetation is typified by a mix of trees and grass and the rainfall is variable interannually and seasonally dependent. The savanna zone is found between mean annual rainfalls of 300mm and 1500mm in Africa, but boundaries and definitions of what constitutes a savanna are not stable (see Huntley and Walker, 1982; Bourliere, 1983; Tothill and Mott, 1985 and Frost et al, 1986 for comprehensive recent reviews). This research is concerned with the savanna areas of southern Zimbabwe which includes the dry miombo woodland area on the edge of the highveld escarpment and on granitic derived outcrops further south and the typically 'lowveld' vegetation in the lower rainfall areas. The regional study area has average rainfall totals ranging from c. 850mm to c. 500mm, but in all areas the dominant characteristic is its variability.

2.2 Agroecosystem properties

Much of the work on African savanna ecology to which this Chapter refers has been carried out in relatively unaltered wildlife or ranching systems. This study is concerned with the agropastoral systems of the communal areas of southern Zimbabwe which, through human intervention, have changed considerably, especially during this century (see Chapter 3). However, many of the principles of a systems approach remain useful.

Conway (1987) has argued that agroecosystems can be viewed as modified ecosystems, where boundaries are imposed by economic activity and system properties can be seen to have both ecological and economic dimensions. Agroecosystems exist at different levels of a hierarchy ranging from a relatively simple field/paddock system through the farm and livelihood system to wider economic interactions. As Allen and Starr (1982) point out lower level patterns are not predictable from higher level processes and scale is a vital consideration in any study of complex systems.

In this study two levels are focused upon. In Chapter 4 the regional livestock populations dynamics and the interactions between biological and economic factors in determining livestock population dynamics over time are addressed, while in subsequent Chapters the livelihood systems of different producers in different ecological zones are investigated. It is the interaction between these levels, where household level management decisions affect agroecosystem patterns or where macro-level policies influence local scale interactions, that are of particular interest.

As with other systems, agroecosystems can be analysed in terms of their key properties. Previous studies have focused on the determination of flows of productive resources (eg energy cf. Coughenour et al (1985) for a pastoral system), following the tradition of the classic

early ecosystem research (Odum, 1968). In this study there is a greater concentration on the trade-offs of production dynamics. This approach derives from an increasing interest in the dynamic properties of ecological systems developed largely among population biologists during the 1970s (eg May, 1973; May, 1981), where theoretical modelling approaches explored the stability properties of different dynamic systems. Conway (1987) argues that agroecosystems can be analysed in terms of the trade-offs between four properties - productivity, stability, sustainability and equitability. These properties describe the level, variation, resilience and distribution of production and can be measured in ecological or economic ways.

Table: 2.1: Agroecosystem and ecosystem properties (after Conway, 1987)

Productivity: The increment in numbers or biomass per unit time. In savanna ecosystems this may be measured as biomass production and agroecosystems as yield or net income.

Stability: The constancy of productivity in the face of small disturbances, measured by the coefficient of variation of yield. In mathematical ecology this refers to local or neighbourhood stability.

Sustainability: The ability of the agroecosystem to maintain productivity over time in the face of large disturbances, eg. repeated stress or large shock. This relates to global stability or resilience of ecosystems.

Productivity

Assessment of productivity of savanna systems requires measures that include economic and ecological components. If the focus is livestock productivity, it is vital to ask

what are the key primary production constraints. These may relate to either overall biomass production or fodder quality, depending on the savanna type or year. Deciding on an appropriate measure is critical.

The same applies to economic assessments. An appropriate measure, especially for subsistence production, is critical in any evaluation of the comparative economics of different systems (Behnke, 1985 and Chapter 5). Conventional monetary valuations may not capture the complexities and diversity of integrated strategies of rural livelihood systems.

Stability

Stability refers to the ability of a system to return to an equilibrium position following a perturbation (Holling, 1973). A system may have a number of stable states to which it is attracted (cf. Walker et al, 1981 for savanna tree-grass dynamics, Noy Meir, 1975 for grazing examples and May 1977 for the general theoretical argument). A stable system thus shows little variability through time. In savanna systems a distinction needs to be made between functional stability (in terms of primary production) and compositional stability (in terms of species composition), since they may be negatively correlated (McNaughton, 1977).

The question of risk and coping with uncertainty is central to the farmer/herder responses to the stability properties of an agroecosystem. The economic anthropological literature addresses farmer production strategies in dryland areas with some quantitative methods, but with an acknowledgement of the limitations of conventional agricultural economics methods in the context of imperfect markets and complex production functions characteristic of most African rural situations (eg. Starr, 1986). An alternative emphasis has been to investigate through case studies the specific strategies of farmers to the uncertain environment (eg Richards, 1986; 1989).

Resilience and sustainability

May (1981: 87) suggests that:

> "Resilience characterises the magnitude of the population perturbation the system will tolerate before collapsing into some qualitatively different dynamical regime.".

In the case of African savanna systems stresses would include continuous high levels of herbivory or erosion and shocks would include the effect of drought. Shifts to alternative states might relate to permanent changes in the woody-grass balance of the savanna or permanent changes in potential productivity, primary or secondary.

Under the influence of stresses or shocks a resilient system's parameters defining its boundaries may change considerably (ie the system may be quite unstable), and so allow the system to accommodate further disturbances more easily (Walker et al, 1981).

The sustainability of African farming systems has become increasingly a focus of the environment-development debate (WCED, 1987). However much of this discussion has been focused at the macro-level with the development of accounting techniques that internalise externalities and acknowledge the implications of the degradation of environmental capital (Pearce et al, 1988). Alternatively bioeconomic models address the situation in mathematical terms, integrating insights from population dynamics with the application of market based economic analysis (Clark, 1976).

These approaches to sustainability have not been applied effectively to the household level, where the trade-off between individual economic welfare and societal environmental protection is most acutely felt. This is particularly so because of the paucity of data on the

interaction of environment and livelihood strategies. Here the argument remains at a general level, emphasising the complexity and diversity of resource poor farming systems (Chambers, 1987).

Scale

In examining system properties scale is important. Frost et al (1986) point out that considerable variation in production or species composition can occur in grasslands at the local scale, giving the impression of instability, but if viewed over longer time frames or within a landscape context, the system appears to exhibit more stable properties. DeAngelis and Waterhouse (1987) suggest that the greatest challenge to understanding complex ecosystems is to understand the role of dynamic patches as part of wider systems often with non-equilibrium behaviour. They argue that the prediction of the spatial and temporal patterns of ecological communities within a landscape requires the development of new techniques.

This is particularly true for agroecosystems where complexity is increased by the additional influence of human economic activity, for dryland systems where spatial patchiness and temporal variability are dominant characteristics and for peasant farming systems where equilibrium models have limited application.

An agroecosystem approach can provide a useful conceptual model for interdisciplinary analysis and offers the potential for bridging the gap between ecology and economics, as each of the key agroecosystem properties have both economic and ecological measures and can thus assist in developing an integrated analysis.

This Chapter is concerned with the trade-offs between productivity, stability and resilience/sustainability in savanna systems. An examination of the properties of different savanna types found in the study area (sections

2.3 to 2.8) will form the basis for exploring the livestock management implications of these differences (section 2.9).

Livestock and range management policy recommendations are conventionally derived from a set of assumptions about range systems derived from the range management experience in the US, Australia and commercial systems of southern Africa (the 'mainstream' view, Sandford, 1983). These can be contrasted with ideas derived from savanna ecology. The dichotomy developed below is not wholly real, as there is great overlap in influence and ideas between the different approaches. However the distinction is useful in highlighting some of the practical implications of the different views; most policy recommendations for livestock and range management in Zimbabwe are derived from the 'mainstream' view (see Chapter 3). The implications of the agroecological approach will be the focus of the next sections of this Chapter.

Range management view	Agroecological view
Focus of management on compositional stability of grassland with objective aimed at a diverse sward of 'climax' grassland in topland areas.	Species compostion very variable; management focussed on functional properties of different land types, including small patches.
'Carrying capacity' related to rainfall and topland grassland production. Assessments based on deviations from 'climax' grassland associations.	'Carrying capacity' complex and derived from understanding of economic context and consideration of limiting factors to secondary production.
Grassland is preferred to trees - effort is often spent in 'bush removal' programmes.	Browse is essential for production, especially smallstock. Trees may improve quality of grass.

Management for grassland quality not prominent, as supplementary concentrate feeding usually recommended.	Differences in grassland quality (eg sand veld vs clay veld) important; annual grass species can be advantageous.
Management of movement through paddocking and complex grazing rotations.	Movement is adaptive in response to changing resource availability.
High stocking rates are assumed to be damaging to production; conservative stocking rates are required.	High stocking rates are required for sustaining the agropastoral system; opportunistic management is needed.
Heavy use assumed to mean environmental degradation. Indicators include: changed grass species composition, bush encroachment and increased erosion.	Impacts of changes in physical resources on secondary production are unclear.

The following sections will examine these contrasting views with a review of the literature. Section 2.3 will explore the implications of different limiting factors for savanna structure and function. Primary production processes (section 2.4), vegetation compostion and quality characteristics (section 2.5) and the impacts of herbivory (section 2.6) will be examined in order to investigate the implications for livestock productivity, stability and sustainability. A classification of savanna types in terms of these properties and an investigation of spatial variation in savanna systems (section 2.7) leads into a characterisation of the savanna types of the study area (section 2.8) and hypotheses about livestock management systems in the area (section 2.9).

2.3 Limiting factors and savanna structure

The structure and functioning of semi-arid savannas is critically determined by the trade-off between available

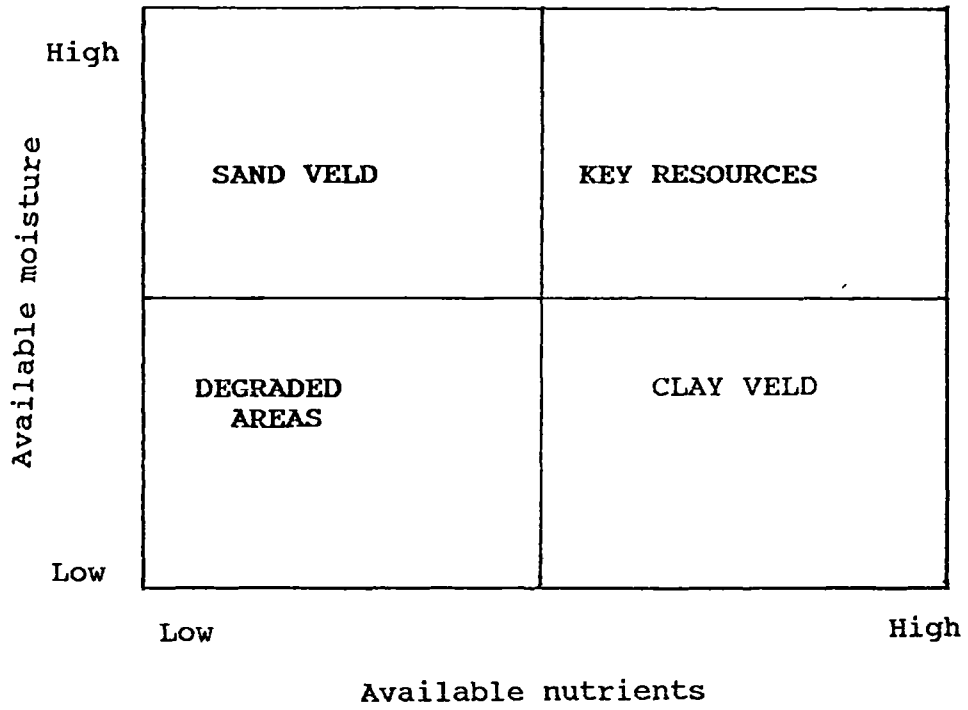
soil moisture and available nutrients (Huntley, 1982; Bell, 1982). Along the continuum between savannas that are totally water limited and those that are nutrient limited a number of different savanna types can be identified (Walker, 1985) (see Figure 2.1 modified from Frost et al, 1986). An important contrast is between the water limited savannas of the more arid areas and those with higher water availability but nutrient poor soils. However such a classification should not give the impression that savanna structure and function is deterministic and predictable. A range of composite factors interact often with cumulative and synergistic effects acting at different rates and at different spatial/temporal time scales (cf. McNaughton, 1983 for the Serengeti system).

This section examines the influence of soil moisture and soil nutrient properties on savanna structure and function. This trade-off is explored in terms of patterns of woodland-grassland and nutrient cycling found in savanna areas.

Rainfall and soil moisture

In dryland savannas, rainfall is recognised to be a major controlling factor in determining savanna structure. Grass yield - rainfall relations have been determined for a number of different areas (eg. Rosenzweig, 1962; Rutherford, 1978; Dye and Spear, 1982; Deshmukh, 1984; McNaughton, 1985). The relationship is not stable and is site specific, as demonstrated by Rutherford's (1978) compilation of data for southern African systems. It is the spatial variability in the amount of effective received rainfall that is significant in relation to productivity. This varies enormously and is conditional on the pulsed nature of rain storms, their timing and the influence of edaphic and topographical factors on the rainfall-production relationship.

Figure 2.1: Limiting factors and savanna structure



Rainfall amounts are highly variable within semi-arid environments. This pattern of high interannual variability of rainfall is reflected within Zimbabwe and within the study area (see Appendix 1). Interannual variations are also set within longer term oscillations. In southern Africa a cyclical pattern with a stable 20 year periodicity and a less stable 10 year cycle has been shown for long time series of rainfall data (Tyson, 1978). Distinct dry and wet phases can be identified, and Tyson predicted the rainfall shortfalls of the early 1980s on this basis. Longer term cyclical patterns of rainfall are superimposed on year to year uncertainty in rainfall amount and pattern. Particular rare events (eg extreme drought or high rainfall) can also have a large impact, especially when several factors influencing savannas are combined (eg drought, high herbivore levels, fire). It is not therefore simply the average combination of different factors that is important, but the "co-occurrence of independent episodic events" (Walker, 1985) that can have marked effects on community structure, population dynamics or local economies. The context of drought events in the study area will be examined in this light in Chapter 7.

The potential stocking rate of animals in a particular area has been found to be closely correlated with annual rainfall (Coe et al, 1976; LeHouerou and Hoste, 1977). However this relationship is mediated by soil type. Soil moisture may be limiting in most years in heavy textured soils with low available water capacity, but only occasionally in sandier soils (Knoop and Walker, 1985).

Soil nutrient properties

Bell (1982) has argued that the correlation between animal density and rainfall, derived by Coe et al for a number of wildlife populations, focuses on nutrient rich volcanic soil systems to the exclusion of others existing on soils derived from the rift or poor nutrient soils. He presents

new data to support the hypothesis that the rainfall - carrying capacity relationship is modified by soil type, with higher population densities expected on soil types with higher nutrient content for a given rainfall incidence. The mechanism proposed considers the availability of food in terms of the ratio of metabolic to structural constituents; this differs according to savanna type. In nutrient rich savannas high quality food supports a high biomass of herbivores. In poorer nutrient systems, animals adapted to low quality food can survive. He suggests further that in nutrient poor systems population densities decrease with increasing rainfall higher than 800mm. East (1984) compiles species specific data to support the hypothesis and concludes with McNaugton and Georgiadis (1986) that the relationship fits within the arid to dry subhumid zone, though not necessarily in moister savanna areas.

Community structure of savanna systems are thus seen as determined by a balance of available soil water and nutrients. Bell (1982) proposes a successional model to explain the observed differences between the two savanna types. On poor quality soils a woodland with a low quality herbaceous layer is supported. Larger herbivores are able to survive in this environment gaining nutrition from bulk intake of low quality vegetation, but at only relatively low densities. In this situation the woodland cover remains stable and open grassland areas are not a dominant feature. On higher quality soils a mixed herbivore community can be supported at higher densities because of the better quality feed resource. Such herbivores may suppress woodland and encourage grassland areas. The high herbivore biomass possible in such areas results in lower standing crop of herbaceous material compared to the poor soil savanna type.

If this hypothesis is applied to livestock production systems in savanna areas, it expects the clay veld savanna systems to support a high but fluctuating population of mixed herbivores (cattle and goats) with the potential for

significant offtake (Bell, 1982: 212). In the sand veld system lower densities of bulk feeders (cattle) can be expected with lower per area offtake potential.

Nutrient cycling

Patterns of nutrient cycling are also significant in understanding savanna dynamics (Menaut et al, 1985; Penning de Vries and Djiteye, 1982). In nutrient rich savannas more typical of arid areas, nutrients may be released in a pulsed fashion with the commencement of the rains. In moist, nutrient poor savannas nutrient release is slower and more stable. The degree to which these patterns of release contribute to actual constraints on plant growth at different stages is unclear. Frost (1985) contrasts the different rates of nutrient cycling in the woody and herbaceous layers. Grass layer cycling is much faster, with much of immediate nutrient availability related to this component.

A major research project in the Sahel has claimed that nutrients are the key constraint in Sahelian systems above 300mm rainfall (Breman and de Wit, 1983; Penning de Vries and Djiteye, 1982). This work contrasts the high quality annual grasslands of the arid zone with the poorer quality nutrient limited grasslands further south and explains patterns of livestock transhumance in these terms.

Woodland-grassland balance

The availability of soil moisture is perhaps the critical factor in determining the woodland - grassland balance (Walter, 1971 emphasised this with extensive early work in Namibia). Soil moisture availability is determined by the interaction of rainfall, the landscape and soil structure. Cole (1982) discusses the importance of the landscape forming processes of geology and geomorphology in determining different savanna vegetation associations. Local topographies and soil profiles have been emphasised

by Tinley (1982). He notes that the presence or absence of a pan horizon, its distance from the surface and the soil permeability to rain are the most important factors determining soil moisture content and thus the spatial distribution of woody cover and grasslands (Tinley, 1982: 183). For instance, the presence of a hard pan is a common phenomenon in the valley systems of savannas. This can result in impeded drainage, the formation of a perched water table giving hydromorphic conditions preventing the establishment of trees. The high water availability results in increased grass production and a system distinct from surrounding tree-grass savanna. Such vlei/dambo (1) systems are important components of the nutrient poor sand veld savannas in Zimbabwe.

Following Walter's work in Namibia (1971), Walker et al (1981) proposed a model of savanna vegetation dynamics principally determined by the availability of water at different soil depths. Trees and grass compete for water resources within the surface soil layer (Knoop and Walker, 1985), but trees have greater access to lower soil water. Depending on the infiltration properties of the upper soil layer different combinations of trees and grass can be expected in a savanna. In heavy soils the upper soil layers retain a significant proportion of incoming water, thus allowing the growth of a vigorous grass layer that can potentially outcompete regenerating trees. In sandy soils, most water penetrates to the lower soil layers and the community can be expected to be dominated by trees.

This competition between grass and trees for soil moisture is seen to be a major determinant of savanna structure (Walker and Noy Meir, 1982). Competition between trees has also been found to be a significant factor in determining the densities, woody biomass growth rates and spacing of savanna woodland (Smith and Walker, 1983 for Acacia woodlands).

Grazing pressure on heavy textured soils has been found to

have a significant effect on infiltration through the formation of caps, compacting soil structure, removing litter and decreasing the prevalence of perennial grasses (Kelly and Walker, 1976 for SE Zimbabwe). Under higher grazing pressures therefore increased run off and decreased infiltration can result in the system tending towards different stable states ranging from open grassland to encroached woodland (Walker et al, 1981). Under the conditions of the higher infiltration properties of sand veld savanna, the grass layer is always insufficient to outcompete the woody component, so a woody-grass system remains relatively stable.

2.4 Agroecosystem processes: primary production

The response of grass production to variations in rainfall in different savanna types has been reported for 15 - 19 year data series by Dye and Spear (1982) for four sites in southern Zimbabwe. The data shows that the correlation between rainfall and grass production is much higher for the clay veld savanna sites than for the sand veld. On the clay veld (Matopos thornveld) grass production is highly unstable fluctuating between 609 kg/ha and 3604 kg/ha (bushed areas) and 1170 kg/ha and 4130 kg/ha (cleared areas). The clay veld has high potential production in good rainfall years reaching levels higher than for the sand veld site (maximum: 2403 kg/ha (bushed) and 3174 kg/ha (cleared)). In drought years however sand veld production is higher than clay veld production, demonstrating the greater stability though lower potential productivity of grass production in sand veld savannas. The levels of production shown in Dye and Spear's data are reflected in other studies in similar savanna types (2).

Grass production is also affected by the degree of tree cover present. The removal of the tree layer results in significant increases in herbaceous production as shown by the above data (Barnes, 1979; O'Connor, 1985 present a

range of data from southern Africa that supports this). Dye and Spear show that in all but one site the removal of trees results in the stabilisation of grass production over time. This is particularly important in the clay veld savanna site where increases in grass production, especially in dry years, were found to be significant. The clearance of trees is found to have different effects depending on the degree of selectivity. Experiments carried out in Tuli area (Kelly et al, 1978) show that the removal of large trees has little effect on grass production, but removal of smaller individuals resulted in large increases in production.

Grossman et al (1980) have investigated the influence of the tree layer on the amount of grazeable biomass in Burkea savanna. They found that although total biomass was higher in open areas away from trees, the amount of biomass, accumulation rates, crude protein content and the amount of digestible organic matter of forage species was similar or higher under trees (3). This result implies that in terms of the impact on grazing the negative impact of the tree layer may be less than the studies simply on biomass totals would suggest, and that tree clearance, as often recommended by range management packages, would be an inadvisable strategy (Grunow et al, 1980).

The production of biomass from the tree layer shows a similar contrast of patterns of productivity and stability in the two savanna types as shown by grass. In the clay veld, leaf and twig production is closely rainfall and growth coincides with rainfall events (Huntley, 1982). By contrast, in sand veld areas a determinate growth pattern is observed where leaf growth occurs independently of rainfall and in relation to photoperiod and increasing temperatures at the end of the dry season (Lawton, 1980 for miombo woodland). Growth thus derives from accumulated reserves and the early leaf-out may be an adaptation to rainy season insect attack allowing secondary chemicals to build up or to allow trees to capitalise on early rainy

season nutrient flushes with an increased transpiration potential (4). This seasonal dimension of stable production, independent of rainfall, of sand veld savanna trees will be explored later (Chapter 8) in relation to browsing strategies by livestock. Studies of available biomass and production of the tree layer of different savanna systems in southern Africa show a wide range of patterns (5; 6).

Clay veld and sand veld savanna woodlands also have contrasting fruit production patterns. In the sand veld miombo the great diversity of fruiting trees is important for human nutrition (Wilson, 1987), but there can be large variations in annual production (Malaisse, 1974). In the clay veld, the Acacia species produce large quantities of pods (West, 1950; 7).

Production is modified by both grazing and browsing. Barnes (1972) reviews simulated grazing experiments and shows how cutting height, frequency and timing all have influences on primary production of grass in southern Zimbabwe. McNaughton (1985) shows how medium intensities of grazing increase overall production. Primary production of grasslands thus must be viewed within the context of use by herbivores. Herbivores alter the nature of the grass sward, increasing production and fodder quality and may act to facilitate grazing by other animals in terms of a grazing succession (Vesey Fitzgerald, 1960; Bell, 1971). Browsing similarly may act to increase leaf production, where growth is indeterminate (ie clay veld savannas), and may double seasonal leaf production (Rutherford, 1978: 646).

2.5 Composition and quality

The high nutrient status of the clay veld savanna supports vegetation in both the tree and grass layer of a higher nutritional quality than the sand veld (Plowes, 1957 for grasses; Walker, 1980a for browse). This is in part due to

the overall higher soil nutrient availability, but is also related to the pattern of nutrient release and turnover and the type of grass/tree species favoured in the two savanna types (cf. Tolsma et al, 1987).

In clay veld savanna a pulsed release of nutrients at the onset of rains encourages the presence of an annual grassland. The slower more regulated release of nutrients in the moister savannas tends to increase the survival opportunities of perennials (Menaut et al 1985). The nutrient poor conditions of such areas may be alleviated by various nutrient pumping mechanisms activated by translocation of nutrients via tree leaf fall to the surface (Swift et al, 1987) or through the alternate wetting and drying of soils.

The differing patterns of nutrient dynamics complement the different adaptations of annuals and perennials to more arid and moister conditions respectively. An annual dominated herb layer allows a more rapid recovery following drought, so although relatively unstable, production levels are of high quality and quite resilient.

The different levels of nutrient availability to plants and the corresponding differences in herbivore pressure observed also results in differences in defence strategy employed. In grasses it has been suggested that in nutrient rich savannas chemical defences predominate, while in nutrient poor savannas structural defences are more important (Walker, 1985: 85). In trees an opposite pattern is observed since spinescence is a feature of the arid savannas where herbivory is most intense (Huntley, 1982: 111), but secondary chemical defences are important in the sand veld savannas (cf. Cooper and Owen Smith, 1985).

Changes in soil chemical properties over longer time scales in relation to climatic shifts can also have effects on compositional status. For instance, Western and van Praet (1973) attribute the disappearance of Serengeti Acacia

woodlands to long term cyclical hydrological changes that affect soil salinity.

Variations in grassland quality occur within each of the savanna zones according to differing balances of soil and nutrient availability. Fertilisation experiments on different grassland types demonstrate the effect of plant available nutrient constraints (Mills, 1966 for Matopos and O'Connor, 1985 for other areas in southern Africa). A significant, and often ignored factor, is the role of tree cover in influencing the composition and so quality of grass available. Grass species growing under trees are often of a higher quality than surrounding areas in sand veld miombo; species such as Panicum maximum being encouraged (Kennard and Walker, 1973; Bosch and van Wyk, 1976). A similar pattern is observed in relation to crop growth in such environments (Abel et al, in press).

The compositional stability of the grass layer of different savanna types has been monitored at Dye and Spear's sites (1982). This research showed that in clay veld sites grass species changed dramatically under different rainfall conditions, whereas in the sand veld composition was much more stable. This finding is reflected in other studies in southern Africa (O'Connor, 1985). In these systems therefore functional/production stability and compositional stability show the same patterns across different zones.

Local refuges, in depressions with higher levels of moisture content, are very important for the recolonisation dynamics and rapid recovery of clay veld areas (MacDonald, 1978), thus maintaining species composition over longer time frames. Other factors that act to maintain compositional stability in savannas are the existence of extensive, long lived seed banks, the adaptations of plants for dormancy and phenological and developmental plasticity and the presence, in perennial dominated grasslands, of extensive underground biomass that can act as reserves of ungrazeable material (Walker, 1985).

The range management concepts based on climax successional theory which expect 'good' and 'poor' condition to be related to different stages in a unidirectional succession and particular expectations about grassland composition (eg Rattray, 1957; Ivy, 1969 for two Zimbabwe examples: 8), appear to have little utility in the context of the immense dynamic variation shown with rainfall levels in savannas.

The same argument could be applied to the tree layer, where changes in water availability through variations in rainfall (including cycles) and the impact of fluctuating populations of herbivores, results in altering the competitive balance between trees and grass and resulting in vegetational changes that do not necessarily coincide with a 'climax' or Clementsian view of succession in savannas (Walker, 1980c).

2.6 The impact of herbivory

Clay veld savanna

On heavier soils heavy grazing can result in the compaction and capping of soil resulting in an impermeable layer and reduced infiltration (Kelly, 1973 for SE Zimbabwe). Although this may be reversible with the removal of animals, it does result in impaired production of grass and the creation of bare patches. In terms of Walker et al's (1981) model high levels of herbivory on such soils will be likely to shift the tree-grass balance away from the mixed savanna equilibrium to an alternative stable state of bush encroached range.

The formation of a network of bare patches under intensive use of clay soils sets up localised degradation processes and changed patterns of run-off and run-on (MacDonald, 1978 for the heavy clay soils of the Matopos). MacDonald argues that the existence of such bare areas increases the system's resilience, as these areas act as water harvesting

surfaces and the run-off that accumulates in small depressions is consequently higher than if extensive grass cover existed. Because of this additional availability of water, refuges are created that allow the rapid recolonisation of grasses following drought. Such species, it is suggested, might have died out if the refuges were absent.

Spatially heterogeneous erosion processes initiated by herbivore use or rainfall events result in local accumulations of soil and water (eg Stafford Smith and Pickup, 1988 for the case of Australia). The net result on overall system primary production is unclear, but grazing animals are likely to make use of this changing pattern of availability of primary production (Pickup and Stafford Smith, 1987).

Termites may have major effects as herbivores in clay veld savannas, consuming significant proportions of the primary production and being major competitors with livestock. They may also act to establish bare patches within heavy soil grasslands thus contributing to the dynamics of the erosion process described above (Bissett and MacDonald, 1974).

Sand veld savanna

Sand veld savannas are more resilient in terms of the impact of persistent grazing stresses. Barnes (1965) reports on a long-term grazing experiment in sand veld savanna in Zimbabwe that found no significant changes under heavy use. Infiltration properties are such that the formation of compact hard layers are less likely, although algal mats may form and so reduce infiltration dramatically (Frost et al, 1986). The higher proportion of perennials with ungrazeable reserves increases the resilience of the system (cf. Noy Meir, 1975; Walker and Noy Meir, 1982) by allowing rapid recovery of production and perennial species swards on the removal of grazing pressure or the cessation of drought.

Herbivory and the tree layer

The impact of herbivores on the tree layer of different savannas is variable. Heavy browsing pressure on established trees appears to have little effect and may even promote growth. The role of secondary chemicals in deterring browsing may be important. The major effect of browsing is on regeneration. Taylor and Walker (1978) found fewer woody plants in the game section of a ranch in SE Zimbabwe than in the cattle section, apparently due to the higher browsing intensity of the game population. Pellew (1983) has discussed the role of browsing by large mammals and Belsky (1984) the role of small mammals in controlling woody species in the Serengeti. In livestock systems, the role of goats in controlling regeneration is well known (DuToit, 1972).

Grazing systems

Different types of grazing system (eg rotational vs continuous) have been found to have little effect on the stability or resilience of grasslands in southern Africa (eg review of experiments by Gammon, 1978 and O'Connor, 1985), although patterns of resting are significant on clay veld where continuous grazing is most likely to produce bare patches. The timing of grazing pressure is particularly important in this respect; this can have differential impacts on species. However, it is the stocking rate that is the primary determinant of any changes in savanna composition or production.

Fire

Fire is an important modifying factor in savanna functioning and acts in some ways as large scale herbivory, yet acting with a different pattern of selectivity. Fire is particularly important in the moist, nutrient poor savannas, occurring regularly and resulting in selection

for many adaptations (Walker, 1985). In the more arid clay veld savannas fire has an important effect through the reduction of the woody component and if combined with other factors (eg critical drought years, herbivory etc.), fire can have a significant effect on species composition (Trollope, 1982). Although fire had an important part to play in affecting the savannas of the study areas in the past and were part of local management strategies, today little surplus herbage is available and herbivory is far more significant. For this reason the role of fire will not be considered further.

Trade-offs in system properties

Due to the higher quality of vegetation on offer in clay veld savannas higher stocking rates under a given rainfall regime can be expected on clay veld (following Bell's (1982) argument). Such populations though can be expected to fluctuate more dramatically if resource limited (cf. Caughley, 1976; Sinclair, 1975) because of primary production instability. Lower stocking rates on sand veld and the greater production stability of such systems are more likely to result in more stable animal populations and less dramatic changes in savanna structure.

High stocking rates may alter the nature of rangeland and increase its resilience (Walker, 1980b). Heavy grazing may result in the increase of unpalatable species that increase the proportion of ungrazeable biomass so increasing resilience and the ability of the system to cope with large shocks or stresses. Where grazing shifts the vegetation away from perennials towards an annual cover, this benefit does not result, but production quality increases with a decrease in the stability of production and an improved ability for regeneration quickly after drought.

The effects of heavy grazing on different vegetation types has not been greatly studied. The high resilience of savanna systems is often claimed, but what are the limits

and what factors do result in semi-permanent changes? On clay veld, reduced litter, perennial cover and lowered clay contents are known to occur under heavy stocking rates (eg. Kelly, 1973; O'Connor, 1985). Perhaps the most important effect in terms of the overall impact on savanna productivity, stability and resilience is the effect stock have on soil structure in terms of compaction and changes in infiltration rates (Frost et al, 1986; Gambiza, 1987).

As Walker (1980b) argues, the managed rangelands of commercial ranches in southern Africa, with low quality production but high stability, may have low resilience because of the long term selection of their grasslands. With the coming of drought or changes in management dramatic changes can occur that would not happen under the heavier stocking rate systems of the peasant sector. Walker notes:

> "Under conditions of good veld management the composition and structure of the vegetation changes such that the system becomes potentially more susceptible to severe degradation than one which has been subjected to at least periodically severe or excessive grazing."

The low sustainability of cattle ranching in southern Zimbabwe, as observed by Child (1988), and the maintenance of high stocking rates in the communal areas over many years may reflect this phenomenon. The question of degradation under communal area conditions will be pursued in more detail in Chapter 9.

2.7 Savanna types and spatial variation

The contrast between savanna types of different nutrient status has been the basis of key livestock management strategies for a long time. Huntley and Walker (1982) comment:

> "The presence of distinctive nutrient rich 'sweet veld' and nutrient poor 'sour veld' with associated floras, faunas and environmental problems has long been recognised amongst southern African farmers, but its wider implications are only now being realised..".

For instance, Cobbing (1976) notes the Ndebele cattle movements being in relation to seeking dry season sweet veld and Huntley (1982) records that the early Boer trekkers also made adaptive use of this distinction. Within the local study area, this basic distinction between different savanna types is central to local understanding of agroecosystem functioning and classification.

In southern Africa, the early classifications of vegetation, and particularly grassland types, have focused on this distinction too (eg Acocks, 1953; Rattray, 1957). Only more recently, with the work in Nylsvley (South Africa), Matopos (Zimbabwe) and the Serengeti has a greater understanding of the comparative dynamics of different savanna systems been arrived at. A distinction is made between eutrophic, mesotrophic and dystrophic systems (Huntley, 1982). This strictly applies to non-calcareous soils, where eutrophic systems have greater than 15 me/100g clay exchangeable Ca, Mg, K and Na and dystrophic systems have less than 5 me/100g clay. However the eutrophic/dystrophic distinction is often generalised to refer to nutrient rich and nutrient poor savannas (9).

Catenas and local variation

A catenal sequence can be envisaged with wooded savanna on the upper slopes on poor, coarse textured soils with scrubby savanna on the shallower soils of the mid-slope and taller trees (often Acacia) on the deeper illuvial soils in an open grass-tree structure (cf. Thompson, 1957; Walker, 1985: 85). Within the catenal sequence, patches exist of different characteristics (eg. vleis) to the surrounding savanna. Earlier savanna ecology work emphasised the importance of catenas (eg. Michelmore, 1939; Milne, 1947,

Morison et al, 1948). In terms of understanding farming and livestock management strategies the interaction of different components of the landscape is critical (see Richards, 1986 for a discussion of catenal farming systems in West Africa).

Habitats, patches and their use

Within broad savanna types can be found different habitats differentiated by edaphic and vegetational characteristics. Some sub-habitats may be quite small in area yet have important functional significance in terms of system functioning. A good example is the role of vleis in the grazing system of the study area (see Chapter 8). The response of herbivore communities to this mosaic patterning of available habitats has been studied extensively in savanna wildlife systems (eg. Anderson and Herlocker, 1973; Ferrar and Walker, 1974). Despite a degree of resource partitioning in terms of habitat selection and differential use of plant species and parts, wildlife communities display a considerable amount of overlap in their use of resources (Walker, 1976). The rangeland science literature has given less emphasis to the role of habitat diversity in livestock systems, concentrating primarily on management systems that can be applied uniformly over large areas (Stoddart and Box, 1955). However spatial variability is equally important in livestock management, since forage quality and quantity varies considerably within rangeland and varies hugely on a seasonal and interannual basis.

Heterogeneity exists at different spatial scales and such patterns will influence herbivore foraging and survival strategies in different ways. At the micro-scale, variations in vegetation composition and production may be influenced by the patterns of disturbance induced by either humans or other animals (Belsky, 1983, 1987), by varying patterns of run-on or run-off (MacDonald, 1978), by local edaphic differences influenced by termitaria or mineral accumulation (Dye and Walker, 1980), by the influence of

trees on grass species composition (Kennard and Walker, 1973) or patterns of nutrient cycling (Campbell et al, 1988) and by a whole range of other factors. Superimposed on this small scale pattern is heterogeneity at a larger scale created by catenal/topographic effects on soils and associated vegetation. These patterns are then set within the context of macro-differences in savanna structure and functioning (eg the difference between eutrophic and dystrophic zones). Just as wildlife communities are influenced by this patterning (eg McNaughton, 1985 for a review), so must extensive livestock systems in similar environments.

In addition to variations in vegetation resources in space and time, the role of water resources must also be considered. This question is well recognised in range management and discussed in the context of the siting of water points. In wildlife communities also the availability of water can have a major effect on community structure (Western, 1975). It is the interaction of the vegetation and water resources that is often critical in trying to understand how a herbivore population is regulated. Sinclair (1977) discusses how for the Serengeti buffalo population the key factor in explaining buffalo densities was the length of riverine resources available. This was because these strips acted as 'key resources' during the dry season and thus supported the population at a critical time in terms of water and forage provision.

Any assessment of population 'carrying capacity' therefore must examine the spatial availability of critical resource patches and determine their influence on population regulation. A simple gross assessment, as often advocated in range management manuals (cf. Ivy, 1969 for the method used in Zimbabwe), without due consideration of patterns of use and habitat patches will be very misleading.

Sustainability in terms of maintaining the herbivore population may be determined more by the availability of

'key resource' patches and their status than by the overall state of the topland areas. If degradation of productivity of a vlei grazing area for instance occurs this may have a proportionately greater effect on livestock populations than an equivalent area of adjacent sand veld. Identifying those areas that are critical to system resilience is an important step in understanding system properties. Avoiding actions that reduce such areas' productivity is thus a vital step in ensuring the system's sustainability. Vlei areas may be prone to erosion and desiccation under heavy use. Tinley (1982) observes the process of headward gulley erosion in vleis from a relatively insignificant nick point. Especially if combined with a series of dry years, bush encroachment can occur and the vlei area loses permanently its productive properties.

Movement responses of animals to patchy resources

Variations in vegetation production, quality and structure all affect the response of herbivores. Animals may be drawn towards patches of high biomass or areas with particularly palatable species or may only be able to graze an area if the structure has been changed by previous use (Bell, 1971). The most dramatic responses exhibited are the major migrations of animals in the Serengeti grasslands. However the visibility of such spectacular phenomena should not hide the fact that more sedentary animals, including domestic livestock in Zimbabwe, exhibit comparable responses but at more local scales. McNaughton (1985) comments:

> "Resident herds in areas of the landscape... with dry season refuges duplicate many of the features of the migrations of the major grazers."

The commonly observed feature of grazing being heaviest in grasslands that are intrinsically more productive (McNaughton, 1985), illustrates foraging behaviour that can be responsive to changes in vegetation at the different spatial scales described above.

At the macro-scale livestock move between different savanna types in transhumant migrations between arid, nutrient rich areas to wetter nutrient poor areas. In the Sahel this pattern is well established (Breman and deWit, 1983) and is comparable to the sweet - sour veld migrations in southern Africa. At more local scales, many studies observe the concentrated use of particular local resources such as river banks or vleis by cattle (eg Theisen and Marasha, 1974; Acres et al, 1985). At the micro-scale preferences for grazing under trees with palatable grass has been noted, as well as patterns induced by avoidance/preference of defecation/urination sites (eg Putman, 1986 for a temperate grazing system).

This hierarchy of patterns of spatial heterogeneity influences the stability and sustainability properties of the system (10). In terms of livestock management, movement between patches at different spatial scales is a significant adaptive strategy to cope with uncertainty in the environment. This may occur locally between different portions of a catena or at a larger scale between different systems, exploiting the differences in system properties between nutrient rich and nutrient poor savanna types. Crop production strategies can also be seen in this light. In different years and in different seasons the benefits of different patches at different spatial scales alter and an adaptive response involves the exploitation of this for stabilisation of production. For instance, in drought years only certain areas may produce crops and these then can be traded with deficit zones. The interaction of cropping and livestock management responses are critical in developing an understanding at an agroecosystem level of the importance of spatial use in response to environmental variability and this will be a major focus of Chapter 8.

Figure 2.2 introduces a schematic transect through different savanna zones typical of the study area. It provides a summary of the contrasting properties of

different savanna types in terms of their productivity, stability and resilience/sustainability and illustrates the spatial patterning of different resource types within such areas, indicating the implications for livestock production.

The next section will explore the vegetation patterns found in the local Mazvihwa study area, in relation to the issues brought up by the literature review.

2.8 Savanna ecology within the study area

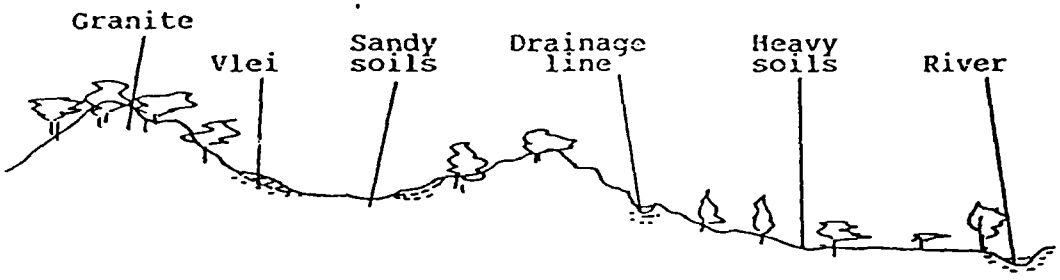
This section is aimed at exploring the distinctions between different savanna types, both in terms of the nutrient rich - poor classification and subhabitats within these zones. It will be argued that these distinctions are useful in explaining the differences observed in the study area and can thus be used to form the basis of a set of hypotheses about agroecosystem properties and their influence on local livestock and crop production strategies.

Within the study area the nutrient rich clay veld savanna can be typified by the Colophospermum mopane - Combretum - Acacia species complexes found on heavier soils in the drier areas. Within the regional study area these savanna types are most dominant in the drier zone of Chivi, Mberengwa and parts of Zvishavane districts. In the local study area this savanna type is found on the clay veld plain of Mazvihwa. The second major savanna type is typified by the Julbernadia - Brachystegia 'miombo' woodland found on the sandy, granite derived soils. In the regional study area this type is dominant in Shurugwi and Gutu districts. Within the local study area this type of savanna is found within the Bungowa hill zone of Mazvihwa CA. Grasslands found within the study area are characterised by Rattray (1957) as being of the Eragrostis - other species type in the drier areas (eg Mazvihwa), the Heteropogon - other species type in intermediate areas (eg Runde and parts of Chivi CAs) and the Hyperrhenia - other species type further north.

Figure 2.2: Savanna types and systems properties

P = Productivity; St = Stability; R = Resilience; S = Sustainability

SAND VELD		EDGE ZONE	CLAY VELD



	NATURAL RESOURCES		
Major Soils	Poor sandy soils and granitic outcrops (Dystrophic)		Heavy soils; nurient rich (Eutrophic)
Vegetn	Dry miombo		Mixed Mopane-Acacia
Key Res.	Vleis	Drainage lines	River banks, pans, drains
	ECOSYSTEM PROCESSES		
P	Low potential productivity; poor quality vegetation		High potential production high vegetation quality
St	Stable production		Unstable production
R	Resilient to heavy grazing		Lower resilience, but rapid recovery usual
	AGROECOSYSTEM PROPERTIES		
P	Low livestock density of bulk feeders. Crop production high in vleis.		Higher densities possible of mixed herbivores. Crop production high in good years.
St	Animal populations & crop production stable, especially due to vleis		Animal populations and crop production variable Recovery generally rapid after drought.
S	Animal and crop production sustainable, especially if 'key resource' areas remain productive.		

Goldthorpe (1957) reports a natural resources survey of the adjacent Belingwe ICA (11). This study recognises seven vegetation types in the area. These are: thornveld, Terminalia sericea veld, Colophospermum mopane veld, Brachystegia/Julbernadia areas, Mountain acacia patches, Uappaca kirkiana veld and vleis. In the clay veld zones the grassland varies between dense Setaria, Digitaria and Urochloa stands in the valleys to sparse Eragrostis, Themeda and Rhyncheletrum on the hills. In the sand veld a sparse grass cover is described for the miombo woodland which includes Heteropogon contortus and Hyperrhenia sp., but dense grass swards are noted for the vleis. Disturbed areas are indicated by Aristida spp. and Pogonarthia sp.

Patches within the landscape

The position of a particular vegetation type within the overall landscape is important to recognise, as catenary sequences and variable topography result in a mosaic of different ecological communities. Although the basic distinction between the two savanna types identified above is important, it is also important to recognise the variations that exist within such areas. Low lying areas at the base of catenary sequences are the sites of water and nutrient run-on and accumulation. Water flow and erosion processes thus modify such patches increasing available water and nutrients and changing the characteristics of the savanna type in contrast to the topland areas. Similarly areas adjacent to rivers and streams are modified by alluvial deposition and the increased water availability.

In the clay veld savanna of the study area such run-on patches are found as shallow pans within the gently undulating landscape. These are known locally as makawa. Drainage lines (makwatara) are also significant. Also important are the alluvial strips along streams and rivers that dissect and drain the area. Here vegetation is again distinct from the topland clay veld areas.

In the sand veld savanna areas, vleis represent distinct patches (Rattray et al, 1953; Whitlow, 1985). Vleis have variable definitions but a general one is offered by Rattray et al (1953) as:

> "Low lying or gently sloping open tree less tract of country which acts as the natural drainage area of the surrounding high ground and is therefore frequently subject to seasonal waterlogging".

Soils tend to be black, slightly acid and of high humus content and underlain with sand if the surrounding parent rock is granite. Vleis possess a distinct flora including sedges and reeds if continuously wet. Periods of drying can result in the invasion of trees from the surrounding topland, but generally only such trees as Ficus spp are found on the vlei margin. As with the patch environments described for the clay veld savanna, the significance of such areas is only recognised when the system as a whole is examined, as these patches although in overall terms small in area can act to alleviate key constraints to production through the provision of plant available water and nutrients in critical seasons or years. For this reason they can be termed 'key resources'(Scoones, 1987).

Vegetation description of the study area

A basic quantitative description of the savanna types was carried out in the Mazvihwa study area. This is supplemented by the work carried out on the tree resource (Wilson, 1987 (12); see also Appendix 3) and grass species (see Appendix 4). The quantitative description was aimed at providing supporting evidence for a local classification of vegetation types and relating this to the savanna ecology literature. It also provided insight into the feed resource of cattle and goats for the foraging behaviour study reported in Chapter 8. For this latter reason transects were established within the foraging range of three of the four cattle/goat herds used for the foraging study. These were positioned along a gradient from the riverine edge of

the clay veld through clay veld topland (both grazing and arable) to the edge zone into the sand veld topland miombo woodland and arable and including two contrasting examples of topland vleis.

At each site a map of vegetation types was drawn using aerial photographs, ground observation and discussions with local informants. This delineated different vegetation and land use categories according to local classifications. Within each vegetation type a transect line was chosen randomly. These were of 100m or 50m, if the vegetation was particularly homogeneous. Grassland was sampled along the transect line and woodland sampled along belts of varying widths.

Local classifications of land use and vegetation types combine general properties (the distinction between the clay veld area and the sand veld area), vegetation distinctions, soil differences and topographical/catenary contrasts (eg. topland vs bottomland patches) (Nyamapfene, 1983). The chosen transect sites in the Mazvihwa study area are described briefly below. Their position in relation to the different savanna zones - clay, edge and sand - is shown in Figure 1.5. Historical changes in the land use of the transect sites is investigated in Chapter 3.

Clay veld savanna transects

The Mazvihwa plains area is known locally as the deve or the forested plain. The parent rock is granite, but there are varying degrees of influence of basic rock doleritic intrusions and underlying alluvial/colluvial deposits. The heavier soils, with high clay content, are known locally as chiwomvo. These soils have high fertility and are quite deep, especially when derived from ancient alluvium/colluvium (Thompson, 1973). The illuvial deposits from the granitic hills tend to be light red-brown loamy sands to sandy loams which are shallower. The heavier soils that lie along the base of the granite hills of Bungowa are

locally known as gan'a. These are also of high fertility, but have poor structure and become incredibly hard in the dry season sufficient to make a metallic "gan'a" sound when hit with a hoe.

The vegetation in heavy clay soils is dominated by Colophospermum mopane in areas undisturbed by previous cultivation, with other associated species, particularly Combretum apiculatum, in positions lower in the catenal sequence. Many of these areas were heavily cut in the early part of the century as part of commercial logging operations (Goldthorpe, 1957; Wilson, 1985; see Chapter 3). In old field sites Acacia spp. dominate, while a unique vegetation association is found along riverine strips. Within the clay veld area transects were established in a C. mopane area, in an Acacia spp. patch and along the riverine strip.

Arable areas are generally cleared of woodland. However remaining root stock can regenerate annually in fields that have not been destumped. Some trees are preferentially retained in the fields for shade, fruit and soil improvement (Wilson, 1989) and along grassy contour bunds/ridges small, heavily harvested trees exist (Abel et al, in press). One transect was established along a contour ridge bund.

Within the clay veld, sodic soil patches exist known locally as chimamhare. These are areas where fine particle clays and minerals accumulate and a distinct vegetation association exists (Dye and Walker, 1980). Within the sodic soil areas accumulations of salt occur in smaller patches. These are important salt licks for animals and were in the past used for the collection of salt for human consumption. The sodic soil areas are dominated by stunted Colophospermum mopane within the study area and one transect was sited within a sodic area.

Within the heavy red soil areas patches of sandy loam (muscheche gobvu) exist, particularly in areas of slightly higher elevation and in areas that have been farmed for some time. In other areas gravely soils (rukangarabwe) are found in the mid-lower slope. Hills formed by doleritic intrusions again have quite a distinct vegetation often with Adansonia digitata being prevalent. Drainage lines and pans tend to have similar vegetation to the surrounding area, but with greater production of grass and a higher density of trees. Transects were sited in a drainage line/sink system that started within the arable area and drained into adjacent grazing land.

Within the clay veld, transects were chosen at six sites. Belt transects of 100m x 10m (for trees below 1m) 100m x 20m (for larger trees) were studied. Each site had a different history of utilisation and this was investigated using aerial photographs in conjunction with interviews with local informants. This information will be discussed in Chapter 3, where the history of land use change is explored in depth. Here the concentration is on contemporary patterns.

The dominant tree species are shown in Table 2.2. For each belt transect the woody vegetation biomass was assessed in relation to stem density, height classes by species and an indicator of browse volume. Stem density was assessed in terms of the number of stems present per unit area. A stem did not necessarily relate to separate plants, but often constituted coppice regrowth. If coppicing/pollarding occurred at a height above 30cm it was regarded as a single stem. Heights were measured with 3m graded poles or by visual estimation. Browse volume was calculated as the volume of canopy between ground level and 2m. Dominance in Table 2.2 is in relation to available browse volume.

Table 2.2: Dominant species in clay veld transects (top five in order) according to stem density. Contribution of species to total browse volume is recorded in brackets.

Mopane transect: Colophospermum mopane (86.3%), Acacia tortilis (10.7%) Grewia monticolor (1.4%), Lonchocarpus cappassa (0.9%), Combretum apiculatum (0.6%).

Acacia transect: Acacia tortilis (51.2%), Grewia flavescens (18.85%) Combretum apiculatum (12.8%), Grewia monticolor (6.9%), Acacia nilotica (6.4%).

Drainage line: C. mopane (41.3%), C. apiculatum (7.0%), Grewia monticolor (10.4%), Acacia tortilis (4.6%), Grewia flavescens (1.3%).

Riverine: Acacia sp. (57.3%), Grewia flavescens (14.3%), Croton megalobotrys (11%), Combretum collinum (7.4%), Diospyros mespilliformis (1.2%).

Contour: Acacia tortilis (86.6%), C. apiculatum (8.3%), Sclerocarya birrea (3.9%), Gardenia spatulifolia (1.1%), C.mopane (0.01%).

Table 2.3: Stem density and browse volume in clay veld transects

Transect	Stems/hectare	B Vol (m^3/ha)
Mopane	3580	4396
Acacia	1360	5528
Drainage	3800	6816
Riverine	2400	9415
Contour	800	651

Within the clay veld zone much of the woodland is of low height classes and with high stem density. This represents a heavily harvested coppice structured woodland (Scoones, 1988a). In terms of available browse volume, biomass is nevertheless quite high. In addition, the species composition shows a high prevalence of high quality browse species (see Chapter 8 for a more extensive discussion).

Sand veld savanna transects

The sandy soils (musheche) of this zone are derived from the granitic inselbergs that form the base rock. These are poor quality sands with low clay content and are slightly acid. The sand veld zone is characterised by a diverse miombo woodland dominated by Julbernadia globiflora and Brachystegia spiciformis. In areas that were previously cultivated, regeneration is dominated by Terminalia sericea and an alternative mixed miombo type woodland appears to develop. Two transects were established in the sandveld miombo.

Within this complex of bare granite rock and sandy toplands are important patches known as vleis or dambos (makuvi). Transects were sited in two vleis, one with concentrated drainage at the valley head and the other lower down the catena in a more open situation and under heavy use.

Sodic patches are rarer in this zone because the through flow of water prevents their formation. Termitaria are sites of concentration of clays through the action of termites and these are important sub-habitats.

Table 2.4: Major tree species on the sand veld transects (top five) by browse volume.

Sand veld 1: Grewia flavescens (21.9%), Dichrostachys cinerea (17.2%),Tabernaemonta elegans (16.7%), Flacourtia indica (15.6%), Grewia monticolor (12.7%)

Sand veld 2: Mubaribari (unidentified) (15.04%) Grewia flavescens (13.8%), Vangueria sp. (11.7%), Grewia monticolor (9.0%), Dichrostachys cinerea (8.3%). [Julbernadia globiflora (5.5%)].

Table 2.5: Stem density and browse volume in sand veld transects

Transects	Stems/ha	B Vol (m^3/ha)
Sand veld 1	940	2860
Sand veld 2	405	1540

A comparison of Tables 2.3 and 2.5 highlights the differences in structure woodland in the clay veld and the sand veld. In the clay veld there is a high stem density, a predominance of low height classes and consequently a high browse volume. In the sand veld, stem density is much lower and as a proportion there are more large trees (5m +). There is consequently less potential browse available in this zone.

The transects chosen did not cover the full range of sub-habitats identified. However the aim was not to gain a full vegetational description of the area, but to explore the basic functional distinctions between clay veld and sand veld and within these systems the distinctions between topland, bottomland 'key resources' and arable areas. The

way production dynamics of these areas differs is explored next.

Patterns of available biomass

The degree to which the production patterns of different savanna types observed in the literature are reflected in the study area was investigated for grass and crop production. No attempts were made to estimate leaf or woody biomass production (13).

The sites described above were investigated on three occasions: February 1987, August 1987 and March 1988. These represented the maximum standing crop in a good year (1988), a drought year (1987) and during the dry season following a drought (1987), representing minimum standing crop under current stocking rates. Above ground biomass was harvested in 10 - 20 quadrats (depending on the variability of the samples). 50 x 50 cm^2 quadrats were randomly positioned along the vegetation transect.

The grass/herb biomass was weighed as dry weight following oven drying. The same positions along the quadrat were used on each occasion, but alternate sides of the transect line used for wet-dry season measures. It should be noted that the measurements taken were not production measures but relate simply to standing crop.

Table 2.6: Grass Standing crop measures (g/m^2)

Year: Season:	Poor Wet	Poor Dry	Good Wet	Ratios	
Transect	2/87	8/87	3/88	87/88	Wet/dry
Clay veld topland:					
Mopane	14.7	4.8	69.9	4.7	3.0
Acacia	32.2	2.3	123.8	3.85	13.77
Clay veld key resource:					
Riverine	50.7	5.3	216.6	4.3	9.5
Drainage	137.8	31.4	100.6	0.7	4.4
Clay veld arable:					
Contour	325.6	44.8	-	-	7.7
Sand veld topland:					
Sand veld 1	49.9	20.6	110.8	2.2	2.4
Sand veld 2	35.5	12.0		-	2.9
Sand veld key resource:					
Vlei	615.4	411.1	1000 (*)	[1.6]	1.5
Sand veld arable:					
Contour	213.8		251.7	1.2	-

(*) = estimate

The levels of standing crop are immensely variable between sites, but the range falls within the bounds expected for savanna sites of this type (2). The important point to focus on is the variability between areas, between seasons and between years. Comparing clay and sand veld topland areas, the patterns observed over much longer time series and with more intense sampling by Dye and Spear (1982) are reflected. In a good year (1988) the clay veld has potentially higher standing crop than the sand veld (eg. compare Acacia transect with sand veld 1 transect), but in

a drought year the sand veld levels are consistently higher. Clay veld grassland has higher variability of standing crop both between seasons and between years (as reflected in a comparison of sites where ratios of standing crops are calculated, see Table 2.6).

This study has gone beyond the characterisation of the savanna systems in these terms, to investigate the standing crop patterns of different patches within these savanna types and to investigate grass crops in the arable zone. This data highlights a number of important points:

- If the ratio of standing crop in the topland areas to the 'key resource' areas (drainage line, riverine, vleis) is looked at, the significance of such patches is underlined. For instance, in the clay veld during 1987 the ratio of Mopane transect standing crop to drainage line standing crop was 1:9 in the wet season and 1:6 in the dry season. In the sand veld this contrast is even more accentuated. The ratio of sand veld 2 transect to vlei transect standing crop was 1:17 in the wet season and 1:34 in the dry season during 1987.

- The standing crop of key resource areas is relatively higher in dry years, and is massively higher in the dry season.

- The ratio between standing crop and key resource areas is particularly high in the sand veld savanna, because of the high standing crop levels in the vlei where measures were carried out.

- When the relative areas of the different vegetation types are weighted according to their area of occurrence, a similar pattern emerges. Of total expected standing crop (extrapolating from the transect sites for a 2km radius area), topland grazing would contribute c. 85% of total standing crop in the clay veld site in both years, but only 28% in the dry season. In the sand veld, the 'key resource'

vlei grassland would contribute to between 43% and 46% of total standing crop during the wet season and 66% in the dry season (see Scoones, 1988, for a fuller discussion).

Grain production

The pattern of grain production in different ecological zones also gives an indication of the contrasting production dynamics of different savanna types. All the households who were part of the Mazvihwa sample provided estimates of crop production over three years (84/5 - 86/7) (14). Table 2.7 aggregates the output of all grain types and gives a per hectare yield figure for each zone (15). This can serve as an indicator of productivity for cropping and allow comparisons between the three zones identified (this is pursued further in Chapter 6 in economic terms).

Table 2.7: Grain production (kg/ha) in different ecological zones under different rainfall conditions (84-5: 762mm; 85-6: 451mm; 86-7: 253mm - Zvishavane town).

Year		Clay	Edge	Sand
1984/5	Max	2835	1082	2388
	Min	291	154	511
	Avg	1032	691	1262
	Std	518	297	622
1985/6	Max	752	231	660
	Min	6	1	146
	Avg	173	66	428
	Std	158	59	188
1986/7	Max	282	136	516
	Min	5	9	109
	Avg	101	58	308
	Std	70	34	133

Crop production illustrates comparable dynamics to the

grass layer, with high potential production in the clay vled but dramatic collapses in drought years. The edge zone shows overall low levels throughout. In the sand veld zone a more stable production is shown with significant yields even during droughts, thanks to the stabilising properties of vlei areas to interannual production.

Vegetation composition and quality

Indicators of species richness (number of species present), dominance (No of most common species (N1) over number of all individuals (N_{tot})) and diversity (variance of N_i/N_{tot}) were assessed for tree and grass species in the clay and sand veld transects (see May, 1981 for a discussion of these indices for descriptions of community structure). Dominant species of trees have been discussed earlier. Grass species occurrence is documented in Appendix 4.

Table 2.8: Species richness, dominance and diversity of trees (clay veld transects)

Transect	Richness	Dominance	Diversity
Mopane	6	0.74	0.60
Acacia	10	0.30	0.22
Drainage	10	0.61	0.40
Riverine	15	0.30	0.15
Contour	5	0.66	0.46

Table 2.9: Species richness of grasses (clay veld).

Mopane	13
Acacia	20
Drainage	5
Riverine	7
Sodic	3

Table 2.10: Tree species richness, dominance and diversity (sand veld transects).

Transect	Richness	Dominance	Diversity
Sand veld 1	14	0.35	0.19
Sand veld 2	13	0.26	0.14

Table 2.11: Grass species richness (sand veld).

Sand veld 1	17
Sand veld 2	9
Contour	9

The species richness of woodland in the sand veld miombo system tends to be higher than in clay veld systems (Frost et al, 1986: 26). This generalisation is borne out in the limited sampling of these contrasts in the study area. This reflects possibly both the greater diversity of niches provided by the variable topography/soils and the greater intensity of competition for soil nutrients in the sand veld. According to the data from the limited transect sampling in the study area, the grass layer does not show this pattern.

The fodder quality of vegetation found in the clay and sand veld zones differs, as well as community structure and composition. Appendix 3 presents data on a ranking exercise carried out with a series of key informants in Mazvihwa, where the browse value for different stock was rated for all the trees found in the study area. A wide variety of tree species are browsed under different conditions. However the browse value of clay veld species is generally regarded as superior for both cattle and goats. Cattle favour such species as Combretum apiculatum and

Colophospermum mopane, while goats feed off the variety of Acacia species found in this zone. The timing of the miombo woodland pre-rains flush is also important for browse in the sand veld. Table 2.12 lists the species ranked highest for cattle browse by farmers and relates this to the list compiled by Walker (1980) of the most important browse species in southern Africa. This ranking ties in well with the reported measurements of crude protein content of leaves and twigs of these species in the literature (eg. Rees, 1974; Rutherford, 1979; Lawton, 1980; Barnes, 1979 (16)).

Table 2.12: The most important browse species in the study area for cattle, as ranked by farmers in Mazvihwa.

The top species for cattle (ie those with *** ranking) are shown in the following table. This farmers prioritisation for Mazvihwa CA is compared with Walker's qualitative ranking. The * indicates that the species was included in his listing of "the more important browse species in Southern Africa" (Walker, 1980). If the tree is found in the measured transects in the top five in terms of browse volume (see Tables 2.2 and 2.4), it is marked as either 'C' = clay veld or 'S' = sand veld.

SHONA	Botanical name	Walker (1980)
Mubondo (C)	Combretum apiculatum	*
Mubububuhnu (C, S)	Grewia flavescens	*
Mubvumira	Kirkia acuminata	*
Muchakata	Parinaria curatellifolia	
Muchechete	Mimusops zeyheri	
Mudyahudo	Strychnos potaorum	
Mudzviri'nombe (S)	Vangueria spp.	
Mufupa	Tarenna neurophylla	
Mugaragora	Boscia albitrunca	*
Muhumbakumba	Bridelia mollis	
Mujerenga (C)	Acacia nilotica/rehmannii	*
Mukamba	Afzelia quanzensis	
Mumveva	Kigelia africana	
Munanga	Acacia nigrescens/polycantha	*
Mununguru (S)	Flacourtia indica	
Muonde	Ficus sur	
Mupanda (C)	Lonchocarpus capassa	*
Mupane (C)	Colophospermum mopane	*
Mupangare (C,S)	Dichrostachys cinerea	*
Mupfura	Sclerocarya birrea	*
Mupumbu	Acacia galpinii/albida	*
Murungu	Ozora insignis	
Mushuku	Uapaca kirkiana	
Musumha	Diospyros mespilliformis	*
Rusungwe	Euphorbia tirucalli	
Musvimwa	Lannea stuhlmanni	*
Musvita	Ficus sycamorus	
Musvotogara	Ficus sp.	
Mutarara	Gardenia spatufolia	*
Mutechani	Combretum heroense	*
Mutehwa (C,S)	Grewia monticolor	*

The quality of grassland varies in a similar way to browse. Appendix 4 compiles data from the literature on grass quality (as measured by digestible crude protein). Although species composition overlaps a lot between zones, most studies have found that clay veld grassland is of higher quality. This is reflected by local perceptions and by assessments of species composition in the transect sites.

2.9 Trade-offs in system properties

The previous sections have briefly outlined the state of current knowledge of contrasting savanna systems and related this to the situation pertaining in the study area. The data presented, supported by more in depth studies in comparable areas, provides the basis on which the stratification of the sample population in the local study area and the classification of different parts of the regional study area is made. In Mazvihwa, the agroecosystems of the clay veld, sand veld and the intermediate edge zone can therefore be expected to exhibit contrasting dynamic properties.

Clay veld savannas are characterised by high potential productivity, but great instability which is tightly correlated with rainfall variations. Production patterns are mirrored by the instability of vegetation composition in both the grass layer and in relation to the potential for multiple stable states in the wood-grass balance. Changes in soil structure can result in long term shifts which, although potentially reversible, result in lowered production. Sustainability is therefore an issue in grazing management in clay veld savannas.

Sand veld shows lower variations in production and productivity is less tightly related to variations in rainfall. Patterns of nutrient cycling are also apparently stabilising, although nutrients may be limiting to primary productivity in some situations. Sand veld systems are

apparently quite resilient to both drought and grazing impacts, maintaining both production and compositional stability in the herb layer and less likelihood of shifts in the tree-grass balance. Nutrient loss may be signifcant for the sustainability properties of sand veld, especially in relation to agriculture.

The stability of production at a system level in both savanna types is modified by the presence of 'key resource' patches. These are areas where the critical constraints are alleviated. In the clay veld, pans, drainage lines and alluvial strips have higher levels of water available for plant growth and act to stabilise the seasonal and interannual fluctuations of grass production. In the sand veld, vleis act in the same way particularly as they are a sink for nutrients and water and provide a grass land that is productive when the topland is not, thus stabilising the system as a whole.

The resilience of both savanna systems may be modified by grazing pressure. Higher levels may change the savanna structure, increasing ungrazeable reserves and enhancing the ability of the system to recover from stresses and shocks. Resilience is also affected by the spatial heterogeneity of the system with refuge patches allowing rapid recovery following stresses or shocks without permanent shifts to lower levels of productivity.

Savanna ecology expects crop production under low input systems to respond in a similar way as the grass layer that has dominated the preceding discussion. Critical constraints in the two savanna types would differ, with water being crucial in the clay veld and nutrients in the sand veld. In arable systems in contrast to the range situation, these can be manipulated through the management of inputs.

The consequences of these different properties in affecting the dynamics of livestock populations and in the shaping of

local strategies to livestock management and household economics will be the subject of the remaining chapters of this thesis. Ecological determinants will interact in complex ways with social and economic factors and it will be the challenge of the following pages to unravel some of these interactions. A number of general hypotheses can be put forward. These questions will be central to the discussions of subsequent Chapters.

- Clay veld livestock populations will be characterised by a mixed species system limited particularly by the availability of bulk food. The high quality vegetation allows high densities to be maintained, however these are likely to fluctuate significantly in relation to variations in rainfall incidence. The impact of droughts are expected to be highest in this area in terms of their effect on population numbers. However, populations can be expected to recover rapidly following drought periods, unless extended periods of drought and heavy grazing have resulted in long term changes in infiltration properties of the soil.

- In the sand veld area, bulk feeders (cattle) will be preferred over quality feeders (goats). Lower potential populations can be expected for a given rainfall, but such populations are liable to be more stable over time. Droughts will have a lesser impact in this zone. Even under high grazing pressure there will be fewer expected changes in potential carrying capacity.

- The ability of livestock populations (especially cattle) to survive will be assisted by the presence of 'key resource' areas. Such areas will act to stabilise populations and increase the number of stock the area can hold.

- Movement between areas can be expected such that critical constraints are alleviated. Movement to the clay veld is most likely in high rainfall years when good quality grass is available in abundance. Movement to the sand veld can be

expected during droughts, especially when vleis are present. Herding strategies are likely to be influenced by such considerations.

- The different savanna environments will have differing effects on livestock population and production parameters. These will affect both the long term trajectories of livestock populations and the potential economic value of different livestock species.

- Grain production is expected to follow the same pattern as for grassland. The clay veld is expected to have unstable production with good yields in high rainfall years that must be stored over into future years where low production levels can be predicted. Low levels of crop production, particularly in droughts can be expected to result in the adoption of alternative livelihood strategies beyond arable farming. Such options as paid employment or cattle sales which are to varying degrees independent of rainfall can be expected.

- In the sand veld, crop production is likely to be a more dominant income earning strategy, especially if vlei farming is an option. Where it is not (eg in the edge zone), stable but low levels of production can be expected that may have to be supplemented by alternative income sources on a regular basis unless extensive or high input cultivation is feasible.

- Livestock accumulation and disposal patterns are likely to be different in the different savanna zones. In the sand veld (especially with vleis), income from crop production surplus to consumption needs on a regular basis is most likely. In the clay veld, this may only occur in occasional good years. In the edge zone this situation is unlikely. Disposal patterns are most likely to be related to drought and food deficit situations in the clay veld (depending on storage) resulting in higher levels of offtake; in other areas cattle will be disposed of for other reasons (eg

other cash needs such as school fees which are common to all zones).

- The degree to which production patterns are influenced by these contrasting environmental patterns will vary between different households. A whole range of social and economic factors will influence the impact of environmental factors. The amount of stored capital wealth or assets will influence the ability of different household to cope with variability in the system, as will the availability of environment independent income sources. Social relations of production, household demographic status and other factors will influence the management strategies employed by individuals, households and clusters in response to contrasting agroecosystem dynamics and will so mould management strategies.

These hypotheses will be investigated in the following Chapters. The next Chapter takes an historical view of changing agroecosystems in the study area.

Footnotes

1. In Zimbabwe the Afrikaaner term 'vlei' and the Zambian word 'dambo' are used interchangeably to refer to treeless valley grassland areas most common on the highveld (Whitlow, 1984). In the study area, such areas are known as makuvi (sing. guvi).

2. Rutherford (1978) compiles a range of primary production data for southern Africa. For the rainfall around 500mm, about 1000 kg/ha/yr can be expected, but with large variations. Total above ground biomass production (including twigs/leaves and wood increments) is likely to be around 3000kg/ha/yr. The degree to which this is physically or chemically available as fodder is again very variable.

3. The creation of micro-environments by trees also has an effect on crops. Certain trees are preferentially retained in people's fields (eg. Ficus spp., Parinaria curatellifolia) to provide soil nutrient inputs and improve soil moisture conservation (Wilson, 1988). The relationship

between the effect of trees and crop improvement is however complex (Julie Ingram, pers. comm.).

Appendix 3 contains a listing of all trees found in the Mazvihwa study area and includes a ranking carried out by a number of local key informants on whether different trees promote/don't affect/decrease grass cover.

4. The reasons for early leaf out in miombo woodland were suggested in discussion by Peter Frost and Bruce Campbell.

5. Various measures of standing biomass of woodland in Zimbabwe have been made. For sand veld miombo woodland Ward and Cleghorn (1964) estimate there to be 8.3m^3/ha basal area for stems > 2.5cm. This concentration on basal area measures (of larger individuals) relates more to forestry/timber concerns than to livestock issues, since a coppice structure of low, multi-stemmed trees may provide higher browse volumes. In any case it is this structure of woodland that is most common in the study areas (cf. this study for Mazvihwa; Abel et al (in press) for Shurugwi).

Estimates for clay veld (C. mopane areas) include Kelly's estimates (1973) which ranged from 8700 to 30800kg/ha standing crop. Guy (1981) estimated total biomass of mopane woodland in Sengwa to range from c. 62 - 66 t/ha. This contrasted with 12 - 23 t/ha for miombo woodland and 23 - 57 t/ha for different riverine woodland in 3 different years.

6. Biomass production from the tree layer has also been estimated for various comparable sites to the study areas. Kennan (1969) estimates annual production of 1490 kg/ha from a C. mopane/Grewia woodland in SW Zimbabwe, while Kelly (1973) reports a variation in a single season between 590 and 2120 kg/ha for different sites in C. mopane woodland in SE Zimbabwe. Guy estimates annual production at between 1.1 and 1.3 t/ha depending the year (1981).

Estimates for sand veld woodland show lower production levels. Guy (1981) records between 0.35 and 0.53 t/ha for miombo sites in Sengwa, while Rutherford (1978) estimates production from Burkea woodland at c. 1000 kg/ha/yr.

Other woodland types, such as riverine areas, may produce high levels. The tall structure of riverine woodland often results in low available browse volumes.

7. West (1950) estimates that with a spacing of 25 trees/ha an Acacia tortilis/Piliostigma thonningi woodland may produce 280 kg/ha/year of pods. If the density of trees is doubled he estimates that this would increase to 560 kg/ha/yr.

8. The method for assessment of range carrying capacity advocated by the extension service, Agritex, follows the guidelines of Ivy (1969). This involves the completion of a condition score sheet that notes increaser/decreaser species, degree of soil erosion etc.

9. The distinction between eutrophic nutrient rich savannas and dystrophic nutrient poor savannas is central to the local classification of zones used by local farmers. The discussion workshop held to reflect on the research findings, highlighted how close the conceptualisation of the contrasts between clay veld (deve) and sand veld (makomo) is to the savanna ecology interpretation presented in the literature review of this Chapter. The clay/sand veld distinction as a framework for testing hypotheses has been used by Ken Wilson in the context of human demography, child health and nutrition (Wilson, forthcoming).

10. The relationship between population stability, resilience and environmental herterogeneity has been extensively investigated in the theoretical ecology literature. Increased spatial heterogeneity tends to increase stability and resilience of model populations (see May, 1981 (ed.)).

11. Intensive conservation Areas (ICAs) represent groups of privately owned farms. The Goldthorpe study was carried out in the area to the west of the Mazvihwa study area, but in a very similar environment.

12. The survey of the woodland types carried out for this research benefited enormously from other work being carried out in the area on woodland ecology and use. The inventory of tree resources compiled by Chakavanda and Wilson (Wilson, 1987) provided a dictionary, while the work of Brynn Higgs (undergraduate thesis, Oxford, 1987) was also useful. Subsequently the work carried out as part of the ENDA-Zimbabwe woodland project provide supportive evidence to the interpretations presented here.

13. The definition and measure of primary productivity is beset with problems. A huge range of techniques have been tried including clipping (simulating some grazing), exclosures, remote sensing techniques etc, but none can be said to be truly representative of actual production or relate to directly to plant available material (Rutherford, 1978). Similar methodological problems apply to browse estimation (Rutherford, 1979).

14. The crop production data was collected primarily by Ken Wilson as part of the work with the household sample. The analyses presented here were carried out for this research. Fuller details of the methodologies used are presented in Chapter 6.

15. The crop production data represents the total grain yield output for the areas held by different households. This does not exactly reflect farm productivity as the total field area rather than area planted to grain crops is used to calculate per area outputs. Some of the field area will be planted to non-grain crops (eg groundnuts) or be left fallow.

16. Various measures of browse quality have been carried out in southern Africa, suggesting that crude protein content of leaves of important browse trees is high. For instance, Barnes (1979) quotes a figure of 12.3% for C. mopane, while Lawton (1980) quotes a figure of 15.4% for the same species. The precise figures are not important, since differences in measurements and laboratory procedures result in considerable variation. The important point to note is the quality of the browse in relation to the grass layer. This varies between 2% and 6% (see Appendix). The degree to which chemical assessments of browse actually measure secondary deterrent chemicals as well is not known. Certainly the build up of tannins and other substances is an important factor in plant-herbivore interactions in the miombo areas. In addition, 'quality' may be defined in terms of other factors such as mineral contents etc.

3. HISTORICAL CHANGES IN LAND-USE, LIVESTOCK POLICY AND MANAGEMENT IN SOUTHERN ZIMBABWE

3.1 Introduction

This Chapter attempts to set a number of livestock policy questions in historical context. The influence of colonial policy is examined and it is shown how this transformed the structure of the rural economy and altered livestock management strategies in the study areas, constraining the possibilities of opportunistic responses to variable savanna environments. The concentration on the beef production objective of colonial policy, the impact of destocking and the imposition of fixed, conservative 'carrying capacity' limits are central themes (1).

Section 3.2 examines the transformation of pre-colonial farming systems in the study area, exploring the evolution of an integrated agropastoral system. Section 3.3 investigates the changes in human and livestock populations in the area between 1920 and the present. This provides the background for looking at changes in land use patterns in the Mazvihwa study area using aerial photographs (section 3.4). The emergence of colonial livestock policy is addressed in section 3.5, where marketing and breeding are examined. The destocking period is focussed upon in section 3.6. This provides the historical background for understanding current debates about 'carrying capacity'. The changing nature of the rural economy through the colonial era to the present is examined in section 3.7. These historical changes in land use, farming system and policy are used in section 3.8 to summarise the changing roles of livestock in the farming system, concentrating on the increasing constraints to following opportunistic management strategies.

3.2 The transformation of pre-colonial farming systems

During the nineteenth century, and probably before, the

farming systems of the study areas were dominated by an intensive system of cultivation relying on the mobilisation of tribute labour and the exploitation of the patchy vlei resources of the sand veld (Wilson, 1986; 2). This was probably combined with a certain amount of opportunistic cultivation of topland areas, but the impact was not extensive, as populations were scattered and sparse (Beach, 1980). Such opportunism is described by Zachrisson (1978) in terms of the practice of cultivating red soils only in wetter years. Livestock populations held by the Karanga residents of these areas were not extensive (eg. Portuguese sources quoted by Mudenge, 1974; Roberts, 1980); they were kept primarily for meat and ritual/symbolic functions. Intensive hoe cultivation in lineage controlled groups appears to have been the dominant mode of productive organisation; the relationship between land and labour was such that the use of vleis provided a productive and stable source of livelihood and livestock a useful supplement. The Ndebele, without the opportunity of vlei cultivation, and with a large and expanding territory to control made use of the extensive savanna areas for grazing their large herds in these outlying areas of the Ndebele kingdom (Cobbing, 1976). The political and economic tensions between the Ndebele and the resident farmers is well documented (Beach, 1980) and resulted in the fortification of villages and the retreat to hilltop settlement.

It was not the resident populations, but the influence of the Ndebele cattle that would have resulted in the greatest impact on the environment. This was combined, prior to c. 1850, by the extensive wildlife populations in the area. The boom in the mid-nineteenth century ivory trade in the region resulted in the rapid demise of elephant populations and presumably a changed impact on the local resources, as cattle became the major influence. No-one knows the size of the cattle populations that grazed the lands of southern Zimbabwe at the height of the Ndebele state, as with the size of populations of previous cattle keeping societies in the region (Garlake, 1978), but in all cases the numbers

were probably considerable.

During the 1890s a series of events resulted in a dramatic collapse in cattle populations. The outbreak of rinderpest in the region was probably the most catastrophic. Following the introduction of the disease to the country in 1896, it spread rapidly and resulted in the destruction of a majority of the cattle population (Mack, 1970). The precise impact in the study area is unclear, as Zachrisson (1978) reports that Belingwe escaped the ravages of the disease. Rinderpest was followed by East Coast Fever in 1901 which also had a considerable impact on stock populations. These disease impacts were combined with the extensive expropriation of local stock by the early European colonists. Between October 1893 and March 1896 between 100000 - 200000 cattle were seized from the Ndebele (Phimister, 1988: 16).

The level of livestock and wildlife populations at the beginning of the century were probably the lowest they had been for a very long time. The apparent inexorable rise in stock populations since the beginning of the colonial era gives a false impression, since the period around the turn of the century had seen an uncharacteristic drop in populations and a change in the nature of environmental pressure away from livestock and wildlife to changes in the agricultural practices in the study area.

Two factors combined during the early years of this century that contributed to a significant shift in the nature of agricultural production and resulted in a changed impact on land use within the study areas. Following the defeat of the Ndebele state after the Matabele uprisings and the establishment of colonial rule, the level of security for resident local farmers improved. No longer was it necessary to live in clusters on hilltops and keep livestock in defended kraals from raiding Ndebele groups. Enterprising lineage groups were able to break away from tight chiefly control and adopt extensive farming methods on the topland

areas and live in scattered settlements. Extensive modes of cultivation were made economically feasible with the arrival of the plough technology. The system was transformed from one concentrated on 'key resource' agriculture, with livestock impact resulting from outsiders' transhumant herds, to an integrated agropastoral system where cattle became increasingly central to agricultural production as an input in the form of draft power. The Native Commissioner (NC) of Selukwe describes this transition to extensive agriculture in his 1915 report:

> "With the advent of the plough... more land is tilled. It is extremely badly done... Formerly small gardens were cultivated very well and every atom of ground was turned over."

This transformation of the system occurred over a period of time. The increase of ownership of ploughs is documented nationally (see Table 3.1); those without access to ploughs and cattle remained the majority.

Table 3.1: Plough ownership by Africans (national figures).

Date	Ploughs/person
1910	1 : 333
1920	1 : 45
1930	1 : 19
1940	1 : 12

Source: National statistics, CNC Annual reports

However, group based sharing mechanisms, such as work parties or loaning of cattle (kuronzera), were important factors that allowed the resource poor to cope (3). The ancient practice of cultivation of vleis and river banks using hoe and ridging techniques also persisted as an important mechanism for those without the resources to adopt extensive cultivation techniques. It is likely that

many of the 'owners' of vleis were influential members of lineages who retained control of the most productive and stable resources (Wilson, 1986).

Improved security, the arrival of the plough and the rising number of cattle following recovery from rinderpest, thus enabled farmers to engage in extensive cultivation although this was backed up by the security of 'key resource' use. This shift to an extensive agropastoral system can be interpreted in terms of an adaptation to the contrasting savanna agroecosystem properties (see Chapter 2). Within the Mazvihwa study area an important move was from sand veld areas to clay veld or edge zone residence.

This reached its height in Mazvihwa in the late 1920s and early 1930s when key lineage clusters established themselves in the clay veld area. The ability to cultivate large areas (using ploughs) meant that the variability in production levels characteristic of this savanna type did not result in dramatic food deficits, as large amounts could be stored from large harvests in good years. Even in poor years the low yields per unit area resulted in at least some grain being reaped for the household since large fields were cultivated. People regarded the high fertility clay soils and extensive land availability as important incentives to move home sites. In the clay veld, the majeke gardens cultivated along the river banks were also an important component of the farming system complementing the more risky, yet less labour intensive, extensive cultivation.

One of the earliest colonists of the clay veld zone in Mazvihwa recalled the reasons for the establishment of their home there in the 1920s:

> "We moved to Gudo by our own choice, since there were no longer the Ndebele. The soil was good and the water sufficient. It was an empty deve area (forested plain), where lions and other dangerous animals were still found (Interview with Mr Gudo, 20.10.87)

Extensification of agriculture increased overall outputs and marketed surplus from the peasant sector (Phimister, 1988: 71-72) and increased the productivity of labour. Certain individual agricultural entrepreneurs (the hurudza) were able to farm large areas, successfully reaping significant returns and storing large amounts. These stores would then be used in times of drought to exchange for cattle or other assets (including daughters) with food deficit households. Considerable wealth was accumulated in this way by certain individuals.

During the 1920s - 1930s cattle populations rose considerably. Extensive grazing resources and the beginnings of a provision of a vetinerary care dipping service (4), meant that cattle populations boomed. This was especially so on the good grazing of the clay veld. People comment that early droughts did not result in problems for the cattle of Mazvihwa in both the clay and sand veld. An informant from the clay veld comments:

> "Most of the past droughts did not affect livestock... of course some cattle could die, but very few. This was the result of the termites finishing the grass." (Interview, Gudo, 20.10.87)

If crops suffered as they did on a number of occasions during the first decades of the century (eg. 1912, 1916, 1922, 1931, 1933 (cf, Zachrisson, 1978 and NC Annual reports), the increased availability of cattle as an exchange asset became important (Holland, 1986). The relative stability of crop production from the sand veld, especially when vleis were cultivated, meant that farmers of this zone could trade grain for the cattle of the clay veld during drought years. This pattern of exchange of crop and livestock resources became a feature of the rural economy and central to the flexible responses of communities to the variable environment (5).

"In some parts of the district practically no crops

were reaped, but in others the crops were fairly good and by natives exchanging cattle for grain amongst themselves they managed to get sufficient food for their own requirements." (NC Belingwe report, 1927)

"Local bartering of cattle for grain amongst themselves was sufficient to supply those in need with food." (NC Chibi, 1942)

Cattle dominated the livestock exchange and cash economy during this early period. Donkeys and goats were not nearly as significant. An old man from Mazvihwa reflected on the role of goats in the 1930s and before:

"Long back, goats were only kept for emergency food and for visitors. There was plenty of bush meat at that time. Goats only increased when there was less predation (Madyakuseni, 18.10.86)

The early part of the century thus saw a significant change in the land use patterns of the study area through the extensive clearance of land for agriculture and the rising populations of livestock. This process was accelerated by outside forces initiated by the increasing demands made by settlers and mining enterprises on environmental resources. For instance, extensive logging of large trees for mine props (and later fuel) by commercial companies, employed by the newly established Shabanie mine in Zvishavane, resulted in the selective clearance of large areas with the study area (Wilson, 1985). The pattern was repeated in other areas of the country and was commented on by the 1939 McIllwaine Commission:

"The chief destruction of the indigenous trees of the country takes place in connection with mining and tobacco farming, the generation of power for miscellaneous uses and the supply of fuel for domestic use" (Southern Rhodesia, 1939).

The structure of the C. mopane woodland was thus dramatically changed. This is well remembered by local people:

> "The thick forest was destroyed by the development of Shabanie mine. People were not happy about the destruction, but you could not voice objections to the Whites, because they would arrest you.." (Interview, Madyakuseni, 18.10.86)

The local cattle populations were also increased by the presence of large herds of transport cattle that were sent to graze on the sweet grass of the clay veld in Mazvihwa. This raised concern about the impact on local populations:

> "Many cattle in the Lundi reserve are so stunted as to be unsaleable and it is believed that this state may be attributable to lack of pasturage...This position is undoubtedly made worse by transport cattle (over 6000 in number) grazing in the reserve" (NC Belingwe report, 1925).

3.3 Changes in human and livestock populations: 1920s-1980s

Patterns of human and livestock population change can be seen by an examination of Figures 3.1 to 3.6. Figure 3.1 shows the pattern of human population change in three communal areas from 1920. Each area shows high rates of population increase over the whole period; this is reflected in overall national trends (6).

The increase in national African cattle populations and decrease in average holdings is shown in Figure 3.2. This shows a high rate of increase up to around 1930, followed by a period of decrease due to destocking (see below) and then a period of recovery during the good rainfall years of the 1970s. The liberation war during the late 1970s saw decreases in populations largely through increased disease with the breakdown of dipping services. Present populations show a period of recovery from the droughts of the early 1980s. This general pattern is repeated in broad outline for the different study areas (Figure 3.3).

Figure 3.1: Human population change, 1923-86 (Ndanga, Gutu and Shurugwi Communal Areas).

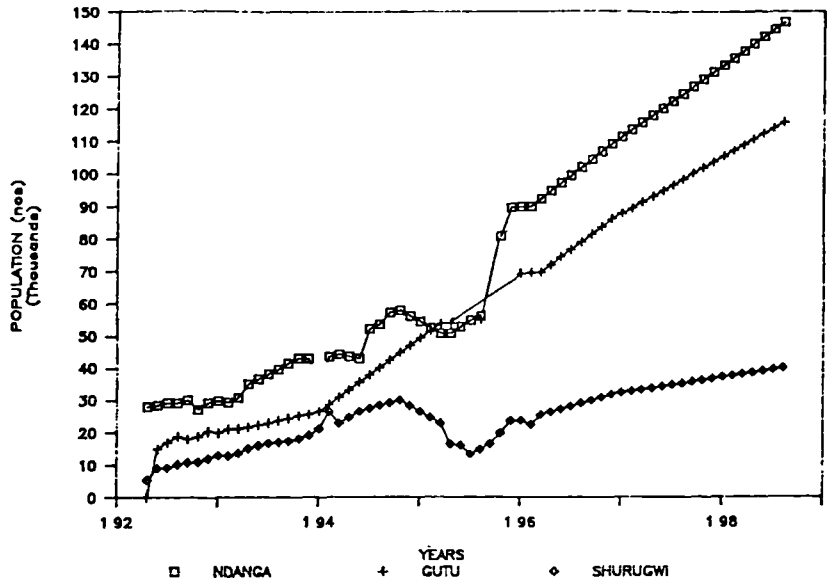
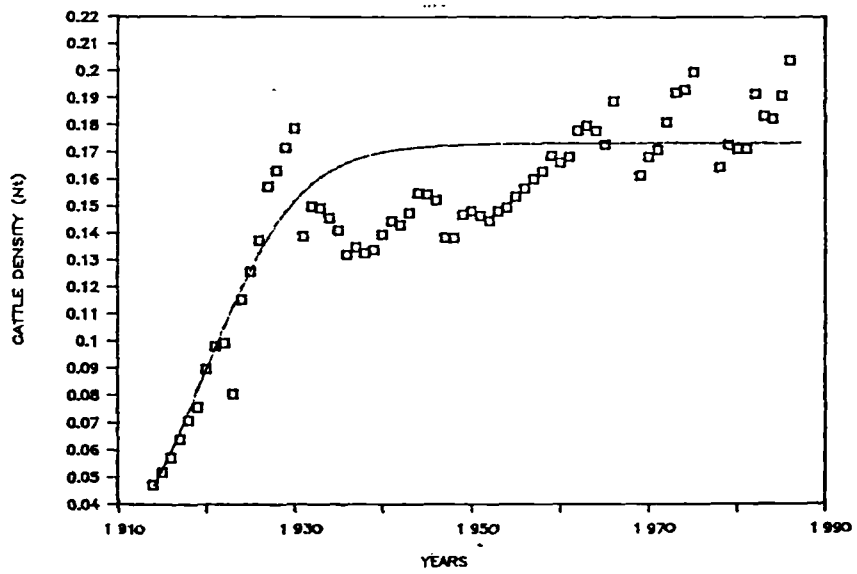


Figure 3.2: National cattle densities and cattle holdings in the communal areas (1914-1986)



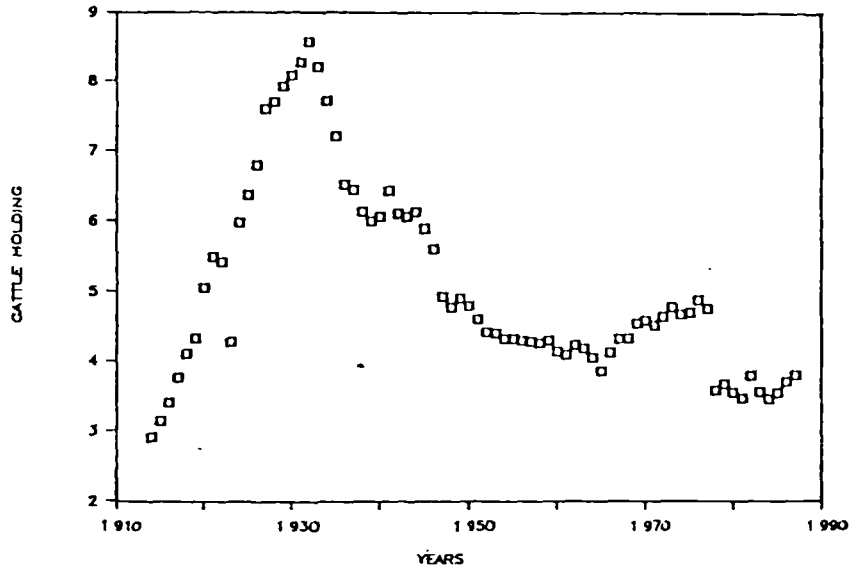
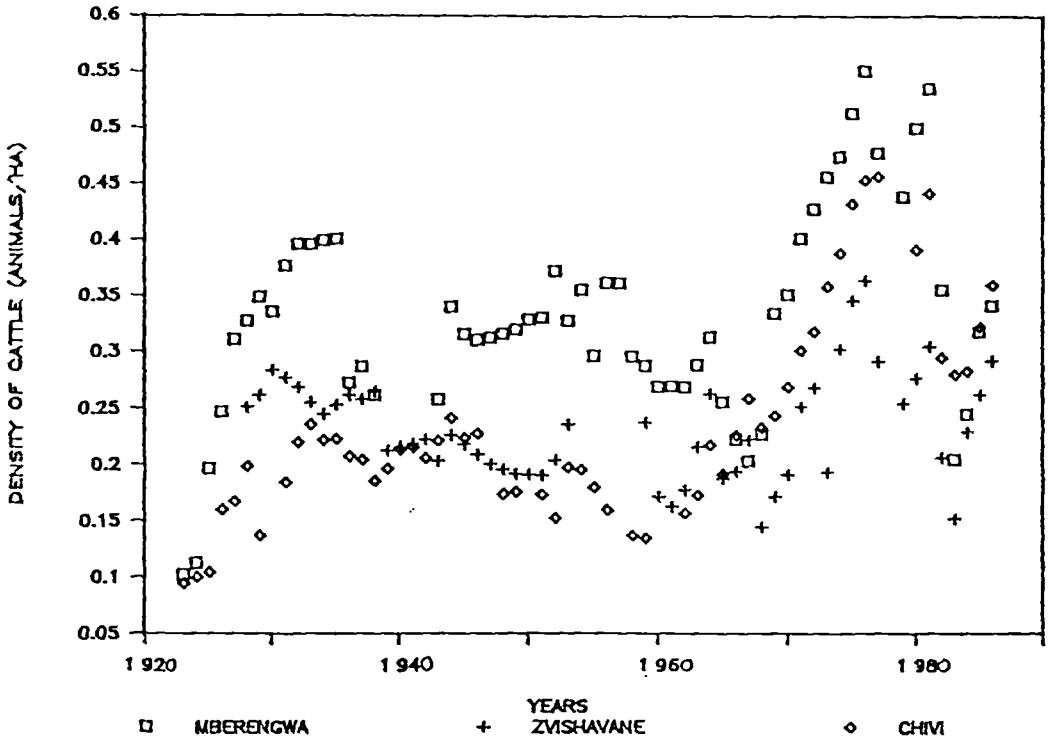
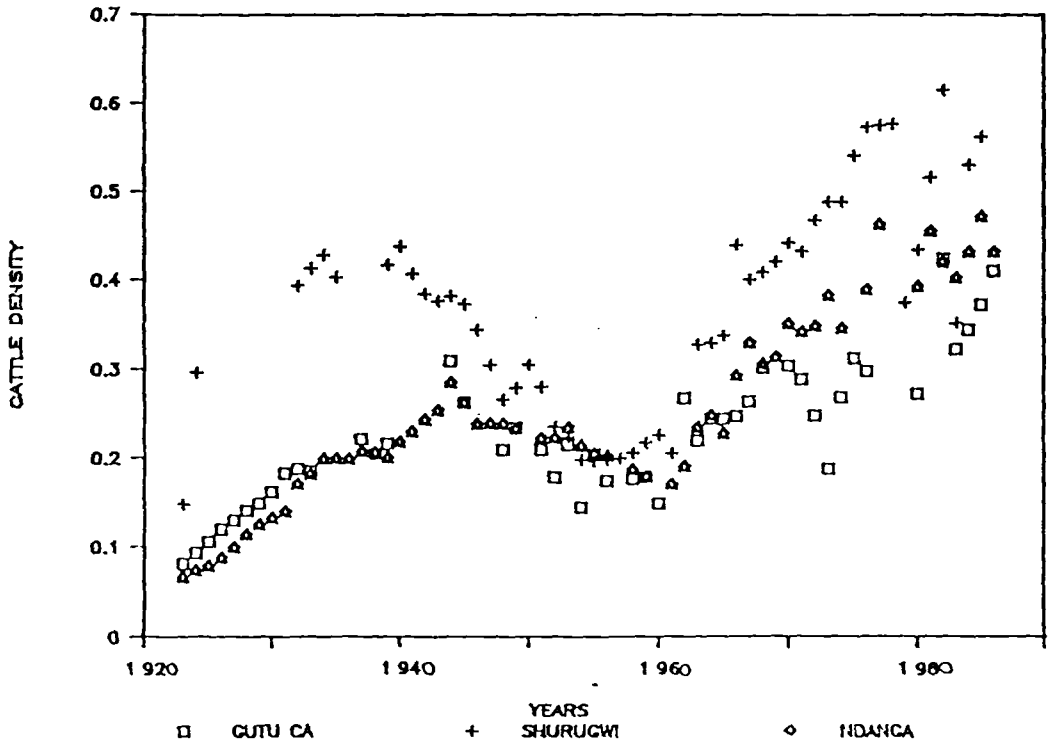


Figure 3.3: Cattle densities in animals per hectare (1923-1986): a. Drier areas; b. Wetter areas.



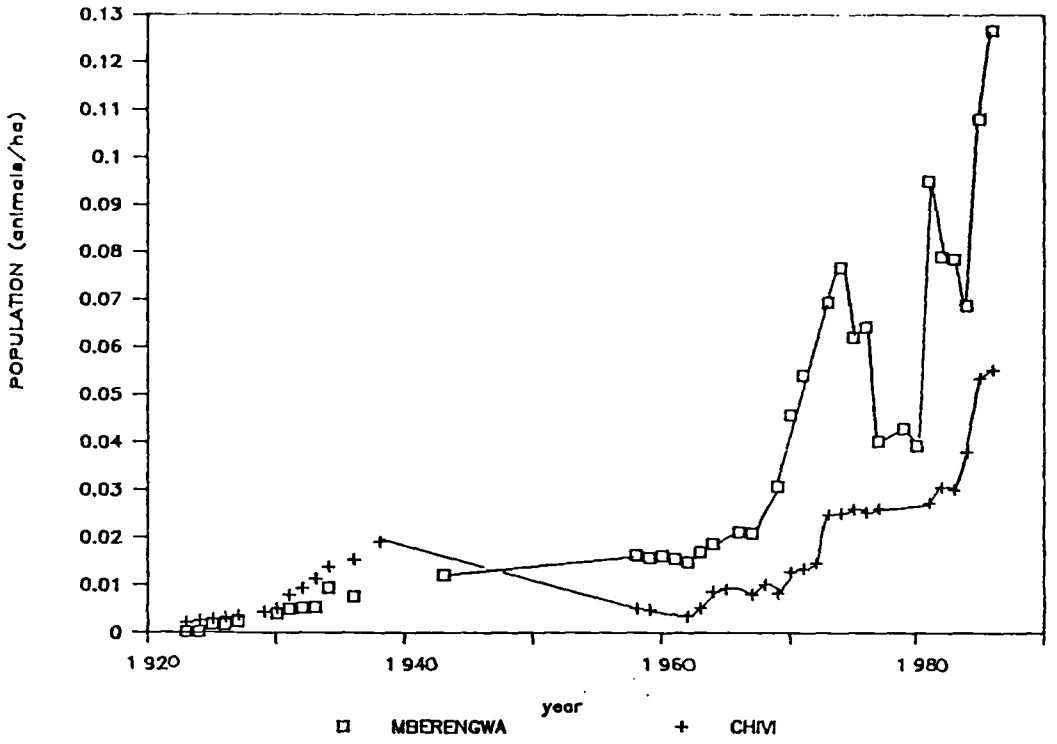


Donkey population change over the same period is shown in Figure 3.4 for different study areas. Prior to the 1960s recorded densities were very low in all areas. It has only been since the 1970s that donkey populations have grown significantly. Again this trend of growth has been offset by the impact of the war and the 1980s droughts. Population densities of donkeys are seen to be significantly higher in the drier study areas.

Smallstock populations (goats and sheep) show a similar pattern (Figure 3.5), with increases in all areas since the 1960s. The liberation war had a significant impact on recorded population levels with all areas showing declines. Populations have rapidly recovered during the 1980s, and the recent droughts have not had a large impact on the overall trajectory of increase. Some records do exist for smallstock populations before 1960. In Chivi, for instance, significant populations were recorded in the 1930s. These then declined during the destocking period.

Human populations increased faster than cattle for most of the period under discussion resulting in an aggregate decline in cattle per household. Figure 3.6 examines this for different study areas, documenting the changes in the average number of cattle per household (taken as 5 people) over time. Declines in per capita cattle holdings were particularly exacerbated by the destocking impact (see below), by 1960 there was on average only 2-3 cattle per household in the wetter areas and 4-6 cattle per household in the drier areas. The economic impact of this change will be discussed in later sections.

Figure 3.4: Donkey densities in animals per hectare (1923-1986): a. Drier areas; b. Wetter areas.



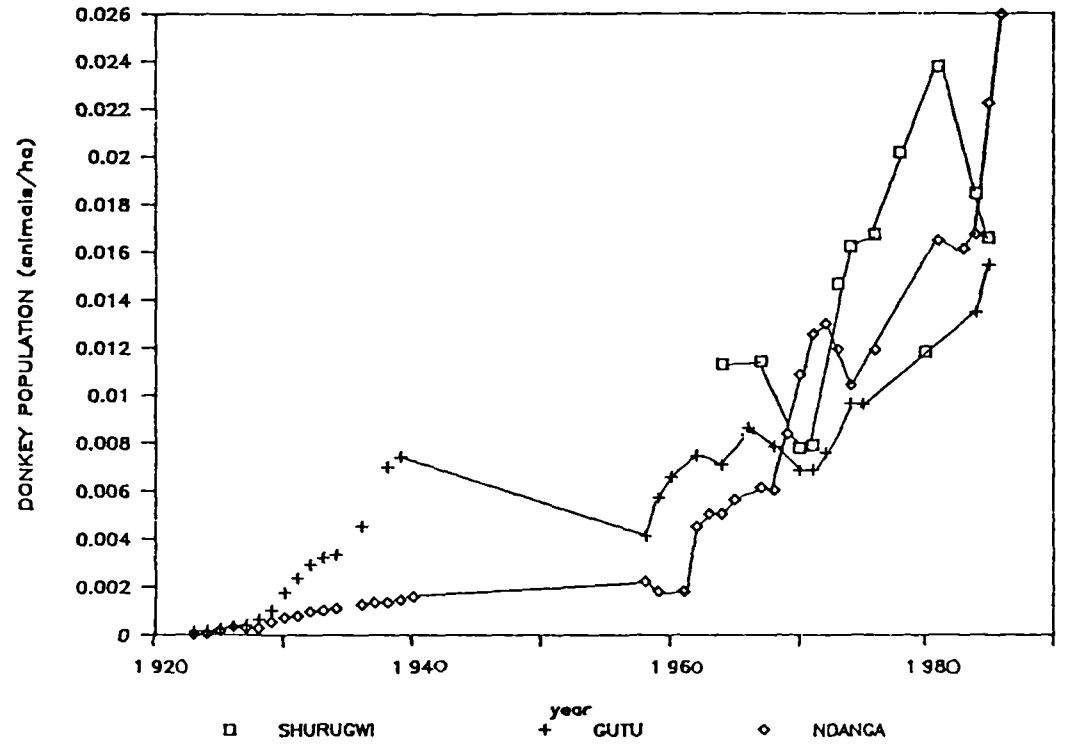
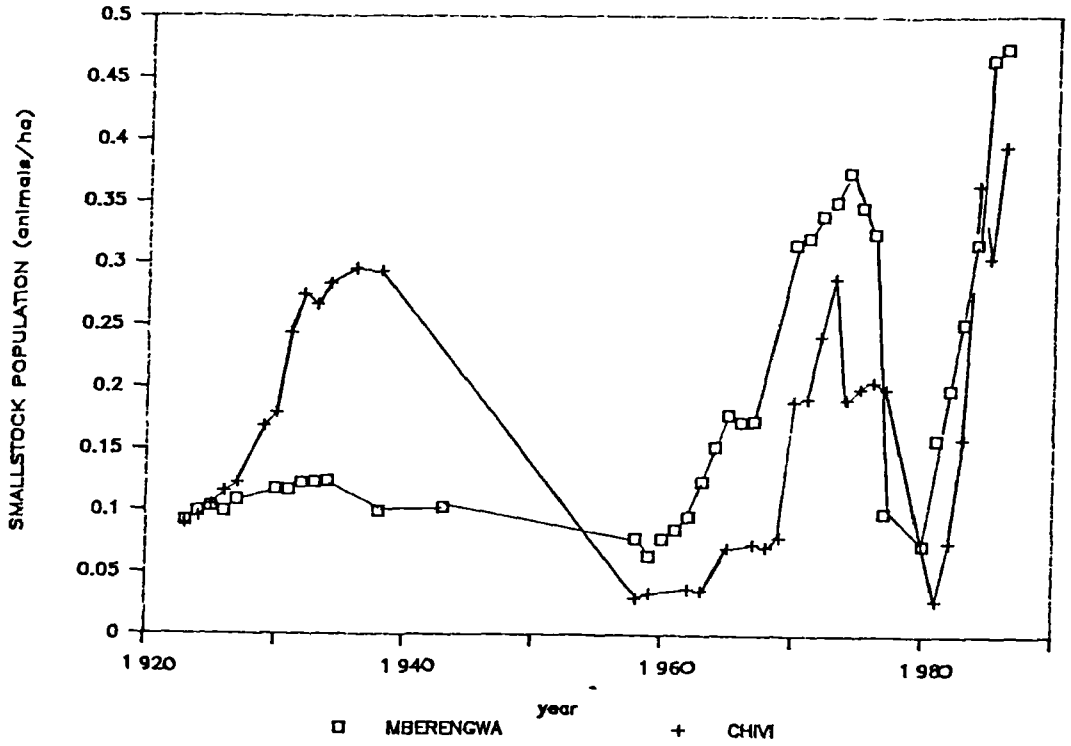


Figure 3.5: Smallstock densities (goats and sheep) in animals per hectare: a. Drier areas (1923-1986); b. Wetter areas (1960-1986).



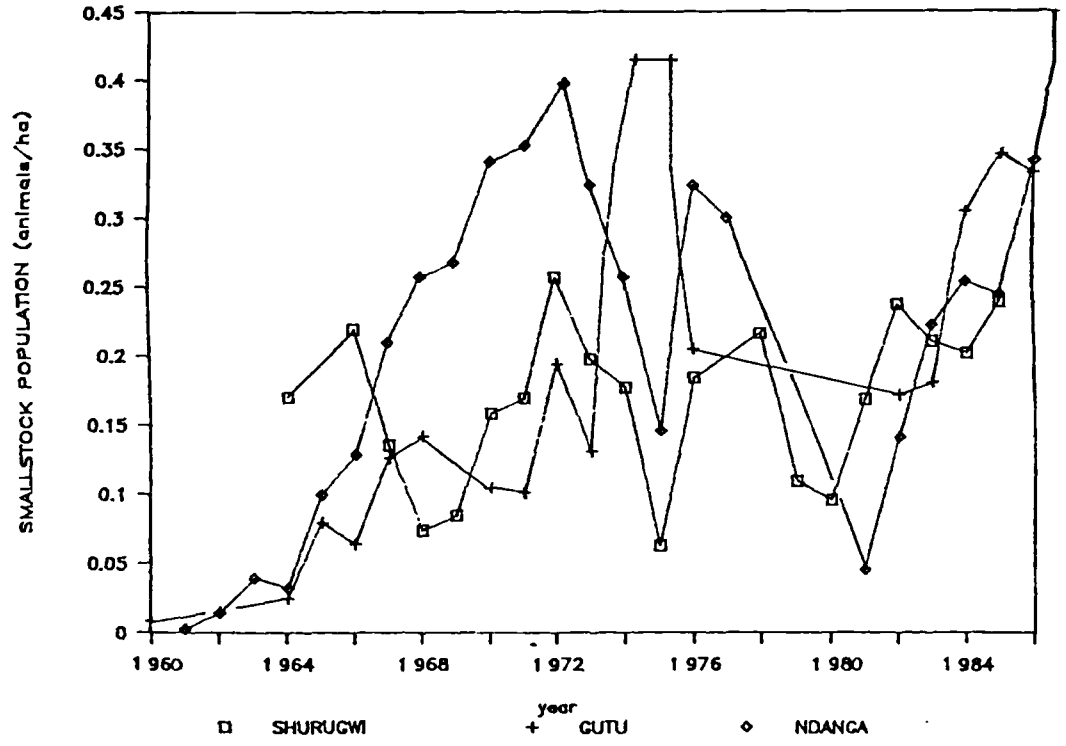
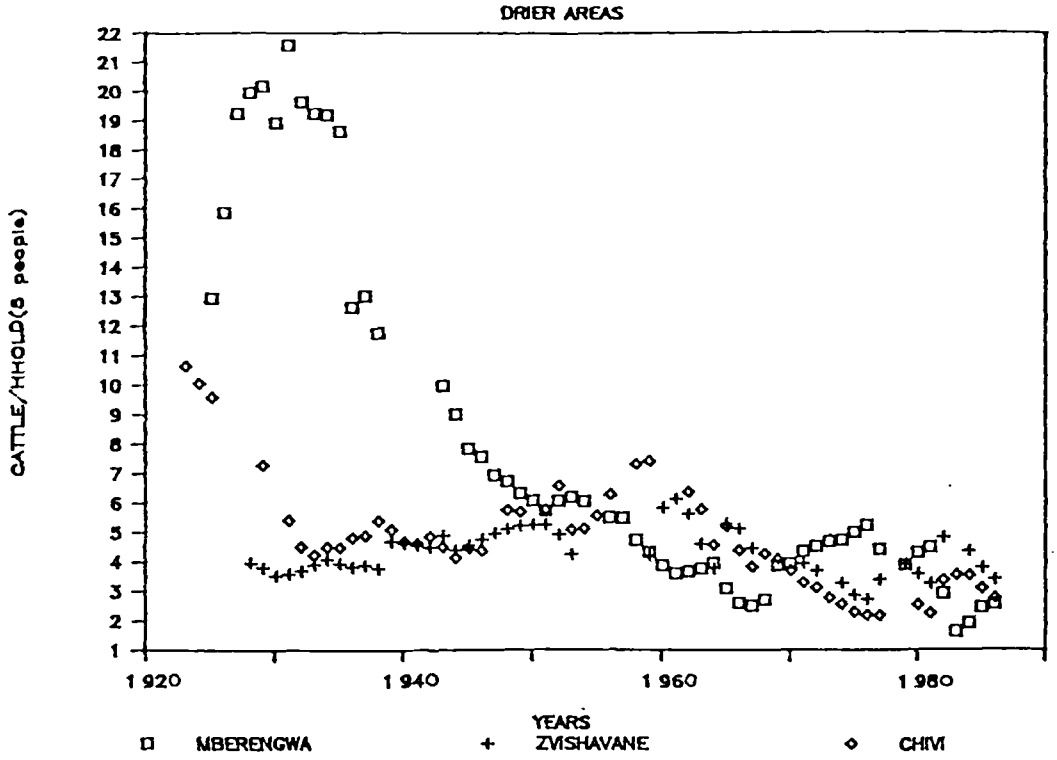


Figure 3.6: Cattle holdings (Numbers per 5 people) between 1923 and 1986: a. Drier areas; b. Wetter areas.



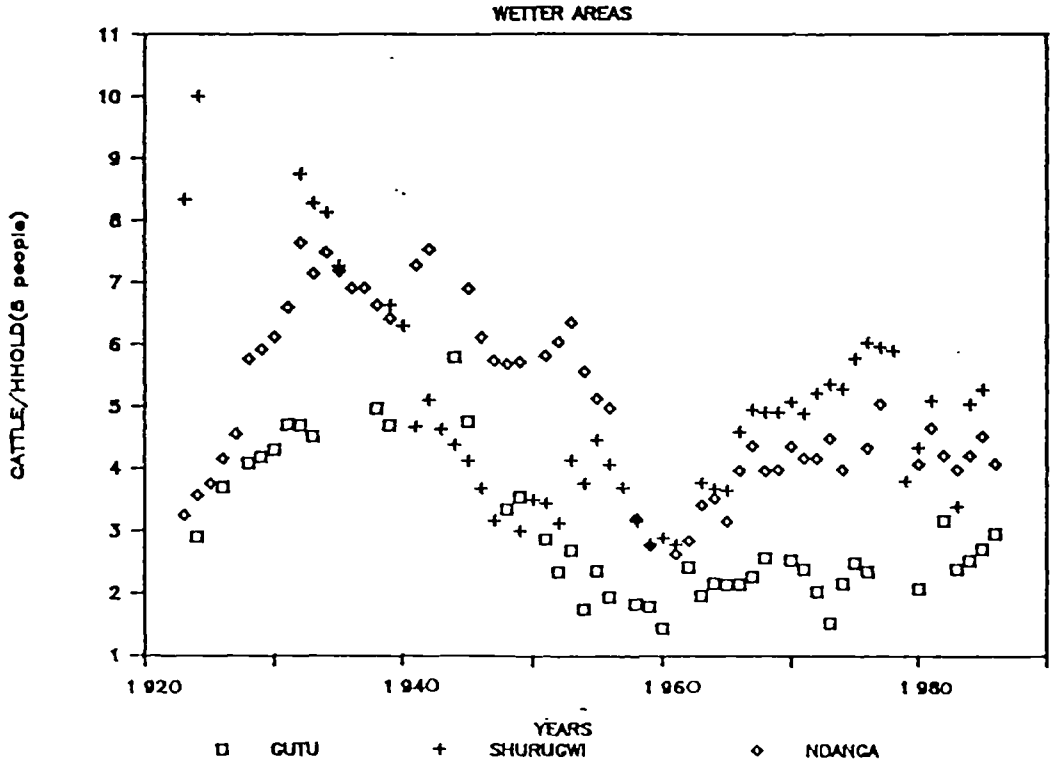
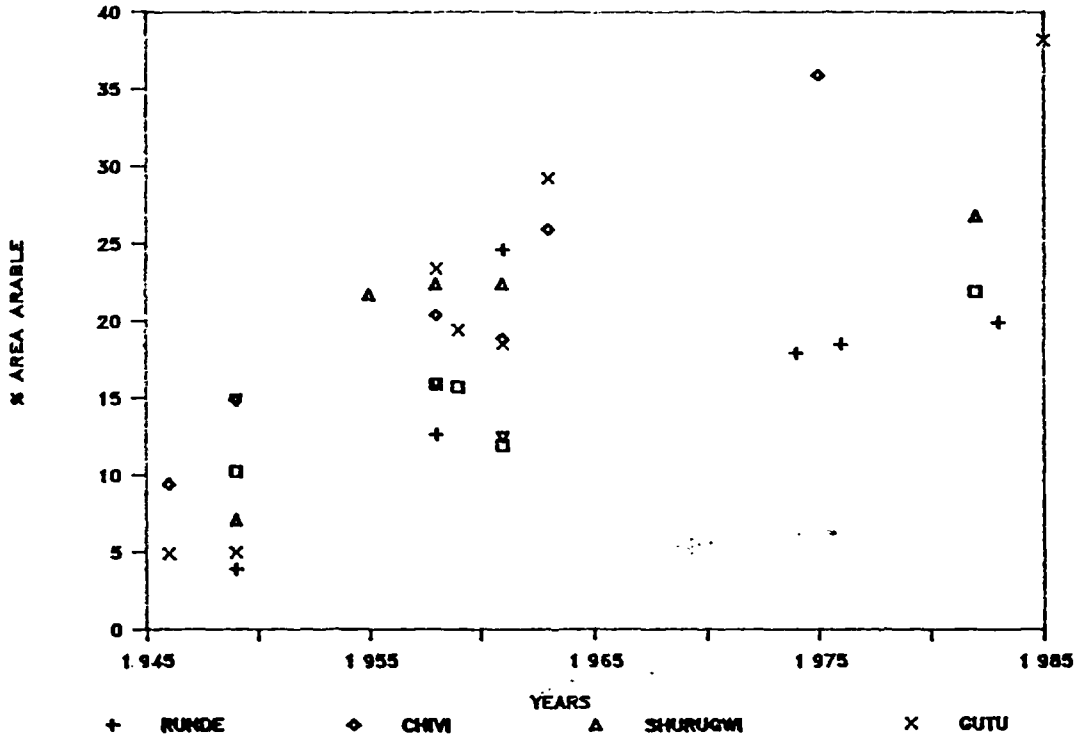


Figure 3.7: Percentage of total area estimated as cultivated in different parts of study area (1945-1986).



These general patterns of livestock population change will be discussed in the following sections of this Chapter in the context of changes in livestock and land use policy during this period. The aim is to give a picture of the political and economic framework that is the backdrop for changes in populations sizes. The investigation of the time series data will be pursued further in Chapter 4, where a more quantitative approach to the economic and ecological dynamics of population change will be taken.

Increasing human populations and the shift to extensive agropastoral production meant that land clearance was dramatic. The percentage of total area that was cultivated increased from c. 10% to c. 40% between 1945 and 1986 (see Figure 3.7; (7)). The impact on livestock populations of this shift is uncertain, as although open grazing areas have decreased massively over time the increase in arable land has resulted in the provision of wet season protected grass resources (especially following contour ridging) and the supply of dry season stover in increasing amounts. The trade-off, in terms of livestock survival, between extensive range grazing and integrated agropastoral systems is clearly complex.

3.4 Land use changes in the Mazvihwa study area

The sequence of administrative and boundary changes that have occurred in the study area is documented in a series of government notices. The details of this will not be explored here (8). Each area has undergone a number of boundary revisions or subdivisions into different units or changes of administrative status (see Palmer, 1977). The Mazvihwa area has had a complex administrative history. Unlike the adjacent Belingwe (now Mberengwa) and Chibi (now Chivi) reserves, this area was not allocated for African occupation in the early demarcation exercises of the colonial era. It remained Crown Land which was supposedly destined to become a European farming land as the other ranches surrounding became. Due to the pressure for land in

the district, the authorities were forced to revise their decision and the area known as Mazvihwa, the largely clay veld zone north of the Gwenombe, became a Special Native Area (9). The Bungowa area to the south remained as Crown Land, although some land was allocated to become a Native Purchase Area. The whole area became a Tribal Trust Land following the Act of 1967 and was known as Mazvihwa-Bungowa. Following Independence the Tribal Trust Lands (TTLs) became the communal areas (CAs) and the whole area will be referred to here as Mazvihwa CA. It lies within what is now Zvishavane district (before 1957 a sub-district within Mberengwa).

Changes in land use and natural resources have continued to the present day resulting from the interaction of government policy moves and changing human and livestock populations. This section explores these changes in the Mazvihwa study area (Mototi ward). The changes that took place within the Mazvihwa study area can be examined from 1939 with the use of aerial photographs (dated: 1939, 1955, 1968, 1985) combined with interpretations derived from interviews with local residents and a study of official records.

1939: Opening of the new land frontier

The pattern of settlement and arable land areas shown by the 1939 aerial photograph for the area is illustrated in Figure 3.8. The patterns show how the new settlers from the sand veld hills chose land for cultivation. Fields in the clay veld zone are predominantly along the Runde and Gwenombe rivers and the various drainage streams. Settlement is scattered, but with homes being close to fields and water sources. The greatest concentration of population and clearance for agricultural land is along the edge of the Bungowa hills in the edge zone. This is the area where the key Vangowa chiefly groups established their homes (10) in an area with some heavy soils, but also access to water resources with drainage from the hills.

Residents here therefore could exploit the benefits of both clay veld and sand veld zones.

The central clay veld remained empty at this time. It is remembered as an area of thick forest, in areas uncleared by the commercial logging companies, with populations of wildlife still present. At this time the Mazvihwa area was all still Crown Land allocated for potential European settlement and did not come under the direct control of the colonial authorities, as residency was assumed to be temporary. This was unlike other areas where Reserves had been created following the series of Land Commissions and colonial agricultural intervention occurred at a much earlier date. For instance, in Shurugwi land reorganisation under the centralisation policy started in 1929 (11).

1955: Increasing resource pressure

The next available aerial photograph set taken in 1955 shows a similar general pattern of land use, but a major extension of land clearance for agriculture, with areas of the central clay veld now cleared for cultivation (Figure 3.9). The increasing pressure of population on the existing reserves in the region, due to the displacement of populations from allocated European land, resulted in the creation of more land for African settlement. In Mazvihwa a significant number of displaced settlers arrived around 1947, having being expelled from farms close to Zvishavane. This influx, combined with expanding local populations resulted in a further decrease in uncultivated land. With high cattle populations at this time, the availability of grazing became severely limited. However the coincidence of this with a period of high rainfall resulted in little direct impact.

Figure 3.8: Cultivated area and settlement patterns in Mototi ward area, Mazvihwa: 1939.

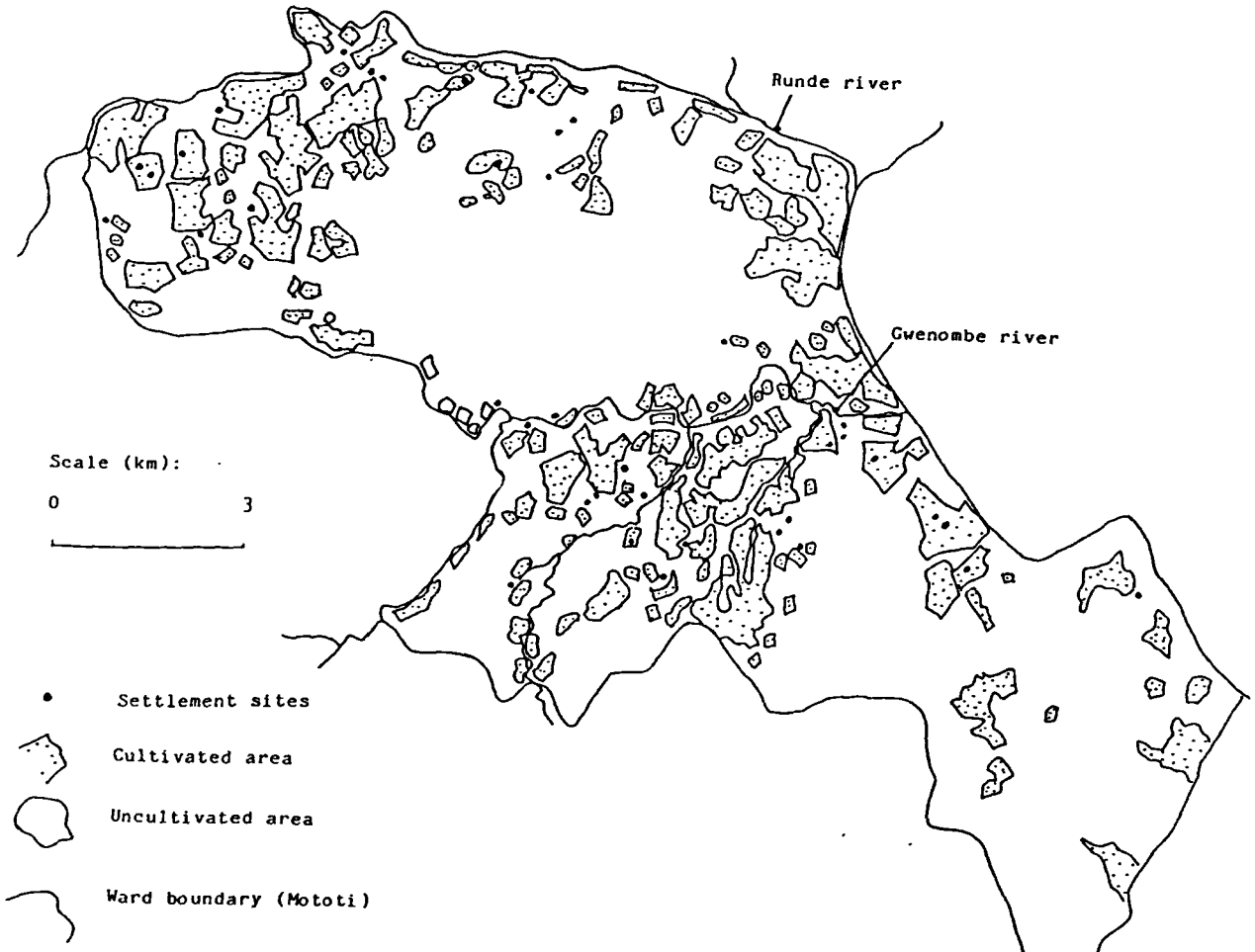
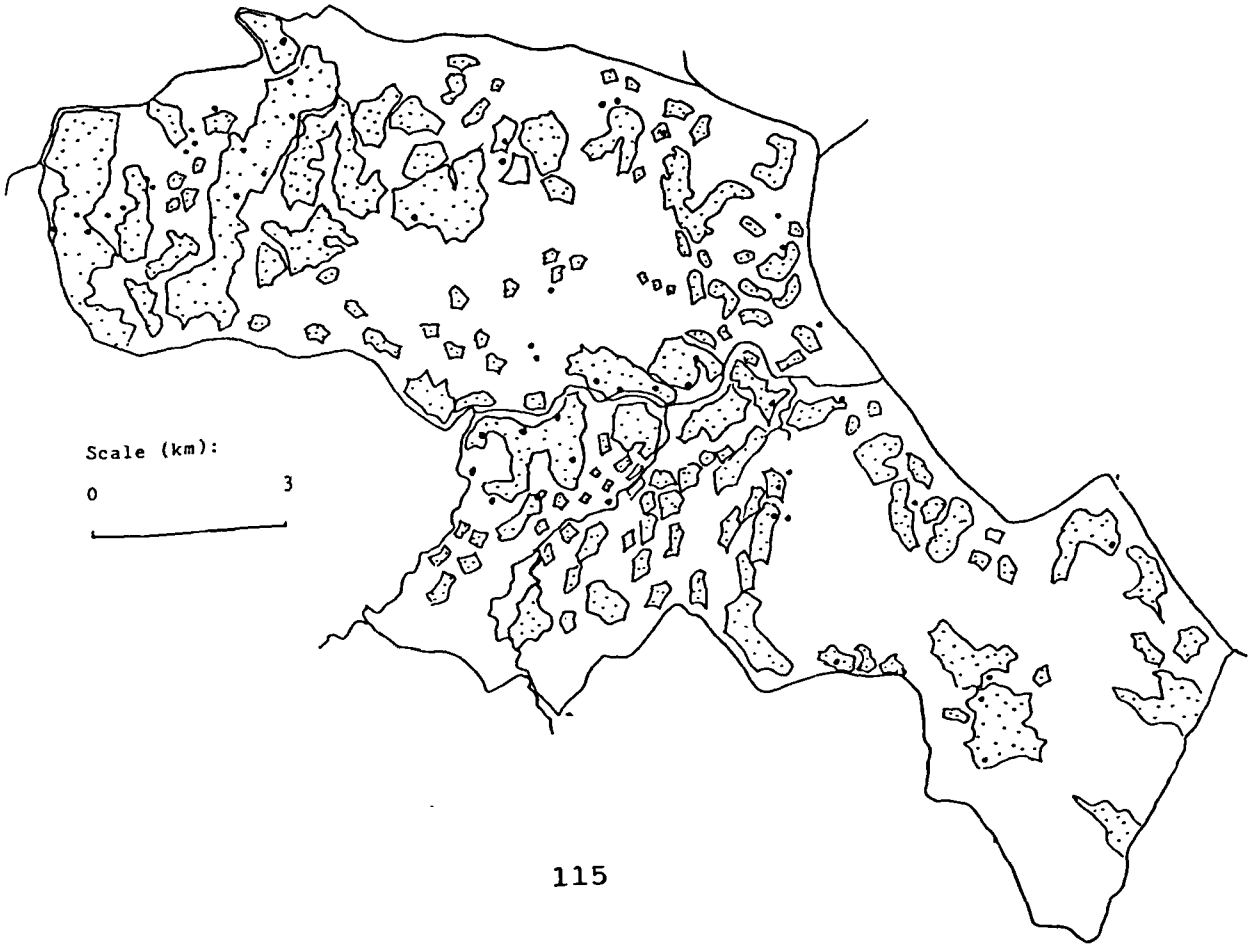


Figure 3.9: Cultivated area and settlement patterns in Mototi ward area, Mazvihwa: 1955.



The extensive, low labour input methods of the early part of the century became increasingly constrained by land shortage. Farmers in many areas started to farm with more intensive methods by the 1940s. Early objections to manuring centred on the consequences for labour:

> "The complaints are that it [manuring] entails considerable labour in carrying the manure in small baskets from the cattle kraal and that it will mean a lot of extra work weeding." (NC Chibi report, 1924)

However by the 1941 the Chibi NC notes that:

> "Manuring is on the increase, but would be more frequent if more transport vehicles were available."

The ANC of Shabani comments in 1944 on the increased intensification of agriculture in the area:

> "A change is taking place and more and more of the natives are farming properly and realise the benefits of contour ridging, rotation of crops, winter ploughing and manuring of lands."

However during the mid-50s, government influence on land use control still remained limited in the Mazvihwa area. Although there was a limited presence of Native Demonstrators and a skeleton dipping/vetinerary service, the major policy initiatives of centralisation, soil conservation works and destocking that had struck the other formal reserves in the area during the previous decades had not yet arrived.

However, the impact of the Natural Resources Act of 1942 was felt with the enforced banning of river bank and vlei cultivation. Except in the more remote hill areas, where vlei cultivation was able to persist without the knowledge of the Land Development Officers, the practice ceased and the majeke gardens were abandoned or were restricted to land some distance (100 feet) from the river bank. This had several effects. The security of 'key resource' cultivation

was removed, forcing farmers to cultivate even larger areas of land or secure alternative income sources (eg migrant labour). On the other hand, the land was now released for 'key resource' grazing, thus improving the grazing resource for the growing populations of cattle. Later interventions restricted this opportunity. For instance, during the 1970s there was a policy of fencing off of grazing vleis (Theisen and Marasha, 1974).

1968: Centralisation in the clay veld

The photograph of 1968 shows a dramatic change in land use patterns in the Mazvihwa area north of the Gwenombe compared to earlier photographs (Figure 3.10). The transfer of status to Reserve and later Tribal Trust Land meant that this area became under the direct control of the Native Department and the implementation of a series of controls under the Native Land Husbandry Act came into effect around 1960.

In other areas centralisation started much earlier (11). From the start of centralisation in Selukwe in 1929, 1.2 million acres had been replanned by 1936 and 10 million acres by 1957 (Floyd, 1959). The same applied to the destocking controls which were only initiated in the Mazvihwa area in 1960-1, just before the abandonment of the policy (see below). In other areas destocking took place from 1945.

Despite the differences in timing, the effects on the patterns of land use were similar, as the policy had a standard formulation. Alvord, the first Native Agriculture Director was keen to impose a system of integrated agriculture based on the rotation of crops and the manuring of land.

Figure 3.10: Cultivated area and settlement patterns in Mototi ward area, Mazvihwa: 1968 (post-centralisation).

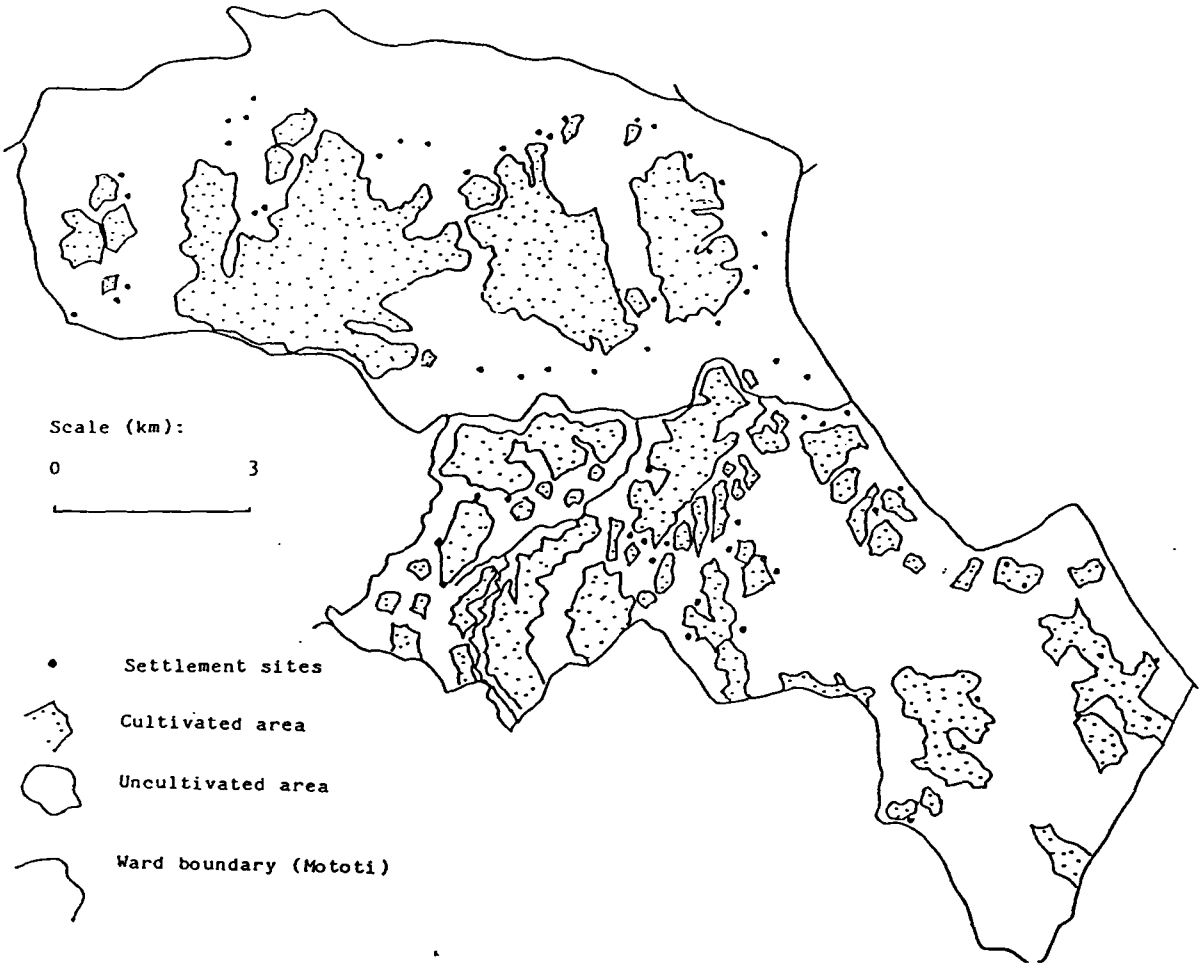
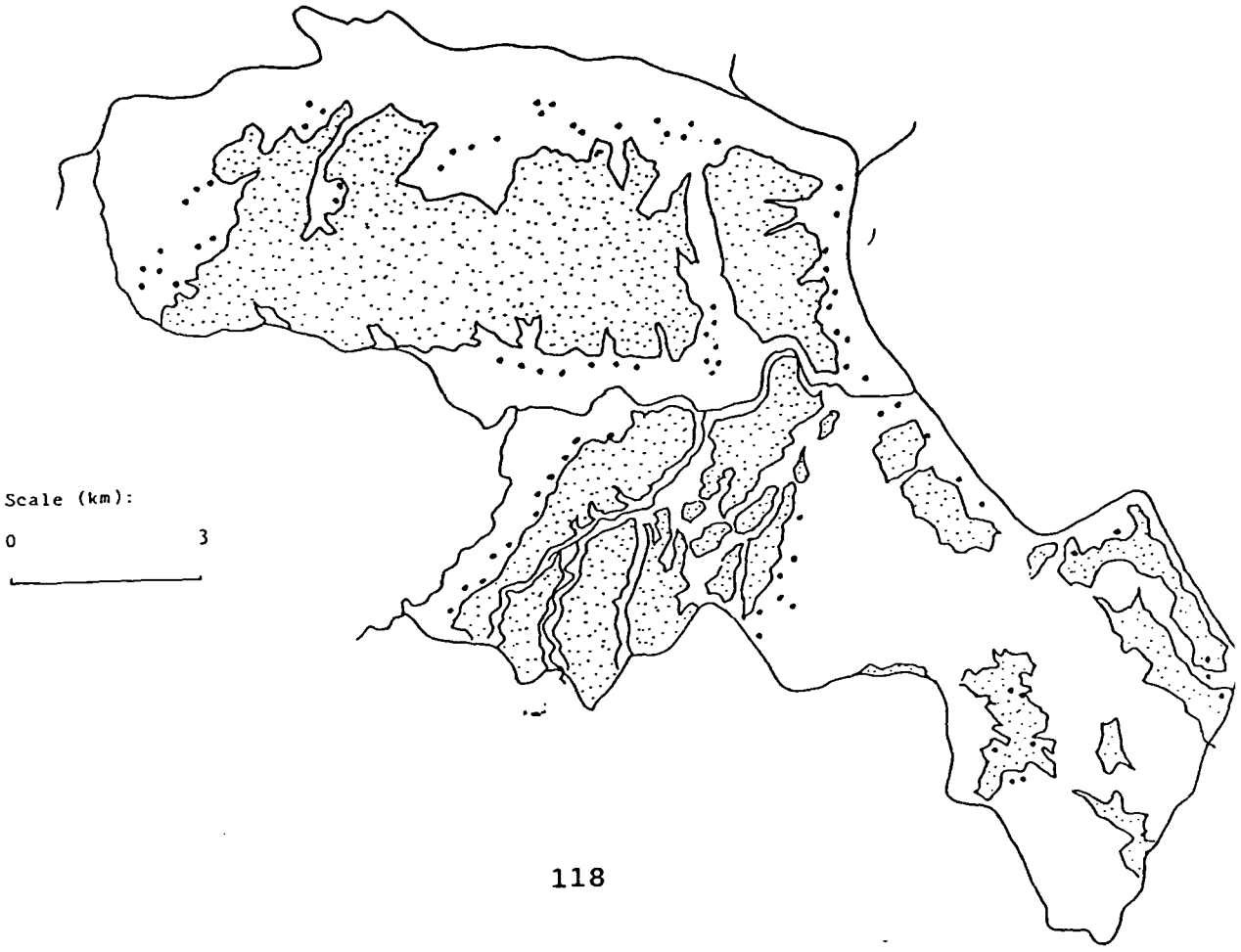


Figure 3.11: Cultivated area and settlement patterns in Mototi ward area, Mazvihwa: 1985.



This required the rationalisation of land so that distinct grazing and arable areas were formed. The allocation of land followed standard patterns, whereby the arable land was allocated to topland areas and the lower lying land adjacent to the rivers and streams was left as the main grazing area. The 'line' of settlement was designed to divide the two blocks. The pattern imposed by centralisation planning was the opposite to the land use practised to date, where low lying areas with water resources had been the principle areas for agriculture (see Figures 3.8 and 3.9).

This technical rationalisation approach had a precedent in the existing policy of trying to consolidate settlements to ease colonial administration. The NC of Ndanga announced in 1926 that:

> "The practice of living in isolated huts or groups of huts all over the the reserve has ceased. In consequence, the patrolling and administration of the district can be simplified and increased efficiency and control has been secured."

Centralisation was enforced, conservation works were hastily constructed and detailed local planning did not occur. Consultation did not enter the plan. Doubts about the technical implementation of centralisation were expressed in the Natural Resources Board (NRB) Enquiry (Oral Evidence) in 1942 in the following exchange (p.28):

> "I don't like this straight line business irrespective of the kind of land: one is arable, one is grazing. It looks as it has been done with a map without any regard to the land itself..."
>
> "I agree... it does not appear to me that the natural features of the country are being taken into consideration when these reserves are being centralised."

The often arbitrary nature of land reorganisation was made

worse by the lack of consultation with local people. Floyd (1959), a long serving Land Development Officer himself, comments:

> "It is doubtful whether the surveyors tapped the fund of native knowledge concerning vegetational and soil associations, built up over the centuries of close relationship with the physical environment." (p. 108)
>
> "One could only wish that more attention and a greater respect had been paid to the wealth of native knowledge concerning the limitation of their tribal country." (p 325)

For Mazvihwa, the result was that the major fields along the rivers were abandoned and new fields were cleared on the remaining topland. The grazing areas were thus largely old field sites with regenerating trees. The available woodland resource was therefore dramatically cut by this move and the nature of the grazing land woodland irreversibly altered. On the clay veld, old field woodland regenerated as Acacia, while the remaining C. mopane areas were remnants of uncultivated patches away from the rivers.

The situation north of the Gwenombe contrasts with the pattern to the south where centralisation was not imposed. Only during the 1970s were a series of soil conservation works and resettlement enforced, following the area's change of status to a Tribal Trust Land. The 1968 photograph shows that the existing pattern of land use was retained, but with an increase in cultivated area. In this area, grazing areas were increasingly constrained as the distance between fields decreased and the uncultivable areas of the hills became the most important resource.

Changes in land use of vegetation transect sites

The detailed history of the transect sites discussed in Chapter 2 is best explored with an understanding of this policy context. The 1939 photograph shows that, the clay veld Acacia and arable contour transects were both

cultivated areas, although there was quite limited cultivation in the region of the arable contour site. Areas of cultivated patches are also shown close to the riverine transect site. Local people were able to point to the sites of previous river bank gardens in the vicinity. However, the transect site itself was never cultivated. In 1955 this pattern was still the case. However by 1968 the Acacia transect area was abandoned due to centralisation and the arable area expanded further up the catena in the area of the arable contour transect site. The Mopane and sodic soil areas were not cultivated throughout and local informants indicated that this had been true prior to 1939 also.

The two sand veld transect sites show no changes in land use over the period for which photographs are available (1939-1985), both being retained as open woodland. One site (sand veld 2) however had been close to a previous settlement site on an adjacent hilltop, as remains were found close by. This had been abandoned much earlier, according to local informants, and its impact on current vegetation patterns is unclear. The vlei transect sites have been grassland through this period, although cultivation/gardening close by is evident. The sand veld contour ridge transect has been part of a field area since 1939.

Current land use patterns

The general pattern shown in the 1968 photograph persists to the present. The 1985 photograph shows the extent of expansion of arable areas since the late 1960s (Figure 3.11). During this time a relaxation of land allocation procedures occurred, with the transfer of rights to tribal authority following the Land Tenure Act of 1970. More significantly, there was a large extension of cultivated land due to 'freedom farming' (madiro) during the liberation struggle. Young people without access to land or limited inheritances from the subdivisions of their

father's land encroached extensively into the designated grazing areas. Some of these field sites remained by 1985 (but fewer by 1988). Others were abandoned following the resurrection of the land use regulations after Independence and the often strict enforcement of 'internal resettlement' into Native Land Husbandry Act designated settlement 'lines' and arable allocations. Other land use regulations (such as the fencing of grazing vleis) broke down during the liberation war and in most areas have not been resurrected.

By the 1980s the empty land of the clay veld deve no longer existed and the pressure on government to deal with the "land question" was intense (Cliffe, 1986). This has resulted in some limited resettlement of people to government resettlement schemes, but also an increasing trend of spontaneous resettlement to underpopulated areas in other parts of the country (notably Gokwe district). Even those who moved from the sand to the clay veld zone as late as the 1950s reflect:

> "I never the thought the place would become so full when I came here. Now I have got only four contours and ten children. It is impossible to feed them. The elder sons have got some land in Chivi and the others have been lucky to find work in town. Me, I am definitely going to try and resettle in Gokwe..." (Matyatini, Gudo, 4.7.87) [By Christmas, he and the family had gone]

The implementation of colonial land use legislation, the settlement responses of resident farmers and the in-migration of outsider groups was neither consistent between different places or coincident in time, however the general pattern presented for the Mazvihwa study area is reflected in large part in the other parts of the regional study area. The dominant importance of addressing the land shortage question is common to nearly all communal areas in Zimbabwe. An understanding of these historical changes is a necessary part of understanding the interactions of

populations, both human and livestock, and their resources.

3.5 The emergence of colonial livestock policy

The land use changes described above must be set within the context of changes in colonial livestock policy. The changing official view of the role of livestock within the rural African economy has shaped the form of livestock policies today and the official perception of the nature of the livestock - environment interaction.

Marketing for beef supply

With the failure to find the second Rand in Rhodesia, the settler government switched its attention early in the colonial era to a concentration on the agricultural and pastoral sector (Phimister, 1988). The failure of many European beef ranching enterprises in the early part of the century meant that the African cattle populations were seen as an important source of meat for domestic consumption and potentially export. The attempts to establish foreign markets in competition with other producers was generally a failure (Phimister, 1978), but a series of export agreements with South Africa and Britain did exist to encourage the policy of promoting the beef industry. This persisted despite the world crash in cattle prices in 1922, the depression of the 1930s, the series of Foot and Mouth disease outbreaks in the same decade and the restriction of exports during World War II (12). Cattle sales were encouraged from the reserves in order to supply growing demands in the expanding mining towns and urban centres.

Marketing of cattle was initially carried out with itinerant traders, registered by the government, or directly with local butchers, store-keepers or the mines. The registered cattle buyers who started in the 1920s and travelled the countryside securing purchases boosted sales, as this reduced the necessity to travel large distances to

trading points. Into the 1930s there was no shortage of sales from the study areas, particularly in the drier regions as cattle trading had become a central part of the local survival strategy, especially in droughts.

The sale or exchange of cattle was not alien to the local populations as pre-colonial records demonstrate. These point to the existence of extensive trading networks with the Portuguese and the Zimbabwe states (Mtetwa, 1978). During the early colonial era cattle were sold in preference to engaging in mine wage labour, especially when prices were high. The question of changing price responsiveness over time will be dealt with in Chapter 4.

The informal trading system was replaced by the auction markets as the official control of the beef supply industry became centralised, particularly with the take over and heavy subsidisation of the Cold Storage Commission in 1938. Zachrisson (1978) notes how organised sales that started in Belingwe in 1935 resulted in a diversion of sales away from local traders and butchers.

The Cattle Marketing Act of 1946 added a series of levies (13) on the sale of cattle, comparable to the system of levies imposed by the Cattle Levy Acts of 1931 and 1934. It also imposed a weight grading system of pricing that was heavily biased against animals of low weight; the primary product of the reserves destined for the local market. The subsidy in effect went to the European producer of export quality animals. This system was regarded as highly unfair and coincided with an increasing reluctance to sell to official markets. The CNC noted this in 1948:

> "There is discontent at the Native Cattle Marketing Act because higher prices are paid at the European auction sales....they cannot or will not see the advantages of guaranteed, stabilised prices."

The start of the destocking policy however meant that enforced sales resulted in a plentiful supply of slaughter

animals supplied at low prices.

Breeding for beef

The encouragement of cattle sales from the reserves, through the constant beseeching of people to sell by officials of the Native Department, was combined with a breeding policy designed to upgrade the 'scrub bulls' held by African farmers. These scrub bulls were largely the small, hardy Mashona cattle which were good for draft and transport but not for beef (see Chapter 5 for a discussion of the cattle breeds found in the study area).

From the 1920s a policy of introduction of beef bulls to the reserves was initiated. Bulls were purchased from the Native Trust Fund established in 1924 with the receipts of dipping fees. From 1925 to 1930 there was a recorded increase from 918 to 3737 grade bulls in the reserves (Phimister, 1988: 141). This was combined with a castration campaign aimed at transforming the local animal to one that could command a higher potential in terms of beef production. The NC of Selukwe stated the policy objectives in his report of 1925:

> "It is hoped that the Native will realise shortly that it will be to their advantage to raise a few graded cattle in preference to keeping a large herd of almost valueless scrub cattle. Until this is realised they cannot hope to compete in the cattle market to their advantage."

Or more significantly to the nation's advantage, as reflected by a later commentator on the same issue:

> "The fantastic, but latent wealth [of African cattle], should be exploited by the national economy." (Sec for Internal Affairs, 1970 quoted by Weinrich, 1975).

This period of enthusiasm for beef breeding in the reserves coincided with the collapse of the European ranching industry; between 1925 and 1938 there was a large decline

in European owned cattle and many ranching enterprises went out of business due to the effects of the depression (Phimister, 1988: 176). Predictably the breeding policy failed to resolve the urban beef supply crisis; by the end of the 1930s it was abandoned. Some NCs commented on the policy results:

> "No grade bulls were supplied to the natives [in 1939] as they dislike them.... there is but little improvement in the class of animal kept." (ANC Shabani, 1939)

> "There are no more grade bulls left in the district." (NC Chibi, 1941) [despite several hundred being supplied over the previous decade]

Attention was increasingly switched to upgrading local breeds and experiments were started at Makaholi research station in 1942. This was later combined with another attempt to introduce 'quality' animals into the reserves. During the 1940 - 50s bulls were allocated to a series of local leaders and bull paddocks were established. Again a crisis in the domestic beef supply industry was probably close to the top of policy makers minds. The growing urban markets in the 1940s and the failure of the European or African sectors to supply sufficient meat precipitated the crisis which was aggravated by drought (Phimister, 1986). However the emphasis of the breeding policy had veered away from exotic breeds to a reliance on local genetic stock. The Secretary of Native Affairs warned in 1950 that:

> "While the natives should not be prevented from acquiring their own bulls of exotic strain, it was felt that this was undesirable and should be discouraged wherever possible." (Sec Native Affairs report, 1950).

In some areas breeding attempts continue today. The genetic stock has not been transformed, but the nature of the resulting Tuli or Afrikaander - Mashona cross-breeds has been of some advantage in terms of improved draft power performance (see Chapter 5), but the consequences for beef

production have not been as planned. Despite this, the concern with beef production objectives has persisted into more recent policy debates (LeRoux et al, 1978; Government of Zimbabwe, 1986 (14))

3.6 Destocking and the 'carrying capacity' debate

The colonial concern with commercial beef production was overlain by the increasingly serious issue of the land question. The 1925 Land Apportionment Act expected the establishment of the native reserves and the expulsion of Africans from designated European land and from the land still owned by the land speculating companies soon after its enactment. This did not happen and many Africans remained on unalienated land into the 1940s. Growing political pressure, combined with the influx of European settlers following 1945, resulted in a pressure on the Native department to resolve the problem by enforcing the movement of Africans to designated areas. Some extra land was found (such as Mazvihwa), but the resulting squeeze on resources in the reserves provoked increasing alarm. These concerns combined to set the scene for the environmental and stock control policies of the late 1940s and 1950s.

One plank of the policy aimed at responding to the resource squeeze in the reserves was the centralisation programme designed to 'rationalise' land use and allow more effective use of the limited land, another was the option of destocking of livestock under the Natural Resources Act. These aspects of land use policy were finally consolidated under the Native Land Husbandry Act of 1951. The evolution of these policies and particularly the issue of destocking reveals a lot about the conflicts between environment and development as seen from the historical perspective. This debate sets the background to the confusion over issues of 'carrying capacity' and 'land degradation' in the communal areas of Zimbabwe today.

Concern about the state of the natural resources in the reserves increased during the 1930s. This reflected both a regional and global increase in concern about environmental degradation and soil erosion in particular (Blaikie, 1985; Beinart, 1984). This translated into new emphases in scientific training and shifts in colonial policies across British colonial Africa.

With the progressive implementation of the centralisation policy throughout the 1930s and 40s grew the cry for more comprehensive measures to tackle the perceived impending environmental crisis. This came from a variety of sources and the interaction between these different protagonists shaped the evolution of land use and environmental policy over the coming decades.

The technical scientists responsible for agriculture and natural resources were heavily influenced by the growing debate in South Africa following the experience of the 1922 drought and the subsequent policies of destocking and environmental protection. The interpretation of the causes of the dust bowl in the dry areas of the US in terms of over-use was also an influential factor in the emerging consensus that environmental degradation was a serious problem in the reserves (cf. Beinart, 1984).

This debate amongst the technicians inevitably influenced the Native Department civil servants responsible for the administration and control of the reserves. They were in charge of implementing a set of polices that were intended, in the 'official view', to increase the productivity of the reserves (centralisation, manuring, rotation etc.). This was necessary in order to accommodate a growing population in increasingly small areas. If this was threatened by environmental collapse, more demands for land from the local population and an increased need for government food support would not be well received by the government under the changing political environment of this period.

The politicians of central government represented a different constituency and supported the interests of the growing population of settlers. The 1925 Land Apportionment Act was implemented slowly throughout the 1930s with more and more land being appropriated by the settlers for new ranches or farms. The African population was therefore increasingly constrained and the pressure on the environments of the designated reserves increased dramatically. The political pressure was such that the implementation of the land apportionment policies could not be constrained or curtailed by prospects of environmental degradation. Something had to be done.

In 1939 a commission of enquiry into the preservation of the Natural resources of the colony reported to the government (the McIllwaine report). They noted:

> "Many of the Native areas are heading for ruin through overstocking and that unless something is done to regulate the number of stock in the others large stretches of land will become useless." (Southern Rhodesia, 1939)

This was one of the first times that stock control had been mentioned as a policy recommendation. A cautious voluntary approach was recommended to start with, but more severe measures were not ruled out.

> "Much can be done to secure their voluntary cooperation in remedying the evil of overstocking and overgrazing, but there may be, and likely will be, cases where, in the interests of the land and the Natives themselves, compulsory destocking will be found necessary." (Southern Rhodesia, 1939).

The 'voluntary' approach to destocking had been employed in the Victoria District for some years. However early concerns were aired as to the consequences for the local economy:

> "Whatever view may be taken of the number of stock in

> relation to the limited areas in which natives are constrained to live.... it seems patent, in relation to the needs of a people living very largely by pastoral and agricultural pursuits, the holding of cattle cannot be held to be excessive if there is any hope of a reasonable standard of living." (NC Chibi report, 1938).

The Natural Resources Board was formed as a result of the 1939 report and was given the responsibility of looking into the matter further. In 1942 a major consultation exercise took place led by a South African range management specialist, Dr Pole-Evans. He had been instrumental in initiating the range protection measures following the 1922 drought in South Africa, he had recently returned from the US where he had been heavily influenced by the raging debate over the dust bowl and he had been on a mission to Kenya to investigate the grazing management issues in the Native areas. He arrived in Rhodesia with a set of notions about the problems and ideas about the solutions that many local officials shared.

The oral evidence of the NRB Native enquiry reports a series of interviews carried out during 1942 with key people in different parts of the country. It provides an important insight into the official view of the native Administration prevailing at the time. They were very concerned about the increases in population density and readily took on board the view of the technical scientists that destocking was the answer to impending doom. The PNC of Matebeland and the CNC, Simmonds comment:

> "We have concentrated native cattle in inadequate reserves with unfortunate results. The matter is now most serious and we have to consider destocking.."

> "There is a large population both human and cattle which, under the Land Apportionment act will eventually have to be accommodated in the Native Reserves and Areas."

The opportunity for compulsory destocking came with the

Natural Resources Act of 1942 which allowed the Native Department to stipulate maximum stocking rates for all reserves (15). Initial surveys were carried out using dip record statistics and a set of carrying capacities laid down according to rainfall (Table 3.2). This represented a simplistic view of stocking potential without the consideration of soil resource differences or an inclusion of natural resource heterogeneity, now recognised to be important in the savanna ecology literature (see Chapter 2).

Table 3.2: Carrying capacities according to the official formula (Report of the Secretary for Native Affairs and CNC, 1947)

	Acres/LU
High Rainfall	10
Medium rainfall	13.33
Low rainfall	16.66

In 1945 the CNC announced the targets for destocking in 'overstocked' reserves. These included Belingwe, Selukwe, Lundi, Chibi, Ndanga, Gutu within the study area. The target levels for destocking to estimated carrying capacity (CC) for cattle are shown in Table 3.3.

Table 3.3: Early destocking in study areas (from Director of Native Agriculture Annual report, 1944)

	1944 cattle	CC cattle	ha/LSU	% o/stock
Mberengwa	78291	72093	5.42	8.5
Runde	16699	10952	5.91	52.4
Chivi	55544	39074	6.4	42.1
Gutu	69864	50764	4.26	37.6
Shurugwi	23181	13999	4.36	65.5
Ndanga	74589	58094	4.76	28.4

Some areas required stock reductions of 60% or more. Branding at dip tanks took place of so-called scrub stock and people were required to dispose of these cattle at the local markets. The flood of cattle onto the market forced down prices and people received little compensation for the loss of their assets. Permits were issued to regulate the number of stock held per person - usually a maximum of 4 or 5 was allowed, but it appears to have been immensely variable and arbitrary. People were also urged to sell or kill goats and donkeys, but no systematic campaign was carried out against these stock. Evasion of this was very difficult. Some managed to put their stock onto neighbouring farms and refrained from dipping them, others distributed them to stockless relatives so that they would be represented on their dipping cards, but nevertheless a large number of stock were culled in the early years of destocking. It was a very traumatic experience for local people.

Local perceptions of destocking

An old man from Chedume in Mazvihwa commented:

> "Destocking was a terrible pain and loss. But there was nothing we could do. It was the law". (interview 3.7.87)

At a group discussion in Mabika in Chivi someone commented:

> "When destocking came there was not any explanation given by the whites. Many of the cattle were sold cheaply; it was like mere giving away of cattle. The Europeans must have loved it as they bought many cattle for their farms." (Interview, 10.9.87)

Farmers generally dispute the Europeans claim that the area was overstocked. They argue that the lack of grass was due to diminished rainfall. The old man from Chedume commented:

> "Before destocking there was little grass, but grass only increases with more rainfall; it had nothing to do with the numbers of cattle" (3.7.87)

Others argued that overstocking was only localised, because of the concentrations of cattle created because of the centralisation of settlement and the establishment of the 'lines':

> "The fact that people were concentrated in lines made it appear to be overstocked. In fact there were no more cattle. Because cattle are grouped together then the effects on the land can be seen" (Interview, Cllr of Masinire, Chivi, 26.8.87)

A further argument, that again is often central to local peoples' arguments about the destocking period, is that settler land expropriation and concentration of people in the reserves was a major cause of certain areas getting overpopulated:

> "When the farms came the people saw the problems of overpopulation. When a farm gets into a place with people that land will be dying." (Interview with Masoche, Mazvihwa; 9.8.87)

Peasant arguments therefore take issue with the technical interpretation of overstocking by range management specialists and argue that the rainfall variable on grass productivity is not being considered. They also argue that degradation is not uniform and particular settlement and land use patterns result in concentrations of stock and so localised problems of erosion. Finally they address the issue of land degradation within the wider context of the political economy of land. Inequitable land distribution inevitably results in land degradation in certain areas.

The impact of this very draconian policy for environmental protection was noticed by local administrators in the Native Department. The statistics on stock populations for the study areas (Figure 3.3) show the significant changes

in stocking densities resulting. The policy also had a detrimental effect on herd structures and economic livelihood. The Chief Native Commissioner (CNC) in his annual report of 1948 comments:

> "In achieving the object of reducing the total stock holdings to its carrying capacity we are at the same time in some cases reducing individual holdings to an uneconomic figure."

The following year showed a slow down in destocking following an alarming survey that demonstrated the impact of the policy on stock populations. The CNC reports in 1949:

> "[Destocking] was not pursued this year, as it already had affected such a change in composition of the herds that drastic revision of the regulations was considered necessary."

The Native Land Husbandry Act period

These revisions coincided with the revamping of the whole agricultural policy in the reserves with the start of the massive programme of intervention outlined in the Native Land Husbandry Act (NLHA) of 1951. This combined a continuation of the centralisation policy, increased destocking, expansion of soil protection measures, intensified agricultural extension to be implemented in all areas with a massive push from the Native Department and supported by a loan from the IBRD (World Bank). A central focus of the NLHA was the allocation of individual rights to land and grazing. In a region of 25" to 28" of rainfall, it was estimated that the standard allocation per household would be 8 acres of land and 6 livestock equivalent units, each needing 10-12 acres of grazing. This was aimed at evening out land and stock holdings and encouraging 'viable economic units'. In addition a market in land and grazing rights was introduced (16).

Further surveys of the reserves were commissioned to revise

destocking targets. Range specialists were sent on rapid tours of the reserves in order to assess carrying capacity for particular areas. These were then reported to the grazing assessment committee and a target cattle population set. Local leaders were invited onto the committees but their opportunity for revision of levels was limited.

It represented a slightly different approach to the assessment of carrying capacities that:

> "..instead of classifying all reserves into one of three rainfall groups, each reserve should be surveyed and its grazing capacity assessed on its merits." (Minute Director of Native Agriculture to the CNC, 1946)

Although the approach represented a more fine-tuned and targeted approach, compared to the broad rainfall zones used before, it nevertheless resulted in some criticism. How was it possible to assess the potential carrying capacity of an area with such a cursory view and without an understanding of the patterns of use within the local production system? The NC of Gutu expressed his concerns in his report of 1944:

> "So much has been said about overstocking in this district after the most cursory examination by folk deemed to have expert knowledge....[but] the condition of stock to the last day of the year was extremely good... [yet] mathematically this district is grossly overstocked."

The report of the Secretary for Native Affairs of 1952 emphasised the need to take a flexible approach:

> "It is certain that these assessments, dependent as they are on so many factors of water, soil and pasture must not be regarded as immutable, but constantly watched to maintain a proper balance between pasture and stock, as well as between stock and agriculture."

Throughout the NLHA period the debate continued over the

advisability of the destocking policy. The natural resource specialists were adamant that it must be continued to protect the grassland, the Vetinerary department officials were happy to see increased sales and an apparent commercialisation of the cattle economy after so many years of beseeching the locals to sell, but doubts were expressed from some quarters. The Native administration, burdened with implementing the policy in the face of rising nationalist opposition, became worried. Later on even the technical parameters for the policy began to be questioned.

In a 1955 report to the assessment committee for Selukwe reserve, the NLHA administrative officer, von Memerty, voiced some serious complaints about the impact of the destocking policy following an extensive survey in the area (17).

> "To about half of the individual stock owners it meant near disaster. About half of the stock owners who had borderline workable holdings of 5 to 8 head of stock were reduced to 4 animal units, others to 3."
>
> "I am fully convinced that destocking is in itself a negative policy and where it is severe must be followed up at the earliest possible moment.. with a positive policy of grazing and stock improvement."

A change to a more 'positive' approach was echoed by many in the Native Department and the technicians were required to come up with a new package of more palatable measures. The grand plans of the Native Land Husbandry Act were abandoned in 1961. Increasing resistance to the measures was being faced and non-cooperation or disruption meant that little was being achieved. A new approach was called for. In a long essay presented in the 1961 CNC report the Commissioner hailed the arrival of the 'community development' phase of agricultural development in the reserves with an emphasis on positive measures and extension.

The 1963 commission of enquiry into the beef cattle

industry of Southern and Northern Rhodesia reflected this change of emphasis. It both questioned the technical basis of some of the destocking measures of the past 15 years and the approach to implementation.

> "In some areas regarded as overstocked there has been no drastic deterioration in the grass, indicating that assessment of the livestock carrying capacity of the area has probably been on the cautious side."

> "A new approach to the problem [of overstocking] based on educational propaganda and extension is now regarded as imperative.."

Grazing management: the 'positive' approach

Destocking had become politically impractical and despite many of the technicians still recommending it, it was abandoned. During the 1960s the scale of intervention in the reserves, or the TTLs as they became, was reduced. Many of the same policies and technical recommendations persisted. The same people, most of their professional life being centred on the implementation of the NLHA policies, were still in place and so little of substance changed. In 1970 the Director of Veterinary Services reminisced about the days of destocking in his annual report:

> "The resistance of the African to selling a reasonable percentage of his cattle is really depressing when one reflects on the position prior to 1961 when DCs enforced culling of old scrub stock."

The livestock policies that succeeded the NLHA emphasised grazing management:

> "Particular attention... has been given to the promotion of a more positive policy towards improving pasture conditions for native owned cattle. Rotational grazing is the obvious first step." (Secretary for Native Affairs report, 1957)

The idea of paddocking the grazing land had been around

since the 1930s and was recommended both by McIllwaine in 1939 and Pole-Evans in 1932; some paddock schemes had been implemented as early as 1947 in Zimutu (CNC report, 1948). It was not until the 1960s that the idea really took off in the official mind (Dankwerts, 1974; Froude, 1974) This period saw a number of loan financed schemes being implemented within the study area (18).

The historical evolution of the grazing scheme policy is documented by Cousins (1987; in prep). The parallels with the themes of the destocking debate are interesting to draw, as many of the similar technical concerns were transferred to a 'new' solution. Again beef production and environmental protection were seen as the central rationales for the advocacy of the policy. Stock control was seen as key to the success of any grazing management scheme and this would allow the realisation of effective beef growth rates and higher offtake. Paddocking would also allow greater management control and the opportunity for the introduction of controlled breeding (19).

Despite the transformation of practical policies on the ground, the official view that the reserves were overstocked and the land degraded never changed. Cleghorn's 1965 questionnaire survey to the District Commissioners to assess 'degradation' proclaimed that a large proportion of the TTLs were 'overgrazed' and 'overstocked'.

No-one had learnt much about the experience of destocking and the links between ecological and economic effects were never made. The debate had taken place in different departments, in different places, with different languages and with different pressures. Above all the different actors had different world views: the technical scientist contrasted with the implementor, who were in turn different to the colonial politician. The peasant farmers' views never entered the official debate at all, but they too had a very different perspective.

Today, despite the political transformation of Independence, the focus of livestock policy recommendations remains little changed from the NLHA policies (Drinkwater, 1989).

3.7 The changing rural economy and the role of livestock

The success of the expansion of the agropastoral economy in the African farming areas in the early part of the century is often commented upon (eg Palmer, 1977; Ranger, 1985; Phimister, 1988). The expansion of agricultural output and the entry into the market economy was quite dramatic. The new mining centres within the study area in Shurugwi (Selukwe mine), Zvishavane (Shabanie mine), Chivi (Mashaba mine) and Mberengwa (Buchwa mine) provided an important and growing market for agricultural and livestock products. There was a corresponding diversification of the rural production base to include marketable vegetable, fruit, pig or milk products (cf. Zachrisson, 1978). Local informants recall the selling of grains, groundnuts, meat and milk at these nascent urban centres, resulting in the flow of cash to the rural areas and the purchase of consumer goods, notably clothes and groceries such as sugar or tea. Some key entrepreneurs purchased bicycles, carts or even motor vehicles.

Although the cattle trade had been heavily depressed by the decline in prices following the 1922 market collapse, this picked up towards the end of the decade. Cattle became increasingly central to the local cash economy and a means of acquiring traded goods in the new market centres. Grain also had a role, but a series of droughts (especially in the early 1930s), lower relative prices and more competition from European producers meant that this market was not so lucrative.

The success of the African farming enterprises, even in the dry areas of the study sites, did not go unnoticed by both

the early European settler farmers, who were struggling to make a living and meeting stiff competition, and by the mine employers, who were finding great difficulties in recruiting a permanent workforce. Phimister (1988:78) quotes a colonial official on the subject:

> "There is such a demand for produce and cattle that there is a great inducement for the natives to remain in their kraals and supply these wants."

The NC of Belingwe reports that people were only prepared to be seasonal labourers:

> "Sufficient labour was offered in the first part of the year... but there have been shortages latterly. This is usually the case.. as there is a general exodus of indigenous natives at the commencement of the rains to return to their villages to plough..... there can be little inducement for an able bodied native with a wife and family to support to work from sunrise to sunset for 15/=." (NC Belingwe report, 1934)

The asbestos mines of the district were particularly unpopular with local residents because of very poor working conditions and the mines increasingly recruited from Malawi or Zambia. In 1927 the situation was described for the main study area:

> "The demand [for labour] is far in excess of supply. The asbestos mines are unpopular and experience great difficulty in recruiting.." (Belingwe NC report, 1927)

By 1933 increasing labour was being supplied because of the opening of a series of small gold mines in the district (NC report). But people still did not see mine work as a permanent option, more as a strategy for expediency in the face of difficult conditions. For instance in 1928 the Gutu NC reported that there had been a flood of people seeking employment following poor crops over two years, but once this was over many returned to farm. He also notes that some individuals invested in ploughs and hired their

ploughing services out. Another instance when labour supplies increased was in the 1922 drought when the alternative security mechanism, cattle exchange or sales, was not an option, due to low prevailing prices.

From the early part of the century, government had started to impose a series of taxes and fees on the rural population. In addition to the other roles of cattle already discussed, cattle became an important route through which people could 'meet their obligations to government'.

During the 1930s, as a response to the deepening crisis in the European agriculture sector, government instituted a series of direct constraints on African commercial agricultural or pastoral production. This started with the Maize Control Acts (1931 and 1934) and the Cattle Levy Acts (1931 and 1934). These were followed by the Native Cattle Marketing Act (1947). The motivation of these Acts seems to have been, in part, to encourage a local migrant labour economy (Palmer, 1977) with a permanent workforce. The result was a progressive undermining of the agropastoral economy.

The increase in the participation of Africans in the European run economy was significant during the early 1920s. By 1926, the participation of 'indigenous natives' in wage employment ran at 35% nationally (Arrighi, 1970). From this time remittance income from off-farm sources became much more significant in the local economy both in terms of investment capital, providing cash for cattle or plough purchase, in terms of the provision of consumer items (clothes, blankets) and in terms of the provision of security in times of stress, such as drought. As the cattle economy became undermined through the destocking policies of the late 1940s this became especially true. The Assistant Native Commissioner of Shabani discusses the future prospects for the study area, spurred into thought by the experience of the disastrous 1947 drought:

> "Were such a drought as this to strike the local reserve [Runde] with its present economy at a time when it had no bank in the form of excess livestock the results would be more than calamitous.... the reserve native is being forced to maintain a dual existence, working away from home and leaving his family behind; particularly when the economy of an overpopulated reserves such as Lundi is productive of few marketable surpluses." (ANC Shabani report, 1947)

There was of course no single pattern of response to colonial agricultural legislation or movement to increased incorporation in the formal wage labour economy. It is clearly too strong to state that the African rural economy had been 'destroyed' by the end of the 1930s (Palmer, 1977: 243). Periods of decline existed during the depression and the Second World War, but booms also occurred in the early 1920s and the early 1950s (Mosely, 1983). These patterns are also regionally differentiated. Different areas had different patterns of change over time in the relative contribution of agriculture, livestock and remittances to the household economy. For instance, in Shurugwi and parts of Chivi or Runde, the early establishment of the mines, the improved communications links to other parts of the country and the competition from relatively advanced settler agriculture in the area, meant that the agropastoral economy came under greater external pressure than more remote places. There was consequently a significant involvement in the wage labour economy from the 1920s. Places like Belingwe, Matibi or Mazvihwa were different. These areas were more remote, with less access to the mining centres, the agricultural economy was under less pressure from settler competition, as most of the surrounding areas were beef ranches, and the local cattle economy was thriving. In such areas significant involvement in the wage economy did not occur until the 1940s (although many individuals did engage in work) (cf. Phimister, 1988: 77-78).

3.8 Historical changes in the role of livestock

The key changes during this century in the role of cattle in the rural economy of the study areas can be summarised:

- The significance of cattle as meat/cash providers has progressively diminished over time. This is related to the increasingly important role of cattle in the agropastoral system as providers of draft and later manure inputs, as the system became more integrated and the numbers of 'surplus' cattle in relation to farming needs diminished. This general picture is obscured by the fact that some owners did indeed retain large herds and so were in a position to sell, however the historical pattern of differentiation in cattle ownership is unclear (19). Other sales continued as responses to immediate financial crises (cf Steele, 1981), often prompted by the increasing demands of the colonial state who required the regular payment of a whole series of taxes by the African population (20).

- The role of goats as providers of meat and cash has undoubtedly increased over time as their populations boomed especially into the 1960-70s.

- The increasing constraint on land resources has also resulted in changed pattern of livestock management responses to drought. In the past local resources were available to sustain cattle in droughts, however the need to migrate to seek alternative feed resources or to actively store fodder has increased over time (see Chapter 7), making the option of cattle management more risky.

- The increase in donkeys in recent years can be seen in part as a response to the increasing susceptibility of cattle populations to drought.

- Interviews with farmers also suggest that the social context of livestock management has also changed (21). The tight lineage clusters that were established with the early

migrations into new land frontiers at the beginning of the century have grown and fissioned, resulting in a more individualistic mode of production with less group holding of stock under a lineage head and less cooperative work and loaning practised. However this is by no means a uniform trend and in the Mazvihwa area there is evidence of changes in the form of lineage production organisation in response to changing resource circumstances (see Chapter 6).

- The role of cattle as exchange entitlements (cf Sen, 1981) in drought has reduced over time. The exchange of cattle for grains between different savanna zones or within zones and between the hurudza farmers and others has practically ceased. The importance of official markets for both grain and stock has meant that cash is usually the medium of support rather than exchange. The importance of the role of migrant labour remittances has also altered the responses to drought and the significance of cattle in the local economy.

- The comparative returns from agriculture (except under particular conditions of rainfall or access to 'key resource' areas) as compared to potential earnings from migrancy have progressively shifted in favour of the option of migrant labour, as pay and conditions have improved, while land areas have decreased. This means that the sources of income for capital investment in livestock (particularly large assets such as cattle) is likely to be more concentrated in remittance sources than in agriculture. This question will be dealt with for the contemporary situation in Mazvihwa in Chapter 6.

3.9 Livestock management in a variable environment: conservatism or opportunism?

The notion of a fixed carrying capacity determined by range management procedures and relying on the assumptions of a beef production objective to maximise weight gain under conservative stocking rates persists today, despite

attempts to argue another case (eg Sandford, 1982a). Recent policy statements reiterate the assumption of irreversible degradation in the CAs and the need to address this with stock population regulation:

> "The most important aspect of livestock production which is occupying the mind of Government is the accumulated and continuing deleterious effects of overstocking and overgrazing in the Communal Lands which are causing severe and potentially irreversible ecological degradation... A comprehensive national programme that focusses on these problems will be implemented.. Such a programme will include stock control, better land management and destocking where necessary." (Government of Zimbabwe, First Five Year Development Plan, 1986)

Basing livestock policy on the notion of a fixed and conservative stocking rate is undermined by a consideration of some of the issues developed in Chapter 2. An understanding of savanna ecology highlights the importance of interannual variability, spatial heterogeneity and species specific adaptations to savanna agroecosystems. These questions have been largely ignored with the imposition of beef oriented range management techniques. However these issues are not new and have been commented upon regularly by observers of these areas during this century.

Interannual patterns can be illustrated by a series of qualitative observations made in Belingwe district between 1928 and 1947:

> "Considerable deaths occurred from either poverty or disease, particularly in the Lundi reserve that is overstocked" (1928)
>
> "Very few deaths occurred from either poverty or disease. This is undoubtedly a splendid cattle district." (1930)
>
> "On the whole grazing conditions have been shocking.."

(1934)

"He [Cattle Inspector Gifford] is of the opinion that the reserve [Belingwe] is not overstocked and contained some of the finest native cattle he had yet seen." (1938)

"The reserve [Lundi] is overstocked; as a consequence and aggravated by drought 1000 out of a total of 17000 head died of poverty." (1942)

"Cattle continued, despite the unprecedented drought, in good condition [in Lundi]." (1947)

The conclusions reached as to whether the land is 'overstocked' are dependent in part on whether the observations take place in a drought or a good rainfall year, or during different periods of longer rainfall cycles. The NC for Gwanda put it succinctly in 1936:

"It was amply illustrated during the past year that the absence of rain for extended periods during successive years is the major cause of the grazing being effaced in various areas... The excellent rain that fell in the early part of the year... has produced a luxuriant growth of grass in many places where it was thought this was non-existent."

Savanna systems are characterised by instability, yet high degrees of resilience. It is this instability in actual production levels that the NCs of Belingwe are observing. This is highly correlated with rainfall (depending on savanna type and other factors; see Chapter 2). The detection of changes in resilience properties (ie degradation) are much more difficult, as savannas can bounce back to previous production levels, even after extended periods of drought as happened in Gwanda in 1936.

Under an opportunistic stocking strategy that attempts to track the environment and stock at high levels (cf Sandford, 1983) interannual changes in condition, sales or death rates can be expected. Because this does not tie in

with the expectations of a conservative stocking strategy (as advocated by most ranch management experts and the colonial technocrats in Zimbabwe), where stable production rates are expected under low stocking levels, this does not mean that the opportunistic system is 'overstocked'. The implications of high stocking rate, opportunistic strategies for savanna agroecosystem resilience will be further considered in Chapter 9.

Another critical aspect of savanna ecology that the uniform carrying capacity approach often fails to note is the importance of the spatial heterogeneity of grazing resources for system stability and resilience (see Chapter 2). Again these ideas are not new. For instance the Chibi NC noted the significance of patchy vegetation resources in the district:

> "Large tracts of land are to be seen where grass growth is always poor and scanty, though other tracts with apparently the same soil conditions are fairly well grassed" (Chibi NC , 1934)

In a similar vein, the Selukwe NC comments on the importance of 'key resource' patches for livestock sustenance:

> "Native cattle ... have come through an appalling period of heat and want very well... Of course, there are places where the banks of streams kept moist and supply a fair amount of grazing. Here cattle kept fine. (NC Selukwe, 1937)

The adaptations of local breeds of cattle to savanna environments, and particularly browse, is also a significant consideration in the carrying capacity debate.

> "The hardiness of the native beast is undisputed. Its survival in the dry weather in badly overstocked areas where there appears to be nothing left for subsistence, is something to be wondered at." (NC Gutu, 1945)

Adaptations to interannual variability are central to opportunistic management strategies. Changing constraints to flexible management are considered next.

Constraints on opportunistic strategies

The opportunities for a flexible and opportunistic strategy to livestock management have become increasingly constrained over the last 50 years. In the past, flexible responses were central to local strategies. These options have been limited by a number of factors discussed in this Chapter:

- Increasing land pressure through the implementation of colonial land policies and the impact of the internal increases in populations has resulted in the decrease in the margins of flexibility afforded by larger grazing areas.

- The option of movement of stock has been restricted by vetinerary regulations (22) and the impounding of stray cattle (under the Pounds and Trespass Acts).

- The exchange of cattle and grain between areas to cope with interannual variability has largely broken down.

- The destocking of cattle, combined with increased human populations, resulted in the decrease in numbers of animals available per household and the need to hold on to animals to sustain livelihoods, rather than exchange or sell in response to drought and deteriorating forage conditions.

All of these factors have combined to change the nature of the role of livestock in the rural economy and force the adaptations of local strategies to cope with interannual variability. The strategies employed by cattle owners during the 1982-4 and 1986-7 droughts will be the focus of Chapter 7. A more detailed investigation of livestock population changes, sales patterns and 'carrying capacity'

levels which will be the subject of the next Chapter.

Footnotes

1. Much of the historical background included in this Chapter is based on archival material available primarily in the National Archives of Zimbabwe in Harare. In particular the District Commissioner's annual reports are used to fill in on local background. These were read for each of the study areas for the period between 1920 and 1948 (after this date the reports were not readily available in the Zimbabwe National Archives). The annual reports of the Chief Native Commissioner or the Secretary for Native Affairs also provide insight into the historical dimension of the policy debate. These reports, including the report on Native Agriculture were consulted for the period c. 1900 to 1970. In addition to archival material interviews with key informants in some of the study areas (Mazvihwa, Runde, Chivi, Mwenezi, Shurugwi, Zaka) allowed an oral historical picture to be built up. This complemented, often contrasting with, the comments made by the colonial officials. Historical interviews were carried out by myself, Billy Mukamuri, Marx Mahobele (Mwenezi), Frank Matose (Zaka) and as part of the CSC/FC training course in Shurugwi. The environmental history interview work carried out by Ken Wilson and Billy Mukamuri prior to the start of my fieldwork was immensely helpful for setting the context for further and comparative interviews.

2. Ken Wilson has documented this period extensively based on work carried out with Billy Mukamuri and others in Mazvihwa. A detailed treatment of changes in agricultural policy during the colonial period is provided by Drinkwater (1988). I am grateful to them for many discussions on the context of historical changes in production systems in southern Zimbabwe.

3. Mudenge (1974) observes that the practice of kuronzera existed during the Rozvi empire in the early nineteenth century. It existed as an important method for the redistribution of cattle.

4. Dipping services were established following the 1914 Ordinance and made compulsory from 1918. This initiative came in part from pressure from European ranchers with

exotic, disease susceptible animals. By 1923 it was estimated that 75% of all African owned cattle were being dipped (Phimister, 1988: 66). Dip tanks were at first very scattered but during the following decades many more were built. Coverage has been almost complete since then, with a break during the liberation war when dipping services were largely abandoned in the study area.

5. The role of livestock in the exchange economy, especially during drought is well documented in reports from the period. The following are a few examples:

1912 Streams of cattle from Belingwe to the north were noted (Holland, 1986:13). The DC of Chibi noted that 12-13000 cattle had been exchanged, while in Belingwe 10000 were recorded.

1916 "Many bags of grain pass through traders in exchange of cattle. Between May and December some 32000 were acquired by traders" (CNC report)

1922 "Following the collapse in cattle prices fewer were sold, but nevertheless in Belingwe 1000 were sold while 5000 were killed for food".

1927 "Natives disposed of their cattle to traders for grain; 4000 cattle were slaughtered for food in the district" (Chibi report)

1933 "Many stock and much meat was exchanged for grain" (NC report Chibi)

1934 "Natives were able to sell cattle for grain as the [foot and mouth] movement restrictions had been lifted. (NC Belingwe report)

1940 "A bad year for stock...those without sufficient food could barter and trade for stock in this way sufficiency was brought about" (NC Gwanda report).

1941 "No famine relief was needed as the natives were still getting good prices for cattle and traders had plenty of grain" (Chibi report)

1942 "In Chibi area local bartering of cattle and cash for grain was sufficient to supply those in need of food (Chibi report)

1947 "Natives from Chibi, Belingwe , Insiza and some from Nuanetsi come here to buy food swamping local supplies...

1951 Increased disposals of stock were noted in many areas this was attributed to: "the poor agricultural season and the need to obtain cash to purchase or meat to barter for grain." (CNC report)

6. Human populations: DC's made an annual estimate of human population in their areas based on a computation derived from tax returns. This only gives a rough indication of total population as taxation was never complete, the proportion of the population living away was not calculated and the method of estimation was crude and changed on several occasions. However the data does give insight into overall patterns. The censuses of 1969 and 1982 give more recent estimates; extrapolations are made on the basis of interpolation between data points.

Livestock populations: District Commissioners had responsibility for cattle dipping from its establishment in the early 1920's. Annual reports usually contain census information on cattle, smallstock and donkeys. Sometimes information on birth and death rates were also included. From 1946 detailed stock censuses were reported as part of the Chief Native Commissioner's report. Since the 1960's census data is based on the returns compiled by the Department of Veterinary Services. District level data was derived from files held at district level offices. The data is scattered and incomplete, but extensive searching ensured that a reasonably full picture for the period between 1923 and 1986 can be presented. The accuracy of the data is good, as dipping was compulsory and comprehensive recording systems (dip cards and registers) were imposed. The data for smallstock and donkeys cannot be relied on to such a high degree, as these population estimates are based on occasional censuses rather than systematic weekly (or bi-weekly in the dry season) recording over nearly 60 years.

7. Estimates of cultivated areas are given in the returns compiled for the Native Agriculture during the 1940s and 1950s. Later estimates for some areas come from Agritex files and published sources (eg. GTZ, 1985; ICRA, 1987;

Abel and Blaikie, 1988; Whitlow, 1979).

8. Boundary changes subsequent to 1923 are important to consider for the purposes of estimating livestock densities. When livestock populations are considered in relation to area, the area refers to the geographical limit of the communal area existing at the time. For instance, some reserves changed area during the period. Shurugwi lost some reserve land around 1925 due to the creation of Native Purchase Areas. However more land was added to the east of the reserve later on during the late 1950's. These boundary changes were discovered as part of a search of administrative archival material. The figures are adjusted accordingly for the derivation of stocking rate figures. Where an area known as a single CA today was once two or more administrative units they are combined to the single unit. For instance prior to 1957, Runde CA was Lundi reserve and a separate Lundi-Chibi reserve. Similarly, Mazvihwa CA was Bungowa reserve and Mazvihwa Special Native Area. These were only combined later as a single Tribal Trust Land, the equivalent of today's CA. The whole of Runde CA and Mazvihwa CA constitute the communal land area of Zvishavane District. All of these separate elements are combined when analyses are carried out at the district level.

9. Special Native Areas were declared in 1950 as a response to the growing calls for more land to be allocated for the African population. These were usually areas formally allocated for European occupation, but were never settled.

10. The pattern of settlement and land allocation of the various groups represented in the sample households in Mazvihwa has been documented by Ken Wilson.

11. Centralisation started in Shurugwi in 1929, in Mberengwa in 1940, in Ndanga in 1942, in Chivi in 1945 and in Runde in 1939.

12. The 1930s Foot and Mouth Disease outbreaks caused major problems for cattle economy in the reserves as movements, sales and exchanges were banned. The Nuanetsi ANC comments in 1931:

> "A further calamity was in store in the shape of the outbreak of FMD, whereby the principle form of wealth became valueless as a means of exchange."

The CNC wondered during a later series of outbreaks:

> "... whether the prevention is not more drastic than the disease. When it is realised that .. the cattle are immediately concentrated to prevent the disease spreading, the animals must stand for the most of the day... grazing and land deteriorates, deaths from poverty increase, no movement is permitted and all.. sales and culling ceases." (Sec. for Native Affairs report, 1953).

During the 1930s there was a large concentration of ranch cattle kept in quarantine within the Mazvihwa area.

13. The additional costs imposed by the Marketing Act included a 10% levy on the sale price of the animal to be paid to the African Development Fund, a 7.5% handling charge and a 1.5% sales commission.

14. Cattle fattening attempts proved quite successful in the 1970s when the price ratio between cattle and grain was favourable for stall feeding. Weinrich (1975: 109) reports that the CSC was receiving an increasing proportion of its beef from African stall fed cattle in 1970.

15. Regulations for compulsory destocking came into force in 1943. A government notice was served by 1944 that deemed 42 of 92 reserves 'overstocked' (CNC reports).

16. Grazing rights and land rights were exchanged, with prices between L4 - 12/acre for arable land and L5-12/grazing unit. By 1963, 19600 had been exchanged equivalent to 1.08% of land held by Africans (Weinrich (1975:26) quoting Holleman (1969)).

17. The redistribution of cattle to stockless relatives was a well known evasion tactic of the regulations:

> "The whole question of cattle ownership is becoming farcical. Herds are being split up amongst members of a family with each ostensibly owning 4 or 5 head." (NC Selukwe, 1948)

In the same year the NC of Chibi noted that the number of "owners" had risen considerably during the year due to redistribution to relatives. The degree to which the destocking policy actually resulted in an increase in

equity in cattle ownership, rather than simply temporary holding, is unclear.

18. The paddock schemes in the Mazvihwa clay veld never really operated. Loans were taken out in c. 1963, fences established and a system of rotation devised by the demonstrators. However people from outside took little notice of the fencing and finally the schemes were abandoned during the liberation struggle (Sources: Interviews with Mapako, DC Report, 1964).

19. The historical pattern of differentiation in cattle ownership is difficult to discern. Observers in the 1920s noted some differentiation (Phimister, 1988: 141) and by the end of the 1930s there were a significant number of households with no cattle (Steele, 1981). Following destocking in Shurugwi the pattern of ownership shifted dramatically with no large herd owners noted, but still a skewed distribution observed (von Memerty, 1955). By the 1960s, field researchers (eg. Johnson, 1968) recorded a significant number of stockless people. Weinrich (1975) indicates that 60% of homes owned less than 4 animals and 32% had none in the Shoko area in 1969. The exact implications of these figures is unclear as 'ownership' and 'holding' is not differentiated (see Chapter 6).

20. Financial obligations to government included the Native Tax, Dip fees, Dog tax and school fees.

21. Interviews in Mazvihwa substantiate the view that there has been some shift towards individualisation of production. For instance:

> "In the old days not even one person was left without cattle and so short of draft, since there was a lot of cooperation and loaning among the people (Mai Vafi, 27.5.87)

22. Movement restriction started during the 1930s with the first Foot and Mouth Disease outbreaks. These restrictions were repeated during the 1940s and 1950s. Following Independence, and the granting of the Lome export agreement, the EEC has required a considerable tightening of FMD regulations. The result has been a zonation of the country with no movement of stock allowed between FMD infected, buffer zones and clear areas. Extensive fencing has been erected to prevent movement.

4. THE ECONOMIC AND ECOLOGICAL DYNAMICS OF LIVESTOCK POPULATION CHANGE IN SOUTHERN ZIMBABWE: 1923-1986

4.1 Introduction

Chapter 1 posed the question: why do communal area livestock populations keep on growing? This Chapter is concerned with exploring this question with an economic and ecological analysis of cattle populations in the study areas between 1923 and 1986. Changes in population size result from the interaction of economic decisions (to buy, sell or migrate), ecological conditions (that affect birth or death rates) and government intervention (to set prices, enforce destocking etc.). Policy changes that have affected cattle populations were explored in Chapter 3. This Chapter uses that analysis as a background for investigating what actually happened in each of the regional study areas, in order to begin to answer the question of why and how cattle populations have continued to grow to levels well beyond official 'carrying capacities'.

An understanding of the economic motivations of producers is critical and is pursued in this Chapter in relation to the changing sales response and the influence of price, rainfall and holding size on sales rate. Biological parameters are investigated in relation to changes in density and rainfall. Population levels observed are thus dependent on the interaction of these factors. A dissection of economic and ecological influences assists in the more effective definition of 'carrying capacity' for these areas.

This Chapter focusses on the regional study areas and contrasts the population dynamics of cattle in the wetter areas (Shurugwi, Gutu, Ndanga) with the drier savanna areas (Mberengwa, Zvishavane, Chivi). This allows the testing of some of the hypotheses generated in Chapter 2 on the implications of contrasting savanna ecology for animal population dynamics. At this regional scale of analysis

aggregate data from official sources are used for the period 1923 to 1986. Similar themes are then pursued with more detailed data from the local case study area, but over a shorter time frame, in subsequent Chapters.

In this Chapter, sections 4.2 and 4.3 investigate the changing sales response of cattle producers in the study areas between 1923 and 1986. Hypotheses about economic motivation and production objectives are explored with the available data. In sections 4.4 to 4.9 ecological factors are investigated; patterns of density dependence and population regulation are explored using simple models. Other factors that influence population dynamics are considered in section 4.10 and the implications for livestock management of the preceding economic and ecological analysis are investigated in section 4.11.

4.2 Cattle sales: explaining historical patterns

This section is concerned with understanding the changing pattern of sales response of livestock producers in the study areas over the period 1923-1986. The relationship between aggregate sales levels and factors such as price, rainfall, cattle density and average cattle holding will be investigated to explore various hypotheses about livestock owner motivation and market responsiveness. This study at the regional level, comparing the wetter and drier zones, is aimed at providing some insight into livestock producer economic behaviour within a historical frame. This will complement the more detailed cross-sectional, but single time frame, work presented in Chapter 6.

Economic behaviour of peasant livestock producers

A variety of models of economic behaviour of livestock keepers can be presented to explain patterns of response to market and non-market incentives to sell animals. Four alternative, but not exclusive, models can be examined

using the sales data.

Profit maximisation: The price responsiveness of livestock producers is often characterised by a short-run negative and a long-run positive supply response (Jarvis, 1974). This is consistent with profit maximisation behaviour and is explained in terms of the build up of herd inventories in the short term in response to higher prices in the expectation of future higher prices; these animals will then be sold in the longer term. This is seen in the classic cattle cycles of the large scale beef industry. The negative supply responses of African pastoral producers has also been interpreted in this light (eg. Low, 1980), suggesting a market orientation consistent with profit maximisation behaviour that counters the 'reluctance to sell' arguments of those who claim the existence of a 'cattle complex', where cattle are retained for 'cultural' significance (Herskovits, 1926 for the classic claim and Mtetwa, 1978 for a refutation for the Zimbabwe situation). In an agropastoral situation the build up of herd inventories will concentrate particularly on increasing the number of oxen. These will not contribute to the future sales supply of the herd, so the long-run response exhibited can be expected to be different to a beef breeding herd.

Sales for immediate needs: This may also result in a negative supply response; in this case in both the short and long-run. If cattle are sold to supply regular requirements, such as school fees, a higher price will result in fewer cattle being sold, as the cash can be raised by selling fewer animals. Immediate needs may also vary between years. For instance failure of crops due to low rainfall may result in the increased sale of animals to compensate for food deficits. Sales will therefore be negatively correlated with rainfall. Target incomes may also increase over time, as 'needs' increase with the greater availability of consumer items, education or other facilities requiring payment.

Accumulation of asset holdings: Cattle may be retained as an asset and not sold, except under extreme conditions, since their service or investment/asset value to a producer may be higher than the sales value. In this case producers can be expected to accumulate animals to increase the service provision of cattle. Disposals will therefore be independent of price fluctuations. Increased real prices may therefore affect accumulation rates as cash/grain equivalents will buy fewer animals. Only when herd sizes become large, when the service/insurance needs of the producer are satisfied and the cost of continued accumulation becomes high (eg herding labour), will price responsiveness be shown. Large herd owners with 'surplus' cattle are therefore more likely to behave as price responsive beef producers.(*)

Imperfect markets: The imperfect nature of rural markets (poor communication of prices, long distances to sales pens, irregular sales etc) and the scale of government intervention may act to disrupt any conventional supply relationship such that producers act independently of 'official' market forces and sales levels are controlled by government intervention. The periods of Vetinerary restrictions on sales and the policy of enforced destocking are examples of this (see Chapter 3). Although there may be interaction with unofficial markets (internal markets, illegal sales to butchers, sales to commercial farmers), these will not be detected in the statistics of sales to official sources.

Various authors have commented on the nature of the sales response amongst southern African cattle producers. Doran, Low and Kemp (1979) have suggested that cattle producers in Swaziland retain animals as a store of wealth and so respond negatively to price incentives. They argue that target incomes change with rainfall variations, as drought induces increased sales because of crop failure. Low, Kemp

and Doran (1980) explore this further by developing a regression model that explains the variations in cattle offtake with variations in cash needs and alternative cash supply. Jarvis (1980) argues that this interpretation is consistent with a profit maximisation model, where cattle are retained both as a store of wealth and for future sales. Rodriguez (1985) investigates the supply response of the Zimbabwe CA sector between 1965 and 1983 and also finds a negative relationship between sales and price. Similarly, Mosely (1983:103) records a negative supply response for national supplies in Zimbabwe between 1948 and 1961, but notes that: "repeated government intervention to ban, restrict or increase cattles sales had the effect of boldily shifting the supply curve" on a number of occasions.

Historical patterns in the study area

Observers of livestock production in the study area have regularly commented on the lack of sales of cattle. The negative price response is often observed.

> "This resistance of the African to selling a reasonable proportion of his cattle is really depressing..."(Veterinary Services report, 1976)

> "Although the prices have risen the local tribesmen have not shown any added interest in selling.. " (Vet Services report, Midlands, 1973/4)

However the resistance to sell has not always been a feature of stock owners living in the study area, particularly during the expansion of the local economy in the late 1920s and early 1930s:

> "The Shabani mines provide the native owner with a good market for cattle and small stock." (NC Belingwe, 1930)

> "Natives were in a mood to sell freely and there were plenty of buyers wanting large numbers." (NC Chibi, 1934)

The nature of local producers' price responsiveness has been commented by a number of observers:

> "It is thought that the decrease in the numbers of cattle sold is in part due to the higher prices ruling; native stock owners being able to obtain all the money they needed through selling fewer cattle." (NC Chibi, 1934)

Similarly the NC of Belingwe pointed, in 1944, to a range of factors that had reduced sales levels. There had been a decrease in spending opportunities, as fewer goods were in the stores, wages were higher and meeting a greater proportion of cash requirements and grain/cattle prices had increased so meaning fewer units had to be sold to raise the required cash.

Steele (1981:46) suggests that this was not so in other areas with cattle owners opting for herd inventory build up with increased prices. Referring to the Hartley NC's report of 1937 he notes that:

> "Hartley experienced a fall-off in sales to Europeans in 1937, despite firmer ruling prices, because Africans, like stock-exchange speculators, wanted to see how far the market would go before they committed large amounts of stock."

The incidence of drought and the failure of crops is regularly mentioned as an important incentive to sell cattle:

> "There was increased offtake due to poor prices combined with a food shortage... " (NC Gutu, 1932)

> "Cattle are only disposed of when there is a shortage of grain, but a good harvest means that more cattle are killed for feasts." (NC Ndanga, 1941)

Good harvests, in addition to increasing the number of ceremonial slaughters, result in a drop of sales:

> "There has been a drop of nearly 50% on the figure sold last year. This is due to the good past season as plenty of grain was available and less dependence was placed on the income from cattle." (Vet Services report, Victoria, 1971/2)

Cattle producers have thus been affected by a variety of

market and non-market forces. As Steele (1981: 46) notes:

> "Sale to Europeans was only one of several equally 'economic' choices which might be available to the cattle owner, and unless he had a pressing need to obtain cash, he might prefer to use his cattle for ploughing, or for lobola [bridewealth], or as a form of investment if the European market did not offer what he considered to be a representative price for his stock."

Each of the different model sales response patterns has been shown by producers in the study area in different forms. The historical transformation of the production system and the influence of colonial policies has had a dramatic effect on the form of livestock production within the study areas (see Chapter 3). For this reason it is worth examining separately the supply response patterns of different periods.

- 1923-1986: This period covers the full data set and will be used to investigate any long term and stable patterns. A contrast between the drier areas (Mberengwa, Zvishavane, Chivi; average rainfall c. 570mm) and the wetter areas (Gutu, Shurugwi, Ndanga; average rainfall c. 810mm) can be made.

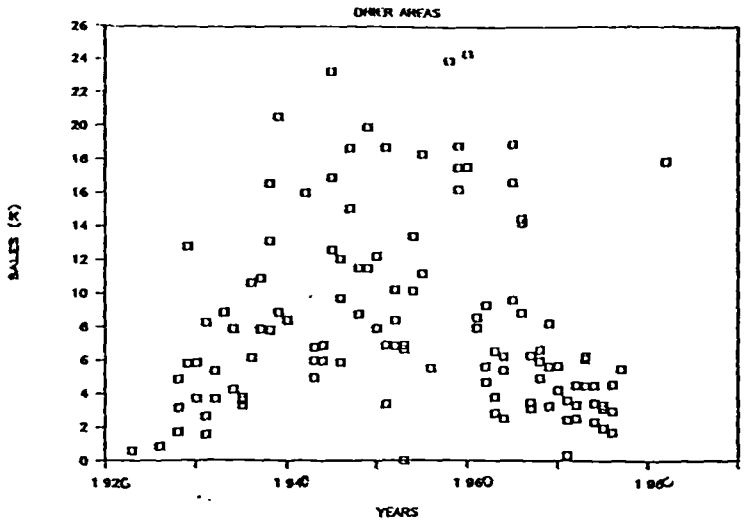
- 1923-1945: This period relates to the phase of livestock increase and consolidation to the beginning of the destocking policy. At this time land scarcity was not so severe and average numbers of stock per household remained high (1).

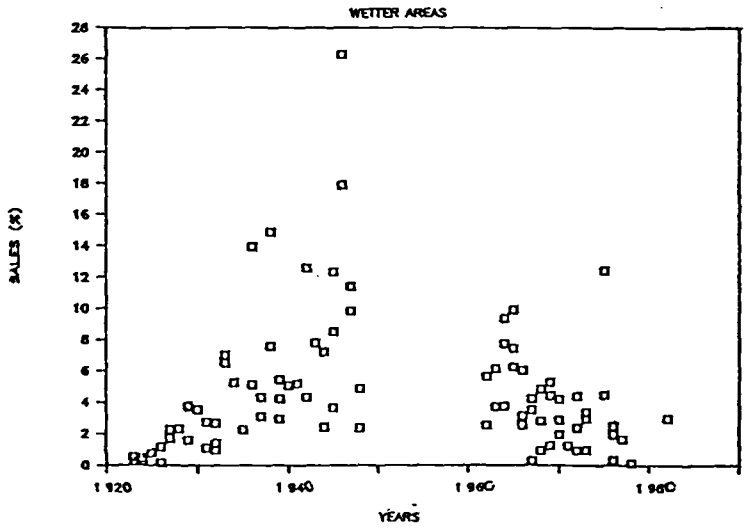
- 1961-1986: This is the post-destocking period including the recovery of stock populations during the 1960s and 1970s and the restrictions on official sales during the liberation war of the late 1970s. At this time increased land scarcity was evident and average holdings had declined.

Relating the sales rate data to the underlying cattle population trends illustrates how producer behaviour changed. In the early period sales rates rose dramatically while actual cattle populations were rising towards the 1930-40s peak. In the later period, cattle populations were higher overall, meaning lower actual offtake for a similar percentage sale level. During the destocking period (1945-60) high enforced sales rates were imposed, up to 2.5 times an intrinsic growth rate of 10%, resulting in a declining population total.

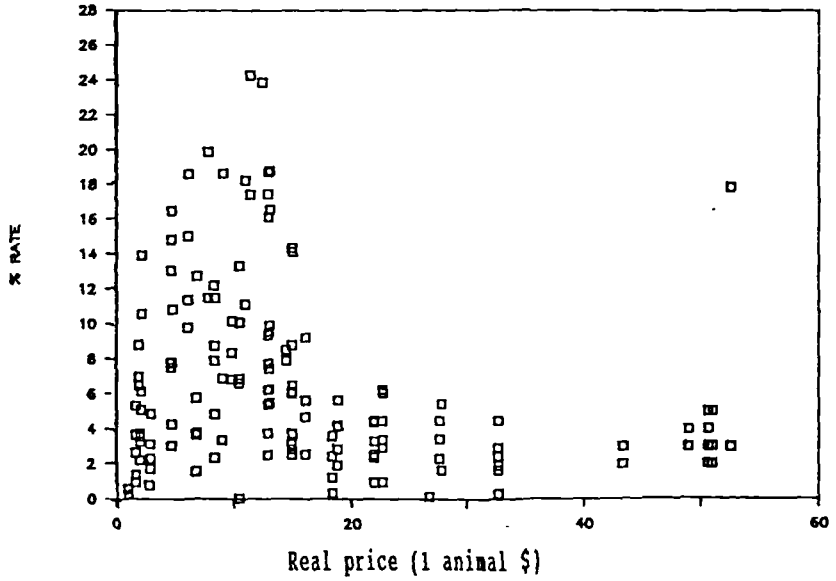
Figure 4.1: a. Sales rates of cattle (%) in drier and wetter areas: 1923-86. b. Sales rates and real price: all areas, 1923-86.

a





b



4.3 Investigating the supply response

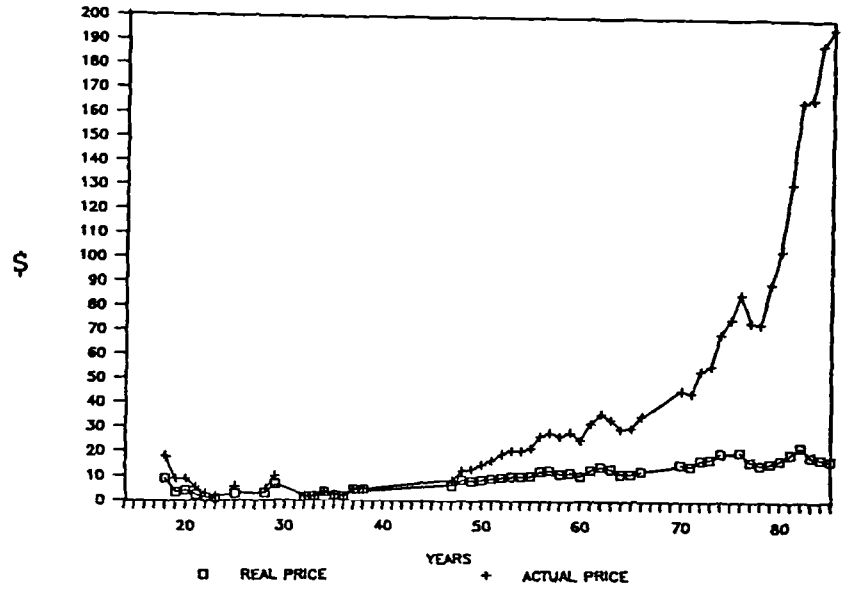
The sales data for the drier (Mberengwa, Zvishavane and Chivi) and wetter areas (Shurugwi, Ndanga and Gutu) are shown in Figure 4.1. This shows sales rates from 1923 to 1986 (sales numbers as a percentage of total herd size (2)), and thus includes a herd inventory variable within the analysis (Low, 1980). Figure 4.1c shows the relationship between sales rate and real price for all areas over the same period.

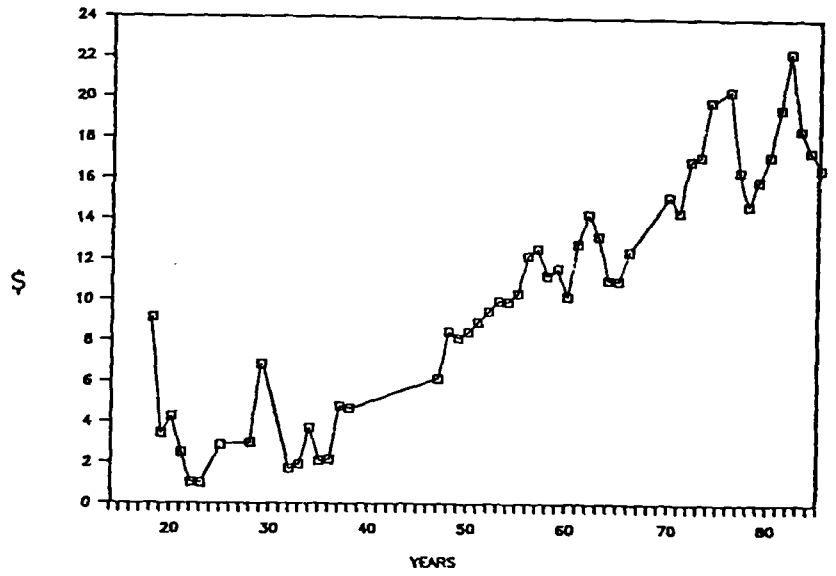
Price response

Price levels of cattle over the period are shown in Figures 4.2 a-c. The real price variation (deflated by the Consumer Price Index;(3)) can be compared with the cattle/grain price ratio (Figure 4.2c), which gives an indication of the exchange value of cattle for grain. For instance, in the early 1920s, particularly following the crash in cattle prices of 1922, one animal could purchase only one or two bags of grain. There was therefore no incentive to sell or exchange animals.

Table 4.1 investigates the relationship between sales rate and real price with correlation analysis. First all areas were investigated for the full period, then the distinction between wetter and drier areas was pursued. Next, the patterns of sales response between different periods (1923-45 and 1961-86) were investigated, again looking at the distinctions between areas within these periods. Real price in the year of sale was used in the analysis presented here. A combined price level of the current and previous year was also investigated to look at lagged price responses. The patterns were the same as shown here.

Figures 4.2: Cattle price changes (1914-1986). a: Real and actual prices. b: Real price. c: Real price and cattle:maize ratio (Nos of bags grain to one animal)





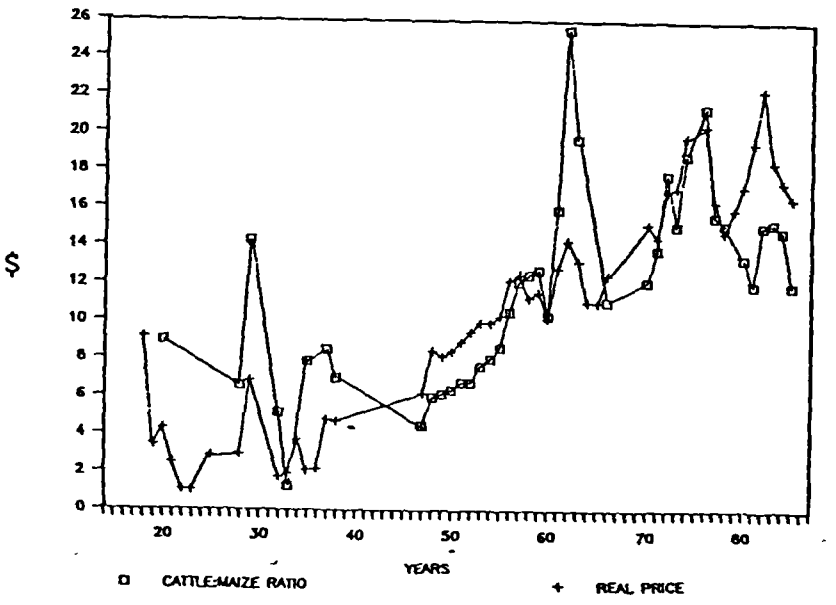


Table 4.1: Relationship between sales rates and real price of cattle.

Period	Area	Correl	N	Sig
1923-86	All	-0.2	150	*
1923-86	Drier	-0.32	91	**
1923-86	Wetter	-0.31	60	*
1923-45	All	0.33	38	NS
1923-45	Drier	0.58	19	*
1923-45	Wetter	0.13	19	NS
1961-86	All	-0.3	69	*
1961-86	Drier	-0.04	37	NS
1961-86	Wetter	-0.53	29	*

Note: Correlations show the Pearson correlation coefficient result, with significance levels where * = $p<0.01$ and ** = $p<0.001$)

The correlation analysis shows no large difference in supply response between wetter and drier areas over the full period, but in particular periods different patterns are observed. Between 1923 and 45 a positive relationship is observed which is stronger in the drier areas, while between 1961 and 86 a negative relationship is shown which is most apparent in the wetter areas.

These relationships were investigated further with the construction of a simple supply model that describes the supply curve as a log-log model between price and sales rate (4). This assumes that prices are set exogenously by demand in other sectors. The monopolistic meat marketing system in Zimbabwe since the 1930s has meant that the Cold Storage Commission is responsible for setting cattle prices (see Chapter 3). Models for the same periods were investigated with regression analysis (Table 4.2).

Table 4.2: Supply models: sales rate and price relationships (log-linear regression). SE1 = standard error of coefficient; SE2 = standard error of elasticity.

1923-86 (All areas): r^2 = 0.04 DF = 148; Sig F = 0.01
Sales = 2.0 $(Rprice)^{-0.2}$ (SE1 = 0.2; SE2 = 0.08)

1923-86 (Drier areas): r^2 = 0.04; DF = 89; Sig F = 0.05
Sales = 2.3 $(RPrice)^{-0.21}$ (SE1 = 0.1; SE2 = 0.3)

1923-86 (Wetter areas): r^2 = 0.23; DF = 29; Sig F = 0.005
Sales = 0.01 $(RPrice2)^{-0.5}$ (SE1 = 0.17; SE2 = 0.4)

1923-1945 (All): r^2 = 0.26; Resid DF = 36; Sig F = 0.001
Sales = 0.4 $(RPrice)^{0.9}$ (SE1 = 0.25; SE2 = 0.29)

1923-45 (Drier areas): r^2 = 0.43; DF = 17; Sig F = 0.002
Sales = 0.63$(RPrice)^{0.98}$ (SE1 = 0.33; SE2 = 0.27)

1923-45 (Wetter areas): r^2 = 0.21; DF = 17; Sig F = 0.05
Sales = 0.63 $(RPrice)^{0.79}$ (SE1 = 0.44; SE2 = 0.37)

1961-86 (All): r^2 = 0.14; Residual DF = 87; Sig F = 0.0001
Sales = 4.3 $(RPrice)^{-0.99}$ (SE1 = 0.3; SE2 = 0.9)

1961-86 (Drier areas): r^2 = 0.05; DF = 35; Sig F = NS
Sales = 3.0 $(RPRice)^{-0.48}$ (SE1 = 1.1; SE2 = 0.36)

1961-86 (Wetter areas): r^2 = 0.33; DF = 27; Sig F = 0.001
Sales = 5.6 $(RPrice)^{-1.55}$ (SE1 = 1.26; SE2 = 0.42)

Several patterns are interesting to note. In both wetter and drier areas an overall negative price response is shown for the full period. The general pattern of the relationships shown are the same in both areas, even though

average sales rates are higher in the drier areas (8.5%) than in the wetter areas (4.2%). The contrast between the earlier and later period is shown in the form of the supply models. The positive supply response between 1923-45 is shown in both areas, while a negative supply response is seen in both areas between 1961 and 86, although in the drier areas the suggested relationship is not significant.

The log-linear models of price response show a production elasticity of 0.9 (for all areas) in the earlier period prior to destocking. In the later period a negative production elasticity of -0.99 is seen. These vary between areas with the drier areas showing a higher positive production elasticity in the early period and the wetter areas showing a higher negative production elasticity in the later period. It should be noted however that these figures are only true elasticities if the stock population remains constant as in these models it is sales rate, rather than actual offtake that are related to price.

These patterns suggest the possibility of different types of economic behaviour being exhibited in the two periods. In the earlier period a more conventional beef production behaviour is exhibited, where higher prices results in an increased sales rate. The short-run negative supply response and inventory build up mechanism is not shown however. Positive price responsiveness may be because the service function of cattle was already being served with high average holdings and producers could afford to respond to the market. This was particularly the case in the drier areas, where cattle populations were higher and stock sales more important to the rural economy.

By contrast in the later period, these conditions do not hold and producers retained cattle in preference to selling them. Higher prices thus meant that fewer cattle had to be sold to meet immediate needs. This is particularly so in the wetter areas where resource constraints are higher, agricultural production is more important and cattle are

retained for service use.

Rainfall and sales rates

It can be expected that rainfall levels will be negatively related to stock sales rates if the 'target income' mechanism is operating. This will be most likely in the later period when stock availability is more constrained and in the drier areas, where the need to raise income from cattle sales in drought is most apparent.

The relationship between sales rates and rainfall (previous season) can be investigated using correlation as above. Rainfall as an average of the two previous seasons was also related to sales rate for the same data sets. The same pattern was shown so the data is not presented here.

Table 4.3: Correlations between sales rates and previous seasons rainfall.

Period	Area	Corr	N	Sig
1923-86	All	-0.23	227	**
1923-86	Drier	-0.2	91	*
1923-86	Wetter	-0.02	97	NS
1923-45	All	-0.2	80	NS
1923-45	Drier	0.13	30	NS
1923-45	Wetter	-0.07	41	NS
1961-86	All	-0.3	89	*
1961-86	Drier	-0.35	48	*
1961-86	Wetter	-0.13	30	NS

Note: Significance levels: * = $p < 0.01$; $p < 0.001$

Rainfall levels show consistent negative correlations with sales rate across all periods and areas, except in the drier areas in the earlier period. The reasons for this are

unknown. Rainfall is more closely related to sales rate in the later period and in the drier areas. This supports the contention that drought/crop failure related sales are more likely in the drier areas and that in the later period producers switched to an immediate sales/crisis responses sales strategy, reflected in the negative supply response for this period shown above.

Combined price and rainfall relationships

The combined effects of rainfall and price are examined next. Log-linear production models are investigated in Table 4.4.

Table: 4.4: Relationships between sales rate, price and rainfall

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1923-86 (All areas): r^2 = 0.2; DF = 147; F Sig = 0.000
Sales = $7.7(Rprice)^{-0.2}$ $(Rain)^{-0.9}$
(SE1 = 1; SE2 = 0.07; SE3 = 0.16)

1923-45 (All areas): r^2 = 0.2, DF = 29, F Sig = 0.03
Sales = 4.3 $(RPrice)^{0.53}$ $(Rain)^{-0.54}$

1923-45 (Drier areas): r^2 = 0.28; DF = 15; Sig = 0.08
Sales = -0.81 $(Rprice)^{0.61}$ $(Rain)^{0.31}$
(SE1 = 2.3; SE2 = 0.28; SE3 = 0.38)

1923-45 (Wetter areas): r^2 = 0.2; DF = 14; Sig: NS
Sales = $9.0(RRprice)^{0.4}$ $(Rain)^{-1.22}$
(SE1 = 4.5; SE2 = 0.4; SE3 = 0.6

1961-86 (All areas): r^2 = 0.34, DF 63, Sig F = 0.000
Sales = 9.9 $(RPrice)^{-0.87}$ $(Rain)^{-0.94}$

1961-86 (Drier areas): r^2 = 0.1; DF = 34; Sig F: NS
Sales = $5.7(Rprice)^{-0.47}$ $(Rain)^{-0.44}$
(SE1 = 2.3; SE2 = 0.36; SE3 = 0.33)

1961-86 (Wetter areas): r^2 = 0.52; DF = 26; Sig F: 0.001
Sales = $12.7(Rprice)^{-1.3}$ $(Rain)^{-1.2}$
(SE1 = 2.4; SE2 = 0.37; SE3 = 0.36)

These results demonstrate the patterns shown for the separate analyses above. The positive relationship of sales rate with rainfall for the drier areas in the earlier period remains anomolous. Otherwise the previously demonstrated patterns of positive and negative price responses in the early and later periods respectively, combined with a negative sales rate response to rainfall levels are shown in the combined sales models. As with the previous regression analyses, only a small proportion of the variations in sales rates are explained by rainfall and price variations. There are clearly other factors involved.

Density and holding

It is important to recall that decisions about sales are made at a smaller level than the aggregates being investigated in the above analyses. Although there is no data available on changing distributions of cattle ownership, a rough approximation can be made of cattle holding size by relating cattle and human populations together. As the density of cattle populations has increased along with human populations, the average holding size has declined (see Figures 3.3 and 3.6 for the data on changing cattle density and holding size). Consequently, the number of cattle 'surplus' to agricultural input requirements, and so available for sale, has declined.

Over the full period between 1923 and 1986, decreased holding size is related to lower sales rates (but correlations insignificant). This relationship is complex, with differences being shown between different periods. For instance, during enforced destocking the 'surplus sales' mechanism was clearly not operating. Similarly, during the more recent period increased holding sizes coincided with the late 1970s and the restriction of official sales due to the war. At this time there was no opportunity to dispose of any 'surplus' animals.

Without detailed data on individual ownership patterns and insight into local decision-making there are limited inferences that can be drawn from this aggregate data. It will be the aim of Chapter 6 to investigate sales patterns in some more detail, relating stock holding size to sales patterns.

External factors and supply

In the period between 1945 and 1960 the impact of the government's enforced destocking policy overrides price, rainfall and holding size responses. Policy action therefore acts in effect to shift the supply curve upwards; increasing supply for the same price/rainfall/holding levels. The destocking period shows the highest sales levels in the drier areas for the full period, 1923-86 (5).

Externally imposed restrictions on sales also are also evident. The collapse in the cattle market in the early 1920s and during the depression in the 1930s were affected by forces external to the economy. In particular years in the 1930s and 1940s sales were restricted due to Foot and Mouth regulations (see Chapter 3) and during the latter half of the 1970s the official marketing mechanisms largely broke down due to the effects of the war.

Sales responses: a summary

Sales responses are therefore complex and general patterns are difficult to extract from aggregated regional data sets. Different producers clearly have different production objectives and combining all producers in an overall sales response model is a gross oversimplification.

The nature of producers' economic responses is best investigated with a more focused study that differentiates between producers with different herd sizes and with different alternative income sources. An investigation of

the investment and disposal patterns at the local level will be the major concern of Chapter 6.

The general patterns suggested by the regional scale time series analysis can be summarised:

- Cattle producers are positively responsive to price in the period 1923-45, but negatively responsive between 1961 and 1986.

- Sales increase with decreased rainfall levels, especially in the more recent period.

- Sales rates increase with higher average cattle holding sizes. The relationship is confounded by external factors that influence supply.

- Supply levels to official markets can be significantly affected by external factors such as destocking, war and vetinerary restrictions.

- The beef production pattern shown in the earlier period has given way to a sales response influenced more by rainfall and immediate needs/target sales. This may be in part attributed to reduced holding sizes; fewer cattle meaning that fewer are available in excess of service requirements for agropastoral production.

The way these changing patterns of economic response affect the overall pattern of cattle population change through this period will be investigated in the following sections.

4.4 The interaction of economic and ecological factors and the dynamics of cattle population change

This Chapter will continue with the discussion of the changes in livestock populations over time and turn to the biological factors that affect the patterns of cattle population change. The biological parameters of cattle populations are affected by stocking strategies and so by the changing form of the livestock economy. This section will review the changing interaction of economy and ecology

and investigate the properties of cattle populations in the study area to explore appropriate definitions of 'carrying capacity'.

Livestock populations grew rapidly from the 1900s which meant that by the 1930s surplus cattle, in excess of agropastoral requirements, were available to some and a beef economy, possibly responsive to price incentives, could exist alongside the cattle in a service role (draft etc.). This was interrupted by the imposition of destocking policies and increased resource constraints (primarily land) on producers. By the 1960s the service function of cattle was dominant and animals were retained for a variety of uses; sales became more restricted to crisis situations, resulting in negative price responses. This meant that more and more cattle were retained to provide agricultural inputs for the growing populations during the 1960s and 1970s.

The 'economically desired population' in an agropastoral economy thus relates to the need to have sufficient draft power and other inputs to supply the human population. In cattle population terms this has meant a growing need for higher numbers. Increased densities of animals inevitably have an effect on the survival chances and the reproductive success of the population as resources become more and more scarce with higher populations. Populations reach a limit when the rate of growth of the population tends to zero. This can be termed the 'bioeconomic carrying capacity', when the rate of births plus purchases equals the rate of deaths plus sales. (6). This of course fluctuates considerably in the variable savanna environments being considered here (see Chapter 2), as resource availability is in part dependent on rainfall. As populations tend towards resource limits, droughts are likely to have an increasing effect on population numbers.

As needs for cattle as inputs to agriculture increased, the 'economically desired population' tended towards a

'bioeconomic carrying capacity'. Economic forces thus drove the cattle population upwards towards an equilibrium level where cattle populations were regulated by resource scarcity impacts on birth/death rates (eg during the population peak of the 1970s) and population numbers were affected by environmental vagaries (eg early 1980s droughts). The 'equilibrium' level was not static and varied considerably according to (primarily) changes in rainfall. This resulted in the increased necessity to adopt opportunistic management strategies that could be responsive to environmental variation.

This summary of ecological and economic interactions in the study area cattle populations over time suggests a number of hypotheses about the changing interaction of populations and resources:

- As human populations increase, the cattle population density will tend towards a 'bioeconomic carrying capacity', under the investment conditions of an agropastoral economy (cf. Haaland, 1977).

- As cattle population densities increase, birth and death rates of cattle populations change such that a population equilibrium is reached (ie resource related density dependent factors act to regulate the population) (cf. Sinclair, 1975).

- Populations will be constrained from reaching an equilibrium level by the effect of droughts that result in large population collapses as the population tends towards an apparent equilibrium (ie density independent key factors influence population size).

Following from the arguments presented in Chapter 2 on the comparative dynamics of different savanna systems, contrasts in the cattle population dynamics of different areas can be suggested. The contrast between the moister, largely dystrophic savanna areas of Shurugwi, Gutu and Ndanga can be compared with the drier, more eutrophic savanna areas of Chivi, Mberengwa and Zvishavane (7).

- The higher rainfall areas will have higher levels of primary production and so will have higher expected equilibrium densities, but the eutrophic nature of some parts of the more arid zone will in part offset this distinction (cf. Coe et al, 1976; Bell, 1982).

- The variability of the primary production in the more arid areas is likely to be reflected in higher instability in cattle populations in these areas. This includes a greater susceptibility to drought. This will also result in a greater deviation from the reaching of any 'equilibrium'.

- The intrinsic rates of growth of the more arid, eutrophic areas, especially following drought, are likely to be more rapid than in the moister savannas.

These questions will be examined by investigating changes in biological population parameters with changing density in order to identify an 'equilibrium population' level (section 4.5). The issue of what is the 'bioeconomic carrying capacity' level for different areas is then pursued in sections 4.6 and 4.7, by examining patterns of population change over time.

4.5 Population parameters and evidence of density dependence

The relationship between mortality/natality rates and cattle density was investigated for the data set. The aim was to discover the nature of any density dependent regulatory factors and to examine the influence of density independent factors, such as rainfall, on population size. This analysis allows for the estimation of 'equilibrium population densities', where the rate of birth equals the rate of death.

Data on birth and death rates is recorded infrequently in the data (8). To ensure reasonable case sizes, study areas were combined in this analysis. The analysis was carried out on three groups of data: all areas; the 'wetter' areas (Ndanga, Gutu, Shurugwi) and the drier areas (Zvishavane,

Chivi, and Mberengwa).

Mortality patterns

Death rates (%) were regressed against cattle density and rainfall. The regression was weighted by cattle population size (9). When the regression between death rate and density was carried out for all years, the result was insignificant and there were a number of major outliers highlighted on residual plots.

A further investigation of the outlier cases revealed that they were years in which major cattle mortality is recalled by local people living in the study areas: 1965, 1968 (end of dry season cold spell) and 1982. Mortality in these years was boosted from an average rate of around 2-4% to up to 25%. Clearly different processes are occurring in such stress years.

All cases for these three years were removed from the data set and the rest of the data examined further. Again death rate was regressed against density and rainfall. The results are shown in Table 4.5.

Table: 4.5: Relationships between death rates, rainfall and cattle density (non-stress years).

Drier areas: $r^2 = 0.27$; N = 35; $p < 0.005$. [Equation D1]

Death rate =	4.98 (Nt) -	3.9×10^{-3}(Rainfall) +	3.02
SE:	(2.04)	(1.1×10^{-3})	(0.87)
T Sig:	0,02	0.001	0.001

Drier areas: $r^2 = 0.24$; N = 36; $p < 0.005$.

Death rate =	$- 2.9 \times 10^{-3}$(Rainfall) +	4.19
SE:	(1.4×10^{-3})	(0.86)
T Sig:	0.005	0.000

Wetter areas: r^2 = 0.66; N = 37; p < 0.001. [Equation W1]

SE:	Death rate = 8.2 (Nt)
T Sig:	(1.45)
	0.000

All areas: r^2 = 0.61; N = 62; p < 0.001. [Equation A1]

	Death rate = 7.51 (Nt)
SE:	(0.86)
T Sig:	0.000

The results show that some form of density dependent effect on death rate is occurring in non-stress years. In the case of the drier areas, the influence of rainfall is also seen to have a significant effect. This is not the case for the wetter areas.

For non-stress years in all areas combined, the relationship between death rate and cattle density is very weak; for an increase in density from 0.2 animals/ha to 0.4 animals/ha the death rate increases only by 3% (for all areas). By contrast, if a stress year intervenes the death rate may increase to 25%.

Whereas stress years may well act as the 'key factor' affecting population size, some component of mortality rates in other years may act as the population regulatory factor (cf. Varley et al, 1973). Differentiation of mortality patterns into age, sex and seasonal components is not possible with this data set. It is therefore not possible to indicate at what stage in the life history of an animal, within which sex class or in what season density dependent and independent mortality is concentrated.

Density independent stress years

The question of whether the stress year mortality was acting in a density dependent manner was also investigated. No relationship was found between death rates during stress

years and the population density immediately before the mortality, nor in relation to both the density in years t and t-1 (ie cumulative effects of high density). The data set for stress years was small, so extensive analysis of relationships was not possible.

The stress years used in this analysis were low rainfall years, perhaps combined with another stress such as the 1968 cold snap. However, during the period 1923-1986 there are many other years which might have resulted in high mortality due to environmental stress. Stress years may be identified in relation to annual rainfall deficit. Years of 25% below long term average (1923-1986) rainfall were therefore analysed as a separate subset (10). Death rates in both the wetter and drier areas were related to density in the rainfall deficit year and in the previous year and as a combination. Data for death rate was not available for all years (11), but no significant relationships were detected, supporting the contention that drought mortality acts in a density independent manner.

Birth rates

The relationship between birth rates and population density was analysed in a similar way. Birth rates did not show stress year effects to the same degree as death rates. The relationships with rainfall were much weaker than for death rates and did not enter the regression models. Both wetter and drier areas showed significant density dependent effects on birth rate. The results of the regression relationships are shown in Table 4.6.

Table 4.6: Relationships between birth rate and density

Drier areas

All years: $r^2 = 0.17$; N = 29; $p < 0.05$. [Equation D2]

Birth rate =	-20.65 (Nt)	+ 23.1
SE:	(6.14)	(2.1)
T Sig:	0.0014	0.000

Non-stress years: $r^2 = 0.24$; N = 26, $p < 0.01$.

Birth rate =	-24.1 (Nt)	+ 24.9
SE:	(0.7)	(2.3)
T Sig:	0.000	0.000

Wetter areas

All years: $r^2 = 0.23$; N = 30, $p < 0.01$.

Birth rate =	-31.6 (Nt)	+ 26.21
SE:	(11.0)	(4.0)
T Sig:	0.007	0.000

Non-stress years: $r^2 = 0.27$; N = 27; $p < 0.005$. [Equation W2]

Birth rate =	-36.62 (Nt)	+ 27.7
SE:	(15.7)	(5.9)
T Sig:	0.03	0.000

All areas (non-stress years): $r^2 = 0.21$; N = 61; $p < 0.001$. [Equation A2]

Birth rate =	-21.7 (Nt)	+ 24.01
SE:	(6.1)	(2.1)
T Sig:	0.001	0.000

Although no relationship with annual rainfall was discovered, birth rate might be expected to show lagged relationships with rainfall, due to the delay time on

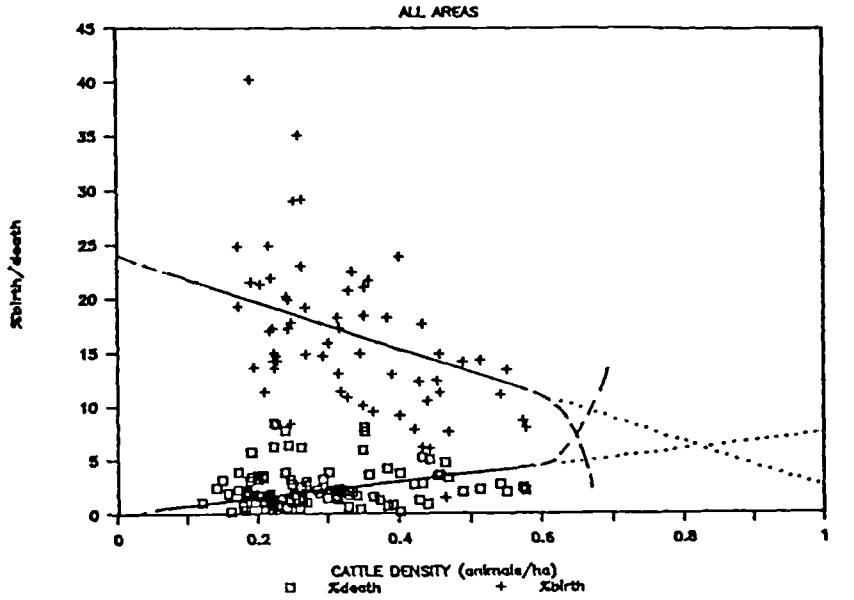
population size imposed by gestation periods. A depressed plane of nutrition caused by a failure in primary production is known to have direct effects on conception rates, pregnancy success and birth rate (Richardson, 1977). However when regressed against rainfall for the previous year, combined with the current and alone, no significant relationships were observed. This of course does not discount the effect of rainfall on birth rates, as overall seasonal rainfall is sometimes a poor indicator of fodder availability; timing and patterning of rainfall may be equally important.

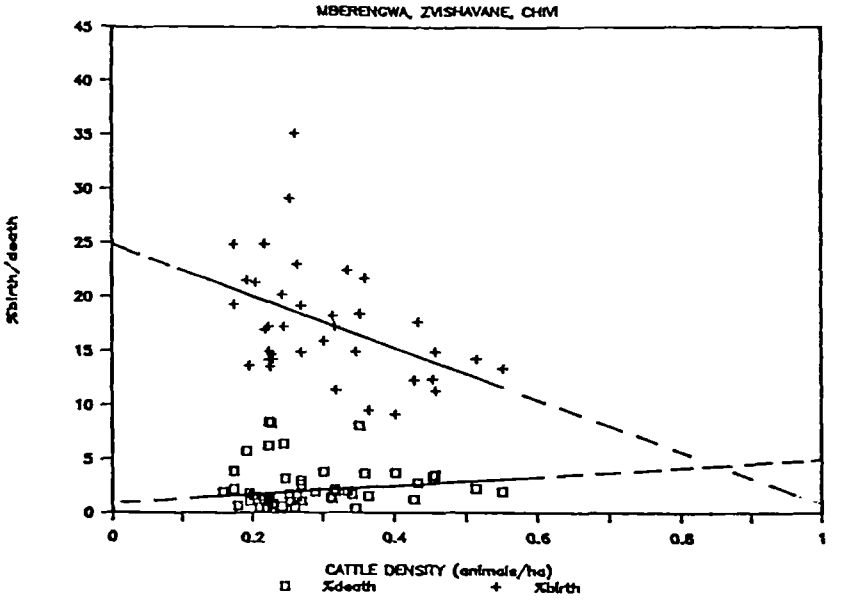
Equilibrium density

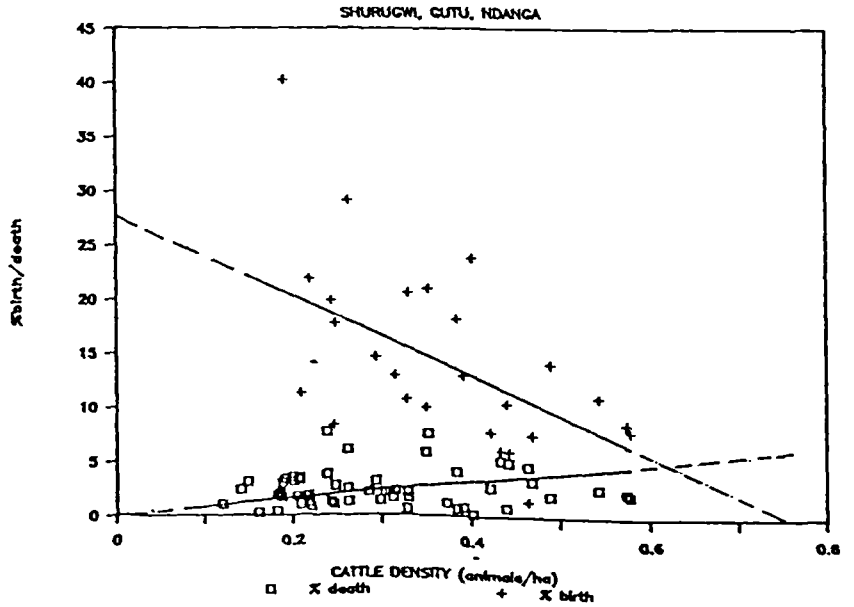
Data on the relationship between birth and death rates and density is shown in Figure 4.3 for both the drier and wetter areas. Linear models are fitted to the data derived from the analysis presented above. For the wetter areas equations W1 and W2 are plotted, while for the drier areas equations D1 (assuming 550mm rainfall) and D2 are used.

When birth and death rates are equal the population remains at a stable level, assuming no offtake, immigration or emigration. By extrapolation of the regression lines of Figure 4.3 (assuming linear relations beyond the bounds where data is available) the equilibrium density can be estimated. The assumption of linear relationships between birth/death rates and densities up to an equilibrium is unlikely to hold and a curvilinear pattern is more likely. We can expect a threshold effect, whereby survival is dramatically reduced when the plane of nutrition is reduced below a certain level through increased density. This hypothetical relationship is shown (dashed lines) in Figure 4.3a. If this occurs, then the equilibrium densities would be at a lower level than those predicted by linear extrapolation.

Figures 4.3: Birth/death rates and cattle density. a: All areas, b: Drier areas, c: Wetter areas. (--- = extrapolation of model beyond data points).







For the three data sets the 'equilibrium' level of density calculated by linear extrapolation is shown in Table 4.7. Where rainfall is a determining factor the density estimates are given for different levels of rainfall.

Table 4.7: Estimates of equilibrium densities

All areas: equilibrium level = 0.82 animals/ha
(using equations A1 and A2; calculated for non-stress year and based on linear extrapolation)

Wetter areas: Equilibrium level = 0.62 animals/ha
(using equations W1 and W2)

Drier areas: Equilibrium level dependent on rainfall (based on equations D1 and D2):

Rainfall	Non-stress	All years
250	0.66	0.78
300	0.70	0.79
350	0.73	0.80
400	0.77	0.81
450	0.81	0.81
500	0.84	0.82
550	0.88	0.83
600	0.92	0.83
650	0.95	0.84
700	0.99	0.85
750	1.02	0.85
800	1.06	0.86
850	1.10	0.87

To summarise the results of this section:

- Density dependent birth and death rates are shown in non-stress years for both wetter and drier areas; variations around the relationships described may be attributable to age/sex structure effects of populations and differences in

management.

- Population size is however affected by the impact of stress years (eg. drought) by increasing mortality rates. Effects of rainfall variation on birth/death rates are more pronounced in the drier areas.

- Equilibrium density estimates, based on linear models of birth/death rate and density, range from 0.6 to 0.8 animals/ha, with higher potential levels shown for the drier areas.

- Actual populations do not reach such levels, as non-linear relationships are likely at higher population densities and because of the stochastic effects of rainfall variation on population size.

This analysis of the relationship between biological population parameters and density gives some indication as to the underlying dynamics of the populations. However, much residual variation remains unexplained by the simple regression models used here. Sources of this variation will be considered in section 4.9.

4.6 Carrying capacity assessments

A number of methods have been suggested in the literature for assessing carrying capacity in grazing systems. These include comparative analyses of different areas, production-consumption predictions and simple population dynamic models. Each of these will be used to compare with the equilibrium level estimates derived above.

Comparative analyses

Comparisons of biomass densities across different sites are related to environmental variables (rainfall, soil type

etc) and a relationship is derived that relates biomass to known environmental characteristics. The method assumes that all sites used in the derivation of the relationship are at equilibrium ecological carrying capacity.

Coe et al (1976) derived a relationship from 24 wildlife areas in Africa between herbivore biomass and rainfall:

$$\log(H) = 1.552\ (+/-0.329)\log(R) - 0.62(+/-0.903)$$

where: H = herbivore biomass (kg/km2)
R = mean annual rainfall (mm)

For the study area data an estimate of expected biomass density can be made using Coe et al's (1976) relationship (Table 4.8), assuming the mean weight per animal is 250kg.

Table 4.8: Carrying capacity estimates from comparative analysis.

Area	Rain (mm)	Density (animals/ha)
Mberengwa	516.76	0.16
Chivi	531.83	0.16
Zvishavane	571.89	0.18
Ndanga	759.72	0.28
Gutu	785.46	0.30
Shurugwi	1054.24	0.47

Production-consumption estimates

Production-consumption estimates are based on the derivation of a relationship between vegetation production and rainfall. In turn a relationship between vegetation production and herbivore consumption is calculated. Thus a relationship between herbivore biomass and rainfall can be determined. There are obvious problems associated with this

approach since it is often unknown what the exact relationship is between vegetation production and herbivore production. For instance, plants are selectively eaten in relation to factors of nutritive quality, structure etc (see Chapter 2).

Le Houerou and Hoste (1977) estimated such a relationship for the Mediterranean and Sahelian-Sudanian zones. The Sahelian-Sudanian relationship was:

$$Y = 0.0004\ X^{1.001} \qquad r^2 = 0.89;\ n = 45$$

where: Y = TLU's (250kg)/ha/yr
X = mean annual rainfall (mm)

The levels for the study areas can again be estimated on the basis of this equation (Table 4.9).

Table 4.9: Estimates of 'carrying capacity' from production-consumption relationship.

Area	Rain (mm)	Density (TLU/ha)
Mberengwa	516.76	0.21
Chivi	531.83	0.21
Zvishavane	571.89	0.23
Ndanga	759.72	0.31
Gutu	785.46	0.32
Shurugwi	1054.24	0.42

Modelling methods

A model is a hypothesis about pattern that can be investigated with data to try to identify a 'signal' amongst the 'noise' of the real world. Simple growth models can be used to investigate the underlying dynamics of population growth and estimate growth rate and carrying capacity parameters.

There exist a wide range of simple deterministic models for single species populations that describe growth trajectories over time (eg. May and Oster, 1976; May, 1981). The family of equations that describe variations of a logistic growth curve have been used extensively in applied population analysis. Much of this field has been developed in the context of sustained yield harvesting of fisheries (Pitcher and Hart, 1982) applications to wildlife harvesting have been limited (Caughley, 1976) and to domestic livestock production virtually non-existent.

In discrete form, for harvested populations, some examples of logistic growth models are:

$$N_{t+1} = N_t \exp[r(1-N/K)] - C \qquad \text{[Eqn 1]}$$

$$N_{t+1} = N_t + rN(1-N/K) - C \qquad \text{[Eqn 2]}$$

where: N_{t+1}, N_t are population size at time t+1 and t
- r = the intrinsic rate of increase
- K = population size where growth rate zero or bioeconomic carrying capacity.
- C = offtake

For equation 1 Caughley (1977; after Morista , 1965) shows that during logistic growth the trend of $(N_{t+1}-N_t)/N_t$ is linear on N_t. Therefore both r and K can be estimated through regression if successive estimates of N are available.

For equation 2, before removals, it rearranges to , $N_{t+1}-N_t = rN - rN^2/K$. Therefore a regression of the change in N for a unit time against N and N^2 will provide estimates of r and K. Both equations offer similar estimates of sustainable yield. The Maximum Sustainable Yield (MSY) is harvested from a population size of N = K/2 at an instantaneous rate of r/2 yielding rK/4 animals per year (see Caughley, 1977: 179).

However, herbivore populations are unlikely to grow

according to a logistic growth curve. This is because the herbivore-plant system violates a number of the logistic's assumptions. Most importantly, the logistic assumes that the food resource is inert and renewing and is unaffected by the herbivore. This is clearly not true as herbivores affect both the rate of fodder production and the resource base (Caughley, 1976: 203). Interactive models of plant-herbivore dynamics are therefore more realistic, but they do require a range of parameter estimates (cf. Caughley and Lawton, 1981) unavailable for the present data.

The simple logistic also does not account for herbivore eruptions or oscillations. These can result from time delays in, for instance, natality response to changed resource levels. This can be accounted for by the delayed logistic function. Dependent on the time lag and the intrinsic rate of growth, the modelled population can exhibit a variety of dynamic behaviour (May, 1973).

Fowler (1981) comments that for large mammals non-linear effects between birth and death population parameters and population density are expected, because of the nature of large mammal life histories. When combined with the consequences of differential effects due to age structured populations, MSY levels are expected to be closer to equilibrium density (around 0.75K) than under the simple linear logistic model.

There are innumerable variations on the general theme of the logistic growth model, each tailored to a specific situation. As they become more complex they tend to become more data hungry as parameters increase. In addition assumptions become more complex. For the present examination of the data the simplest models will be used. The assumptions must continually be remembered and the limitations recognised. However, the aim is suited to the simplicity of the models, gaining insight into fundamental patterns, rather than specific numerical answers.

4.7 Population growth: analysis of simple models

Two growth models were fitted to the data for cattle populations in the study areas between 1923 and 1986. The first was the logistic model, described above. The second was a simple growth model that assumed a density dependent removals term and a constant rate of additions to the population. This seemed a reasonable assumption because of the importance of purchases, rather than simple intrinsic increase on the approach to equilibrium (ie in the periods of growth from 1923 and 1961).

Both models were investigated with and without the harvest term (based on the sales and slaughter data). Both models were investigated in relation to population density (animals/ha). The equations used in the regression are:

Logistic growth model:

$$Nt+1-Nt + C = rNt - rNt^2/K$$

where: r = intrinsic rate of population growth
Nt = Population at time t
Nt+1 = Population at time t+1
C = Sales
K = Carrying capacity (with or without sales)

Simple growth model:

$$Nt+1-Nt = A - BNt$$

where: A = purchases less harvests
B = proportion of deaths
A/B = bioeconomic carrying capacity, 'K'.

The relationships were also investigated for portions of the data between different dates, to see if data from particular periods was having an undue influence on the overall result. The following periods were investigated:

1923-1935: to investigate whether the early period of population growth to equilibrium was in any way fundamentally different to later periods.

1935-1986: the period following the period of high

early growth was investigated to contrast with the above.

1923-1986 (not including 1945-1961): the full destocking period was left out of the analysis to see if the policy induced depression from 'equilibrium' numbers had any impact on the overall results derived from the aggregate data.

1923-1986: including all cases.

The results of these analyses are presented in Tables 4.10 and 4.11. Models of population growth for each of the study areas are presented where the regression model is significant ($p < 0.01$). Models for periods between 1923-86, 1923-45, 1923-86 (not including 1945-60) and 1935-86 were derived for both the logistic and simple growth models. These considered the 'bioeconomic carrying capacity', determined by the interaction of biological (births/deaths) and economic factors (sales/purchases). Sales were regressed out for a set of models for the period 1923-86, thus giving an indication of the effect of sales in depressing population levels below an 'ecological carrying capacity' to a 'bioeconomic carrying capacity'.

Population growth models are fitted to the Shurugwi and Mberengwa study area data in Figure 4.4. The models trace the rise in population to an apparent equilibrium level between c. 1930 and 1945. Thereafter, the population density drops due to destocking (from 1945 in Shurugwi and the early 1950s in Mberengwa). Following the end of destocking in 1961, populations recover to their previous level in the early 1970s, but then overshoot due to high growth rates during the wetter years of the mid-late 1970s. By the mid 1980s, the populations had again returned to a level comparable to that found in the earlier 'equilibrium' period, following the oscillation caused by the early 1980s drought.

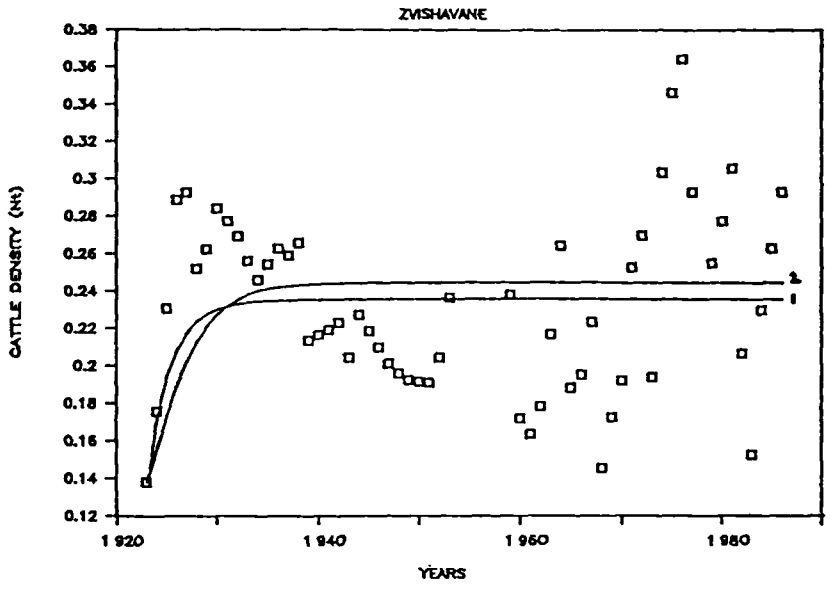
Table 4.10: Regression models for logistic growth model (including estimates of r and K)

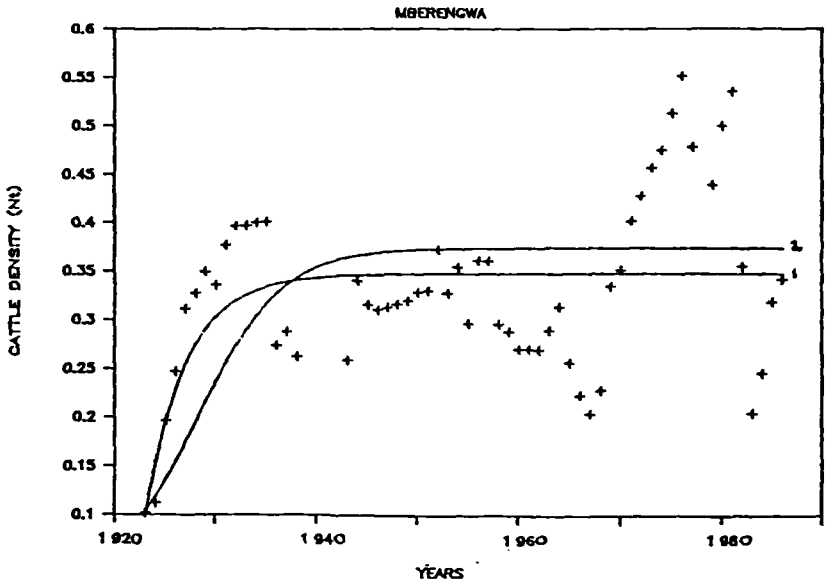
AREA	REGRESSION	r2	SE (Nt)	SE (Nt2)	T sig(Nt)	T sig(Nt2)	r	K
1923-1986:								
MBERENGWA	Nt+1-Nt = 0.22(Nt)-0.58(Nt2)	0.12	0.08	0.22	0.013	0.011	0.22	2.67
ZVISHAVANE	Nt+1-Nt = 0.3(Nt)-1.25(Nt2)	0.13	0.1	0.4	0.012	0.009	0.3	4.1
RUNDE	Nt+1-Nt = 0.36(Nt)-1.48(Nt2)	0.15	0.1	0.6	0.021	0.015	0.36	4.11
MAZVIHWA	Nt+1-Nt = 0.5(Nt)-2.2(Nt2)	0.26	0.15	0.6	0.002	0.001	0.5	4.4
SHURUGWI	Nt+1-Nt = 0.25(Nt)-0.58(Nt2)	0.13	0.1	0.22	0.016	0.012	0.25	2.34
GUTU	Nt+1-Nt = 0.16(Nt)-0.643(Nt2)	0.11	0.08	0.31	0.07	0.04	0.16	3.97
1923-1945:								
MBERENGWA	Nt+1-Nt = 0.63(Nt)-1.67(Nt2)	0.68	0.22	0.66	0.034	0.053	0.63	2.65
1935-1986:								
ZVISHAVANE	Nt+1-Nt = 0.26(Nt)-1.1(Nt2)	0.12	0.13	0.54	0.06	0.05	0.26	4.23
RUNDE	Nt+1-Nt = 0.27(Nt)-1.11(Nt2)	0.11	0.15	0.6	0.07	0.07	0.27	4.04
MAZVIHWA	Nt+1-Nt = 0.42(Nt)-1.96(Nt2)	0.16	0.23	1	0.08	0.06	0.42	4.63
SHURUGWI	Nt+1-Nt = 0.42(Nt)-1.03(Nt2)	0.42	0.14	0.3	0.008	0.002	0.41	2.48
NOT INCLUDING 1945-1961:								
ZVISHAVANE	Nt+1-Nt = 0.37(Nt)-1.42(Nt2)	0.17	0.17	0.66	0.04	0.04	0.37	3.8
SHURUGWI	Nt+1-Nt = 0.588(Nt)-1.36(Nt2)	0.52	0.16	0.3	0.0015	0.0006	0.58	2.31
INCLUDING SALES								
MBERENGWA	Nt+1-Nt+S = 0.28(Nt)-0.588(Nt2)	0.31	0.08	0.22	0.002	0.013	0.28	2.1
ZVISHAVANE	Nt+1-Nt+S = 0.5(Nt)-1.72(Nt2)	0.34	0.13	0.52	0.0006	0.0025	0.5	3.44
SHURUGWI	Nt+1-Nt+S = 0.73(Nt)-1.588(Nt2)	0.63	0.116	0.25	0.000	0.000	0.73	2.17

Table 4.11: Regression models for simple growth model (including estimates of K)

AREA	REGRESSION	r2	SE (Nt)	SE (const)	T sig(Nt)	T sig(const)	K
1923-1986:							
MBERENGWA	Nt+1 - Nt = -0.22(Nt) + 0.075	0.15	0.07	0.02	0.005	0.004	2.88
ZVISHAVANE	Nt+1 - Nt = -0.345(Nt) + 0.08	0.16	0.11	0.02	0.004	0.004	4.25
RUNDE	Nt+1 - Nt = -0.3(Nt) + 0.069	0.14	0.11	0.028	0.014	0.017	4.3
MAZVIHWA	Nt+1 - Nt = -0.466(Nt) + 0.098	0.25	0.13	0.02	0.001	0.001	4.75
SHURUGWI	Nt+1 - Nt = -0.151(Nt) + 0.06	0.1	0.08	0.03	0.07	0.07	2.51
GUTU	Nt+1 - Nt = -0.155(Nt) + 0.035	0.11	0.07	0.17	0.04	0.05	4.4
1935-1986:							
ZVISHAVANE	Nt+1 - Nt = -0.348(Nt) + 0.078	0.16	0.14	0.03	0.02	0.02	4.46
SHURUGWI	Nt+1 - Nt = -0.442(Nt) + 0.169	0.28	0.15	0.06	0.001	0.015	2.61
NOT 1945-1961:							
ZVISHAVANE	Nt+1 - Nt = -0.39(Nt) + 0.099	0.2	0.16	0.04	0.03	0.023	3.93
SHURUGWI	Nt+1 - Nt = -0.65(Nt) + 0.27	0.43	0.17	0.076	0.0012	0.002	2.38
INCLUDING HARVEST, 1923-1986:							
ZVISHAVANE	Nt+1 - Nt = -0.393(Nt) + 0.11	0.2	0.136	0.03	0.007	0.001	3.57
MBERENGWA	Nt+1 - Nt = -0.145(Nt) + 0.073	0.1	0.01	0.02	0.056	0.005	1.98
SHURUGWI	Nt+1 - Nt = -0.652(Nt) + 0.29	0.52	0.126	0.05	0.0000	0.0000	2.25

Figures 4.4: Growth of cattle populations (1923-1986). Logistic (1) and simple (2) growth models: a: Zvishavane, b: Mberengwa and c: Shurugwi.





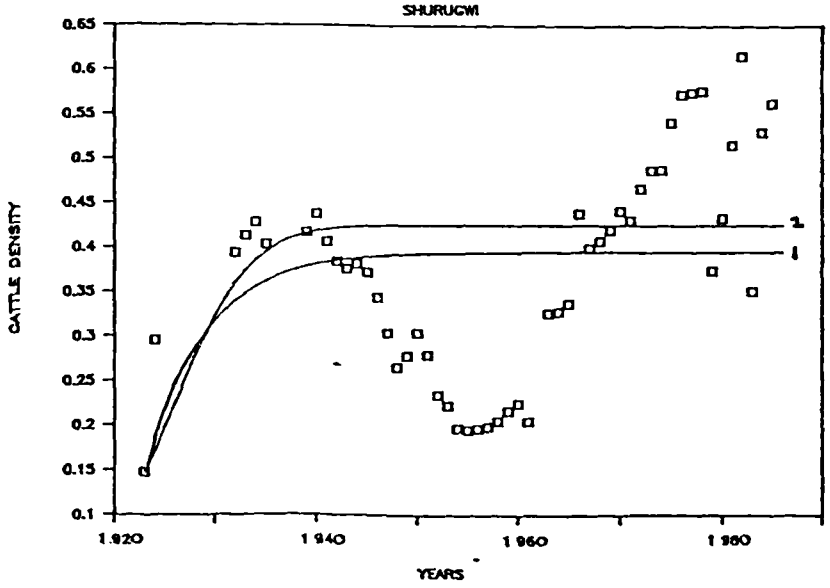
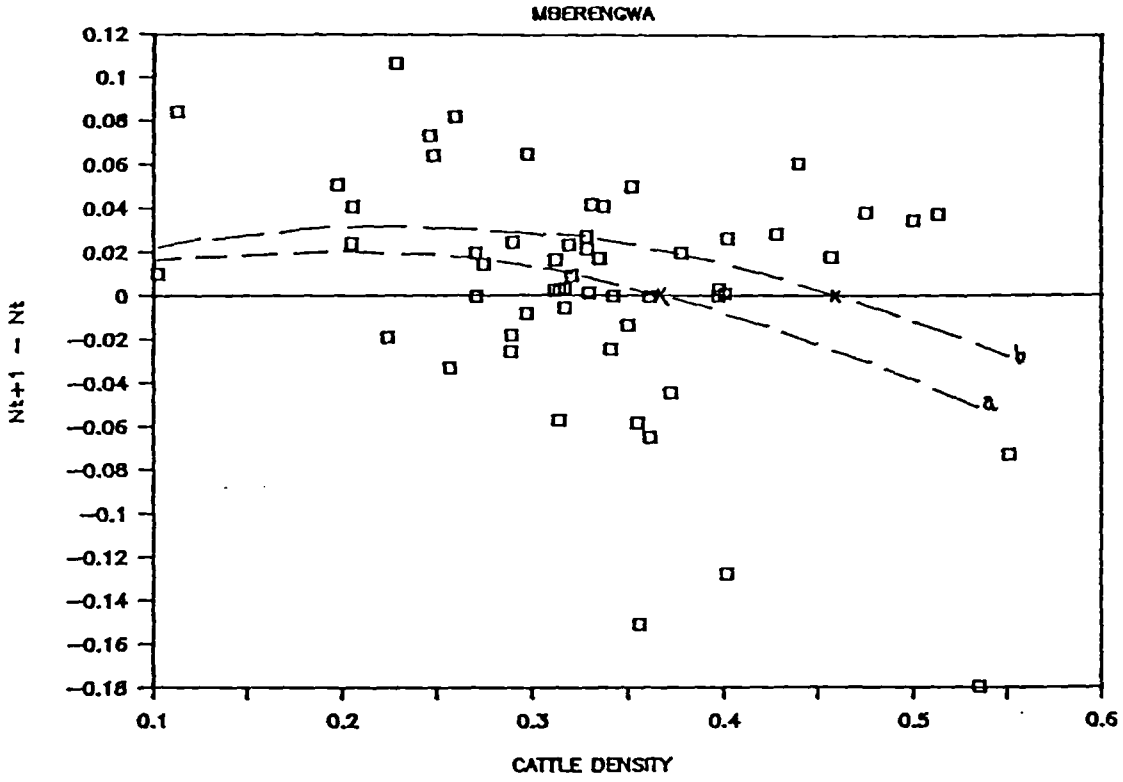


Figure 4.5: Fitted logistic models: a. Harvest term included (bioeconomic 'K'); b. Harvest term removed (ecological 'K')



Under their current simplistic formulation, the models are unable to account for the variations caused by cyclical fluctuations of rainfall, interannual stochastic effects or government destocking interventions. However, they do manage to capture elements of the underlying dynamics of population growth, highlighting differences in estimated 'carrying capacity' levels between areas.

Figure 4.5 examines the Mberengwa data with a plot of Nt against Nt+1 - Nt. The logistic model with and without the harvest term is also plotted, where Nt+1 - Nt = 0 represents the 'carrying capacity' level. The two model plots illustrate the difference between the 'bioeconomic carrying capacity' and the 'ecological carrying capacity' level. The former is below the latter, as sales depress the equilibrium population density.

Table 4.12 combines the 'K' estimates from all regression relationships calculated (derived from Tables 4.10-4.11). As Table 4.12 shows, the investigation of different time periods did not highlight any fundamental difference in 'K' levels. The aggregate data will therefore be used as a suitable indicator of overall pattern.

Table 4.12: Estimates of 'K': bioeconomic 'carrying capacity' and 'ecological carrying capacity' (Columns 2 and 6 (*)). Estimates in Ha/animal.

	1	2*	3	4	5	6*	7	8
Drier areas:								
Mberengwa	2.7	2.1	-	-	2.9	2.0	-	-
Zvishavane	4.1	3.4	3.8	4.2	4.2	3.6	3.9	4.6
Mazvihwa	4.4	-	-	4.6	4.7	-	-	-
Runde	4.1	-	-	4.0	4.3	-	-	-
Chivi	3.8	-	-	2.4	-	-	3.5	-
Wetter areas:								
Shurugwi	2.3	2.2	2.3	2.5	2.5	2.2	2.4	2.6
Gutu	4.0	-	-	-	4.4	-	-	-
Ndanga	-	-	2.4	-	3.0	-	-	-

Where:
1: Logistic model 1923-1986
2: Logistic model 1923-1986 (including harvest term)
3: Logistic model 1923-1986, with 1945-1961 removed
4: Logistic model 1935-1986
5: Simple model 1923-1986
6: Simple model 1923-1986 (including harvest term)
7: Simple model 1923-1986, with 1945-1951 removed
8: Simple model 1935-1986

In general, estimated 'K' values show higher densities in the wetter areas. Mberengwa is an exception to this pattern however. The relationship between average annual rainfall and estimated 'K' is shown in Table 4.13. If rainfall is closely correlated with grass production and so directly related to the number of animals the land can support, a correlation between mean average rainfall of an area and its carrying capacity is expected, as assumed for the empirical analyses (section 4.6).

Table 4.13: Estimated bioeconomic 'K' values and rainfall

	Rain	Animal/ha	Ha/animal
Mberengwa	516.8	0.37	2.7
Chivi	531.8	0.26	3.8
Zvishavane	571.9	0.24	4.1
Mazvihwa	571.9	0.23	4.4
Runde	571.9	0.24	4.1
Ndanga	759.7	0.42	2.4
Gutu	785.5	0.25	3.9
Shurugwi	1054.2	0.43	2.3

Where: Estimates relate to bioeconomic 'K' level for logistic model between 1923-1986, except for Ndanga where simple model estimate used.

Despite the general distinction between wetter and drier areas, the data does not show any clear relationship between estimated 'K' and rainfall. Coe et al (1976) and Le Houerou and Hoste (1977) expect a log-linear relationship, but the data does not show this. The relationship between 'K' and mean average rainfall thus remains obscure. The coefficients of variation of rainfall in the different areas are not sufficiently different to offer an explanation in relation to rainfall variability (12).

4.8 Comparing 'carrying capacity' estimates

The previous sections have provided different estimates of 'carrying capacity' for the study areas. These are:

- Estimates based on empirical rainfall-population density models.

- Estimates of 'equilibrium density' from extrapolation of birth/death rate relationships with density.

- Estimates of 'bioeconomic carrying capacity' based on 'K' levels calculated from the logistic and simple growth models.

- Estimates of 'ecological carrying capacity' based on 'K' levels calculated from growth models with the sales removed.

The magnitude of estimates of bioeconomic 'K' from the logistic growth model (range: 0.23 - 0.43 animals/ha) coincide with the expectations of the empirical models (section 4.6; range: 0.16 - 0.47 LSU/ha). However if 'ecological carrying capacity' levels are considered these show higher levels (up to 0.5 animals/ha).

The expected general relationship between higher rainfall and increased 'carrying capacity' is seen, but with no clear relationship. At this aggregate level, differences due to soil type influences on population dynamics cannot be discerned.

The estimates of equilibrium density (section 4.5; for all areas = 0.82 animals/ha) are higher than both the bioeconomic and ecological 'K' values obtained by the analysis of the growth models. For the wetter areas the average bioeconomic model estimate is 58% of the equilibrium estimate and for the drier areas it is 30%.

The extrapolation of a linear relationship between birth/death rates and density for estimating 'equilibrium densities' is probably an unacceptable assumption, since the birth rates are likely to sharply decline and death rates increase as population densities approach equilibrium. However, potential population levels, higher than observed levels, are likely to be possible, if drought and other factors do not depress the population. The 'equilibrium density' level thus gives an indication of maximum possible population densities without the

intervention of stress years.

The estimates of 'K' from the simple growth models are derived from an analysis of population change including the effects of drought and sales (in the case of bioeconomic 'K' estimates) which act to depress equilibrium levels. These factors are excluded from the equilibrium density estimates derived from birth/death rate vs density assessments. As a consequence, the equilibrium densities derived from this analysis will be higher representing the potential population levels in the absence of drought or sales.

Estimating 'carrying capacity' levels using simple equilibrum models may give the misleading impression that such levels are somehow fixed. As the fits of the models to the the actual data points show there is much variation around the model trajectory. This variation has a number of sources. Most important is the effect of climatic variation, both interannual and cyclical. It is adaptations to this variation that are more important to farmer strategies than the average level around which populations fluctuate. A detailed examination of local adaptation to environmental variability will be the major theme of Chapter 7, which will investigate the responses of livestock populations to drought. This more detailed case study will explore some of the factors that may explain the scatter of unexplained variation around the simple models. A range of factors are likely to be important; these will be considered in section 4.10.

4.9 Population growth rates

Rates of population growth can be measured in different ways. The data here refers to the exponential rate of increase, where $r = \ln(Nt+1/Nt)$. This relates to the intrinsic rate of increase r_{max}, which is the rate at which the stable age structured population grows with no

resources limiting (Caughley, 1977).

Estimates of intrinsic growth rate can be derived from the analysis of the logistic population growth models for the different study areas (Table 4.11). The following estimates of r_{max} were made for the different study areas (Table 4.14).

Table 4.14: Estimates of r_{max} from logistic model

	1	2	3	4
Mberengwa	0.22	0.28	-	-
Zvishavane	0.3	0.5	0.4	0.3
Mazvihwa	0.5	-	-	0.4
Runde	0.36	-	-	0.27
Shurugwi	0.25	0.73	0.58	0.42
Gutu	0.16	-	-	-

Where:
1: Logistic model 1923-1986
2: Logistic model 1923-1986 (including harvest term)
3: Logistic model 1923-1986, with 1945-1961 removed
4: Logistic model 1935-1986

The data presented in Table 4.14 shows that for the 1923-86 model, the 'r' levels are higher in the drier areas. This follows the expectations of savanna ecology. However, when other variants of the model over different time periods are examined, the patterns are not clear. What are the possible factors that determine differences in r_{max} values between areas? One possible candidate is rainfall, but the correlation of r_{max} (from the logistic estimate) with mean average rainfall (1923-86) for the different areas gives no significant result.

The average value of r (where: $r = \ln(Nt+1/Nt)$) can be computed for a series of population figures. Periods when

the population is being released from a density level below the 'carrying capacity', and is therefore presumably not resource limited, are typified by the post destocking era c. 1960-1978 and the early increase 1923-1935. An example of a period of population collapse, from levels above the long term 'K' value, is the decline during the 1982-3 drought.

Table 4.15 estimates average 'r' levels for these different periods for the different study areas. In addition, maximum, minimum, drought period and variation of levels are shown.

Table 4.15: Estimates of average 'r' levels

	1	2	3	4	5	6
Mberengwa	0.13	0.04	-0.48	0.56	-0.55	0.12
Zvishavane	0.05	0.05	-0.35	0.45	-0.43	0.12
Chivi	0.06	0.07	-0.40	0.43	-0.40	0.23
Shurugwi	0.18	0.03	-0.20	0.49	-0.45	0.09
Gutu	0.07	0.01	-0.27	0.36	-0.39	0.01
Ndanga	0.10	0.06		-	-	0.09

Where:
1: 1923-1934 growth period
2: 1961-1978 growth period
3: 1982/3 drought
4: Maximum
5: Minimum
6: Coefficient of variation

Table 4.15 shows that the rate of population growth in the drier areas is higher than in the wetter study areas during the period 1961 - 1978. No pattern is evident for the growth period between 1923 and 1934. The impact of in-migration was probably more important during the 1920's (explaining the high rates of growth) than between 1961 and

1978, when population increase in the study areas was largely driven by natural increase.

Maximum intrinsic rates of growth are found to be higher in the drier areas. The drier areas also show the highest rates of decline over the full period and during the 1982-3 drought. This variability in the growth dynamics of the drier areas is reflected in the fact that these areas have higher coefficients of variations of annual 'r' levels over the period 1923-1986.

The impact of rainfall deficits on population growth is investigated in Table 4.16. The average finite rate of increase is calculated for each area for years with 25% below the long term (1923-1986) average rainfall.

Table 4.16: Finite rate of increase for years 25% or below average rainfall.

Areas	1935-86	1960-86
Mberengwa	-0.001	-0.003
Zvishavane	-0.008	-0.032
Shurugwi	-0.01	0.01
Gutu	0.04	0.01
Ndanga	0.01	0.03

For a similar 25% reduction in long term average rainfall, the rates of cattle population increase/decrease are different in the different areas. The wetter areas have higher exponential rates of increase than the drier areas for years with rainfall 25% below the mean for 1923-1986. This is shown when the data is analysed over the periods 1935-1986 and 1960-1986. The negative rate shown in the Shurugwi data between 1935 and 1986 does not follow this pattern. However, this is due to high rates of destocking in the drought years of 1947 and 1950.

The general hypothesis, derived from the analysis of the ecology of savanna vegetation dynamics in Chapter 2, that intrinsic growth rates tend to be higher in the drier environments after droughts, where recovery is faster due to a more resilient system, appears to be tentatively borne out by the data. The effect of reductions in rainfall in the drier areas is more significant, as growth rates decrease dramatically. The population crashes exhibited in these areas, especially during the 1982-3 drought, are also more pronounced. The variation in 'r' levels between years is also highest in the drier areas. The drier environments therefore show a more variable, but more resilient pattern of population dynamics.

4.10 Other factors influencing cattle population dynamics

Ecological explanations based on the contrasting dynamics of savanna in relation to rainfall and soil contrasts have had some success in explaining differences in population dynamics between the study areas. The hypothesised pattern which expects drier, eutrophic areas to show unstable populations with good recovery properties and wetter, dystrophic areas to show more stable patterns of population dynamics with slower potential growth rates is borne out in general terms by the data.

The relationship between 'carrying capacity', rainfall and soil type expected by the literature was difficult to dissect with the aggregate data. The higher population levels in the wetter areas do coincide with expectations, but the 'K' levels reached are clearly the result of a complex interaction of local ecological and economic factors. The general pattern in all areas is that estimated 'K' levels are high, reflecting the observation that cattle populations have been maintained at high densities in the communal areas.

In the same way hypotheses about 'carrying capacity' levels that expect higher population densities in the wetter areas are also generally supported.

The economic dimension must be added to this set of ecological explanations. The sales response models investigated in sections 4.2 and 4.3 have shown how historical changes in the economic environment influence the pattern of sales and so overall population dynamics.

This analysis of ecological and economic factors over time has gone some way towards explaining the fundamental factors determining observed cattle population dynamics. But it is clearly not the whole story. In this section a few other possibilities, that cannot be explored quantitatively with the data, are offered. These factors will be important in explaining variations not accounted for by the simple models investigated in previous sections.

Age and sex structures of populations

Aggregate models of population size do not take account of differential effects due to the age and sex structure of the population. A population's susceptibility to drought mortality, its ability to recover after declines and the degree of sales from a population are all critically affected by its age and sex structure. These factors were not considered in the analysis of previous sections, as disaggregated population data was unavailable. However, age and sex determinants of drought survival and sale are considered in later Chapters.

Seasonal dimensions

Annual data on population change, birth/death rates and sales levels gives no impression of the impact of intra-annual, seasonal factors on population dynamics. Mortality, fertility and sales peaks may be concentrated at particular times of year and conditions then may have a major effect

on overall patterns reflected in annual data. For instance, mortality is generally concentrated in the late dry season and early wet season. It is thus resource availability at this time of year that has a disproportionate effect on overall population change and any density dependent regulation through mortality. A consideration of the timing of births, deaths, sales etc. and so the action of density dependent/independent factors is thus vital in building up a more complete picture of population dynamics. This is attempted in Chapter 7.

Local patterning of resources

The analysis of this Chapter has been at the CA or regional scale without consideration of the heterogeneity of resource availability within areas. Chapter 2 has demonstrated the varied nature of available fodder resources, differentiated at the local scale between different savanna types (eg clay veld and sand veld) and between topland and 'key resource' grazing areas. A consideration of the use of the resource base by cattle will help to explain the form of resource constraints felt by animals in different areas and years. This issue is explored in Chapter 8 with a study of cattle foraging behaviour.

Use of extended grazing resources

Population densities were calculated by dividing the cattle census with the total area of the CA in question. This assumed that there was no other grazing available outside that boundary. Prior to the complete occupation of the European ranches, grazing was often more extensive than the immediate delimited zone of the reserve and cattle made extensive use of the ranch land. As the settlers took up residence in these areas there was generally a greater enforcement of boundaries and cattle 'poaching' grass would be impounded. The access to extra grazing varies considerably between study areas. The farms around

Shurugwi, for instance, were occupied during the 1930's and extra grazing was only gained at some risk. By contrast in Mberengwa extensive ranches surround the area and the use of this land (illegally) persists today. This may explain why Mberengwa can sustain a cattle density not much different to Shurugwi, yet receive on average only about half the rainfall. The existence of resettlement areas in the proximity also may allow cattle to be moved and grazed there, yet still be registered as part of the CA herd.

Use of grazing by other stock

The CA livestock grazing system is a multi-species system. The above discussion has concentrated on cattle, but the existence of goats, sheep, donkeys and (in the past) wildlife should not be forgotten in discussing the responses of one species to environmental changes. Goat and donkey populations have varied considerably throughout the period for which the data has been analysed (see Chapter 3). Inevitably they will have had some effect on the population parameters of the cattle.

In the mid-1980s cattle densities in the drier areas were approximately 0.3 animals/ha, while goats and donkeys were 0.35 and 0.1 animals/ha respectively. If these are converted to Livestock Units (LSU: cattle = 0.66, donkeys = 0.5 and goats = 0.2), the total stocking rate is 0.32 LSU/ha, rather than 0.2 if cattle alone are considered.

The use of CA grazing resources by animals not 'belonging' to the censused populations is possible under certain circumstances. During the 1920s and 1930s Mazvihwa and Runde CAs were used as grazing grounds by transport oxen owned by the early trekking companies. Similarly, during the 1930's a series of Foot and Mouth Disease outbreaks resulted in the movement of large herds of commercial cattle to quarantine sites (see Chapter 3).

Movement of cattle in drought years between areas also

affects the local populations. Large movements between areas have been rare in the study sites during the period under study. Most movements occur at the more localised level. These movements do not affect the assumptions of the study. However, other movements of non-censused cattle into an area will mean that the actual population estimates are underestimates in the 'sink' area and overestimates in the 'source' area. In the Zvishavane, Chivi and Mberengwa areas these large movements are recalled for the 1965 and 1982-3 droughts. The earlier patterns of cattle exchange between areas would not constitute large movements of non-censused cattle as the exchange would be recorded as a sale in one site and an addition in the other. Large movements are not recalled for the wetter areas, but were a much more common phenomenon in the lowveld areas such as Nuanetsi and Gwanda (see Chapter 3).

Management practices

Differences in aspects of livestock management between households or clusters may have significant effects on livestock breeding patterns or drought survival. For instance, the ability to move animals to different areas in drought may not be possible for all people and may result in differential patterns of survival. Such factors are not considered in the simple bioeconomic models presented here. However, the effects of different management strategies on cattle in the Mazvihwa sample are investigated in Chapters 5 to 7.

Investment and disposal decisions

The economic sales response models investigated in this Chapter have taken a very aggregated view to livestock owner production objectives and economic behaviour. Different people will inevitably respond in different ways to price incentives, rainfall deficits etc. Investment and disposal decisions are likely to be highly differentiated according to such factors as current asset holding,

alternative income sources, access to markets, ecological zone and agricultural success. A detailed examination of investment and disposal decision making for the contemporary situation in Mazvihwa will be presented in Chapter 6.

Disease control

The effectiveness of early attempts to control tick diseases through compulsory dipping may also contribute to differences in population characteristics in the different areas. Dipping coverage started earlier in the densely populated areas (ie Shurugwi, Runde, parts of Gutu, Ndanga and Chivi) and was only implemented later and less extensively in such areas as Mazvihwa, Runde and Mberengwa.

A detailed consideration of each of these factors would probably result in an improved understanding of the residual variation not explained by the bioeconomic models explored in previous sections. Time series data on such issues is lacking and so cannot be pursued with the present data set. However the detailed examination of livestock use and management in the Mazvihwa sample households does provide some insight into these questions for the contemporary situation.

4.11 Implications for livestock management

Official vs. estimated 'carrying capacity levels'

Official 'carrying capacity' levels for the various study areas (Agritex files) are presented in Table 4.18 alongside the estimates of 'carrying capacity' made in section 4.7. The data is presented in ha/LSU. The previous discussion has generally referred to 'animals', without relating to a reference size. In Table 4.17, one 'animal' is assumed to be 0.66 LSU. This assumes a herd structure of 20% calves (=

0.3LSU), 50% cows (= 0.7LSU) and 30% bulls/oxen (= 1LSU). (The definition of standard livestock units varies hugely within the literature).

Table 4.17: Official and estimated 'carrying capacity'

Area	Official	1	2	3
Mberengwa	9-10	2.67	4.04	
Zvishavane	9-10	4.1	6.21	1.83
Chivi	9-10	3.8	5.77	
Shurugwi	6-8	2.34	3.55	
Gutu	6-8	3.97	6.01	2.43
Ndanga	6-8	2.99	4.53	

Where: 1: Estimates from simple growth models (see above) in Ha/animal; 2: Estimates from simple growth models in Ha/LSU;3:Estimate from equilibrium model in Ha/animal.

Why are the estimates so different? The reasons for the divergence between the equilibrium estimates and the growth model estimates (Columns 1 and 3 in Table 4.17) has already been discussed. This is particularly evident for the drier areas where the instability of savanna production and the major impact of stress years on cattle populations results in the potential equilibrium density never being reached and an actual, but highly variable, population density is maintained at a lower level. The divergence is less in the wetter areas, where savanna dynamics are more stable allowing a greater convergence between the two values.

This section will concentrate on the divergence between the official carrying capacity level and the estimated 'K' levels (for cattle) according to the growth models (Column 2 in Table 4.17). A cursory look at the figures shows that there are significant disparities between the estimates. The gap would widen even further if smallstock and donkeys were included in the model estimate.

There appear to be two central reasons why the two

estimates are different. First, official 'carrying capacity' measures use indicators that underestimate potential stocking rates by ignoring 'key resource' grazing and basing assessments on ideals of 'climax' topland grass species composition. Second, official estimates are designed for beef production systems, where conservative stocking rates for maximising weight gain are required.

The method for assessing official carrying capacity levels is based primarily on the assessment of 'topland' grazing resources and rating the grassland in terms of its state in a supposed succession. As Chapter 2 has argued, this methodology has severe limitations in the context of dynamically variable grassland systems. In addition, the concentration on topland grazing resources, neglects the role of 'key resource' grazing (see Chapter 2), as well as the browse and arable land components of the feed resource. Because of this, the conventional range assessment method is prone to underestimating the potential animal stocking rate the land can hold; it rather aims at a vegetation-herbivore equilibriuim with high reserve vegetation biomass and low animal densities. (13)

In the context of land extensive beef production systems this method is probably appropriate. It has been well tested by generations of skilled ranchers in southern Africa. It provides 'carrying capacity' estimates not related to potential stocking rates, but to rates that allow for the maximisation of beef production (14).

The maximum sustainable yield (MSY) level of a population showing a logistic growth trajectory is at a level half of the 'K' value (maximum potential population) (Caughley, 1977). For large animals with different growth curves it may be up to 0.75K (Fowler, 1981).

The official 'carrying capacity' levels do indeed appear to be between 0.5 and 0.75 estimated 'K' levels. But, as the discussions in the earlier part of this Chapter have

argued, peasant livestock owners today are not beef producers. MSY levels for beef production are therefore irrelevant to their production objectives. Their primary objective appears to be to accumulate sufficient cattle to meet (primarily) agricultural input needs. This is demonstrated by the examination of the price response data (section 4.3). Under current human population pressures this implies a large cattle population. The aggregate result of the individual accumulation of stock since the end of destocking period has been a cattle population increase that has tended towards the 'K' level.

Official 'carrying capacity' estimates may be large underestimates of potential, but an examination of the cattle population growth patterns suggests that due to density dependent regulation of numbers, and the effects of drought, the potential for further expansion of current population numbers is very limited. A period of good rainfall, such as in the 1970s, may increase the potential level marginally, but this will not be permanent, as populations will be forced downwards in any succeeding dry spell, as in the early 1980s. In order to sustain the livelihoods of the growing human population and provide cattle inputs to the agricultural population of the study areas more land for grazing will have to be found, as it appears that, unlike before, the cattle populations will not continue to grow (15).

Opportunistic and conservative stocking strategies

At the high stock population levels that persist in the study areas, the need to be responsive to the variability of the environment is clear. In stress years a number of options are open for the opportunist: destock through sales, destock through movement out of the area or accept the trade-off between high mortality in stress years but greater overall productivity (however measured) in 'normal' years. By contrast a conservative strategy would recommend stocking at a level low enough to avert significant

mortalities in stress years, resulting in stable production at a lower per area level in other years (cf. Sandford, 1982b; 1983).

The regression relationship between death rate and population density for non-stress years for all areas (Equation A1, Table 4.6) can be used to investigate the implications of recommending different types of drought management strategy. The equation is: Death % = 7.51 (Nt)

In non-stress years a typical cattle density of 0.26 animals/ha results in a mortality rate of 2%, according to the equation. However, in stress years observed mortality rises to 20% (or more); this is equivalent to increasing the stocking rate to 2.6 animals/ha in other years. If this linear density dependent relationship holds over this range (16), then stocking levels should be reduced to one tenth of existing levels for a 2% mortality to be expected in such stress years.

A stocking rate of just 0.026 animals/ha (38.5 ha/animal) is clearly impossible in the land constrained situation of the Communal Areas. The losses of production this would imply would clearly not be acceptable. Chapter 5 investigates the economic role of cattle in the Mazvihwa study area; using the figures generated there the costs of any destocking exercise in terms of production and services foregone would be considerable.

Opportunistic strategies are not without costs. These relate to the costs of mortalities and the environmental impact resulting from the inability to track the environment perfectly. Costs in terms of damage to the environment of high, flexible stocking rate policies are often used as arguments for conservative stocking rates. This issue will be dealt with further in Chapter 9. However, according to this somewhat simplified calculation, a conservative strategy is clearly uneconomic and an opportunistic strategy, where as many cattle as possible

are sold or moved in a drought year, is preferable.

Livestock owners in the study areas do attempt to follow opportunistic strategies (17). In the past they included exchange sales of livestock with grain surplus areas and movements to areas where fodder was available. These were often the underutilised settler ranches in the vicinity. More recently the ability to respond opportunistically to stress years has been constrained through such factors as the occupation of neighbouring ranches and strict vetinerary control on movement and inter-district sales (see Chapter 3). This may be one reason why the stress years of 1965, 1968, 1982 are more recent, yet previous years with apparent considerable environmental stress (eg through low rainfall) did not result in such high levels of mortality. The attempts at employing opportunistic strategies during the recent droughts of 1982-3 and 1987-8 are discussed for the local case study of Mazvihwa in Chapter 7.

Issues for local level analysis

The results of this Chapter raise a number of questions that require further investigation with local level data. This will be the task of subsequent Chapters. Key issues highlighted here are:

- The analysis of sales responses suggests that, in the recent period, producers are negatively price responsive, but do sell cattle for immediate needs (eg in drought). Only when cattle holdings are high and the local service needs met will 'surplus' animal sales be expected. The actual disposal decisions of stock owners in Mazvihwa will be explored in Chapter 6.

- The variability in population levels due to drought has been shown to be important in determining overall population dynamics. This varies between wetter and drier areas. A local level analysis of population dynamics of

cattle and goat populations will be the subject of Chapter 7; investigation of population changes with data on age/sex structures, management inputs and local ecology will help to explore some of the sources of variation seen in aggregate regional models.

- 'K' population densities have been shown to be higher than normally assumed by conventional range management measures. It has been suggested that the use of opportunistic management strategies allows this. The components of such strategies will be investigated in Chapter 7, in relation to livestock movements in drought, and in Chapter 8, in relation to localised habitat utilisation by cattle.

- This Chapter has shown that high population densities have been maintained in the study areas over the last 50 years, with variations due to government intervention and variations in rainfall levels. The impact of these populations on the resource base has not been explicitly considered. The question of whether high stock populations result in permanent degradation in terms of loss of stock productivity will be explored in Chapter 9.

- Cattle and other stock populations have been shown to continue to grow over long periods and are maintained at high levels even after collapses due to drought. The high population growth rates are due to both biological growth and cattle purchase. The different patterns of stock investment between different households in the Mazvihwa study area will be the subject of Chapter 6. First, Chapter 5 will investigate the economic rationale for stock investment.

Footnotes

1. The average holding across all areas between 1923 and 1945 was 8.8 animals. This dropped to 4.22 if the 1945-86 period is considered and to 3.9 for the 1961-86 period (see data in Chapter 3).

2. Time series data on cattle densities and sales are derived from NC/DC's reports for the period prior to c. 1947. Annual reports usually contain census information on cattle (numbers, and often sales, births, deaths). After this time the Economics and Marketing section of the Native Affairs department published sales summaries in annual reports. More recent information is based on Cold Storage Commission data and the cattle marketing section and Veterinary Department of the Ministry of Lands, Agriculture and Rural Resettlement (see also Chapter 3 for sources of data).

3. The consumer price index is used as the deflator. Since there is no index for the rural consumer, the low income urban African index is used for the period up to 1949. Between 1949 and 1958 this index is unavailable and the European index is used. From 1958 the low income urban index is again used. The urban index is the weighted combination of five municipal towns within Zimbabwe, representing the purchases largely of mining families and junior civil servants (Southern Rhodesia Year Book, 1952). The basket of goods used for estimating the index has changed a little over time. From 1914-1941 food, fuel and lighting only were included. After 1941 clothing and 'other sundries' were added. In 1964 transport, drink and tobacco were added. The index used here is the full index. Despite the clear inadequacies of equating rural and urban consumers, the index suffices as an indicator of changes in real prices. Due to the close interaction of the rural and urban economies any cash raised through stock sales are likely to be spent on items reflected in the consumer index (food, school fees etc.).

Cattle prices are derived from a number of sources. Before formal market records were kept by the DC's offices or the CSC, occasional reference is made to prices fetched on the local market in DC's annual reports. When these are recorded in any of the areas where the full archival material was examined (ie the six districts), it is assumed that this was the standard price across the whole area. Of course this is not realistic, as there were often large price differentials between districts which were exploited by entrepreneurial traders. However such prices do give an indication of relative interannual variation for this period for the area as a whole. After c. 1945 annual returns from CA sales are recorded in the NC's annual

report. The price schedule varies between different grades and for different times of year. The average price received per beast offered for sale in that year is taken as the standard. From 1961 data is based on local market records from Chivi, Zvishavane and Mberengwa where the total cash takings is divided by the number of animals sold and the average of all sales pens for which information was available taken. For more recent prices the price per beast is derived from published information on $/kg dressed meat. Cattle prices are deflated from a 1914 base.

4. The form of the price response model chosen to investigate the data is often an important factor influencing interpretations. Rodriguez (1986) uses three different models over different periods for national supply data for Zimbabwe and finds very different price elasticities depending on the model used.

In this study a log-linear relationship was investigated, assuming a curvilinear supply curve and allowing the estimation of production elasticities. The data available is not evenly spread. Sales rate data for the earlier periods is scarce and consequently lower degrees of freedom for models for this period are attained.

5. Sales data for the destocking period for the wetter areas is sparse, so no conclusions can be drawn for these areas. Indications are that a similar pattern occurred (see historical discussion in Chapter 3).

6. 'Bioeconomic carrying capacity' is the stable population reached when births+purchases = deaths+sales+slaughters; the rate of growth is zero. The 'ecological carrying capacity' is the population density when births = deaths. This is the maximum equilibrium density when the rate of population growth is zero due to resource limitations. The 'ecological carrying capacity' tends to be higher than the 'bioeconomic carrying capacity' as offtake depresses the level of the latter. These terms are derived from population ecology (eg. Caughley, 1983) and the bioeconomic modelling of populations. These models take an equilibrium view, implying that 'carrying capacities' are static. Of course they are not and vary widely with climatic and other variations. However the concept does have some heuristic use in terms of understanding basic elements of population dynamics, but management applications must be careful to address the consequences of variability.

7. As already discussed, this distinction does not hold for all areas. There are patches of eutrophic savanna in the wetter areas as there are parts of the drier areas that have distinct dystrophic properties. The distinction based on soil characteristics will be pursued for the local study area (Mazvihwa) where clearer boundaries exist and the effects are not confounded by rainfall. In this regional analysis, the focus is on the generally contrasting properties of 'wetter' and 'drier' savanna types.

8. Birth and death rate data was only discovered patchily. The majority of the data is derived from the period between 1960 and 1980, when populations were increasing following the destocking period. This time series is investigated further in Chapter 9.

9. The simplest regression models are reported here. A whole range of possible models were tested with the data (eg involving logarithmic transformation), but the more complex models were no better at explaining the pattern of the data and so are not reported here.

10. Years of below 25% average rainfall (series: 1923-1986)
Mberengwa: 23,24,27,28,34,38,41,47,50,,60,64,68,70,73,82,83
Zvishavane:
23,24,27,28,30,31,34,38,40,47,50,54,60,65,68,71,73,82,83
Chivi:
23,27,28,34,36,38,40,41,47,50,54,64,68,70,73,83,84,86
Gutu: 23, 31,36,38,47,50,51,54,60,64,65,68,71,73,82,83,84
Shurugwi: 23,24,27,42,47,50,60,64,65,68,73,82,83,84
Ndanga: 23,24,27,38,44,47,50,54,60,64,65,66,68,73,82,83

11. Data on birth and death rates for the below average rainfall years was particularly sparse, so only limited analysis was attempted.

12. Coefficients of variation of annual rainfall (1923-86) for Mberengwa (0.33), Zvishavane (0.36), Chivi (0.35), Shurugwi (0.32), Gutu (0.34), Ndanga (0.32) show little variation between areas.

13. The choice of vegetation-herbivore equilibrium is a normative one based on management objectives. If the objective is to totally conserve the vegetation (eg for soil conservation) then the equilibrium chosen may be with no animals. If the objective is to conserve herbivore biomass (eg. game in a National Park), the appropriate

equilibrium would be when the herbivore numbers were at a maximum. If the objective is to maximise offtake then the equilibrium would be when the rate of change of population size is at a peak. If the aim is to maximise income, then price and cost considerations also effect the model.

14. Experiments carried out in Zimbabwe have concentrated on the impact of changed stocking rate on weight gain parameters. (eg. Mills (1964); Carew (1976); Gammon (1983)). These have been used for carrying capacity estimates. A tactic that has been employed by some agencies is to take the clearly inappropriate official figure and then revise this downwards (allowing higher densities) by some arbitrary amount (eg.GTZ/CARD, 1987).

15. The urgent need for more resettlement land has been officially acknowledged by the government. However the extent of actual resettlement since Independence has been well below targets set (Cliffe, 1986). Of particular interest in the context of alleviating grazing pressures in the communal areas is the Model D concept for resettlement, where adjacent farm land is made available for extensive use by cattle. However, these schemes have always been conceived in terms of a beef production strategy, rather than supporting the cattle populations for agropastoral uses. To date only a few such schemes have been established in Matabeleland. The attempts of local people to aquire more land through the aqcuisition of an abandoned neighbouring ranch is documented by Drinkwater (1988). This has been an ongoing saga in the Runde CA of Zvishavane District since Independence and a series of obstructions have been imposed by government to prevent local people acquiring the land under their own terms.

16. As discussed above, non-linear effects are likely to act at high densities; therefore the assumptions of this model should be regarded with caution. However it is not the actual numbers but the relative population densities under the different stocking strategies that are important here.

17. During both recent droughts commercial cattle ranchers moved cattle to different properties, destocking their drought stricken areas considerably. The larger ranching companies have extensive holdings in different parts of the country, and as long as veterinary restrictions are adhered to, they can transport their animals by truck.

5. THE ECONOMIC VALUE OF LIVESTOCK IN COMMUNAL AREAS

5.1 Introduction

This Chapter addresses the question of why people invest in different types of livestock. Through a simple economic analysis, the value of cattle, donkeys and goats in the case study farming system is examined. This economic assessment of the productivity of livestock forms the basis for a more detailed understanding of their role within the household economy which is the subject of the next Chapter.

The economic value of livestock is determined by their productive use within the farming system. The valuation must therefore take into account the range of factors that determine value to local farmers. In the past many policy proclamations have decried the low productivity of the livestock system in the communal areas. This is because the productivity of the system was being measured according to a single criterion; that of beef output (see Chapter 3).

This view remains prevalent today at all levels. The local Veterinary Department official for Mazvihwa comments in his monthly report:

> "People have shown little interest in destocking their areas to reduce pressure on the land... the CA cattle are not helping our government in its beef exports.. because [they] do not seem to keep cattle for economic reasons. This can be proved by animals in these areas that can live as much as 15-20 years without going for sale". (Veterinary Office, Buchwa, September 1982).

According to the beef production view, goats and donkeys have little role and their increase should be discouraged. Some of the historical reasons for these prevailing attitudes and ideologies in government and other services have already been discussed in Chapter 3. This Chapter will offer evidence from an economic angle that will undermine the thrust of this view.

According to a sales criterion, the CAs do indeed show low

production rates. Offtake from aggregate figures presented in Chapter 4 is in the order of 5%, although additional sales and exchanges go unrecorded in the official statistics. As argued in earlier Chapters the typification of the CAs as potential beef producing areas undervalues the other productive roles of livestock.

5.2 Measuring economic value

The choice of measure for assessing productivity of livestock enterprises has been discussed by Behnke (1985). He compares three alternative ways of assessment - using biological measures of herd productivity, using nutritional assessments of protein/calorie production and using economic measures of profitability of livestock keeping. Different measures come up with different conclusions. For instance, biological herd productivity per animal unit and per hectare will imply very different returns under varying conditions of land pressure. Jones and Sandland (1974) show how the maximum weight gain per hectare occurs at a higher animal density than maximum weight gain per animal. Nutritional measures have been used to compare protein gains per hectare in different systems in Africa and Australia (Cossins, 1985; Coughenaar et al, 1985), showing high returns in African systems using this measure. De Ridder and Wagenaar (1986) convert different functions of a traditional multipurpose herd in Botswana to a single weight gain measure to compare, across the full range of functions, the output of the traditional sector with that of the commercial beef herds. Again they found high levels of productivity in the traditional sector.

In Zimbabwe a few attempts at valuation of livestock in communal lands have already been made. Danckwerts (1974) attempted an economic assessment in a number of grazing schemes in Masvingo Province, while ARDA (1987) have constructed a hypothetical valuation model for a low rainfall area of the country. The central conclusion of these, and other studies in pastoral Africa, is that the

true value of livestock production can only be assessed if the full range of functions is taken account of.

The economic assessment in this Chapter attempts a wide definition of productivity to include both offtake (milk, meat) and services (transport, draft etc.). However certain factors cannot be easily assessed quantitatively. For instance, the role of cattle and goats in the marriage contract and ceremonial activities cannot be assessed in terms of a quantitative comparison, but should not be ignored (see Appendix 5).

The assessment of subsistence production in economic terms presents a number of methodological problems (Chibnik, 1978). The standard agricultural economics approach is to assess the 'farm gate price' of a subsistence product, so ascribing an economic value on the basis of its exchange value (cf Gittinger 1972). However producer prices may underestimate the local use value of the product. For instance, stored grain may be valued particularly highly by a household (and so not sold to the market) for food security reasons. An alternative way to value non-marketed production is to ascribe a 'replacement cost' to the product. The replacement value is that price the producer would have to pay to replace the subsistence product.

Alternative approaches to valuation will hopefully give insight into the economic value of livestock from a realistic, communal area perspective and so suggest what incentives drive investment and provide a clue as to why sales rates are low.

5.3 Constraints on investment patterns

Stock investment involves the allocation of cash resources between different livestock types with different streams of costs and benefits over time in order to maximise utility. The identification of optimal investment pathways that maximise returns will be constrained by various factors:

- Lack of access to investment funds. The purchase of a large, indivisible asset such as an ox requires the outlay of a considerable amount of money. This may not always be available, and a preferred strategy may be to invest in a lower yielding, but lower initial cost, asset (such as a goat) and accrue the returns for later investment in the larger asset.

- The discounting of future benefits. The time flow of costs and benefits is valued in different ways according to the time preference rate of the investor. Those requiring fast returns on investment will discount the future heavily.

- Uncertainty about future benefits. Investors also respond to risk and uncertainty by aiming for a fast payback period or investing in flexible assets that can be disposed of (eg in drought) and then repurchased without dramatic loss if they are risk-averse.

- The combination of assets that an investor aims for will also be affected by responses to risk and uncertainty. Portfolio models suggest that the decision to invest in a particular asset will be determined by the asset's expected rate of return and also on the correlation between this return and the returns on other assets held. A portfolio is thus built up where the individual returns on assets are imperfectly correlated.

- Ecological factors affect the level and variability of productivity of livestock. Different ecological zones with different environmental conditions result in different responses by animals and so different cost/benefit streams with varying amounts of variability. The zone of residence can therefore be expected to influence an investor's decision.

- The size of the existing livestock holding will also act as a determining factor. The marginal increase in costs of maintaining an additional animal will be high if it is the first of a herd or flock, but low if no additional herding/management labour needs to be employed.

5.4 Measuring returns on investment

In agricultural economics a variety of simple measures can be used to assess the returns on different investments (Gittinger, 1972). These include:

Net Present Value (NPV): The present value of an investment's cash flow stream discounted at an assumed rate (usually the opportunity cost of capital). It is formulated as:

$$NPV = SUM \frac{(B - C)}{(1 + i)^t}$$

Where: B = Benefits; C = Costs; i = Discount rate; t = time

Internal Rate of Return (IRR): The rate of interest which, when used to discount the cash flows associated with the investment, reduces its present value to zero. It gives a measure of the 'break even' rate of return of an investment.

Pay back period: The length of time taken to recover the costs of the original investment.

The information presented in this Chapter will be used to develop a simple cost-benefit analysis of the investment options in livestock for different savanna zones, using methods for subsistence product valuation. For cattle, donkeys and goats a variety of components of production must be assessed. These are summarised below:

Benefits and costs of cattle

Benefits: Direct outputs include: meat, milk and manure; service functions include: ploughing and other transport work. The benefit stream is affected by biological factors such as birth and death rates. These are in turn affected by ecological zone, breed type and the age/sex structure of the population. The value of outputs and services relate to local prices; this may vary between areas.

Costs: Costs of cattle production include: herding and veterinary care.

Benefits and costs of donkey production

Benefits: The value of donkeys is largely related to work outputs. Benefits are affected by both biological and economic factors as for cattle.

Costs: Herding is the only major cost of donkey production.

Benefits and costs of goat production

Benefits: The benefits of goat production relates to the production of meat and hides. The realisation of benefits is dependent on birth/death rates, which vary between ecological zone, predation rates, breeds etc. The valuation of sales and slaughters is dependent on local prices for products.

Costs: Herding is the major cost of goat production.

These different costs and benefits will be assessed using production data from the study area. In section 5.10 a cost-benefit analysis is presented and the options for investment are assessed in relation to Net Present Value, Internal Rate of Return and Pay back period measures.

The purpose of this productivity analysis is not to give precise figures, but to provide a comparison between different stock investment options in different ecological zones to try and understand people's preferences and investment patterns from an economic perspective.

5.5 Stock ownership and the distribution of production

The ownership of livestock within the household sample is highly skewed (Figures 5.1 to 5.3). The data is derived from a series of censuses and detailed monitoring of all kraals within the sample (1). Access to livestock is complex and is determined by loaning and sharing relationships. This issue will be fully addressed in Chapter 6, however it is important to note that the economic value of livestock is realised not only through ownership at the household level. Stock are owned by individuals within the household and their control over the productive benefits is important. In addition, stock may be held by households on a loaning arrangement and certain economic benefits are consequently gained. It is important to distinguish between stock access (including loaned animals) and stock ownership (including owned animals kept at the home kraal and others loaned out to others). The flows of benefits will be affected by these relationships.

The returns on cattle holdings will also be affected by herd composition, as different ages/sexes of animals have different economic values. The herd composition of the sample herd (for the mid-1987 census) is shown in Table 5.1 and compared with the estimates from neighbouring Mberengwa (GFA, 1987). The age and sex structure of the sample goat and donkey populations are shown in Tables 5.2 and 5.3.

Figure 5.1: Cattle ownership in the household sample

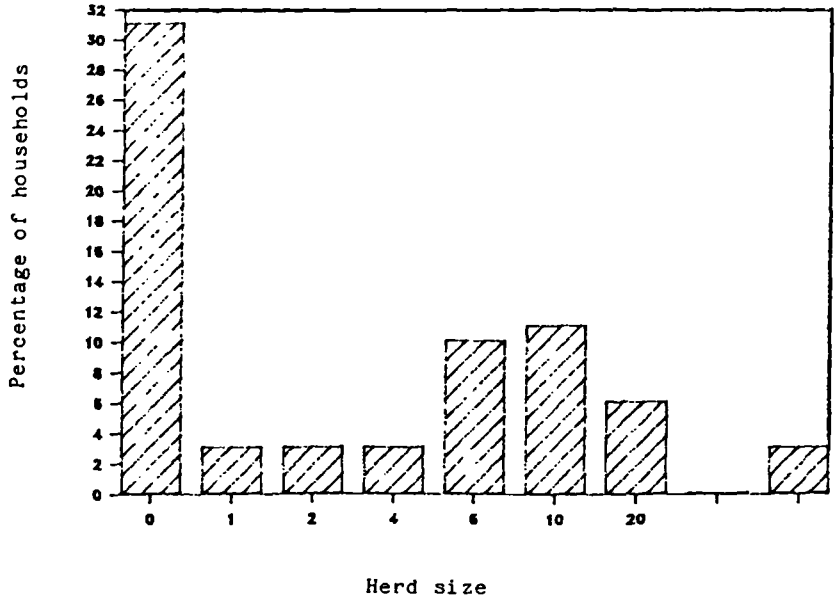


Figure 5.2: Goat ownership in the household sample

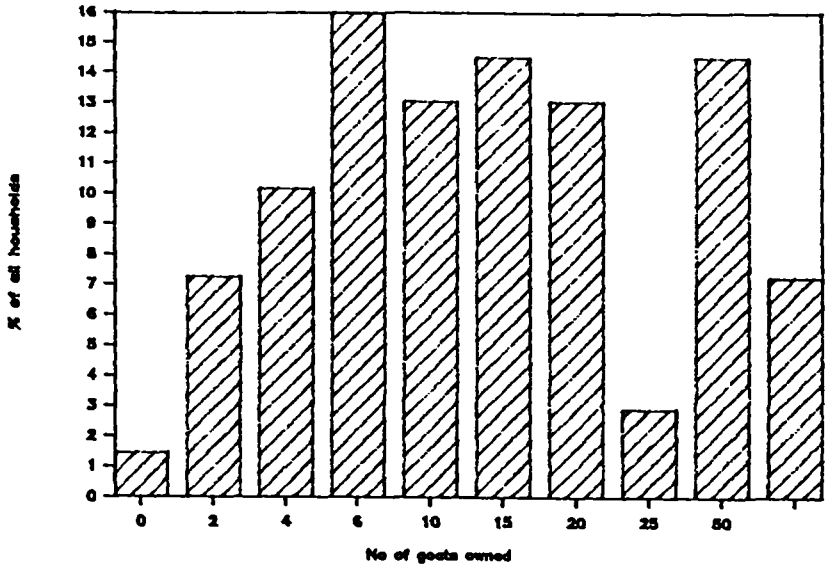


Figure 5.3: Donkey ownership in the household sample

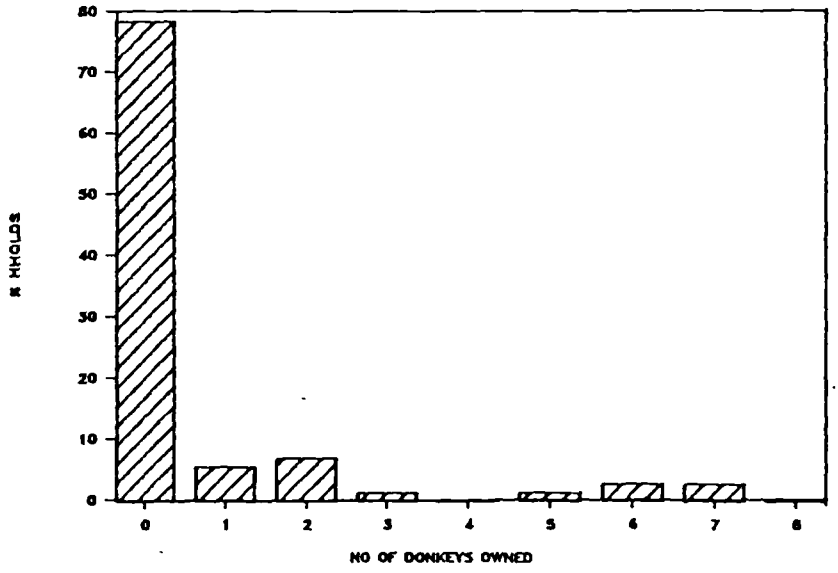


Table 5.1 Cattle herd composition

%	Sample 1987	Mberengwa 1986
Bulls	9.7	3
Oxen	18.9	20
Bullocks		10
Cows	31.3	32
Heifers	13.3	16
Male calves	14.4	
Female calves	12.4	18

Note: In this study bullocks (age 1-4) are not separately counted - these will be either oxen or bulls if post-weaning and castrated/not. Calves in this study represent animals up to weaning age; heifers are female animals between weaning and reproduction. In the GFA study the animals are differentiated by age (apparently from recall from farmers). In this study precise age differentiation was not attempted as dental assessment techniques were not known and farmer was recall variable in precision.

The ratio of male to female cattle is 43 : 57, representing a herd structure where males are retained within the herd for ploughing. Since the CA herds are still recovering from drought, females are kept to sustain herd growth. Adult females also contribute to work.

Table 5.2: Goat flock composition of sample flocks (early 87)

	%
Male goat	7.0
Castrated male	9.7
Female	43.6
Immature female	21.9
Male kid	8.9
Female kid	8.8

The ratio of males to females in the sample goat flock is 26 : 74. There is a high proportion of mature and immature female goats (60%+), representing a flock structure aimed at high growth for offtake and milk production.

Table 5.3: Donkey herd composition (sample 1987)

Age/Sex	%
Male donkey	34
Castrated male	17
Female	32
Male foal	12
Female foal	5

The donkey herd structure shows a bias towards males. The ratio of males to females is 63 : 37. Males are retained for work and are not sold off readily as there are few market opportunities for older animals.

This Chapter focusses on the comparative economic returns of cattle, donkeys and goats. Sheep, pigs and chickens will not be considered in depth. Sheep are owned by only 14% of households in the sample and pigs only by 1.5%. Detailed production data was not collected on these animals. Chickens are owned by nearly all homes, but their economic role is different to other livestock and their production will be considered in the context of household income and expenditure patterns in the next Chapter.

5.6 The value of cattle

The productivity of cattle is determined by the flow of goods and services over time. This must include an assessment of biological productivity as it varies according to climatic factors and the value of the different functions of cattle during the animal's lifetime. The value of male and female cattle is clearly different and in this discussion they will be treated separately.

The analysis will not be differentiated according to cattle breed since so much interbreeding has occurred since the introduction of exotics that a meaningful classification is impossible. The local Karanga (Mashona) cattle are the

original genetic stock in the area. These have been heavily influenced by the introduction of Afrikaanders and Tuli breeds initially in exchanges with local ranchers and later as part of a programme of breed improvement organised by the government (Chapter 3). A local farmer commented on this change:

> "The cattle used to be as small as goats until the Europeans gave bulls to each kraalhead". (Mhike, 3.12.87)

Oliver (1966, 1983) and Nobbs (1927) both agreed on the high quality of the local stock, being drought resistant, good draft animals and prolific breeders, with calving rates of between 72 and 92%. Nobbs noted the qualities of the Mashona cattle as draft animals:

> "The Mashona ox is a splendid draft animal... they seem capable of filling themselves with food off the veld more rapidly than grade stock and so need a shorter time at the outspan." (Nobbs, 1927: 335).

The introduced stock had different qualities that can be compared with the local breeds. Table 5.4 provides a qualitative comparison of cattle breeds, according to a range of criteria, based on a series of interviews in Mazvihwa. A ranking exercise was also carried out with a group of farmers to assess local perceptions of their relative benefits.

Table 5.4: Comparisons of cattle breeds

Ranked Breeds	Characteristics
1. Tuli	Survive droughts; good browsers; eat short grass; grow quickly - good for meat and milk; high calving rate as good as Karanga; excellent draft.
2= Karanga	Small; high calving rate; low meat and milk production; four to a span, but faster than other breeds; first

	calving 3y (compared to 5y for other breeds); drought resistant; used for spirit bulls (if black).
2= Afrikaander	Good draft; good browser; survive droughts.
4 Nkoni	Fast breeders and quick weaners; good milk production; suffer from tick infestation.
5. Brahman	Good draft but difficult to train; need alot of food, but good browsers; high milk production.
6. Sussex	Poor drought survival; need lots of water; good milk production; can plough with span of two.

The dominant cross-breed found today is a mix of either Afrikaander or Tuli with Karanga. This provides a hardy animal useful for a variety of tasks. An increasing trend has been the exchange of oxen for heifers with commercial ranchers in order to facilitate post-drought recovery in the communal areas. The result has been an influx of Brahman, Sussex, Hereford and other beef/milk cows which are not as suited to the local environment as the other cross-breeds.

Local management practices affect the productivity of animals. These practices were discussed with all cattle owners in the sample in a series of interviews. Night time kraaling is a standard practice, but most stock keepers claim this has no detrimental effect on productivity. In drought this practice is generally ceased. Herding management is an important determinant of nutritional maintenance; this will be considered in detail in Chapters 7 and 8.

Bulls are retained within the kraal at a higher level than the recommended overall level of 4%. In part this is

because of the presence of mudzimu (spirit) bulls which make up 33% of the total bull population in the sample (see Appendix 5). Castration of bullocks generally takes place at between 6 and 12 months, but some animals are castrated later up to the age of 3 due to the belief that this improves the strength of the draft animal. Weaning age is variable and depends on the reconception rates of cows. This in turn is affected by the availability of bulls in the local area and the level of nutrition. Active encouragement of weaning through the use of weaning plates or a stick through the calf's nose is done if the calf continues suckling after 18m - 2 years.

Biological productivity

The probability of mortality at various stages during the lifecycle of cattle is usually characterised as a "U" shaped curve, with high levels of mortality up to weaning and increased likelihood of death as the animal gets older, beyond 9-10 years. This simple pattern is further affected by the probability of death through the effects of droughts.

Data from the household sample can be used to assess some of these parameters. The limited time span over which observations were made is a constraint, but alternative data sources for the southern Zimbabwe CA situation are lacking. Interviews with farmers on the comparison of cattle breeds indicated that the Karanga cattle had a typical age of first calving of 3, while the imported breeds generally produced from age 4-5. Calving intervals also vary ranging from a fairly regular 1 year cycle in the Karanga and Tuli breeds, but generally between 1.5 and 2 years in other breeds.

Comparisons with records from other areas in dryland Africa show these productivity parameters are typical. A summary of production indices from various sources is given in Footnote (2).

Calving intervals can be assessed from the cow history data for the period between 1/84 and 6/88 for cows with two or more births recorded. These show differences between ecological zones (Table 5.5)

Table 5.5: Calving intervals by ecological zone

Zone	Interval (m)	N	SD	SE
Clay	17.65	51	7.46	0.2
Edge	14.65	52	5.37	0.7
Sand	15.40	19	5.18	1.2

This suggests a calving rate of 68% (+/- 1%) in the clay veld, 82% (+/- 4%) in the edge zone and 78% (+/- 6%) in the sand veld.

Using the same data and taking all births into account, an assessment of fertility rates can be done for two periods when data for the number of breeding cows is available (post 1982-4 drought and mid 1987).

Table 5.6: Cattle fertility: 1984-5 and 1986-7

Period	No of cows	No births	Calving rate
10/84 - 9/85	43	37	86%
10/86 - 9/87	106	82	77%

The high rate observed during the 84-5 season represents the recovery from the previous drought. The rate is lower during 86-7, but these two rates do not reveal the full range of inter-annual variability (see Chapter 7).

Data for calf mortality was collected by recall from cow histories. No significant difference in rates of mortality

between male and female calves could be detected over the whole period, so the aggregate pattern is presented in Table 5.7 for different seasons or parts of seasons.

Table 5.7: Calf mortality patterns.

Dates	% mortality
1/84 - 9/84	29.17
10/84 - 8/85	18.92
10/85 - 9/86	16.92
10/86 - 9/87	32.93
10/87 - 6/88	25.93

The level of mortality varies over the years, depending on rainfall and other factors. Data was not sufficient to examine the differences between ecological zones.

Adult mortality is also variable with high levels observed in droughts (see Chapter 7), but with relatively low levels of mortality in other years (around 2-3% see Chapter 4). The highest levels of mortality in drought are seen in the clay veld. The cattle population in the serious drought of 82-4 suffered approximately 70% loss to the sand veld loss of 60%. In the 1987 period the clay veld losses amounted to between 20% and 30% while the sand/edge zone suffered between 0% and 15% losses (see Chapter 7). For the period of study during the 1987 drought oxen in the sample suffered only 4% mortality. Cows and heifers suffered 24-29% mortality, while female calves suffered 42% loss. A similar pattern, but with higher rates of loss is shown for the 82-4 drought (see Chapter 7)

The data from the dip records for Mazvihwa provides another source of information for examining patterns of productivity between zones in different years. A summary of annual rates is given in Table 5.8 for the period between October 1983 and September 1988 for two pairs of dip tanks - Gwamadube and Makovora, broadly representative of the clay veld situation and Zerubi and Kwata, broadly

representative of the sand veld situation.

Table 5.8: Births (%B), Deaths (%D), Slaughters (%SL) and Sales (%S) in clay veld and sand veld dips, Mazvihwa. Numbers as proportion of census at October.

Clay veld	%B	%D	%SL	%SA
Oct 83 - Sept 84	0	0.4	1.6	7.8
Oct 84 - Sept 85	35	0	2	1
Oct 85 - Sept 86	16	0	2	0
Oct 86 - Sept 87	13	0	2	3
Oct 87 - Sept 88	7	18	1	2
Sand veld	**%B**	**%D**	**%SL**	**%SA**
Oct 83 - Sept 84	0.4	0.5	4.2	6.3
Oct 84 - Sept 85	24	0	4	2
Oct 85 - Sept 86	20	0	2	2
Oct 86 - Sept 87	14	1	2	4
Oct 87 - Sept 88	6	9	1	1

The dip data shows higher mortality rates for the clay veld population during the 1987 drought period, but the data does not extend far enough back to compare the 1982-4 period. Mortality rates in other years in both zones are low; older cattle that might have died either being sold or slaughtered. The dip record birth rate data (% births of total population) shows fairly comparable patterns between the two zones, but high recovery rates in the clay veld following the 1982-4 drought are notable (see Chapter 7). Assuming that 30 - 35% of the cattle population are breeding females, this represents a 100% calving rate that year in the clay veld and a 74% rate in the sand veld.

Milk production

Milk has a variety of uses, but is primarily used for consumption fresh or when soured. Other uses include the treatment of goat skins for mats, the use as a skin cream, for medicine and as a cooking oil. The market in milk

products is currently quite limited. In the past this was not so and people would travel regularly to Zvishavane on bicycles or on foot with milk for sale in the mine townships. This used to be an important income earner for households with cattle and living in the part of the study area within reasonable reach of the urban market. This has largely stopped because of marketing restrictions. The decline in stock holding has reduced the amount of surplus available for trading. Only one person in the sample was regularly trading milk (illegally) outside the Mazvihwa study area.

Milk production was assessed with a selection of cows within the household sample resident at three different homes. These sites included two in the clay veld area and one in the edge zone; insufficient data was collected from the sand veld area to allow any inter-zonal comparisons of yield. Daily measurements were taken of milk produced for the household from 12 cows between November 1986 and September 1987. A total of 1128 daily measurements were made representing a sample from each of the stages of lactation and across all seasons. The patterns of milk production over a full lactation is illustrated for several cows in Figure 5.4.

The output of milk varies seasonally according to the interaction of fodder availability to the mother and the timing of births. McNab (1965) found that cows calving in May-August had higher lactation yields in a study in Matabeleland. The seasonal production of milk per cow is illustrated in Figure 5.5. Table 5.9 supplies the output figures and the variation.

Figure 5.4: Milk production levels over a lactation

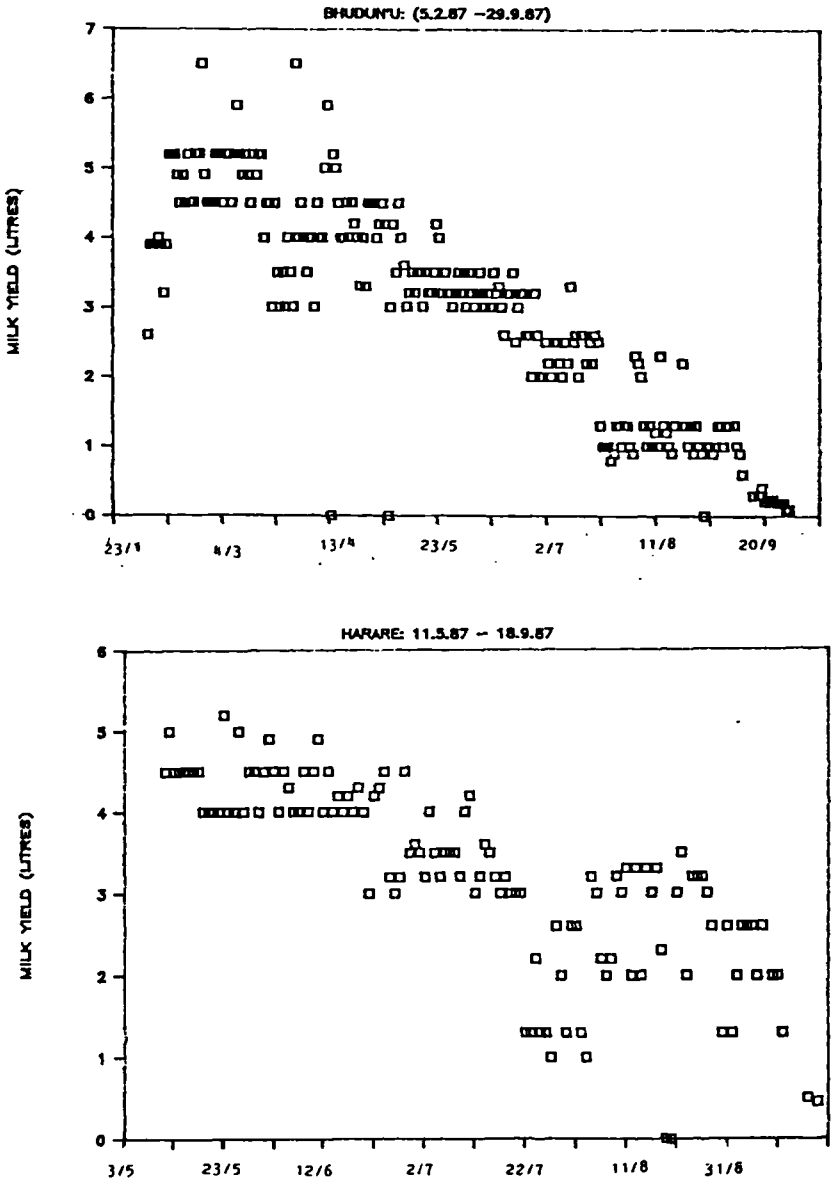


Figure 5.5: Seasonal milk production levels

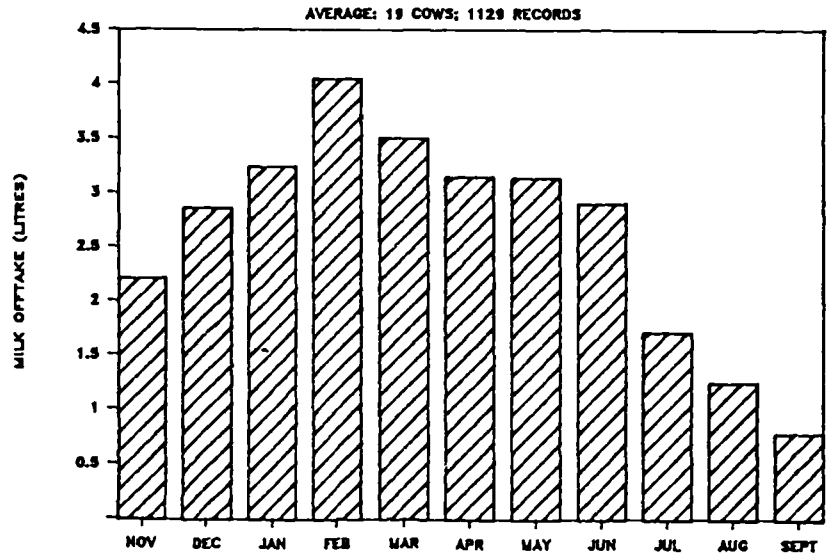


Table 5.9: Daily milk offtake (12 cows Mazvihwa sample)

Month	Average litres	N	SE
Nov	2.22	52	0.15
Dec	2.87	109	0.15
Jan	3.25	120	0.16
Feb	4.06	118	0.13
Mar	3.52	129	0.12
Apr	3.16	78	0.18
May	3.15	89	0.12
Jun	2.91	97	0.11
Jul	1.72	137	0.08
Aug	1.26	132	0.08
Sep	0.80	67	0.08

Overall: Average = 2.67 (+/- 0.05) litres/day

Maximum = 7.10 litres; Minimum = 0.0 litres

Milking practices vary greatly between different households. Cows are commonly milked around 9am following early morning grazing when the calves are kept within the kraal. Some owners attempt a second milking in the evening and keep the calves separate from the mothers all day. Calves are often kept in a separate kraal over night. The degree to which calves are allowed access to the cow's milk will depend on the quantity of milk being produced. As the dry season of 1987 progressed some owners ceased milking and left all the milk to the calves. Milking by households may start in the first week after the birth of the calf if it is healthy, but usually a three week delay is allowed. This allows the calf to ingest the first colostrum milk (mahtyaka) and only the mudzamba milk which arrives after two weeks is taken by humans. Additional human offtake occurs during herding when herd boys do not necessarily abide by these management practices. Weaning takes place after 6 months or so, but some calves suckle for up to a year unless weaning plates are used to restrain them.

The length of lactation period is variable and ranges from

6 to 8 months. Of the cows studied in detail the average was 6 months. Over this period the total output of milk to the household can be expected to be 480.6 litres according to the above calculations. The probability of this being received by the household will be dependent on the calving rate of the cows and the season of birth of the calf. Production rates are variable between cows; being dependent on both the timing of birth and individual variations between cows. Local informants suggests that individual cow differences are a very important source of variation in production levels, being more important than differences between breeds (3).

The value of this output can be assessed in terms of the replacement costs of purchase of milk from local stores. This sells at around 50c/litre for bottled sterilised milk. Locally produced milk is also sold fresh for 30-60c/litre and as soured magi at 25c/small plate. For valuation purposes a price of 50c/litre will be taken.

Access to locally produced milk is dependent on both cattle access (owned and loaned cattle) and sharing relationships within household clusters (see Chapter 6). In discussions on milk production each household was asked about access to milk. 55% of households had access to some of milk from cows held by them during some periods of the year. The larger herd owners shared milk with others or sold it locally. Non-cattle owners either were given milk by relatives and friends or had to buy it. The distribution of these categories is shown in Table 5.10.

Table 5.10: Access and distribution of milk products within the household sample (70 households).

	Cow holders			No direct access	
	Own	Share	Sell	Given	Buy
% of all households	54.8	24.6	13.7	24.6	20.6

Sales and slaughters

Voluntary sales of cattle from the communal areas have always been limited (see Chapter 3). Sales to commercial ranchers who picked up 'scrub' animals, sales to itinerant traders and official registered sales have all been methods of sale of both cattle and goats. All routes exist today, but the official sales are encouraged. Today these give good prices for cattle, some of the more disadvantageous price distortions having been removed over the past decade. However exchanges with commercial ranchers are still popular.

Cattle slaughters are rare today and restricted to big occasions or to instances where the animal is about to die. In the past cattle slaughter is remembered as being much more important. Cattle have a number of ceremonial or symbolic uses where they may be slaughtered or exchanged. These events are not that common, but some of the occasions where livestock are used for ceremonial purposes in the study area are documented in Appendix 5.

During the 1987 study of the sample cattle there were a total of 22 sales or exchanges of cattle and no slaughters. Taking the mid 1987 census, this represents a 5.71% offtake. Data from dip records show similar levels of offtake in other years, but a range from 1% to 8%. This latter estimate represents 'official' sales, and so is probably an underestimate of actual sales levels. This is more accurately reflected in the sample data, where a number of sales were complex exchanges or payment over a period.

Most sales were of oxen (see Table 5.11) and the predominant reason for sale was raising money for school fees (Table 5.12).

Table 5.11: Sales of different cattle types

Type	% of sales	Ave price ($)
Oxen	81.8	440.33
Cows	13.6	375.00
Bullock	4.5	100.00

Table 5.12: Reasons for sale

	% of sales
School fees	45.45
Stock purchase	22.72
Lobola	18.18
Drought	13.63

A further 20 cattle were purchased into the sample herd. This represents a 5.2% increase on the mid-87 baseline. The details of these purchases are illustrated in Table 5.13.

Table 5.13: Purchases of cattle (sample 1987)

	% of all purchases
Heifers	55
Cows	20
Oxen	15
Female calf	5
Male calf	5
Reasons for purchase	
Herd growth	52.6
Herd establishment	36.8
Fattening	10.5

The general pattern of purchasing heifers or younger cows to establish or expand a herd and selling off older oxen can be clearly seen in the data. Sales tend to be when animals are close to the end of their productive working

life. For oxen this is around age 8-10 and for cows around 10. Other sales occur when there is a serious need to raise cash, such as for school fees. Except for those households with large herds, the offtake age is not 'optimal' according to meat production criteria (Ariza-Nino and Shapiro, 1984).

Most sales appear to be from larger herds (see Chapter 6). The realisation of cash from sales is thus differentiated according to herd owner. Large herd owners can make regular sales if the herd size is 'surplus' to agropastoral requirements, whereas smaller herd owners will only sell if the animal has reached the end of its working life or if the household is in urgent need of cash (see Chapter 4).

Manure

The use of manure for fertilisation only became widespread in Mazvihwa in the 1950s following the promotion of its benefits by Agricultural Demonstrators. In other areas it was adopted earlier, but there was some resistance initially to the idea due to the increased labour and transport demands it required (see Chapter 3). Today it is almost universal in the sand veld and widely applied in the clay veld zone, although only once every few years. Cattle manure is preferred for the crop land since it does not tend to 'burn' the crops and spreads fewer weeds, but goat manure is liked in vegetable gardens where weeds are more easily controlled. Donkey manure is regarded as worthless as it can just be "blown by the wind into dust".

Manure has other uses besides as an input to agriculture. It is important in building (especially for preparing floors), is used in the lining of baskets, and on rare occasions can be used for supplementary fuel. In the past, it was used in the 'umbilical cord' ceremony of a new born baby. Economic valuations of these uses will not be attempted.

The amount and quality of manure produced by cattle is dependent on the bulk and quality of feed intake, which in turn relates to the nature of the forage resource and the size of the animal. There have been few studies of manure production from CA cattle, but those that exist suggest that the quality of manure produced is poor with large fractions of sand contained (Mugwira and Mukurumbira, 1984).

Application rates of manure vary widely between households and ecological zones, but GFA (1987: 87) estimate that in Chivi and Mberengwa 1.4 and 1.2 tonnes of manure are applied per household per year. The fertiliser value of manure has been estimated by ARDA (1987). They assume that 1 tonne of manure is equivalent in nutrient status to 200kgs of fertiliser which is worth $60. If an animal produces 1 tonne of manure/year of which 40% is recoverable for application in the arable lands the annual value of manure production per adult animal is taken to be $24.

The value of manure from cattle is dependent on the marginal increases in agricultural production achieved through its application. In poor granitic sands this may be quite significant (Grant, 1981), but on the heavier soils the benefits are less. The value will also be determined by the type of season. In good rainfall years, when soil moisture is not limiting to plant growth the application of manure to heavy soils may increase production, but in low rainfall years manuring may result in the 'burning' of plants. The value of manure not only relates to its fertilisation properties but also to the contribution of organic matter to soil structure. The residual presence of manure also makes any assessment of its application difficult to assess. Farmers tend to rotate the application of manure to different portions of their fields. Improvements in soil structure and fertility may persist over a number of years.

Of the 67 households for which manure use was investigated

for the 1986-7 season there were a range of strategies used in acquiring cattle manure for application in fields and gardens. 50% of households applied manure from their own kraal, a further 10% were given a portion by relatives, while one household purchased a load of manure. 39% of all households did not apply manure during that season. This was due to a number of reasons. Either they had no access at all or they shared a kraal with another household and it was not their turn to remove manure, or they only occasionally dug manure, because of too few cattle or because they did not think the returns on the labour involved in using manure would be repaid. This latter reason was given by people living in the clay zone where the marginal increases in yield from manure application are lower than in the sand or edge zones. This is reflected in the data on manure use presented in Table 5.14.

Table 5.14: Acquisition of manure (total 67 households)

Zone		Own	Given	None	Buy
Clay	(%)	41	10	49	0
Edge	(%)	52	10	33	5
Sand	(%)	86	14	0	0

The amount of manure that becomes available for inputs to agriculture from any one animal is dependent on foraging behaviour and kraaling practices. If herds are kraaled each night the manure produced during that period will be collected in the kraal. Manure produced during the day time may be deposited in the grazing areas or on the fields. Arable land grazing is concentrated in the dry season following harvest (see Chapter 8) and the degree to which dung deposited during this period contributes to soil improvement in fields is unknown. The rapid drying of dung pats and slow mineralisation and decomposition rates suggests that the contribution may be quite small.

The proportion of dung produced at different times of the

day and night and estimates of its weight were carried out in a short study during April 1987 (4).

Table 5.15: Manure production

	Number of cattle days observed	Dung pats Avg No.	SD	% of total
Day	71	23.8	5.3	57.6
Night	36	17.5	3.8	42.4

Note: The average sun dry weight of a sample of dung pat units was found to be 137.5g.

If it is assumed that cattle are kraaled throughout the year, then approximately 879kg of dry dung will be produced per year in the kraal using the above estimates. This is probably an overestimate as the April study coincided with high, moist fodder availability and presumably higher dung production rates than at other times of year. Compared to the manure production rates assumed by ARDA (1987), this level is very high. However if this figure is taken this represents 2.6 carts worth (5). The market value of this depends on the area, and as Table 5.15 shows, very little is actually sold. Discussions with local informants however suggested $10 as a reasonable price per cart. Thus total annual recovered manure production per animal can be calculated as $26.

Work of cattle

Cattle are involved in a range of activities at different times of year. Cattle are joined together to form a work span. These may consist of two or four animals yoked together. They may come from the same owner or several owners may combine their animals to form a span. Within the sample households a total of 41 spans existed during 1987. Arrangements regularly change and by 1988 the number had increased to 49. For the purposes of the present analysis

the 1987 situation will be considered, but the dynamic nature of cooperative relationships of span formation within and between lineage clusters should be remembered, lest a static impression is given by the single time frame data presented here (see Appendix 9).

In the post-drought recovery situation of 1987, spans were constructed from a range of animals, combining oxen, cows, heifers, bullocks and donkeys. Of the spans identified during the study period of 1987 the ratio of male and female cattle and donkeys is shown in Table 5.16 (6).

Table 5.16: Composition of spans in the sample

	Males	Females	Donkeys
Nos	58	57	17
Percent	44%	44%	12%

The 132 cattle used regularly in work spans represents 57% of the total adult cattle population (mid-87 census). The average size of span according to this data is 3.2 animals or 2.8 cattle.

Over a 17 month period from June 1986 to October 1987 the work of cattle spans were assessed on a monthly basis (7). Each household was asked to explain the use of cattle over the previous week and to describe the tasks carried out and the number of days the cattle were used. The cattle used were not necessarily owned by the household; they may have been borrowed or hired. All the work recorded was by the 41 spans of cattle within the sample.

The seasonal pattern of work of cattle is illustrated in Figure 5.6. Activities are aggregated into two groups: agriculture (ploughing, harrowing, threshing, manuring) and transport (water, poles, firewood, fencing, bricks, stover, and harvest transport).

Figure 5.6: Seasonal pattern of work of cattle

For explanation of codes used see Table 5.17

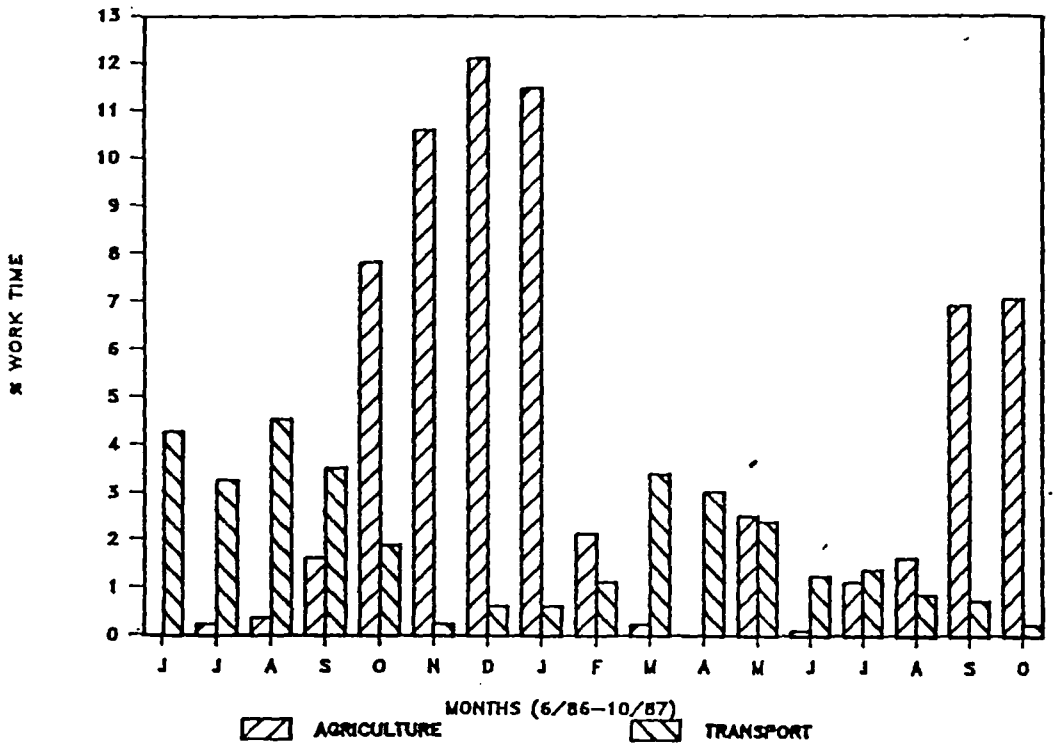
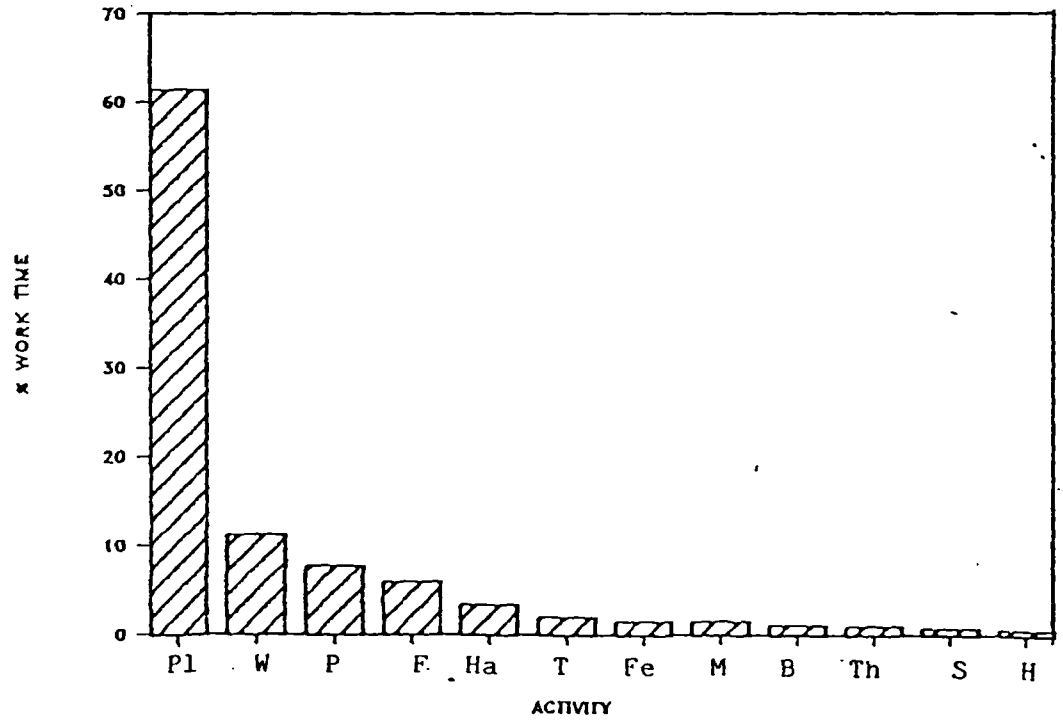


Figure 5.7: Cattle work activities

For explanation of codes used see Table 5.17



The data shows that work peaks during the agricultural season when cattle are employed principally for ploughing. However during the dry season cattle are not idle as important transportation tasks are carried out (March - May) such as harvest collection. Winter ploughing during the dry season is also significant. The pattern of work by individual activities is shown in Figure 5.7.

Table 5.17: Work per span for period 11/86 - 10/87 by activity (codes for Figures 5.6-5.7).

Activity		Span Days/year
Agriculture:		
Ploughing	(Pl)	40.8
Threshing	(Th)	0.3
Harrowing	(H)	2.2
Harvest	(Ha)	0.6
Stover	(S)	0.6
Manure	(M)	0.3
Transport		
Water	(W)	4.3
Poles	(P)	3.1
Firewood	(F)	0.9
Fence	(Fe)	0.5
Bricks	(B)	0.4
Transport	(T)	1.7

The total number of days per year that each span spends working is 55.4 for the period from 11/86 to 10/87. If the year between 6/86 and 5/87 is taken 60.5 span days are worked on average.

Putting a monetary value on this work output of cattle is difficult as there is only a limited local market for hired spans. This is mostly for ploughing where the span owner will also put in his labour to plough certain areas for money. During 1987 the charges ranged from Z$10 to Z$45 per contour (a portion of a field). Hiring for transport was rare and the cost charged included labour and the use of a cart. Depending on the distance travelled and the amount of

labour involved, the charges were comparable to ploughing. Supply factors clearly influence the local price and with cattle as a scarce commodity following the reduction in populations in 1982-4 and the desire of owners to conserve the condition of their own stock during 1987, the prices were consequently higher than those recalled for previous years. However a daily rate of Z$30 for hire during 1987 would be a reasonable estimate of local value. This means therefore that the total value of work carried out during the year ranged from Z$1662 to Z$1815. With an average of 2.8 cattle per span this means the individual animal value ranges from Z$593 to Z$648 per annum. This is split according to activity as follows:

Table 5.18: Value of activities/animal(cattle)/year

Activity	Value (Z$)
Ploughing	436
Threshing/Harrowing	26
Agricultural transport	15
Transport	116

The value of cattle to agricultural production has been demonstrated in a number of studies in Zimbabwe (Collinson, 1982; Shumba, 1984; GFA, 1987). The GFA study shows how estimated grain yields in Kg/household increased by 370% on average with an increase in cattle holding from 0 to 12+. This is partly accounted for in terms of arable area increases which rise by 32%, but yield in kg/ha increase by 174%. The actual value of a marginal increase in cattle holding for increased production varies both between years, farmers and ecological zone; this makes valuation difficult.

The relationship between crop production and cattle ownership can be investigated by correlation analysis. The results are set out in Table 5.19. The cattle ownership data are those for mid-1987. Clearly the actual numbers of

cattle available in other years was different, but the correlation between cattle ownership in mid-87 and estimated ownership both pre- and post the 1984 drought and post the 1987 drought was sufficiently high (r = 0.78 - 0.89; all p > 0.000) to suggest that the pattern of ownership has remained fairly stable across the three years for which there exists harvest data. For this reason the 1987 ownership data are used in all regressions and correlatins to explore the relationships.

Table 5.19: Cattle ownership (1987 data) and crop production: correlation analysis.

	Correl coeff	1-tailed sig	N
(Bags)			
Y84	0.47	0.000	69
Y85	0.54	0.000	70
y86	0.55	0.000	70
(Bags/ha)			
Yha84	0.37	0.002	65
Yha85	0.40	0.001	66
Yha86	0.40	0.001	66
(Z$)			
TOT84	0.32	0.008	69
TOT85	0.48	0.000	70
TOT86	0.32	0.008	70
(Z$/ha)			
Tha84	0.42	0.001	65
Tha85	0.47	0.000	66
Tha86	0.38	0.002	66
(Z$/AEU)			
Tl84	0.25	0.032	69
Tl85	0.33	0.006	70
Tl86	0.22	0.054	70

Notes: Y = Yeild of grain (bags); Yha = yeild/ha of grain (bags); TOT = Total income from all crops; Tha = Total income from crops per hectare; Tl = Total crop income per Adult equivalent unit; 84 = 84-5 agricultural season (8).

A clear positive relationship does appear to exist between crop yields and cattle ownership, both in terms of crop output and yield per unit area. The interaction of factors

affecting overall crop production, and the component role of cattle, will be assessed in the next Chapter.

5.7 The value of donkeys

The number of donkeys being kept in Mazvihwa has increased in recent years. Following the droughts that devastated cattle populations in the early 1980s people are increasingly investing in donkeys as draft animals. Their arrival in the area over the past 30 years has been slow (see Chapter 3). Some comments reflect the local perceptions of their increasing value:

> "The donkeys just arrived one by one. People had found them useful for transport. They came especially during drought when people needed to move food around." (Group discussion, Mapedza, 21.10.87)

> "Donkeys are the only animals that can survive the drought... that is why I exchanged the cattle for them...my son went to school because of donkeys." (Chinguo, Mototi, 13.3.87)

Local people comment that the key advantages of donkeys are:

- Their permanent readiness for work, unlike cattle which need specific feeding, watering and resting times.

- Their skill as draft animals since they move slower than cattle and follow the furrow more efficiently. However they are unable to plough deeply and are best combined with cattle in a span.

- They behave better than cattle and do not damage the carts they pull.

- They are very drought resistant; feeding on bark, twigs and grazing grass very short.

A number of disadvantages were mentioned during interviews:

- The tendency of donkeys to wander off and the need for close herding. This habit increases the likelihood

of them being stolen.

- They are of no use for lobola payments or meat. The milk has only a single use as a treatment for whooping cough.

- Manure is useless for fields.

Their traditional role as a key transport animal remains. Local prices have risen from around $30 up to $100 or more over the period from 1985 as demand has increased.

Biological productivity

The fertility and mortality patterns of CA donkeys have never been studied, so there is no comparative data to work from. The information gained from the sample population of 64 donkeys is given in Table 5.20. The sample population is distributed according to age and sex class as shown in Table 5.3.

Fertility is estimated as the number of foals in the population (assumed born in the last year) as a percentage of total breeding females present during late 1987, when the most accurate census of donkeys was carried out. Mortality represents the death rate of donkeys during 1987 calculated according to the number of deaths as a percentage of the total donkey population. All deaths were recorded during November and December of 1987, at the peak of the drought. In other years people do not recall any donkey mortality, except that due to old age. Indeed the period around November 1987 was a time when people were quite shocked to see donkeys suffering; this was seen as a very bad sign for the survival prospects of any other stock.

The parameters indicated in Table 5.20 probably represent relatively high death rates and low birth rates in the range of levels that donkey populations exhibit under all

conditions. Despite this the donkey population still apparently grows under drought conditions. In a simple calculation assuming death rates according to age/sex categories described above and acting before births the population would grow at a rate of 7.35% pa.

Table 5.20: Donkey population parameters (1987)

Overall rates:	
Birth rate:	52.4%
Death rate:	6.25%
Death rate by age/sex class:	(%)
Male	20.0
Castrated male	0.0
Female	14.3
Female foal	100.0
Male foal	12.5

The data available from the sample donkey population was insufficient to investigate differences between ecological zone. However the impression is that donkeys survive fairly well in each of the savanna environments and no great variation in production parameters between zones is expected.

Sales and purchases

Over the period of study (11/86 to 3/88) when records were kept of sales, purchases and exchanges a total of 7 sales and 8 purchases were recorded. On an annual basis and using the late 1987 census as the baseline this represents a sales rate of 7.6% and a purchase rate of 8.8%.

Prices paid during this period ranged from $45 for a young untrained donkey to $120 for a mature male or female animal. Not all purchases and sales involved cash as some were carried out on the basis of exchange with cattle.

Work

Within the sample there are 53 adult working donkeys; these usually work in pairs for transportation activities. However the precise arrangements change over time with different combinations operating. For most activities it can be assumed that a pair of donkeys work making a total of 26.5 pairs. For trips to the grinding mill a single donkey is used. For ploughing, donkeys may combine with cattle in spans or plough alone (see Table 5.16). The work of these donkeys was monitored over the period 6/86 to 10/87 as for cattle. The pattern of activities on a seasonal basis is illustrated in Figure 5.8.

The range of activities that donkeys are involved in is shown in Table 5.21 and Figure 5.9 (9). Table 5.21 indicates the annual workload of donkeys for the different activities identified. An attempt is made to put a monetary valuation on this work. It is assumed that all transport activities except mill trips are carried out in pairs, usually with a cart. The local cost of hire is around $30/day as for cattle. Whether this cost reflects the true value of the donkey or the fact that labour and use of a cart is also included is again unknown. The access to donkeys does not tend to be highly market oriented. Generally people have amicable sharing relations with other members of lineage clusters and often people outside. In such situations very limited, if any, cash transactions take place (see Appendix 9).

For the purposes of the economic valuation a replacement value method will again be taken to assess the value of donkey's work. Ploughing and other agricultural activities are valued at the same rate as transport assuming again work in pairs. For mill visits single donkeys are used with sacks of grain slung over their backs. The charge rate is much lower ranging from as little as 30c to $2; a rate of $1 per trip is assumed for the purposes of these calculations.

Figure 5.8: Seasonal pattern of work of donkeys

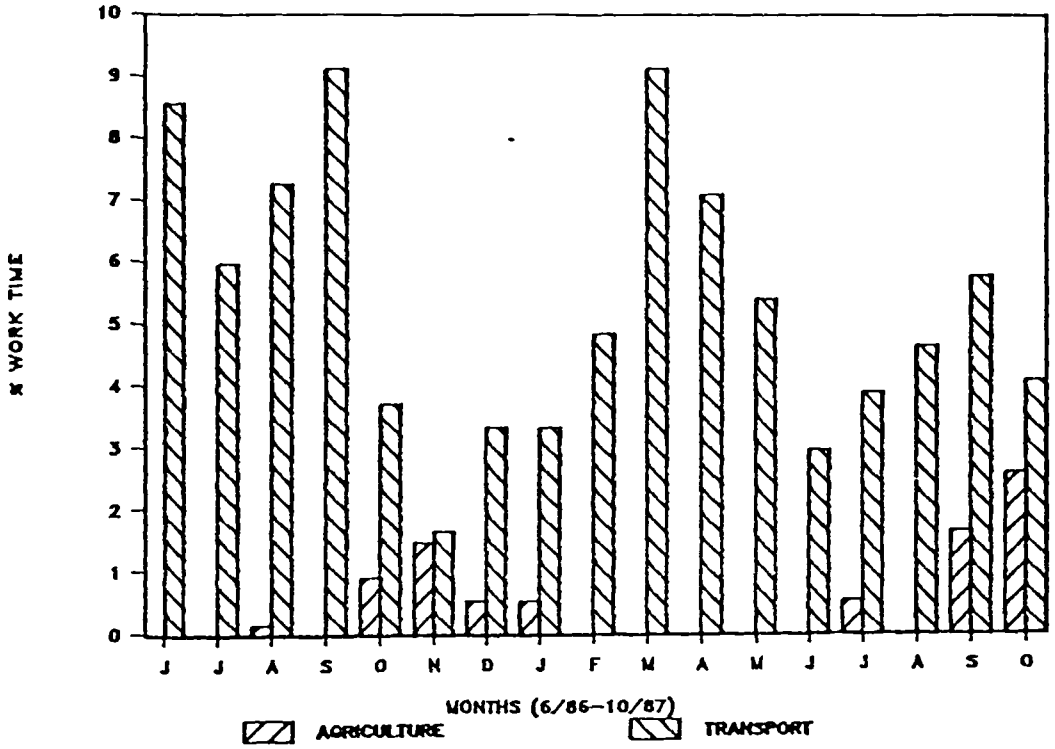


Figure 5.9: Donkey work activities

For explanation of codes used see Table 5.21

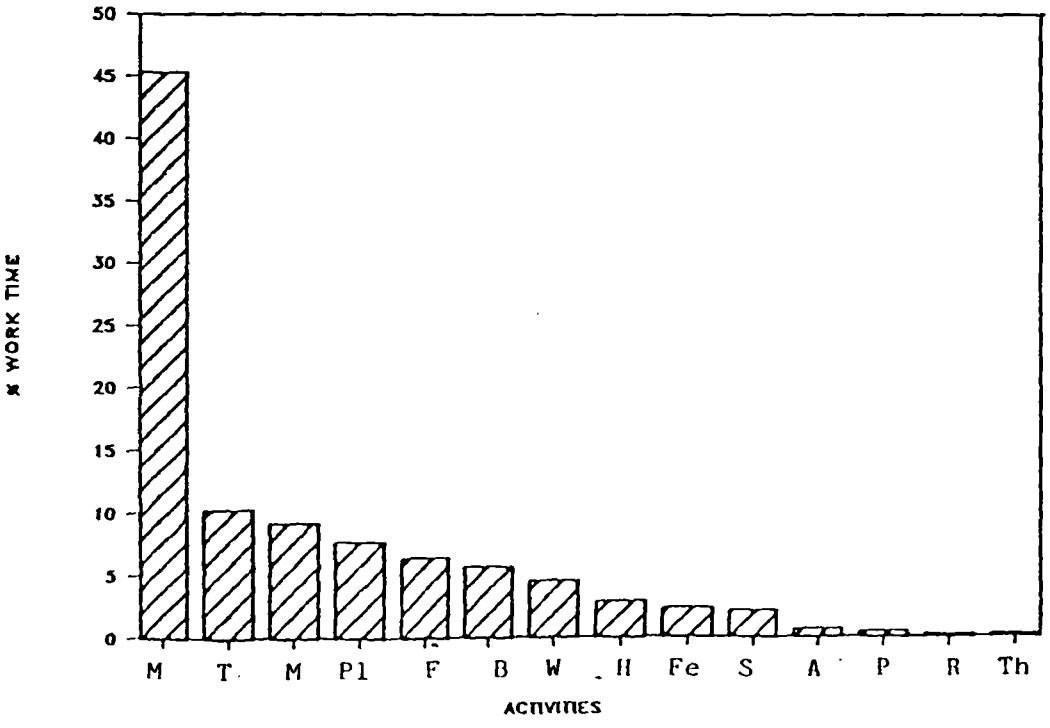


Table 5.21: Work of donkeys (codes for Fig 5.9; Fig 5.8: agriculture = Pl+R+Ma+H+Th; Transport = T+F+B+W+Fe+S+A+P

	Days/donkey pair/yr		Value ($)/donkey/year	
Activity	Yr1	Yr2	Yr1	Yr2
MILL (M)	13.51(*)	12.53	13.51	12.53
TRANSPORT (T)	7.85	5.13	117.74	76.98
MANURE (Ma)	4.53	3.32	67.92	49.81
PLOUGH (Pl)	2.57	5.58	38.49	83.77
FIREWOOD (F)	3.92	2.57	58.87	38.49
BRICKS (B)	4.68	0.30	70.19	4.53
WATER (W)	1.51	3.47	22.64	52.08
HARVEST (H)	2.42	1.66	36.23	24.91
FENCE (Fe)	1.66	1.36	24.91	20.38
STOVER (S)	1.81	1.81	27.17	27.17
AMBULANCE (A)	0.60	0.60	9.06	9.06
POLES (P)	0.30	0.30	4.53	4.53
RIDGE (R)	0.30	0.30	4.53	4.53
THRESH (Th)	0.15	0.15	2.26	2.26
	45.81	39.09	498.04	411.02

Where: Yr1 = 6/86 to 5/87 and Yr2 = 11/86 to 10/87
Value at $30/day per donkey pair
(*) Mill calculations at $1/ single animal

5.8 The value of goats

The value of goats is in their terminal products - meat and to a lesser extent skins. Goats are important sources of cash income for households; slaughter for household consumption is also significant. Milk production is small but important in some households. Manure is used for application to gardens, but rarely to fields as it tends to spread Acacia seedlings.

Within the Mazvihwa study area two breeds of goats are present. These are locally known as the Ndebele and vusiri or Mashona goat. The data collected from the household sample goat flocks did not differentiate between these two

types. There is a good deal of interbreeding so a separate documentation of all parameters by breed type would be impossible. However a series of discussions with farmers helped to frame the general differences between the two. This is summarised in Table 5.22.

Table 5.22: Comparisons of goat breeds

Mashona	Ndebele
Small size	Large size
Medium/low prices ($25 - $35)	High prices ($40 plus)
Early first birth (3-6 months)	Later first parturition (8-9 months).
Short kidding intervals (c. 5 months)	Longer kidding intervals (c. 8 months)
Low twining rates	Higher twinning rates (after first birth)
Weaning age young (3-4 months)	Weaning age older (5-6 months)
More grazing; can eat down to the ground.	Less grazing, more browse
Best in sand veld, hilly zone	Best in clay veld plains zone

Goat flocks within the sample were monitored on a monthly basis from March 1987 to February 1988. Each month the number of births, deaths, sales and purchases was recorded. From this data and the baseline goat flock census carried out in February 1987 estimates of population parameters as percentage rates of overall population (or adult female population in the case of birth rates) can be made. The data represents aggregated rates by zone and does not consider variations between flocks. This is more closely investigated in Chapter 7.

Table 5.23: Population parameters of goats in sample: annual rates (10)

Zone	Birth %/fem	Death Kid	Death Adult	Slt %	Sale %	Purch %
Clay	173.4	27.8	3.7	29.2	12.8	4.2
Edge	220.9	64.6	11.0	25.4	13.5	2.9
Sand	279.2	70.0	19.7	48.2	25.4	5.4
Total	197.3	46.1	7.3	29.8	14.2	3.9

Birth and death rates

Birth rates are high with an overall level of nearly two kids per adult female per year. Farmers claim that birth peaks occur around December and May, but the seasonal data from the sample in 1987 does not highlight this pattern. The sex ratio of all births observed was Male:Female 1 : 1.2 The twinning rates of goats in the three zones is shown in Table 5.24.

Table 5.24: Twinning rates among goats in sample by ecological zone (Number of births recorded = 579).

Zone	Singles %	Twins %	Triplets %
Clay	59	40	1
Edge	65	34	1
Sand	63	37	0
Overall	61	38	1

Assuming an average of two kids per year and a twinning rate of 40% this implies the expected inter-kid interval will be about 8.4 months. This is comparable to other estimates (11).

Patterns of mortality vary significantly across different zones (see Chapter 7). Across all zones 85% of all goat mortality recorded was of pre-weaning kids. The amount of adult mortality was slightly higher in the sand veld zone due to high levels of predation (see Chapter 7), but in the calculations of kid mortality these variations were not taken into account. The kid mortality rate is high at an overall level of 46%. Adult mortality is comparatively low, but ranges between 4% and 20% depending on the zone.

Production inidices based on other studies of goat populations in dryland Africa are shown in Footnote (11) for comparison.

Sales, slaughters and purchases

The pattern of sales, slaughters and purchases by ecological zone is illustrated in Table 5.23. These parameters are measured as the total for the year as a percentage of the baseline population.

Sales represent an overall offtake of 14%. Sales are either of breeding goats (young females) or of goats for slaughter (castrated males). The price for an adult goat ranges from $30 to $45, with an average of around $40, but the local market is not consistent in its pricing levels. The official market for goats is only rarely held and the Cold Storage Commission buys on a weight basis (80c/kg in late 87); prices offered at the official sale ranged from $25 to $65. The added value of (illegally) transporting a goat for sale in town or an area outside Mazvihwa where goats are of poor quality is quite considerable. However, for the purposes of the valuation of goat outputs a $40 average value can be assigned.

Slaughters for home consumption tend to be of castrated male goats, unless the goat flock is excessively depleted, when uncastrated males or young or very old females may be killed. Castrated males are preferred because of taste.

Castration occurs from the age of 1 week (using teeth) to 5-6 months. The lifetime in the flock varies between 1 to 3 years for castrated males to 4-5 years for uncastrated males to between 6 and 20 years for reproducing females, according to local informants.

The value of a slaughtered beast can be made in terms of the replacement cost of that animal, so the sale price can be allocated. Additional value from skins is derived from slaughtered animals. Skins are mostly used for floor coverings in the home, but can be sold to local dealers who buy up goat skins for $5 each.

Purchases are either for increasing a breeding flock in which case young females are bought, or for slaughter. The values attributable to purchases are the same as those discussed above.

Milk

Goats' milk is widely used as an alternative or complement to cattle milk, however its use is somewhat stigmatised. Goats' milk is definitely regarded as inferior to cattle's milk, so people will often deny the use of it or say that it is only the children who collect it occasionally. During discussions of milk use 36% of sample households admitted to the regular milking of goats. Milk is produced in small quantities and used mostly for putting in tea.

If goats are assumed to have on average an 8 month lactation period and an 8.4 month birth interval, there is clearly potential milk available throughout the year. However, production levels drop dramatically in the dry season and it is thought milking then would seriously endanger kid survival. Milking is effectively restricted to a 4-5 month period during the rains when an average amount of 150ml is extracted.

Goats' milk has no market, so it is difficult to suggest an economic value. However on the replacement cost basis the cows' milk value of 50c/litre can be assigned.

5.9 Costs of production

The main cost of maintaining livestock to households is herding labour. Dipping and other veterinary costs are met by government in the CAs.

Veterinary support

The costs of production should include an allowance for the inputs supplied by government. ARDA (1987) have made estimates of the fixed and variable costs of production for communal areas on a per LU basis. The economic costs are summarised below for a dipping set up catering for 1500LU.

Table 5.25: Economic costs of livestock services per LU in communal areas (from ARDA, 1987)

Variable Costs	Z$
Vet service and medicine	3.7
Fixed costs	
Dip depreciation ($9000 over 25y)	0.2
Dip maintenance (5% of $9000)	0.28
Dip fluid ($3750/15000l dip)	2.3
Dip cleaning ($140/dip)	0.03
Water carrier ($1394 pa)	0.3
Attendant ($1802 pa)	0.2
Water supplies	0.28
Total costs	7.3

Environmental costs

If a full evaluation of the costs and benefits of communal area livestock production was being carried out, the environmental costs resulting from the investment in

additional animals should be accounted for.

Some would argue that the addition of more stock to the CAs will inevitably result in some form of environmental degradation and the environmental cost to society incurred would exceed the value in terms of output and services of those additional animals.

However, the data to assess the potential costs of environmental degradation and to suggest the probability of its occurrence do not exist and no attempt at quantitative environmental cost accounting will be made here. However in Chapter 9 a qualitative discussion of the dynamics of degradation in the communal lands and the role of livestock will be presented. Evidence for the likelihood of long term environmental damage can then be placed alongside the estimates of economic value presented in this Chapter, to assess possible relative costs and benefits of different stocking strategies.

Stock herding

Livestock are herded from the onset of the agricultural season with the first rains until harvest. Details of herding practices are discussed in Chapter 8.

For cattle holders there are a number of different options for mobilising herding labour. Cooperative arrangements between different households are popular, where two to four herds are combined and households rotate responsibility for herding. The average number of herds combined in a cooperative arrangement is 2.9. Hiring is another option open only to those households with sufficient cash to employ someone; usually a young boy whose parents have insufficient money to send him to school. The final option is the use of own household labour. The distribution of these options amongst cattle holding households is shown in Table 5.26.

Table 5.26: Herding arrangements

	Cooperative	Hiring	Own labour
% of all cattle holding hh	68	20	12

The valuation of herding labour is problematic. Shadow prices of labour in the rural areas are difficult to assign, because of the lack of a formal labour market. However if the rates used for hiring herd boys is used, the range exhibited amongst the labour hiring households in the sample is from $30 to $60 per month. In each case the herder is given accommodation and food in addition to the wage. This employment will last for approximately six months (eg November to April).

Other labour is hired for agricultural tasks and is rated at different levels according to task. An overall rate of $2/day represents the average; this is the same rate as paid for Cash for Work schemes run by the government.

If a $60/month rate is taken this means a total outlay of $360 over the year. This assumes that the opportunity cost of not using adult labour as a component of the herding strategy is represented by the hiring rate. Children's labour is therefore not explicitly considered. Considering all the possible herding arrangements taken by people in the sample households, the average size of a herd that is looked after by a single individual is about 8. This means the cost of herding per animal is $45/year. A similar cost can be ascribed to donkeys which are generally herded along with cattle.

Goat herding is primarily the responsibility of young children. The herding of goats is often combined with cattle. Many homes leave the goats in the kraal or immediately around the home until children return from

school. Goats are then taken for drinking and brought back with the cattle. Households without younger children either combine with other homes for herding or employ adult labour. No-one hires labour explicitly for goats and since herding is carried out mostly by children costing in monetary terms is difficult. However if a calculation is done on the same basis as for cattle, where a $60/month rate is taken for 6 months herding, for 50 goats the labour cost per goat/year would be $7.

5.10 The valuation of cattle products and services: economic and local assessments

The relative value of different cattle functions

The value of different cattle products and services - draft, transport, milk, and sales is summarised in Table 5.27 and a ranking of different functions given according to the assessed economic values. This summarises the results presented in section 5.6. But how does this valuation, using a whole range of assumptions, relate to local perceptions of different cattle functions?

Table 5.27: Ranked economic value of cattle functions

Function	Economic value/year/adult (Z$)
Draught	462
Milk	180
Transport	131
Manure	13 - 26
Sale	15
Slaughter	0
Total	801-814

Note: Sales taken as a 5% benefit stream from average per head capital valuation of sample herd at mid-87 (12).

A pair-wise ranking exercise was carried out with farmers from different ecological zones and of different sexes. The ranking game aimed to elicit the criteria on which people

value different functions of cattle and to derive a ranked list of the functions of cattle. Functions were chosen to assess and each was depicted diagrammatically on a card. Each card was then presented together with another one and the question asked "Of these two functions which in your view is the most important? Why?", until all possible pairs were combined. The results of the ranking are shown in Table 5.28.

Table 5.28: Farmers' ranking of cattle functions

	Overall	Women	Men	Clay	Sand
N:	12	3	9	6	6
Transport	1	2	1=	1	2
Draught	2	3	1=	3=	1
Lobola	3	1	3	2	4
Milk	4	4	5	3=	5
Manure	5	5	4	5	3
Sales	6	7	6	6=	6
Slaughter	7	6	7	6=	7

Comments by farmers who did the ranking (amalgamated):

Transport — Cattle for transport is essential for carrying manure to the fields, for harvesting and for other things like bricks and poles

Draught — If there is no draught there is no life, for people have to grow crops for food and others for sale

Lobola — Lobola is important as it has so many components. When my daughter marries we will receive many goods including cattle.

Milk — Milk is important in our daily lives, improving the diets of children and adults.

Manure — Most fields in the hills are sandy soils, so manure is important to add soil fertility and

gain better yields and so more money from the GMB (Grain Marketing Board).

Sales — Sales are quite important so I can educate my children and buy clothes for the family.

Slaughter — Cattle are only slaughtered when there is a ceremonial event such as a bira (beer brew for ancestral spirits).

Comparing the economic valuation and the preference ranking by farmers there is good overall agreement as to the relative importance of different functions. The ranking also corresponds closely with the findings of another ranking exercise with farmers in Masvingo Province (Agritex, 1987).

The inclusion of the lobola payment function in the farmers' ranking and its omission in the economic assessment is significant. The symbolic role of cattle in the various parts of the establishment of the marriage contract is regarded as extremely important. In particular, women ranked it highly because of the desire to see their sons successfully married. Although the role of cattle in bridewealth payment is certainly in part an economic function (Kuper, 1982), people see the importance of cattle in this role more than the pure exchange value that the transactions entail. For the 1987 data, on which much of the economic evaluation assessment is based, there were few marriages and only two instances of purchase and exchange of cattle as part of marriage. The general lack of resources for formal marriage following the droughts of the mid-80s has meant that the number of marriages completing the cattle exchange parts of the ceremony has been limited in the past two years or so.

Milk is ranked much higher in the economic assessment than in the farmer ranking. This reflects the perception that milk is a welcome luxury, but not an absolute necessity, like draft or transport. The economic valuation was made on the basis of the replacement cost of the milk produced, but

if a 'willingness to pay' criterion was used to assess value a lower economic rating would probably have been reached. Few people buy milk, but great lengths are gone to, including hiring, to ensure draft power access.

The contrast between the farmer rankings from the two zones bears out the importance of the manure function in the sand veld zone.

The overall argument of both the economic assessment and the farmers' ranking exercise is the importance of estimating value in terms of the range of functions. The complementary functions of livestock are what are important.

The value of communal area livestock

Tables 5.29 to 5.32 use the data on benefits and costs provided in the previous sections and present the results of the discounted cash flow analysis giving indicators of the Net Present Value and Internal Rate of Return of different stock investments in the different ecological zones. A range of assumptions have been made about valuation of benefits and costs; these have been substantiated with data from the sample and dip livestock populations in the previous sections. The estimates used for the cost and benefit calculations are reiterated in Footnote (13).

Table 5.29: Cost-Benefit analysis for oxen in clay and sand veld areas. 5 right hand columns = B-C = Benefit minus cost; 20 = discounted cash flow with 20% discount rate; 10 = Discounted cash flow with 10% discount rate; N = Internal rate of return; 20 + dt = Discounted cash flow at 20% discount rate and under drought conditions (see Footnote 13 for details)

OXEN: CLAY VELD

YEAR	MANURE	PLOUGH	TPORT	SALE	BENEFITS	COSTS	B-C	DISCOUNTED FLOW			
								20	10	132	20+DT
0	3.2	0	0	0	3.2	152.3	-149.1	-149.10	-149.10	-149.10	-149.10
1	6.5	0	0	0	6.5	52.3	-45.8	-30.33	-32.48	-17.41	-27.76
2	13	462	131	0	606	52.3	553.7	343.29	404.49	96.93	286.58
3	13	462	131	0	606	52.3	553.7	270.31	345.71	40.56	206.17
4	13	462	131	0	606	52.3	553.7	212.84	295.48	16.97	148.33
5	13	462	131	0	606	52.3	553.7	167.59	252.55	7.10	106.71
6	13	462	131	0	606	52.3	553.7	131.96	215.85	2.97	76.77
7	13	462	131	0	606	52.3	553.7	103.91	184.49	1.24	55.23
8	13	462	131	0	606	52.3	553.7	81.82	157.68	0.52	39.73
9	13	462	131	0	606	52.3	553.7	64.42	134.77	0.22	28.59
10	13	462	131	440	1046	52.3	993.7	91.04	206.73	0.16	36.91
							5228.4	1287.76	2016.18	0.16	808.15

OXEN: SAND VELD

YEAR	MANURE	PLOUGH	TPORT	SALE	BENEFITS	COSTS	B-C	DISCOUNTED FLOW			
								20	10	137	20+DT
0	6.5	0	0	0	6.5	152.3	-145.8	-145.80	-145.80	-145.80	-145.80
1	13	0	0	0	13	52.3	-39.3	-31.44	-34.17	-16.11	-29.11
2	26	462	131	0	619	52.3	566.7	362.69	428.51	95.19	310.95
3	26	462	131	0	619	52.3	566.7	290.15	372.61	39.01	230.33
4	26	462	131	0	619	52.3	566.7	232.12	324.01	15.99	170.62
5	26	462	131	0	619	52.3	566.7	185.70	281.75	6.55	126.38
6	26	462	131	0	619	52.3	566.7	148.56	245.00	2.69	93.62
7	26	462	131	0	619	52.3	566.7	118.85	213.04	1.10	69.35
8	26	462	131	0	619	52.3	566.7	95.08	185.26	0.45	51.37
9	26	462	131	0	619	52.3	566.7	76.06	161.09	0.18	38.05
10	26	462	131	440	1059	52.3	1006.7	108.09	248.84	0.13	50.07
							5355.2	1440.05	2280.14	-0.61	965.81

Table 5.30: Cost-Benefit analysis for cows in clay and sand veld areas. 5 right hand columns = B-C = Benefit minus cost; 20 = discounted cash flow with 20% discount rate; 10 = Discounted cash flow with 10% discount rate; N = Internal rate of return; 20 + dt = Discounted cash flow at 20% discount rate and under drought conditions (see Footnote 13 for details)

COW: CLAY VELD

YEAR	MANURE	MILK	PLOUGH	TPORT	SALE	CALF	BENEFITS	COSTS	B-C	DISCOUNTED FLOW			
										20	10	164	20+DT
0	3.2	0	0	0	0	0	3.2	152.3	-149.1	-149.10	-149.10	-149.10	-149.10
1	6.5	0	0	0	0	0	6.5	52.3	-45.8	-30.33	-32.48	-15.53	-27.76
2	13	163	462	131	0	46.92	815.92	52.3	763.62	473.45	557.83	103.98	395.23
3	13	163	462	131	0	46.92	815.92	52.3	763.62	372.79	476.78	38.37	284.34
4	13	163	462	131	0	46.92	815.92	52.3	763.62	293.54	407.51	14.16	204.56
5	13	163	462	131	0	46.92	815.92	52.3	763.62	231.13	348.30	5.22	147.16
6	13	163	462	131	0	46.92	815.92	52.3	763.62	181.99	297.69	1.93	105.87
7	13	163	462	131	0	46.92	815.92	52.3	763.62	143.30	254.43	0.71	76.17
8	13	0	462	131	0	0	606	52.3	553.7	81.82	157.68	0.19	39.73
9	13	0	462	131	0	0	606	52.3	553.7	64.42	134.77	0.07	28.59
10	13	0	462	131	375	0	981	52.3	928.7	85.08	193.20	0.04	34.49
									6422.92	1748.1	2646.6	0.0	1139.3

COW: SAND VELD

YEAR	MANURE	MILK	PLOUGH	TPORT	SALE	CALF	BENEFITS	COSTS	B-C	DISCOUNTED FLOW			
										20	10	173	20+DT
0	6.5	0	0	0	0	0	6.5	152.3	-145.8	-145.80	-145.80	-145.80	-145.80
1	13	0	0	0	0	0	13	52.3	-39.3	-26.03	-27.87	-14.04	-29.11
2	26	187	462	131	0	53.82	859.82	52.3	807.52	516.81	610.60	103.00	443.08
3	26	187	462	131	0	53.82	859.82	52.3	807.52	413.45	530.96	36.79	328.21
4	26	187	462	131	0	53.82	859.82	52.3	807.52	330.76	461.70	13.14	243.12
5	26	187	462	131	0	53.82	859.82	52.3	807.52	264.61	401.48	4.69	180.09
6	26	187	462	131	0	53.82	859.82	52.3	807.52	211.69	349.11	1.68	133.40
7	26	187	462	131	0	53.82	859.82	52.3	807.52	169.35	303.58	0.60	98.81
8	26	0	462	131	0	0	619	52.3	566.7	95.08	185.26	0.15	51.37
9	26	0	462	131	0	0	619	52.3	566.7	76.06	161.09	0.05	38.05
10	26	0	462	131	375	0	994	52.3	941.7	101.11	232.77	0.03	46.84
									6735.12	2007.1	3062.9	0.3	1388.1

Table 5.31-2: Cost-Benefit analysis for donkeys (all areas) and goats (clay and sand veld areas). 4 right hand columns = B-C = Benefit minus cost; 20 = discounted cash flow with 20% discount rate; 10 = Discounted cash flow with 10% discount rate; N = Internal rate of return. (see Footnote 13 for details)

DONKEY

YEAR	FOAL	WORK	BENEFITS	COSTS	B-C	DISCOUNTED FLOW		
						20	10	110
0	0		0	125	-125	-125.00	-125.00	-125.00
1	0		0	45	-45	-31.03	-33.33	-19.15
2	0	411	411	45	366	174.08	200.82	66.27
3	31.44	411	442.44	45	397.44	197.50	252.98	39.30
4	31.44	411	442.44	45	397.44	156.44	217.62	18.17
5	31.44	411	442.44	45	397.44	123.91	187.20	8.40
6	31.44	411	442.44	45	397.44	98.15	161.03	3.89
7	31.44	411	442.44	45	397.44	77.74	138.52	1.80
8	31.44	411	442.44	45	397.44	61.58	119.16	0.83
9	0	411	411	45	366	44.92	94.39	0.35
10	0	411	411	45	366	35.58	81.20	0.16
						813.86	1294.60	-4.96

GOATS: CLAY VELD

YEAR	KID	SALE	MILK	BENEFITS	COSTS	C-B	DISCOUNTED FLOWS		
							20	10	55
0	0	0	0	0.00	37	-37	-37.00	-37.00	-37.00
1	0	0	0	0.00	7	-7	-4.73	-5.07	-3.83
2	37.37	0	9	46.37	7	39.37	25.73	30.45	15.77
3	37.37	0	9	46.37	7	39.37	20.80	26.78	9.98
4	37.37	0	9	46.37	7	39.37	16.81	23.56	6.32
5	37.37	0	9	46.37	7	39.37	13.59	20.72	4.00
6	37.37	0	9	46.37	7	39.37	10.99	18.22	2.53
7	0	40	0	40.00	7	33.00	7.45	13.43	1.34
							53.64	91.09	-0.89

GOATS: SAND VELD

YEAR	KID	SALE	MILK	BENEFITS	COSTS	C-B	DISCOUNTED FLOWS		
							20	10	21
0	0	0	0	0.00	37	-37	-37.00	-37.00	-37.00
1	0	0	0	0.00	7	-7	-3.68	-3.89	-3.66
2	25.20	0	9	34.20	7	27.20	13.88	16.09	13.68
3	25.20	0	9	34.20	7	27.20	9.91	12.38	9.70
4	25.20	0	9	34.20	7	27.20	7.08	9.52	6.88
5	25.20	0	9	34.20	7	27.20	5.06	7.33	4.88
6	25.20	0	9	34.20	7	27.20	3.61	5.64	3.46
7	0	40	0	40.00	7	33.00	3.13	5.26	2.98
							1.99	15.33	0.92

The valuation of the opportunity cost of rural capital to estimate a discount rate is impossible as limited credit markets exist for most farmers. The availability of cash for investment is low so a high rate of discount can be expected to be appropriate. With this in mind, a 20% rate is taken and compared with a 10% rate, which is more in line with commercial borrowing rates.

Mortality rates of stock present another problem as they vary widely between years. A probabilistic approach is taken here where the likelihood of death is estimated on the basis of data already presented. From the farmer's perspective this might not make sense if s/he has say only one animal - if the animal dies then no stream of benefits at all will be accrued.

Table 5.33: Summary of investment criteria evaluations

		NPV	IRR	PB	GM
Oxen	Clay	1288	132	3	554
	Sand	1440	137	3	567
Cow	Clay	1748	164	3	764
	Sand	2007	173	3	807
Donkey		814	110	3	397
Goat	Clay	54	55	4	39
	Sand	2	21	4	27

Note: NPV = Net Present Value; IRR = Internal Rate of Return; PB = Pay back period (years); GM = Gross Margin - (Benefits - Costs for adult animal); this does not take account of the herd offtake (sales and slaughters) or herd growth.

The NPV calculations assumed a 20% discount rate; all estimates assumed mortality rates as described above for the less extreme incidence of drought.

The exact figures shown in Tables 5.29 to 5.33 should not

be taken too seriously, as they rely on a range of assumptions. However the general point is that the rate of return on investment is high for all stock, except for goats in the sand veld. Even when the data is analysed with different assumptions for lower expected returns (eg higher death rates, lower birth rates and low prices), the attractiveness of livestock investment is still clear.

Returns to CA livestock production per unit area

The productivity of the communal area livestock system can also be assessed in per area terms. Values are taken from the above cost-benefit calculations with $/animal given in terms of the gross margin estimate for different animals. The stocking rate of animals refers to the figures calculated by the Vetinerary Dept census for Mazvihwa in 1986-7. Herd and flock compositions use the data from the household sample.

Table 5.34: The value of stock in Mazvihwa per hectare: returns per year.

	Herd comp %	SRate Nos/ha	$/animal	$/ha
Cattle				
Cows	31.3	0.08	785.57	63.94
Ox/Bull	28.6	0.074	560.2	41.45
Imm	40.1	0.1	-42.55	-4.42
Donkeys				
Imm	40	0.016	-45	-0.72
Male	30	0.012	366	4.4
Female	30	0.012	397.4	4.77
Goats				
Imm	39.6	0.13	-7	-0.9
Female	43.6	0.144	33.28	4.8
Male	16.7	0.055	-7	-0.4
Total				$113.86/ha/y

The values presented in Table 5.34 do not include any

account of costs of initial purchase or values from sales of adult animals. The values used refer to the second year (for immatures) and the fourth year (for adults) of the benefit-cost stream calculated above. Where different values were calculated for clay and sand veld an average is taken.

This area based valuation can be compared with other estimates of livestock production in Zimbabwean farming systems (ARDA, 1987; Agritex, 1986; Dankwerts, 1974; Bembridge and Steenkamp, 1976). The more recent valuations are shown in Table 5.35, which compare Communal Area systems (CA) and ranching systems (R) in Regions IV and V.

Table 5.35: Official valuations of CA and ranching systems (ARDA, 1987).

	CA(IV)	CA(V)	R(IV)	R(V)
Net Economic Value ($/HA)	14.1	5.9	12.4	5.8

Note: CA = Communal area, R = Ranch; IV = Natural region IV; V = Natural region V. This assumed recommended 'carrying capacity' stocking rates for each zone.

There are several reasons why this study has shown a level of value of the communal area livestock resource that is far higher than estimated elsewhere. These include:

- The inclusion of the value of goats and donkeys

- The use of actual stocking rates not 'official' stocking rates.

- The inclusion of use values such as transport.

- Higher biological production rates shown by the sample data than assumed for other models.

- Different assumptions made about prices.

Comparisons of other estimates with this study suggest that it is less the different estimates in production and price levels that give the disparities in results, but more the first three differences highlighted above. In large part the economic value of communal area livestock is derived from the ability to stock at high levels and use a mixture of species for a variety of uses beyond those conventionally associated with stock - beef, milk, ploughing - to include such uses as transport and outputs like goat meat.

The high stocking rates in the communal areas result in large returns both per animal and per area. There are however trade-offs. The question of environmental costs have already been considered briefly and will be returned to in Chapter 9. Here I want to consider the interaction between stocking rate and the economic value of different functions. An interesting follow up to this economic analysis of individual functions, would be to assess how the different returns from livestock traded-off at different stocking rates. Increased stocking rate will be expected to reduce birth rates and increase death rates (Chapter 4). Stocking rate will also interact with milk production levels. Richardson (1987) provides data from Zimbabwe showing that under a decrease in stocking rate from 3.6 ha/cow to 8.1 ha/cow the milk yield increases by 49% on a per animal basis, but decreases on a per hectare basis by 14%. The work ability of animals will also be affected by stocking rate and the reduced availability of fodder. Fodder availability will also affect the quantity and quality of manure. The exact nature of these trade-offs in the communal area situation remains unexplored. It is therefore impossible to guess at a socially optimal stocking rate for maximisation of returns. What is clear is that the economic stocking rates for the communal area production system far exceeds that which is regarded as economically optimal for beef production.

The comparison between the figures shown for this study and

the commercial ranching enterprises is equally illuminating. The levels of net economic gain from ranching in southern Zimbabwe are generally very low (Bembridge and Steenkamp, 1976; Child, 1988). The figures presented in Table 5.35 show an idealised production model for a commercial beef breeding enterprise (14). Net economic value averages $9.10/ha across the two natural regions. The level of return is highly sensitive to calving rates; in the fluctuating rainfall conditions of this part of the country the weaning rates often fall below the assumed 70%. Actual net economic returns from livestock are very often negative in the ranches adjacent to Mazvihwa communal area and the ranchers survive either due to scale and outside support (in the case of Union Carbide ranches) or through diversifying into extractive activities such as wood sales to the mines or sand sales to the construction industry. The returns per unit land for the CA sector appear to be much more favourable.

5.11 Risk, uncertainty and investment

Although the returns on livestock investment are high, there exist constraints to actually achieving such investments. The actual patterns of investment and the methods of raising liquid capital for stock investment will be discussed in more detail in the next Chapter. Here I want to concentrate on the implications of risk and uncertainty and how this is likely to affect investment decision-making.

Despite the fact that the apparent returns to goats are so much lower than for cattle and donkeys, people still invest in them. Why is this? One important reason is that they do not represent a 'lumpy' investment. Since the marginal utility of a given sum of money will vary widely across households, different people will be able to invest to different degrees. The amount of cash required to buy a goat relates much more closely to the amounts available as

disposable income (from remittances, savings clubs etc: see Chapter 6). The amount needed to purchase cattle requires saving, which is often difficult when there are regular pressing needs for the household budget. Cattle might be purchased from 'windfall' cash payments, such as large GMB cheques from a good harvest or a redundancy payment (both were routes to cattle purchase within the sample during 1987).

The investment in several goats as against one cattle, despite lower overall returns, may be desirable from the point of view of the flexibility of disposal. A single goat can be sold to raise money to match immediate cash needs (school fees, groceries etc), whereas a single cattle may realise more cash but then the whole asset is liquidated and cash is difficult to reinvest (as other demands inevitably arise, such as the requests of relatives).

The complementarity of cattle and goats in terms of their functions is an important criterion in understanding why the investment decision is not either/or. In the same way donkeys complement cattle providing a transport function which is not so well met by oxen spans. The partial independence of the returns from different stock is also a factor in reducing risk if a 'portfolio' of stock assets is built up. Although all animals are subject to drought stresses on production, through increased mortality, reduced fertility and declining milk production, different stock respond in different ways. The more 'drought resistant' goats and donkeys complement cattle in this way.

This dimension of risk reduction through mixed stock holdings is also dependent on ecological zone. The variability in the flow of returns from different stock is dependent on the ecological zone. Very high goat mortality levels are experienced in the sand veld during drought, whereas the clay veld populations are apparently more stable (see Chapter 7). The opposite is shown for cattle. Donkeys appear to have similar levels of variability in

production between zones. The risk profiles of different stock therefore show different patterns depending on the interaction between the animal's biology and the variations of different savanna environments. A risk averse investor might opt for goats in the clay veld, but would be more tempted by cattle in the sand veld. Donkeys with low variability in production parameters would be a good risk averse option in either zone.

The time preference rate of the investor could also affect the decision. For instance, if the investor valued time at anything higher than 20%, then there would be some doubt as to the advisability of investment in goats in the sand veld. According to the data and the assumptions made, all other stock investment options have very fast pay-back periods and high rates of return. Even the most conservative investor would regard purchase as a good option.

The decision to purchase will also depend on the nature of existing stock holdings; the marginal increase in maintenance costs will differ widely between farmers with different existing asset holdings or cooperative arrangements with others. If the farmer has previously no cattle and just a few goats the purchase of an oxen or cow will change the labour costs of herding far more than someone who is already herding a number of cattle, unless s/he can join a cooperative arrangement for sharing herding costs.

The degree to which these different factors of risk and uncertainty enter into actual investment decisions and are reflected in different investment patterns across ecological zones and individual households of different wealth categories will be central to the discussion of the next Chapter.

Footnotes

1. The patterns shown for the household sample are reflected in the results from other studies (eg. Collinson, 1982 for Chibi and GFA, 1987 for Mberengwa and Chivi) as well as the Village Development Committee survey carried out to substantiate the representativeness of the sample (see Chapter 1).

2. Cattle production indices from other areas in Africa are shown below. References are: 1: Dahl and Hjort (1976); 2: Wilson et al (1985), 3: Shapiro (1979); 4: ILCA (1985), 5: Trail et al (1977); 5: Cossins (1985); 7: De Leeuw et al (1987); 8: Homewood and Lewis (1987), 9: Rodgers and Homewood (1986); 10: De Ridder and Wagenaar (1986), 11; Richardson and Khaka (1984) and 12: GFA (1987). Certain parameters may have been measured in different ways in different studies, so the results may not be wholly comparable. Calving rates generally refer to the number of calves produced per year as a percentage of breeding females. Milk production usually refers to the human offtake over a lactation, not full potential yield.

CATTLE PRODUCTION INDICES

Production indices	General 1	Drought 1	Sahel 2	Sahel 3	Mali Agro-past 4	Mali Transhumant 4	Mali Ranch 4	Mali Delta 5	Ethiopia Borana 6	Kenya Gp ranch 7
Age 1st calving (m)	36-48		48	42-60				43		
Calving interval (m)			18					15.6		
Calving rate (%)	50-80	0		40-65	57	52-59	78		75	62-63
Calf mortality (%)	10-40	90		20-40	25	23-34	31		10-23	5-13
Adult mortality (%)	5-15	50		5-10						2-10
Herd mortality (%)	65							7		
Milk (kg/yr)										172-193

Production indices	Kenya Baringo 8	Tanzania Ngorongor 9	Botswana Trad 10	Botswana Ranch 10	Zimbabwe High SR 11	Zimbabwe Low SR 11	Zimbabwe National 12
Age 1st calving (m)							3.5-4
Calving interval (m)							
Calving rate (%)	69	50-60	44	67.7	52.7	69.1	40-50
Calf mortality (%)	79	71			8.6	4.5	
Adult mortality (%)	45	33-43			2.9	1.7	
Herd mortality (%)	60						
Milk (kg/yr)		147-315	162		162	311-504	300-350

3. Comparable data for milk production in Zimbabwe's communal areas is very limited. The Dairy Marketing Board study in the high potential area of Chikwakwa estimated an average of 2kg/day over a 4 - 6 month lactation (DMB, 1984), while the general estimate given for the GFA study (1987) was a yield of 300-350l per lactation or 0.5-1 litre/household per day. Richardson and Khaka (1981) have shown that the milk yields varies significantly with stocking rate under range conditions in southern Zimbabwe. The Mazvihwa results show higher levels of production, even in a relatively low rainfall year. Other data from Africa indicate that there is alot of variation in output levels and lactation lengths (Nicholson, 1984).

4. The dung production study was carried out by Vengisai Ndhlovu and Tavengwa Chifamba as part of research into nutrient cycling initiated by Ken Wilson and supported by ENDA-Zimbabwe. Different individual cattle were observed during the grazing day and the number of dung pats produced counted. The same was done for tethered cattle at night. The dry weight of an 'average dung pat' was calculated by collecting and measuring a sample.

5. The weight of dry dung filling a cart of normal size was estimated by Cephas and Abraham Mawere.

6. This result contrasts with data from Chibi and Mberengwa (GFA, 1987: 85) which suggests a far higher percentage use of oxen (48-51%) and donkeys (33-38%), but corresponds more closely with results from a survey in Masvingo province where it was found that the pattern was: males (44%), females (38%) and donkeys (11%) (Agritex, 1987).

7. The work of stock study was initiated by Ken Wilson in June 1986 and was continued by myself from November 1986 as part of the livestock economics study presented here until October 1987.

8. Adult equivalent units represent a measure used to combine people of different ages in terms of consumption requirements (see Chapter 6).

9. Donkeys' work includes travelling to the mill with grain for grinding, pulling carts with manure, firewood, water, harvests, stover or bricks, dragging poles for building or brushwood for fencing, carrying sick people to the clinic, in ploughing, ridging or threshing and other general

transprort activities.

10. Birth rates are measured as the number of live born kids as a percentage of total adult females at Feb 87. Death rates are measured as: 1) Kid death rates are taken as 85% of all deaths recorded these are measured as a percentage of births recorded during the year. 2) Adult death rates are 15% of all deaths recorded and the rate is calculated as a percentage of the total population at Feb 87.

11. GOAT PRODUCTION INIDICES

Production indices	Mali Sedentary 1	Tchad 1	Sudan Baggara 1	Ethiopia Afar 1	Kenya Maasai 1	Mozambique 2	Zimbabwe Matopos 3	Zimbabwe Bikita 4
Age first kidding (days)	484	415	290		456	738		555
Birth interval (days)	271		238		289	391		
Birth rate (%)	165	113	241	115	147		160	135
Ave litter size (n)	1.23	1.12	1.57	1.1	1.16	1.62	1.67	1.33
Pre-weaning mortality (%)						17-25	10	31
Total mortality (%)						15		12

1. Wilson (1982)
2. McKinnon et al (1985)
3. Reh (1985)
4. Remy and Harrison (1988)

12. The capital valuation assumed prices of Oxen/bull ($400); Cow ($350); Heifer ($250) and calves ($150). Calculations according to sample herd composition gave a total capital value of $100800 (mid 87), $100400 (late 87) and $79650 post drought (early 88). Average per head value at mid-87 relates to a total sample herd of 339.

13. Assumptions used for investment criteria assessments:

Cattle:
Manure: Manure is valued at $26/adult animal/year in the sand veld. For younger animals a proportion of this value (50% year 1; 25% year 0) is taken. In the clay veld the manure is assumed to be less valued (it basically has no market value) and is given half the economic value of sand veld manure.

Milk: Over a 6 month lactation the expected output is 480.6 litres valued at 50c/l. Calving rates in the sand veld are 78% and in the clay veld 68% on average. This means the

annual economic output from milk will be $187.4 and $163.4 for the sand and clay veld respectively.

Work: An value of $30/day/span is assigned making the annual output of work a total value of $623/animal.

Sale: The average costs for marketed animals is taken (1987) from Mazvhiwa cattle sales pens records.

Calf: The calving rate of cattle is taken as 68% on the clay veld and 78% on the sand veld. Calf survival is assumed to be the same being 75% in 80% of years and 45% in 20% of years. The value of a calf is taken as $100.

Discount levels: Discount rates of 20% and 10% are used, but with adult and calf mortality rates added on. Adult mortality rates of 3% in 80% of years and 10% (in the sand veld) and 20% (in the clay veld) in the other years are assumed. Calf mortality is assumed to be as above. A 20% discount rate is used where the conditions of a 20% chance very bad drought are assumed where a 80% mortality is found in the clay veld and a 60% mortality in the sand veld.

Donkeys
Foal: The value of a foal is taken as $80 and the foaling rate 52%. The probability of survival is assumed to be 75%.

Work: At $30/day/pair, the total value of work ranges from $411 to $498/animal/year.

Discount: A 10 and 20% discount rate is used. Added to this are death rates of foals (25%) and adults (6.25%). No sensitivity analysis according to ecological zone or interannual variation is attempted due to lack of extensive data.

Goats:
Kids: Kidding rates in the clay veld are assumed to be 1.73/female/year and 2.8/female/year in the sand veld. Survival rates are taken as 72% and 30% in the clay and sand veld respectively. The sale price of kids is assumed to be $30.

Sale: The final sale of the female goat for meat is assumed to raise $40.

Milk: Production at 150ml/day over 4 months a year at a replacement value of 50c/l gives an annual production of $9.

Discounted flows: Discount rates of 10% and 20% are taken and kid and adult mortality rates added. Clay veld adult and sand veld adult mortality rates are assumed to be 3% and 20% respectively. Kid mortality rates are as above.

14. The budget is estimated for 3.5 year old steers sold off grazing (Agritex, 1986).

6. THE HOUSEHOLD ECONOMY AND PATTERNS OF LIVESTOCK INVESTMENT AND DISPOSAL

6.1 Introduction

The discussion of livestock productivity in the previous Chapter illustrates that investment in livestock makes economic sense, however the conditions under which stock can be bought or sold are not always open to all households all of the time. Investment in livestock is dependent on the mobilisation of cash or exchange assets in order to purchase animals. This varies over time and between different households resident in different areas or with different income flows or levels of existing asset holdings. Reasons for livestock disposals are similarly differentiated. (*)

This Chapter investigates in detail the context in which livestock investment and disposal decisions are made. This will shed light on the local level determinants of stock population dynamics from a household economics perspective, explaining sources of the variation around the aggregate models discussed in Chapter 4. The Chapter thus provides the context for understanding the different patterns of livestock management in drought discussed in Chapter 7. Sections 6.3 to 6.9 investigate patterns of differentiation in the household economy. This data is then used to interpret livestock investment and disposal decisions in section 6.10.

6.2 Patterns of local economic differentiation

A variety of different approaches exist for investigating differentiation in rural economies. Differentiation may be examined in sociological terms, where contrasts in resource access and ownership differentiate groups in society. This complements a household development perspective on differentiation that explains differences in household

economics according to changes in demographic structure as the household ages (eg. Chyanov). Both these approaches to understanding differentiation may be related to materialist distinctions, where 'classes' are conceived in terms of their social relationships of production (Bernstein, 1982: 169).

This Chapter bases its analysis of local level differentiation on a generalised wealth classification of households (see section 6.3). This is a composite classification relating to both asset holdings and income levels. Differences between households in assets and income can be expected to affect livestock investment and disposal. Some general expectations can be outlined. These will be investigated with the data.

- Increased asset holdings (cattle, land, labour etc.) will lead to higher agricultural production and so greater income and opportunities for stock investment.

- High asset holdings provide security and an increased likelihood of risk prone investment (eg accepting longer pay-back times, higher risks of loss through death etc).

- Disposable income for stock investment will vary between income sources (farm income, local off-farm income and remittance sources). The availability of these income sources will vary between different ecological zones, different years, wealth groups and age categories of households.

- Patterns of livestock disposal will also differ between wealth groups, years, ecological zones and age categories of households. This will be linked to the different expenditure requirements of different households at different times.

These general patterns will be affected by various other factors:

- Opportunities for agricultural and stock income returns vary between ecological zone (see Chapters 2 and 5). Crop returns can be expected to be higher and more stable in the

sand veld zone, but with occasional good returns in the clay veld. Cattle income is potentially high in the clay veld, but greater susceptibility to drought offsets this potential. Goat production is likely to be highest in the clay veld.

- Access to key factors of production will be affected by the structure of social organisation as well as formal 'ownership'. Loaning, sharing and cooperative arrangements will affect the impact of ownership inequalities.

- Access to assets and income sources will vary according to the stage in the demographic cycle of the household. Phases of establishment, expansion, consolidation, fission and decline can be expected (Fortes, 1970). This will be influenced by the impact of the migrant labour economy on rural accumulation patterns and household economy (eg. Low, 1986; Guyer and Peters, 1987; Murray, 1987). Changes in household demographic structure can be expected to influence patterns of production and asset ownership (Chyanovian cycles: see Thorner et al, 1966; (1)).

The following sections will examine how livestock investment and disposal decisions are affected by the factors outlined above. Wealth group (related to asset holdings and income) will be seen to affect the pattern of decison-making. This is modified by the effect of ecological zone and inter-annual variability in rainfall which influences the returns on agriculture in particular. The demographic status of the household will also be seen to have an effect.

In section 6.3 the local perception of wealth is examined, providing insight into the dynamics of socio-economic differentiation in the study area. This provides a framework for exploring the relationship between stock ownership and the portfolio of other household assets (sections 6.4 and 6.5). Section 6.5 also explores in more detail the dynamics of ownership and control of livestock and how inter-household relationships influence the options and incentives for stock investment. The way agricultural income varies interannually between ecological zones, wealth groups and age categories is examined in section

6.6. The implications for household food security status is assessed in section 6.7. The role of stock within household income and expenditure flows for different categories of sample households is explored in Section 6.8. The different components of income are investigated in relation to livestock investment and disposal decisions; these include remittance, livestock and crop production incomes (section 6.9). The contribution of different components of income to total income are summarised in section 6.9.

The data presented in sections 6.3 to 6.9 on differentiation provides the basis for examining actual patterns of purchase, sale and slaughter of cattle and goats in the household sample (section 6.10). The general predictions outlined here and explored with the data on asset holdings, income and expenditure patterns and agricultural income can be tested against the actual behaviour of stock holders during 1987 and qualified by a discussion of patterns following a good harvest (1984-5).

6.3 Local perceptions of socio-economic differentiation

The stratification of the household sample according to indicators of socio-economic differentiation is critical to gaining an understanding of the range of livelihood strategies and the different patterns of household economy in the rural areas. But what indicators can be used? What is wealth and differentiation in the local context?

These questions were addressed in a wealth ranking exercise that provides a framework for understanding the local perceptions of differentiation and stratifying the sample according to local categories of wealth (Grandin, 1988; Scoones, 1988c; (2)). Through this process the sample households themselves made the decisions as to the stratification used in the analyses that follow.

Wealth is a complex concept incorporating many different

facets of household asset holding and income earning strategies. Polly Hill (1977) argues that:

> "The outsider's 'objective' description of stratification systems based on certain scientific measurements are not as free from personal bias and prejudice as is commonly supposed, partly owing to the need to select the variables to be measured... there is no intrinsic reason why the outsider's view of the system is any more valid than that of individual members of society." (Hill, 1977: 107).

This was the rationale for the use of a wealth ranking exercise in this study.

The ranking exercise was held with three groups. One group was chosen to represent men of different ages, different 'apparent wealth' levels and from different ecological zones within the sample. Another was chosen to represent women in the sample according to the same criteria. The third group were members of the research/development team all local residents. Each invited member knew a large proportion of the sample members quite well and a smaller selection very well. The methods of the ranking exercise are reported in Appendix 7.

At the beginning of each wealth ranking workshop a discussion of the meaning of wealth was held. The local Shona term is mupfumi defined as "wealth in livestock". The discussions were structured around the themes of contrasting the present with the past and the clay veld with the sand veld. Transcripts of each of the discussion groups were made and the following sections represent a summary of these discussions. These summaries elaborate on the themes presented in section 6.2, providing local context for general suggestions about the nature of differentiation. The issues brought up in these discussions are pursued further with an analysis of household data in later sections, when the differences between ecological zone and the nature of wealth indicators differentiating different groups can be explored with quantitative data.

Historical comparisons

Wealth in the past was seen to be represented by the presence of many cattle and associated loaning sites. Inheritance of assets was the key way to gaining wealth, so that accumulation was a slow process with the richest people in the past being older. Bridewealth payments were seen as an important part of asset accumulation; people noted that in the past it was better to have female children so that, through lobola payments, girls brought wealth in cattle. In the past cash income was not seen as so important. The survival of the poorer groups in the past was seen to be linked to the relations between them and the richer agriculturalists (the hurudza); the poor would beg food or exchange daughters or stock with them in order to acquire food.

The key indicators of wealth today were seen as a combination of good farming, having access to money (remittances), having educated children and building a fine home (a square house with iron/asbestos roofing). With access to off-farm employment it was argued that today it is possible for the young to be wealthy, since they can get work in town and so accumulate assets. Cattle today are far fewer (per household); people noted that a 'rich' man can own just a few cattle and even donkeys are an indicator of wealth. The meaning of mupfumi has clearly changed to incorporate more factors than simply cattle wealth. Money (cash) was seen as increasingly important; this was blamed for increasing jealousy and reduced cooperation.

The rise in importance of secondary education has also changed people's attitudes to wealth. Investment in the schooling of children is seen as a route by which increased remittances (from men) are received and a means by which women are able to marry men with better wage earning potential and potentially receive a higher bride price.

The strategies of the poor were seen to be different to the

past. Today the relations with the hurudza no longer exist and the poor must now rely on government relief to assist them. Someone contrasted the two situations by saying that now "the poor are visible".

A range of indicators for assessing present wealth were discussed (Table 6.1).

Table 6.1: Indicators of wealth

Direct indicators	Proxy indicators
Cattle ownership	Modern home
Successful farming	Children at school
Well paid job in town	Regular use of tea/milk and sugar

When the causes of poverty were discussed, people mentioned a range of factors that would cause 'poverty':

- Poor planning combined with laziness.

- Family background (eg. lack of inheritance) and misfortune (eg. death of a husband).

- Lack of cattle.

- Dependency and indebtedness. For instance, harvest failure meaning reliance on local piece work from others to get food and the subsequent inability to prepare one's own fields for the following season.

- Lack of education of children at secondary school.

Comparisons between ecological zone

The sand veld area was characterised by all groups as the area where wealth through crop production was possible. Wealth was seen to derive from access to vlei farming, where good returns are possible even in drought years. The route to cattle accumulation in this area was seen to be through crop sales and exchanges, where crops could be exchanged with livestock from the clay veld zone. However it was acknowledged that the inputs for agricultural

success in the sand veld were high in terms of manuring the poor soils and labour for baboon guarding. This resulted in agricultural labour constraints and so less opportunity for work away and for education of children. Sand veld people also were seen not to invest in building modern homes; the link between 'wealth' and 'modernity' was seen to be part of the clay veld ideology, related to the closer links with town.

The current source of wealth in the clay veld was seen in terms of remittance income from town. This was regarded as the key route to local accumulation of assets and regular income. In the past cattle were important, as they thrived on the sweet grasses of the clay soils. However the increased incidence of drought impact on livestock had meant that this was not such a key component of wealth any more. The clay veld was seen as the place where the dominant 'modern' indicators of wealth were seen; these were notably the presence of new houses and the higher level of attendance of children at school. These indicators were seen to be linked to the availability of remittance income for such expenditures.

Four wealth groups emerged from the wealth ranking exercise (see Appendix 7). This stratification of the sample will be used to investigate patterns of differentiation in this and following Chapters. Differences between wealth groups' asset holdings, agricultural output and income and expenditure patterns will be the focus of the following sections. The way 'wealth' interacts with ecological and demographic factors will also be pursued.

6.4 The determinants of wealth

Data on a range of factors that differentiate households in the sample was collected during 1987 (3). These can be divided into asset holdings (stock and equipment), agricultural yields, cash income levels and demographic

factors. Table 6.2 provides a summary of the average levels per household by wealth rank and ecological zone. Sections 6.5 to 6.9 will explore these differences in detail and investigate the implications for livestock investment and disposal decisions.

The wealth ranking can be explored further by relating wealth group with the various components of wealth outlined in Table 6.2. Table 6.3 gives the results of a correlation analysis relating wealth group (1 = highest wealth group to 4 = lowest wealth group) to different components of wealth (3).

Table 6.3: Correlation of wealth ranking with different components of wealth (for 64 household cases).

Component of wealth	Coeff correl	2 tailed sig
Assets:		
Field (ha)	-0.45	0.000
Cattle owned	-0.55	0.000
Cattle access	-0.53	0.000
Goat owned	-0.50	0.000
Equipment	-0.62	0.000
Cart	-0.79	0.000
Tin Roof	-0.18	ns
Demographic factors:		
Household size	-0.33	0.003
Age	-0.17	ns
Agricultural yields:		
Yield bags(84/5)	-0.49	0.000
Income and expenditure		
Income ($)	-0.58	0.000
Remittance ($)	-0.27	0.015
Balance ($)	-0.15	ns

Note: A correlation analysis is used assuming the wealth ranking to be points on a continuous distribution of wealth levels. Measures used in this analysis are explained further in Table 6.2 and in later sections.

Table 6.2: Asset ownership by wealth group and ecological zone

	N	ASSETS						DEMOGRAPHY			CASH INCOME		GRAIN YIELD		
		FIELD HA	EQPT NOS	CART %	OWNED NOS	ACCESS NOS	GOAT NOS	TINRF %	AGE CAT	AEU	HHSIZE NOS	INCOME Z$/YR	REMIT Z$/YR	Y84 BAGS	Y85 BAGS	Y86 BAGS
CLAY VELD	42	4.97	2.02	29	3.93	4.32	18.00	50	5.36	5.72	9.41	805.46	441.09	42.67	6.81	3.97
EDGE ZONE	22	5.29	1.68	36	6.59	5.36	15.73	32	5.27	6.10	9.55	870.09	450.48	27.16	3.29	2.71
SAND VELD	7	7.40	2.43	57	11.00	7.14	22.00	29	5.29	8.71	14.14	1324.43	187.14	97.00	29.44	21.30
WEALTH GP1	17	7.78	2.71	100	14.94	10.18	32.35	65	6.06	8.82	13.59	1627.96	583.24	93.56	19.87	12.98
WEALTH GP2	17	4.42	1.94	35	4.41	5.06	17.87	35	4.82	5.11	9.06	853.85	574.74	35.79	6.58	3.94
WEALTH GP3	20	4.68	1.75	5	2.21	3.26	13.00	35	4.95	6.08	9.35	597.70	276.74	25.02	3.33	2.86
WEALTH GP4	17	4.35	1.47	0	0.71	1.41	7.88	35	5.53	4.49	7.76	438.73	244.44	25.09	3.79	2.42
CLAY VELD	1	7.29	2.71	100	14.14	11.00	35.00	86	6.43	7.48	11.14	1586.19	637.86	93.86	16.35	8.30
	2	4.42	2.00	38	3.92	4.77	19.54	31	5.08	5.63	9.67	884.04	630.81	42.22	7.12	3.78
	3	4.72	1.91	0	0.20	1.70	16.73	55	4.91	5.91	9.36	510.95	208.91	29.06	4.35	3.33
	4	4.41	1.73	0	0.82	1.91	6.64	45	5.45	4.50	8.09	480.77	312.10	24.18	2.86	2.09
EDGE ZONE	1	6.70	2.50	100	15.17	9.83	35.33	67	5.67	7.93	12.67	1494.00	786.67	48.00	6.01	4.51
	2	7.67	1.50	50	6.50	6.50	7.00	50	4.50	3.93	6.00	836.50	510.00	16.00	1.73	3.38
	3	4.63	1.56	11	4.44	5.00	8.44	11	5.00	6.28	9.33	716.98	370.00	19.48	1.93	2.21
	4	3.70	1.00	0	0.20	0.20	8.80	20	5.60	4.44	7.60	379.80	152.00	23.09	3.37	1.44
SAND VELD	1&2	7.68	2.67	67	12.50	8.00	23.25	33	5.17	9.40	15.67	1493.00	213.33	23.01	51.50	7.25
	4	5.78	1.00	0	2.00	2.00	17.00	0	6.00	4.58	5.00	313.00	30.00	11.00	8.00	0.00

Different components of wealth combine to make up the local perception. There is a danger in using simple indicators to represent the complex notion of wealth. For instance, tin roofs are sometimes used as an indicator, and were certainly mentioned as something that would increase someones' wealth ranking level in the group discussion, yet over the full sample they do not appear to be useful. The best indicators include: cash income, cattle and goat ownership, equipment holding and crop yield levels (4).

6.5 The distribution of assets and access to the factors of production: livestock, equipment, labour and land

The following sections will investigate the consequences of this differentiation in the rural economy in more detail. The implications for livestock investment and disposal decisions will be the focus of the discussion. First differentiation according to various factors of production - livestock, equipment, land and labour - will be assessed. Differentiation will be investigated in terms of the distribution of current holdings and the relationship with wealth group, ecological zone and patterns of the household development cycle. This will provide insight for the discussion of differentiation of patterns of cash income and expenditure, total agricultural and marketed crop income and levels of food security later sections.

Livestock ownership and access

As the data presented in Chapter 5 has shown, the ownership of livestock is highly skewed. More than half of the cattle present in the sample are owned by 8 people in herds of 12 or more (see Table 6.4). Table 6.2 has shown the differences in stock ownership between wealth rank and savanna zone. Cattle and goat ownership is concentrated in the richer wealth ranks, but is not particulary differentiated between ecological zone (5).

Table 6.4: Percent of all cattle owned (385) and held (Access = 316) by herd size

Herd size	Owned (%)	Access (%)
1-3	2	3
4-6	16	21
7-9	16	26
10-12	9	10
12+	56	41

Access is slightly more evenly distributed than ownership, since loaning relationships redistribute a portion of the animals from the particularly large herds. The first acquistion of cattle by men occurs typically in their early thirties. Raising sufficient cash to purchase a young heifer is predominantly achieved through income from work away from the rural home. The migrant labour economy has been an important source of investment into the rural livestock economy since the early 1930s. Of all the men who were part of the household sample (71), only 2 had never been away to work for any period. Most had spent between 10 and 15 years working in town from their mid-twenties and thirties. This was the time when livestock were purchased, marriages negotiated and new homes established. The investment required for this step is considerable and with few assets of livestock, equipment or labour the opportunity of generating surplus from agricultural activities is limited.

The exact pathway of investment, combining paid work and periods of time working the fields at home, is particular to each individual. A discussion of employment history was held with each man in the sample to investigate the range of strategies taken and how this related to stock investment. A consistent theme emerged among all men, ranging from those who had worked away in the 1930s through to those who started work during the 1970s and 1980s; off-farm employment was a vital route to initial acquistion of cattle. One such discussion illustrates the type of

employment history typical of many:

> "I started work in 1940 in Shabani mine working underground and getting 3c a day. After only a few months I ran away and got employed in the 'yards'(as a servant) by a European. Here I got 6c a day and was able to study from Standard 1 up to 5. I left the job in 1948 and went to Bulawayo and worked for 5 years on a European farm, later I was transferred to become a house guard. In 1960 the European moved to Gweru, but I only spent six months there and got a job with a building company that worked in Chegutu, Harare, Chinhoyi and Mazoe. I stayed with this, but had to run home because of the start of the war. While I was working I bought 6 heifers and these multiplied up to 20 head until they were destocked in 1960, leaving only 5. I also bought goats, sheep and pigs, but not donkeys". (Interview, Mazvihwa, 7.6.87).

The pattern of employment history for all men in a particular household cluster is given in Appendix 8. This gives an idea of the differing opportunities for stock investment through migrant labour for a range of people of differing ages.

The source of initial acquisition of cattle for all men interviewed on the subject (62) is illustrated in Table 6.5, showing the dominant importance of work away as a route to cattle acquistion by men.

Table 6.5: Initial acquisition of cattle

Source	%
Work away	54.8
Crop sales	20.9
Inheritance	11.3
Given by father	6.4
Herding payment	3.2
Local work	1.6
Bridewealth	1.6

Crop sales was the principal route through which women could purchase cattle in the past. Prior to the Native Land Husbandry Act (1951), women had their own land for cultivation. Sales of groundnuts, in particular, resulted

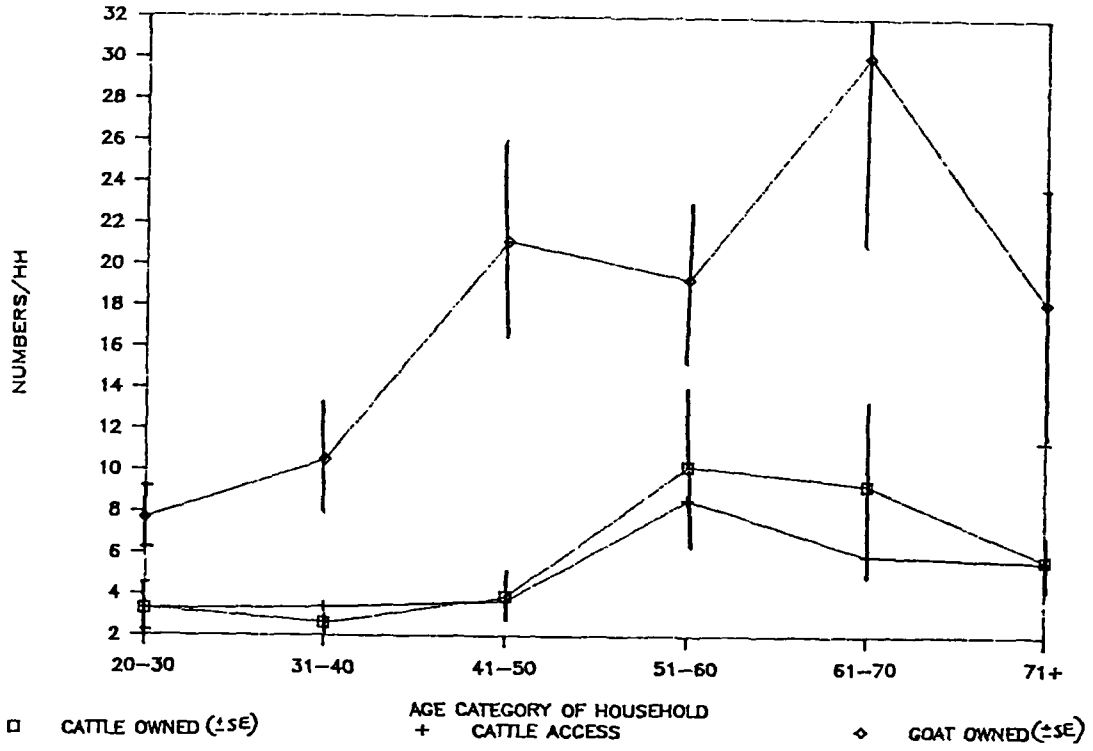
in the accumulation of cattle by some women. This is no longer the case, as women do not have individual rights over land and the income generated from vegetable gardening is insufficient for cattle purchases (6).

The other major route through which women acquire cattle is the cattle presented to the mother on the marriage of her daughter (mombe yeu mai see Appendix 5). This practice has varied adherence in the Mazvihwa area, but a number of women in the sample had acquired cattle in this way in the past.

The differences in stock ownership and access according to patterns of household development can be investigated by relating the age of the household head (7) to ownership levels (Figure 6.1). Although there is considerable variation around the mean level of stock ownership for each age category, a pattern of accumulation and disposal through the household development cycle is suggested by the cross-sectional data.

The data indicates an accumulation of cattle until the age of 50 or so, during the period of household establishment and work away; thereafter the numbers decline as cattle are disposed of for school fees, for secondary school children and later for bridewealth at sons' marriages. Access to cattle shows a similar pattern with age. The data indicates that cattle are predominantly lent to the 31-40 year age group, who show higher levels of access than ownership. Loaning out is practised by the 51-70 age groups. Older and younger people appear to hold their own cattle. Goat flocks are accumulated throughout the person's life, peaking during their 60s. People older than this show lower goat holdings, as they are disposed of to maintain them in old age.

Figure 6.1: Cattle and goat ownership and age of household head



For goats kept at the household kraals, information was gathered as to the individual owners of all goats in mid-1987 (8). For kraals where full ownership information could be obtained goats were distributed amongst men (married), adult women (having had children) and children as shown in Table 6.6.

Table 6.6: Distribution of goat ownership for household sample

Owners:	Men	Women	Children
% All Goats	55.9	30.0	14.1

Table 6.6 shows that children own 14% of the goats investigated. Most of these are goats given to children on the basis of kuidza ropa (testing the blood; see Appendix 5). The acquistion of goats by men and women was investigated in a series of discussions with goat owners (39 men and 46 women) in the sample. The source of finance or exchange used for the acquisition of their first goat was ascertained during the discussion. The results are presented in Tables 6.7 and 6.8.

Table 6.7: Womens' first acquisition of goats

Source	%
Crop sales	26.1
Masungiro	10.8
Cash from husband	10.8
Gift from relative	8.7
Piece work	6.5
Mat sales	6.5
Cash from gardening	4.5
Sugar-grain exchange	4.5
Sale of pots	4.3
Salary/wage	4.3
Pemberera	4.3
Milk sales	2.2
Nanga income	2.2
Savings clubs	2.2
Sale of fowls	2.2

Table 6.8: Men's first acquistion of goats

Source	%
Remittance	38.5
Crop sale/exchange	25.6
Building cash	7.7
Craft work	7.7
Gift from relative	5.1
Beer brewing	2.5
Ploughing	2.5
Herding payment	2.5
Brick making	2.5
Mice sales	2.5

Note: discussion of local terms in Appendix 5.

The dominant sources of income resulting in goat acquistion for both men and women are the receipt of remittances/gifts and the sale/exchange of crops. These account for between about 55% and 70% of all recorded first acquisitons. The remainder resulted from the raising of money through a range of means. These income sources are more gender specific (eg. mat and pot sales, gardening etc for women and brick making, herding, building etc for men).

Livestock loaning and sharing relationships: what are the impacts of inequality in asset ownership?

The inequality of asset distribution appears very dramatic when presented in per household statistics, but what does this mean in terms of access? Loaning and sharing relationships are important to understand if the impact of observed socio-economic differentiation is to be assessed.

The household provides a unit for analysis of rural situations, but is also limiting. The definition adopted for the analyses presented here focuses on the residence unit, but as discussed in Chapter 1, household units are often arranged in clusters. Such lineage clusters are important in controlling access to livestock assets and

organising livestock management (9). Within households there are also important socio-economic factors that determine the control and management of livestock assets. As already shown, men, women and children have different access to and control over livestock. It is necessary to take a hierarchical view of rural production organisation and consider households in relation to both inter- and intra- household organisation.

The interaction between households is critical in understanding the role of livestock, in particular cattle, in the production system. Two types of interaction can be distinguished - one involving sharing within clusters and another involving loaning between households.

Households are often clustered in relation to cattle use and sharing relations. These clusters are also usually kin based clusters centred on an older male patriarch and including his brothers' and sons' families. Not all households are part of such a 'cluster'; some individuals prefer, or are obliged through lack of connections, to work alone (see Chapter 1).

Interactions between households extend beyond the informal sharing and exchange relationships of the local household cluster to connections with other households of relatives and friends further away; the loaning of stock is a critical component in the management of cattle in the study area.

Of the people interviewed on the subject of cattle loaning, 33.3% had been loaned cattle at some time since the early 1960s, while 22.7% had loaned some cattle out. Of those that had been loaned cattle, 48% were from close relatives and 52% from 'friends'. Of those that had been loaned out, 70% had been loaned to relatives and 30% to friends.

The loaning arrangement is usually informally agreed between the two parties and a set of fairly standard codes

of conduct are agreed to. These include the right of the owner to withdraw the animal at any time, the right to come and inspect the beast, the right to be informed of death, illness or injury and the right of the holder to the animal's manure, milk and draft power. All calves remain owned by the original owner and the right to sell or slaughter also remains his. Payment to either party is now rare; in the past the holder used to be given one of the calves as a reward. Today the demand for loaned cattle is so high that this reward has been dropped. The benefits resulting from loaning and sharing relationships are shown in Table 6.9.

Table 6.9: Benefits to owners and non-owners of cattle resulting from loaning and sharing relationships

Benefits to owner	Benefits to non-owner
Loaning arrangement	
Reduced herding	Use of cattle for draft, manure and milk.
Less grazing pressure in local area, especially in drought.	
Assisting relatives and friends.	
Sharing arrangement	
Shared herding	Sharing of draft animals; possibly some access to manure and milk.
Assisting relatives	

Sharing relationships within clusters differ depending on the type of cattle product, service or equipment. Different relationships are observed for the sharing of draft power, herding responsibilities, manure, stover fodder and milk products. Sharing of draft power is perhaps the most significant to overall income and production. Different households have different arrangements; usually the actual owner has priority access and uses the animals first for

his ploughing. This is very important, particularly in the clay veld zone, where response farming to rainfall events is perceived by farmers as critical to agricultural success. However, this pattern is not universal and some owners rotate the use of draft animals between their fields and their relatives; others have more than one draft team and the constraint does not apply.

Donkeys are also shared between families, but the relations tend to be more flexible than for cattle. Fewer homes own donkeys and they are shared more widely; either freely to relatives or for nominal sums of cash to others.

Goats ownership tends not to be related so significantly to inter-household linkages. Some goats are held on a loan basis when a young goat is purchased and is left for a time with its mother or when the new owner does not own any other goats and setting up a new kraal and herding a single animal is not favoured. Sharing of goat products does occur to an extent between households, where milk from goats is taken by children from a number of homes. Similarly meat may be shared between households if a slaughter takes place.

The patterns of sharing within and between household clusters is explored as a series of case studies in Appendix 9. Loaning and sharing of cattle and donkeys (products and services) is discussed and related to the patterns of organisation of lineage clusters, including herding arrangements.

Equipment assets

Other assets are also unevenly distributed. Although most people own a plough, ownership of carts and other equipment (harrows, cultivators etc. (10)) is dominated by the richer wealth categories. Someone commented on the role of carts during an interview:

> "Carts are a useful way of getting money from hiring, if you can manage to buy one from money from a job. They are particularly useful in the sandy soild for carrying termitaria soils to the fields. " (Nyii, Mototi, 1.87).

The distribution of equipment assets between different wealth groups was explored in Table 6.2. This showed that 100% of households in wealth rank 1 own a cart, whereas no wealth rank 4 households do. Similar disparities exist for equipment such as ploughs, harrows and cultivators. However this differentiation shown be household ownership statistics is offset by patterns of loaning and sharing within household clusters (see Appendix 9).

Labour

The differential availability of labour affects the household economy in terms of both livestock and agricultural production.

Research in Zimbabwe has demonstrated the importance of an informal wage labour economy within the rural areas (Adams, 1988). In the Mazvihwa study area people predict that the growing population, limited access to agricultural land and shrinking opportunities for urban employment will result in a growing requirement for young people to seek a livelihood through local wage employment. In the recent past, Mozambican refugees have been employed by households for various agricultural and domestic tasks. Some households employ young boys for herding and others hire domestic help. However most employment is on a casual 'piece work' basis for particular jobs where payment may be in cash or in food. The degree to which this occurs is dependent on the season; only in good years do many people hire labour for agricultural purposes, in other years those with remittance income and a shortage of home labour will be the major hirers (11).

Demographic data for all the households in the sample was collected during 1986 and 1987 (12). This section provides

an analysis of the 1987 data. Household composition data included all members of that home present or absent with a recording of their age and degree of presence.

Table 6.2 has investigated the labour availability between different wealth groups and zones. Wealth group 1 appears to have larger household sizes; this may relate to demographic patterns described below. The sand veld households have on average larger household sizes than other zones; this is explained by the greater prevalence of polygamous households in this zone.

In Table 6.10 various descriptors of household size and composition are used. Household size is the simple number of members weighted by presence or absence classes and the Adult equivalent unit (AEU) measure represents a household consumption indicator (13). Two Consumer:producer (C/P) ratios have been calculated from the data; one considers only local household producers the other takes into account the contribution of family members working away and sending remittances (14).

Table 6.10: The demographic cycle and household structure (for details of calculations of household structure indicators see Footnotes 13 and 14).

Age cat	AEU Avg	SE	C/P(*1) Avg	C/P+W (*2) Avg	HHSIZE Avg
21-30	2.6	0.6	2.00	1.43	6.33
31-40	4.3	0.6	2.00	1.43	7.78
41-50	6.9	0.7	1.43	1.25	10.13
51-60	8.4	1.3	1.66	1.25	13.50
61-70	7.1	1.7	1.66	1.25	11.38
71-80	6.7	1.7	1.66	1.43	11.75
80+	6.4	1.1	1.66	1.35	9.67

The results show increasing consumption requirements as the household ages to a peak during the 51-60 age category. High dependency ratios are shown up to the age of 40 when children are young. The initial establishment phase, when the newly married couple have no children is not shown with

an analysis of aggregated age categories over wide age bands. As children grow up (over the age of 10) they become active workers at home and later still go off to work in town.

A consideration of the migrant labour component of the household composition is important in the rural Zimbabwean context. As a comparison of the ratios shows, the inclusion of migrant workers in the calculations reduces the C/P ratios within all age classes, but particularly for the 51-70 age categories. In the older age categories the dependency ratio does not appear to decline as classically assumed (15), and indeed increases if migrant worker contributions are considered.

Land

Access to arable land was assessed in a survey of sample households (16). This is shown in Figure 6.2. There were large disparities found in access to land on a household basis, with notable differences between ecological zones (17). However on a per AEU basis, there was found to be remarkable equity across zones and wealth ranks (18).

Changes in land holding according to the age category of the household are considered in section 6.6

6.6 Linkages between the crop and livestock economy

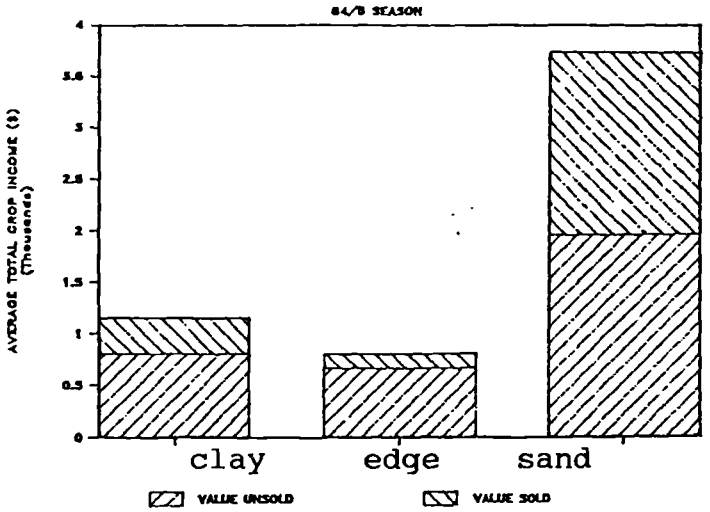
Ownership of and access to key rural based assets discussed in the previous section will have an effect on the different agricultural returns of households. This will be modified by the influence of savanna type and interannual variations in rainfall. The differences in agricultural incomes between households and the influence on expenditure patterns and food security status will be explored in this and the next section.

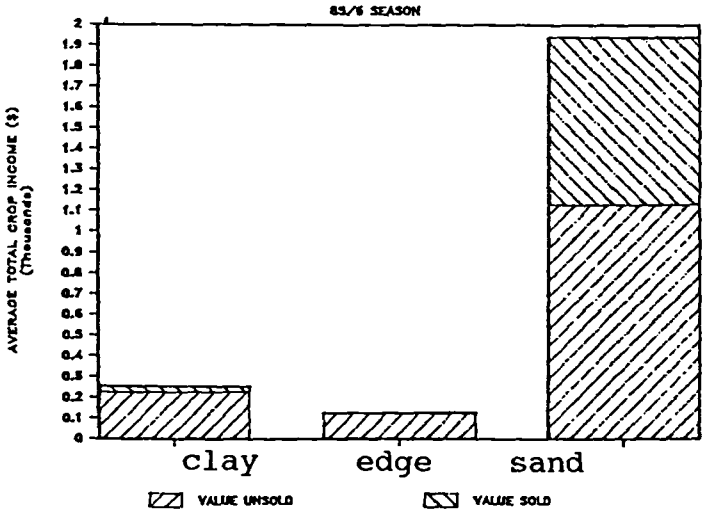
Table 6.11: Total crop income (total, per ha and per Adult equivalent unit (AEU)) and cash sales to GMB and other sources (OS) for 1984-5 to 1986-7 (Z$) for household sample (N = 69)

		YIELD $			$/HA			$/AEU		
		84/5	85/6	86/7	84/5	85/6	86/7	84/5	85/6	86/7
AVG	WEALTH1	3225.67	1270.32	1127.75	376.67	158.12	113.71	406.85	132.97	127.79
	WEALTH2	932.11	223.88	185.59	246.18	74.22	52.11	218.92	53.48	40.30
	WEALTH3	712.87	79.30	87.33	149.59	19.25	20.10	148.57	15.96	22.84
	WEALTH4	639.36	103.55	89.26	177.31	23.32	23.53	157.90	25.32	22.93
SE	WEALTH1	748.42	376.18	510.06	47.95	31.58	36.96	112.47	40.21	66.37
	WEALTH2	134.04	54.60	35.19	36.86	16.41	6.97	38.99	15.97	8.36
	WEALTH3	96.29	12.87	14.45	12.69	3.56	3.31	15.52	3.02	6.71
	WEALTH4	60.98	28.28	27.58	12.78	4.92	5.17	18.11	7.58	6.24
AVG	CLAY	1148.63	246.03	194.28	231.50	56.54	37.88	217.26	43.06	36.68
	EDGE	793.41	119.23	108.26	168.92	21.12	21.32	148.66	19.46	16.04
	SAND	3722.86	1935.92	1862.89	375.89	203.30	172.42	492.70	206.97	225.25
SE	CLAY	161.50	51.23	45.52	19.25	10.94	5.41	22.60	8.42	6.36
	EDGE	131.85	31.93	23.69	20.49	5.14	3.73	15.45	4.94	2.44
	SAND	1608.20	764.97	1079.55	101.44	52.72	72.51	245.25	80.30	141.04
AVG	CLAY 1-2	1633.28	430.04	326.14	310.58	104.32	59.27	284.23	71.31	50.52
	CLAY 3-4	710.15	87.11	80.40	168.24	22.42	21.59	156.67	18.67	24.73
	EDGE 1-2	1203.01	233.17	196.48	209.63	40.06	38.42	164.51	26.19	23.47
	EDGE 3-4	588.61	66.64	67.54	148.57	12.51	15.10	140.74	16.35	12.62
	SAND 1-4	3722.86	1935.92	1862.89	375.89	203.30	172.42	492.70	206.97	225.25
SE	CLAY 1-2	286.93	90.95	85.86	30.75	19.43	9.19	38.67	15.11	10.72
	CLAY 3-4	80.44	12.05	11.69	12.07	3.21	3.08	15.21	2.98	6.04
	EDGE 1-2	300.00	71.61	53.09	48.33	11.77	8.21	24.95	5.86	5.32
	EDGE 3-4	79.22	19.08	13.05	15.27	2.73	2.33	19.27	6.70	1.89
	SAND 1-4	1608.20	764.97	1079.55	101.44	52.72	72.51	245.25	80.30	141.04

		GMB84-5	OS84-5	GMB85-6	OS85-6	GMB86-7	OS86-7
AVG	WEALTH1	1340.29	163.67	176.54	250.76	28.67	316.57
	WEALTH2	215.01	3.70	17.60	5.16	3.51	0.00
	WEALTH3	76.97	10.27	0.00	0.34	0.00	0.00
	WEALTH4	89.93	9.64	0.00	0.00	0.00	3.48
SE	WEALTH1	440.18	54.96	84.61	154.90	18.21	280.46
	WEALTH2	52.39	3.47	14.47	4.84	3.29	0.00
	WEALTH3	23.84	6.73	0.00	0.32	0.00	0.00
	WEALTH4	23.34	5.92	0.00	0.00	0.00	3.38
AVG	CLAY	329.30	21.60	20.25	6.05	11.86	0.00
	EDGE	110.40	27.58	0.93	0.00	0.00	0.00
	SAND	1562.40	209.05	297.40	514.61	0.00	686.82
SE	CLAY	76.26	14.49	10.68	4.27	7.49	0.00
	EDGE	29.90	18.68	0.84	0.00	0.00	0.00
	SAND	974.66	86.70	176.52	325.21	0.00	610.48

Figure 6.2 a-c: Total crop income and cash sales by ecological zone, 1984-5 to 1986-7





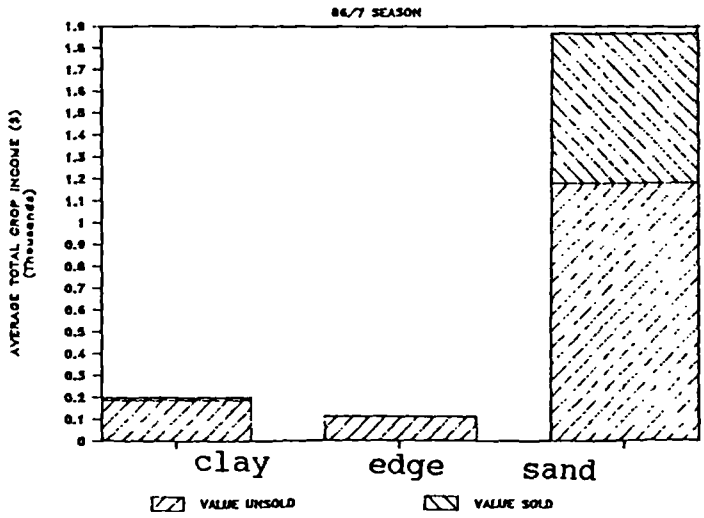
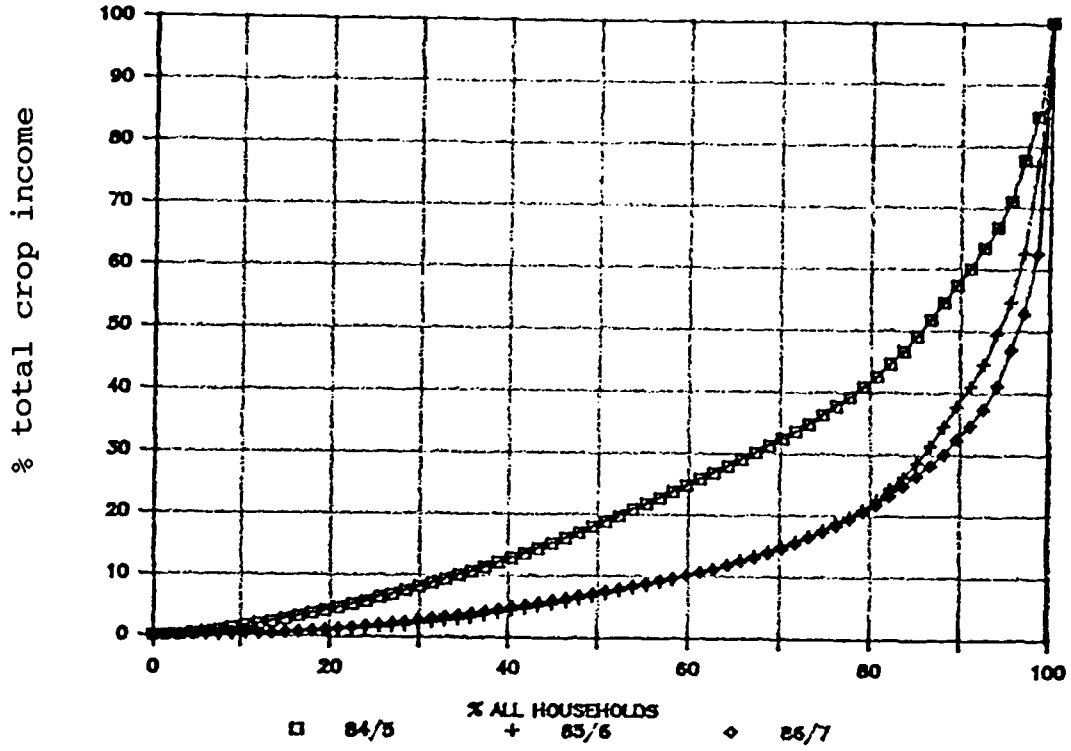
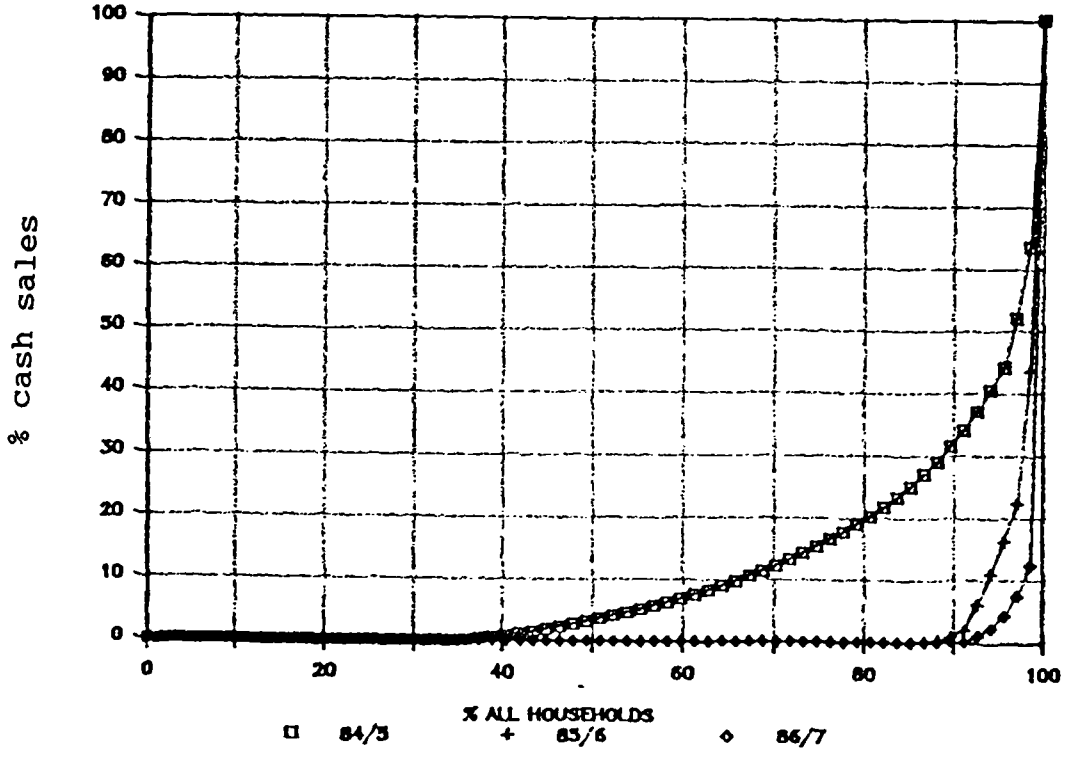


Figure 6.3: a. Distribution of total crop income, b. Distribution of cash sales, 1984-5 to 1986-7





The income received by households from crop production was calculated for three seasons: 84-5, 85-6 and 86-7. Total crop income represents the market value of all crops produced during that season. Yields, sales to the Grain Marketing Board (GMB) and local sales were estimated by recall in terms of bags (or other local measures) and converted into kg weight (19). The value was measured in terms of the official government producer price for the crop during that year (20). Local sales were also valued at this price; this may underestimate the value of local sales, as higher prices can be achieved for off-season sales (especially for early groundnut crops). However the amount of local, unofficial sales is limited, except in the sand veld zone where groundnut marketing is important (21).

Data on the variation in total crop income and sales between years, ecological zones and wealth ranks is presented in Table 6.11. This shows the average (+/- SE) crop income total per household and per hectare and the level of sales both to the GMB and to the local market per household.

The interannual variation in total crop income and sales for different savanna types is highlighted in Figure 6.2a-d. The distribution of total crop income and cash from sales between households is shown in Figures 6.3a-b for three seasons. These patterns are explored further below.

The relationships between total crop income and different factors of production have been investigated by correlation analysis (Table 6.12). Total crop income ($) for three seasons was correlated with cattle ownership (1987 data), labour levels (AEU for the household for that year is taken as an indicator of available labour), land holding (ha, 1987 data), cash income levels (1987 data) and remittance levels (1987 data). The lack of asset/income data for previous years means that the 1987 data is taken as an indicator.

This analysis highlights the likely form of an agricultural production function for this situation. A full exploration of this is beyond the scope of this thesis (23).

Table 6.12: Crop income ($) and factors of production

	Own	Lab	Inc	Land	Remit
Y84	0.46 **	0.46 **	0.72 **	0.70 **	-0.07 ns
Y85	0.48 **	0.44 **	0.66 **	0.57 **	-0.11 ns
Y86	0.34 *	0.26 *	0.66 **	0.62 **	-0.10 ns

Pearsons correlation coefficients. 2-tailed significance:
* = 0.01 ; ** = 0.001

The general pattern is that yield levels (however measured) are closely correlated with ownership of key assets such as livestock (23), are related to labour availability in the household and also to cash income levels received by the household. Remittances are not so closely related to crop production levels and perhaps only indirectly affect crop production, by providing money for stock investment or releasing cash income for direct investment in agriculture (although the amounts spent are small). The negative relationships shown possibly suggest that those with higher remittance income sources have less need to invest time and effort in agricultural production, as their security is assured through access to income from outside the rural area.

Agricultural income

Differences in total crop income and cash income from sales can be investigated in relation to differences in wealth rank, ecological zone and household age category.

Wealth group differences:

Table 6.11 has shown the average (+/-SE) crop income by

different wealth groups for data on harvests in 1984-5 to 1986-7. Total crop income is shown as a total income and in relation to area and household AEU levels. Table 6.11 also shows the patterns of sales between wealth groups for the same period, indicating levels of income received from GMB sales and other sales.

If total crop income is considered, wealth group 1 shows significantly higher levels to wealth groups 3 and 4 (T-test, 2-tailed significance: $p < 0.005$ in 1984-5/85-6 and $p < 0.05$ in 1986-7). Wealth group 1 also shows significantly higher total crop income levels to wealth group 2 in 1984-5/85-6 ($p < 0.01$), but not in 1986-7. Wealth group 2 shows significantly higher total crop income to wealth groups 3-4 in 1985-6/86-7 ($p < 0.05$), but not in 1984-5. Wealth groups 3-4 have insignificant differences ($p > 0.05$) in total crop income in all three years.

Similar patterns are shown if crop income per area or per AEU are analysed. Realised cash income in terms of sales was only substantial in 1984-5. In this year, wealth group 1 showed significantly higher sales income ($p < 0.02$) compared to all other groups. Similarly, wealth group 2 showed higher cash income levels compared to groups 3-4 ($p < 0.04$). Sales income in 1984-5 was not significantly different between wealth groups 3 and 4.

Savanna zone differences:

Differences in crop output between different savanna zones has already been discussed in Chapter 2. The properties of different savanna types results in different levels of potential productivity and variability in output.

The crop income levels according to different measures by ecological zone is shown in full in Table 6.11. The level of total crop income per household in the sand veld is significantly higher in all years compared to the clay and edge zones (T-test, 2-tailed significance, $p < 0.01$). This

is also reflected in the income from sales (for 1984-5, $p < 0.01$). The larger field sizes account for some of this disparity, but yield per hectare figures also show the same pattern. Crop income levels per AEU are also similar, despite larger household sizes in the sand veld zone. The high value groundnut crop in the sandveld is an important contributory factor to increasing crop incomes in this zone, but income levels based only on the grain crops (maize, sorghum and millets) also show the same general pattern.

The lowest total crop income levels for all years are shown by the edge zone households in per household, per hectare and per AEU terms. However the clay zone households show only slightly higher levels of total crop income and there are no significant differences shown ($p > 0.05$).

The coefficient of variation of average crop incomes from each of the three ecological zones was calculated across the three years' data. The results are shown in Table 6.12.

Table 6.12: Coefficient of variation of crop income levels

Zone	Total crop inc. CV %	Income/ha CV%
Clay veld zone	82.7	80.3
Edge zone	94.2	98.8
Sand veld zone	34.3	35.7

There are massive variations in income levels in both the clay and edge zones, whereas the levels are more stable in the sand veld (yet still exhibiting a coefficient of variation of 35%).

The results of crop income levels per household, per hectare and per AEU and their variability between years reflects the pattern expected by savanna ecology when the clay and sand veld zones are compared (see Chapter 2). The

results from the edge zone are anomalous though, as we would expect the crop income levels and variability to show an intermediate pattern (24).

Household age category differences:

The degree to which a household relies on rural agricultural production can be expected to relate to the changing pattern of household demography and the differing access to alternative income sources, notably remittances, at different stages of the household development cycle. With high C/P ratios and less remittance income (young and old households) a concentration on agricultural production can be expected. Table 6.13 presents information for the 1984-5 season for all sample households. During 1985-6 and 1986-7 production levels were very much lower, but the overall pattern of production and sales by different age categories of household was similar.

Table 6.13: Agricultural production and the domestic development cycle.

Age cat	Field area		Yield/ha		Sales (84/5)	
	Avg	SE	Avg	SE	Avg	SE
21-30	2.2	0.25	10.0	2.5	0.0	0.0
31-40	4.1	0.3	5.2	0.5	3.2	1.0
41-50	5.5	0.8	8.7	0.8	21.4	9.7
51-60	6.9	0.7	8.4	1.4	32.7	12.2
61-70	5.9	1.1	7.9	0.7	17.9	7.9
71-80	4.6	0.7	10.6	1.2	24.0	9.4
81+	7.4	2.2	11.7	5.6	71.0	27.7

Note: Field area is measured in hectares. Yield and sales are measured in bags of cereal grain for the 84/5 season only. Sales represent sales to the Grain Marketing Board as well as local sales.

The data shows that field area increases with age to the 51-60 age category and then declines. The pattern of land holding, however, does not respond to the changing C/P ratios shown in Table 6.10, and so does not conform to the

expected pattern suggested by the literature (1). This is because land holding is not unconstrained as suggested by classical demographic models. Land holding is closely related to lineage affiliation and other socio-political factors not accounted for in simple demographic models (16).

The highest yields/ha are shown by the youngest and oldest age groups; those with less access to remittance income. The lowest yields are shown by the 31-40 age category; the dominant wage labour earning group. Yields/AEU show a similar pattern with the highest levels in the youngest and oldest age categories, the lowest in the 31-50 age categories and an intermediate amount in the 51-80 age categories. This suggests that increased intensity of production is being achieved by those groups with less access to remittance income. In addition, the youngest age group appears to be intensifying in order to compensate for small land areas.

Sales are highest among the age groups with lower C/P ratios, suggesting that surplus income from crop production is only made available at certain stages in the demographic cycle. The amount of investment from agricultural sources will therefore be dependent on the combination of low dependency ratios and favourable climatic conditions.

Not all households will therefore be in a position to capitalise upon the products of a good harvest and invest in stock or other assets. Some households will be in a position where the previous run of poor years have meant the accumulation of debts, created to provide food for the large number of consumers in the household, especially if few stock are owned to sell or exchange. In the absence of income from off-farm sources, all the surplus from the occasional good harvest will have to be invested in subsistence or debt repayment, rather than capital investment. This combination of factors is most likely to occur in the young, newly established homes.

Expenditure of crop income

The previous sections have shown that the amount of cash income raised from crop sales is differentiated according to wealth rank, ecological zone and household age category. The potentials for such income also vary over time in relation to rainfall. The opportunities for investment in livestock from crop production are therefore highly differentiated between wealth groups, different areas and over time.

Cash raised from sales of agricultural produce are spent on a range of products. The pattern exhibited for the household sample in 1984-5 is shown in Table 6.14. This represents a ranking of the major items spent; no information on actual expenditures was recalled by informants.

Table 6.14: Top items purchased from 84-5 harvest

Spent on	Of those that sold crops % households
Clothes/blankets	42.5
School fees	40.4
Household items	25.5
Groceries	25.5
Livestock	23.4
Building	12.8
Agric equipment	8.5
Bridewealth	4.2
Debts	4.2
Seeds	4.2
Cattle hire	2.1
Bicycle	2.1

Note: The total sums to more than 100% because most households spent money on more than one item.

As Table 6.11 shows, the cash raised by wealth groups 3-4 in the clay and edge zone from crop sales in 1984-5 was small compared to the other categories. These groups spent

the money on relatively minor expenditures (eg. groceries, household items, clothes/blankets) or on debt repayment. It was only the richer wealth groups that were in a position to invest in larger items such as livestock, bridewealth, school fees or building. The patterns of livestock investment between different groups will be investigated further in section 6.10.

6.7 Livestock and household food security

Livestock investments and disposals and the food security status of the household can be expected to be closely linked. Cattle and goats have been used as an important source of exchange entitlement in times of grain shortage in droughts (see Chapter 3), while goats and chickens provide an important source of nutrition when nothing else is available. Good harvests may provide the opportunity of stock purchase for some, when other committments are not high. Food deficit periods may also be a chance to acquire stock for those with surplus grain to exchange.

The food security situation of different households varies over time according to the amount of incoming harvest and the rate of decline of the stores of grain. As stores decline, and households enter deficit we would expect to see an increase in stock sales in order to purchase food, or at least save other income for that purpose. Those with large surpluses would be expected to be the ones accumulating livestock, either from others in trouble or from elsewhere. The degree to which this dynamic interaction between the food grain and livestock economy occurs can be tested with grain production and consumption data between the 1984-5 harvest and the end of 1987.

The production and use of grain products was investigated with the use of a simple grain flow model (25). The model describes the pattern of grain yield, sales, consumption and post-harvest loss over three years for all the households where a full data set exists (N = 67). The

starting point is the 1984-5 harvest where zero storage levels are assumed (see Figure 6.4; (26)).

The simulation first removes the level of recorded sales from the harvest; these include both GMB and local sales. Following this, consumption by the household for food and beer is removed. Detailed monitoring of consumption levels was not carried out, but occasional studies provide reasonable indicators (27). Consumption (including food and beer) and losses (while in storage) are added up. Grain is not consumed immediately after harvest, so a post-harvest loss term must be added to the consumption level (28). Other uses (eg for livestock feed) are very limited in the study area and were not included.

Following all sales, consumption and loss from pests, a food balance is calculated. This highlights the pattern of surplus and deficit between homes. Surplus stores are assumed to be carried through into the next year's budget, while those households in deficit are assumed to bring their food budget back to zero storage through purchase or borrowing before the next harvest.

The model outputs over three years are shown in Table 6.15 for the household level analysis. The data shows the pattern of grain yields and sales between zones and wealth categories over the three years. Table 6.15 also shows the assumed food and beer consumption levels by household. Table 6.15 shows the end of year positions of households by zone and wealth category. The balance is represented in two columns (Bal and Store) these represent the balance of food (kgs) per household before and after storage losses. The deficit column (Def) provides an average deficit level (those in surplus having zero deficit). The final column is the average end of year surplus level (those in deficit have zero surplus). This is the amount that is assumed to be carried over as storage to be added to by the following year's harvest.

Figure 6.4: a. Grain flow model over one year, b. Simulation output over 3 years.

Figure 6.4a uses terms referred to in Table 6.15 and explained in the text

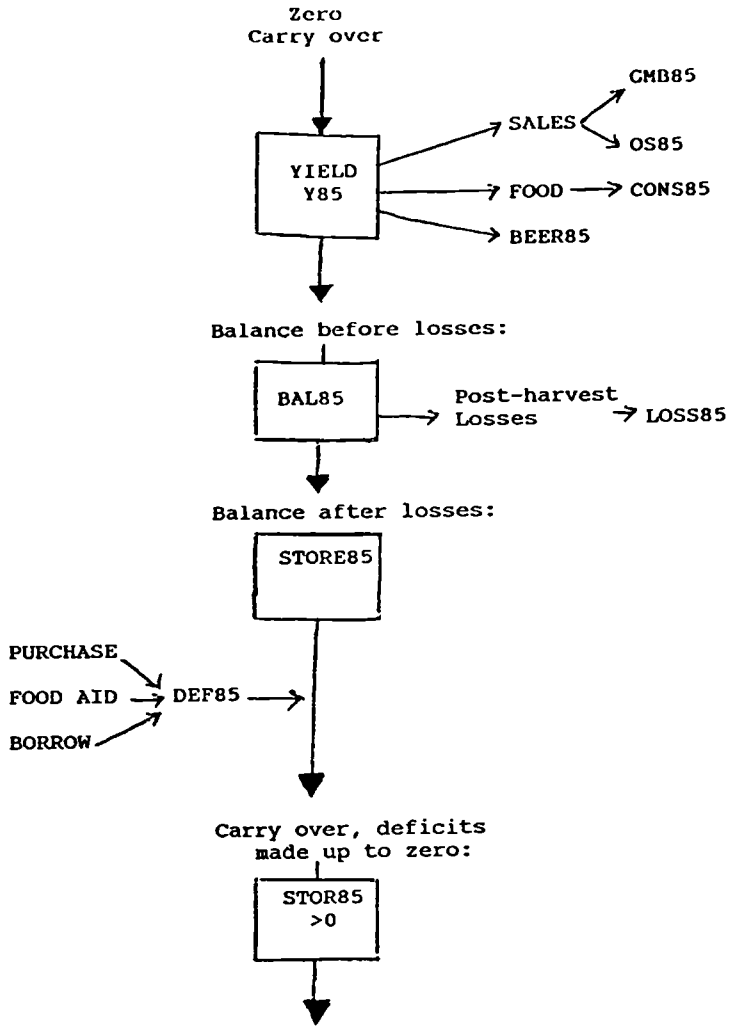
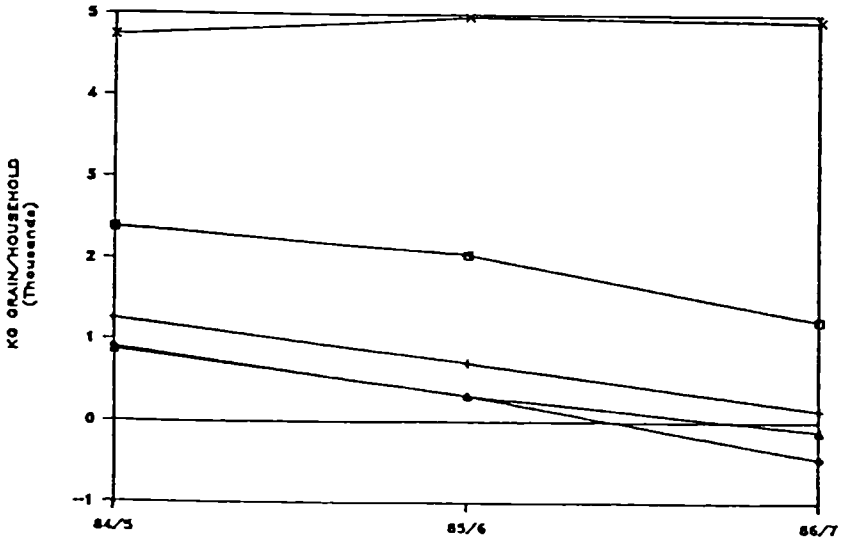


Figure 6.4b shows the average end of year balance after losses (Store85, 86, 87 in Figure 6.4a and Table 6.15) in kg/household for different wealth groups and ecological zones. See Table 6.15 for full details.



□ Clay 1-2 + Clay 3-4 ▲ Edge 1-2 ◆ Edge 3-4 × Sand 1-4

Table 6.15: Food flow model outputs: 1984-5 to 1987 in kg grain per household by wealth rank/ecological zone. Also: consumption estimate inputs to model for food and beer.

AVG		BAL85	STORE85	DEF85	STOR85		BAL86	STORE86	DEF86	STOR86		BAL87	STORE87	DEF87	STOR87
	CLAY 1-2	2675	2407	-2	2409	CLAY 1-2	2301	2066	-47	2114	CLAY 1-2	1415	1255	-185	1441
	CLAY 3-4	1426	1279	-43	1323	CLAY 3-4	825	736	-67	803	CLAY 3-4	212	164	-272	435
	EDGE 1-2	1042	933	-44	978	EDGE 1-2	394	336	-187	523	EDGE 1-2	-421	-435	-552	127
	EDGE 3-4	1007	898	-88	986	EDGE 3-4	409	338	-201	639	EDGE 3-4	-64	-97	-355	259
	SAND 1-4	5268	4741	0	4741	SAND 1-4	5510	4959	0	4959	SAND 1-4	5469	4914	0	4914
STD															
	CLAY 1-2	2412	2171	7	2169	CLAY 1-2	2233	2106	159	2052	CLAY 1-2	2309	2098	406	1924
	CLAY 3-4	1295	1174	172	1110	CLAY 3-4	901	821	178	731	CLAY 3-4	1002	925	436	559
	EDGE 1-2	1024	927	99	874	EDGE 1-2	999	921	324	740	EDGE 1-2	714	598	559	180
	EDGE 3-4	1388	1262	275	1159	EDGE 3-4	1227	1140	469	834	EDGE 3-4	918	863	453	551
	SAND 1-4	4536	4002	0	4002	SAND 1-4	4447	4002	0	4002	SAND 1-4	5015	4513	0	4513

	CONSUMPTION		
	85	86	87
CLAY 1-2	941	1001	1287
CLAY 3-4	790	883	879
EDGE 1-2	1060	1137	1381
EDGE 3-4	892	843	903
SAND 1-4	1237	1346	1761
CLAY 1-2	437	448	685
CLAY 3-4	545	548	657
EDGE 1-2	408	456	585
EDGE 3-4	411	388	454
SAND 1-4	911	941	1333

	BEER (85-
CLAY 1-2	332
CLAY 3-4	335
EDGE 1-2	514
EDGE 3-4	486
SAND 1-4	219
CLAY 1-2	483
CLAY 3-4	284
EDGE 1-2	248
EDGE 3-4	318
SAND 1-4	170

The simulation of the grain flow levels makes a number of very general assumptions and cannot be expected to reflect the exact situation. It is difficult to cross-check as the calculated storage levels prior to the next harvest cannot easily be assessed, as this information remains secret.

In general the model probably portrays a more favourable food security situation than actually existed. The model shows an increasing number of people entering food deficit situations over the three years. This was certainly the case, but it shows only 30% food deficit households before the 1988 harvest. This is almost certainly an underestimate, as many people were purchasing during this period and the government had provided food relief for much of the dry season (29).

The general pattern of differences between zones and wealth categories indicated by the grain flow model is probably correct. The reason that the actual figures may be inaccurate is that grain is intimately linked in with the informal exchanges and payments that are very difficult to monitor effectively. Small amounts of grain may be exchanged for labour or other products, sold or further exchanged, while food deficit households may be given food by relatives. Similarly the consumption estimates, based on AEU levels per household may be affected by extra consumption of grain by visitors or at particular ceremonies.

Agricultural output and livestock investment

Agricultural output is influenced by both wealth rank and savanna type and the level varies considerably between years. Sections 6.6-6.7 has explored the implications of this for total crop income, crop sales and food security. The results of these analyses are summarised below and hypotheses about stock investment and disposal patterns suggested. These are explored in section 6.10.

- Sand veld households consistently out-produce (in terms of total yield and yield/AEU) all other groups. They also have higher sale levels than all other groups.

- Sand veld households are the only group who have no grain deficit households in all years.

- Clay veld households in wealth category 1 and 2 are the next highest producers/sellers; especially in the 84-5 season.

- Edge zone households (wealth category 3-4) produce and sell the least across all years and go into deficit the most.

- Storage is particularly important for clay veld households (wealth category 3-4), where 84-5 production is stored and provides for the household over the following years. Despite two production failures the households still have an average (post loss) balance of 164 kg. Surplus households in this group have 435 kg on average in store in 1987-88, however, storage is also important in other groups.

- Wealth categories 3 and 4, consistently produce less across all years, however they also consume less. But the the average end of season balance is lower in wealth category 3-4 households in the clay veld. This is not repeated in the edge zone where wealth category 3-4 households are better off than wealth category 1 and 2 households in food terms (in aggregate from 85-6 and in per AEU terms in all years).

These patterns, highlighted by the investigation of the agricultural production data, suggest expected differences in stock investment and disposal strategies. We would expect investment by sand veld households in stock in all years and wealth category 1-2 households from the clay veld zone in the good season of 1984-5. Disposals would be expected to be concentrated in the lower wealth categories (especially of goats, as this group owns fewer cattle) and particularly in the edge zone. These patterns are investigated in section 6.10, for data from 1987 and 1985.

6.8 Patterns of cash income and expenditure

Sections 6.6 and 6.7 have investigated agricultural production in the study area. However, cash income generation is not only dependent on agriculture. The discussion of livestock acquisiton patterns in section 6.5 has already demonstrated the importance of off-farm remittance income. This section explores the range of cash income sources and how these influence expenditure patterns. Again the focus is on the differentiation of income and expenditure patterns between wealth groups, ecological zones and household age categories.

Investigating income and expenditure

The detailed pattern of income and expenditure in the household sample was monitored over two periods - between October 1986 and September 1987 and between August and October 1988. Incomes and expenditures have been classified into various categories (see Table 6.16a-b). Discussions of income and expenditure were held on four occasions during 86-7: in December, March, June and September and once in 1988 (in October) (30).

Qualitative understanding of cash flows and informal exchanges was also generated, which helped in the interpretation of the quantitative data collected. This concentrated on estimates of quarterly budgets based on extrapolation of weekly regular income/expenditure amounts over the period and detailed documentation of major income/expenditure.

The close linkages between the urban and rural economy makes the tracing of income and expenditure flows difficult. For instance, some households are resident in town for periods of time and the delineation between the urban and rural household economy is problematic.

Investigating household budgets is notoriously difficult. The detailed knowledge of the households in the sample helped to cross-check some of the possible areas of error, but the actual figures should not be taken too seriously. The analysis that follows concentrates on comparisons of relative income between individual homes, wealth categories, ecological zones or seasons. The areas of error include the missing of occasional incomes and expenditures not recalled by infrequent sampling, the lack of information about 'secret' sources of income (eg prostitution etc), the concentration on cash income and expenditure, underplaying the significance of informal exchanges and bartering of goods with no cash transaction.

Patterns of cash income and expenditure

Figures 6.5 and 6.6 compare the income and expenditure patterns for the two periods when monitoring occurred. There is a great deal of similarity in the relative contributions of different income sources and in patterns of expenditure. The importance of remittance sources is well illustrated; these being slightly higher in the drought year of 1987. The noticeable differences are that in the drought year of 1987 there was some expenditure on food (ie purchased grain or meal), whereas following the better agricultural season of 1988 this is not observed. There is, on the other hand, an increase in expenditure on clothes and bridewealth payments.

The distribution of cash income and expenditure is highly skewed as illustrated in Figure 6.7. The average cash income for 1987 was $865.24 and the median $660. The average cash expenditure was $733.98 and the median $590. The distribution of cash income and expenditure across households shows the same pattern with the top quartile accounting for more than 50% of total cash income and expenditure.

Codes for income/expenditure data (*)

Rem (Remittance), Pwk (piece work), Catinc (cattle income), Hvst (harvest), Gtinc (goat income), Beer (beer brew), Chinc (chicken income), Craft (craft sales), Gning (gardening), Sugar (sugar exchanges), Milk (milk sales), S Club (savings club), Fish (fish sales), Irrig (irrigation).

Groc (groceries), Fees (school fees), Food (food purchase), Tpt (transport), cat (cattle purchase), Agin (agricultural inputs), Bdg (building), Beer (beer), cloth (clothing), Hh (household items), Mill (mill transport/fees), Gt (goat purchase), Donk (donkey purchase), Lab (labour hire), Nanga (traditional healer), Ch (chicken expenditure).

Table 6.16a: 1. Pattern of income by wealth group and ecological zone for 1987 (Average Z$ +/- SE). 2. Income pattern for 1988 estimate (% of total cash income). Codes used see text and Footnote 30.(*)

1986/7	RBM	PWR	HVST	IBRIG	CATINC	MILK	GTINC	CHINC	FISH	BBBR	CRAFT	S CLUB	GNING	S EXCH	TOTAL
AVG:															
WEALTH 1	610.18	93.65	271.02	5.88	409.29	7.06	63.12	79.35	0.59	27.06	25.29	8.82	5.71	20.94	1627.96
WEALTH 2	652.06	100.71	1.18	0.00	0.00	9.82	30.12	7.06	1.76	35.32	3.88	1.76	10.18	0.00	853.85
WEALTH 3	249.15	164.90	2.50	0.00	28.80	0.75	59.85	10.48	2.75	32.37	3.13	0.00	13.15	0.00	567.82
WEALTH 4	215.06	139.31	0.00	0.00	0.00	1.25	18.56	2.63	2.81	27.19	17.94	0.00	13.98	6.00	438.73
SE:															
WEALTH 1	137.68	49.62	218.43	5.71	115.79	6.85	24.61	46.80	0.57	12.46	17.03	8.56	2.61	20.32	224.40
WEALTH 2	124.92	29.07	1.14	0.00	0.00	8.40	14.45	3.22	1.71	23.90	3.42	1.71	5.73	0.00	113.68
WEALTH 3	86.09	43.13	2.44	0.00	23.86	0.73	23.35	4.68	1.85	10.59	1.34	0.00	4.99	0.00	87.43
WEALTH 4	81.07	22.24	0.00	0.00	0.00	0.97	7.94	1.97	2.81	13.78	7.37	0.00	6.50	0.00	76.75

		RBM	PWR	HARVSTS	IRRIG	CATINC	MILK	GTINC	CHINC	FISH	BBBR	CRAFT	S CLUB	GNING	BICH	TOTAL
	AVG	CLAY	452.05	131.44	11.50	0.00	95.07	4.93	42.71	19.16	1.34	23.40	10.46	0.00	13.41	0.00	805.46
		EDGE	417.27	128.45	0.00	4.55	120.14	0.00	34.32	41.14	3.86	50.38	13.52	8.18	8.73	0.00	830.54
		SAND	309.71	88.00	600.86	0.00	141.86	17.14	81.86	4.29	0.00	10.71	17.00	0.00	2.14	50.86	1324.43
	SE	CLAY	76.03	26.12	6.82	0.00	51.23	3.53	12.22	8.03	0.92	7.34	7.25	0.00	3.90	0.00	96.06
		EDGE	118.84	33.81	0.00	4.44	47.97	0.00	14.83	31.97	2.36	19.82	4.83	6.73	3.22	0.00	135.75
		SAND	102.68	55.51	503.61	0.00	101.53	15.87	48.99	3.26	0.00	9.92	10.18	0.00	1.98	47.08	471.06
1988		RBM	PWR	HVST	IBRIG	CATINC	MILK	GTINC	CHINC	FISH	BBBR	CRAFT	S CLUB	GNING	S EXCH	TOTAL
(*)																
BAND1		24.47	8.07	19.03	0.00	26.41	0.67	10.55	2.55	0.00	2.15	4.10	0.00	2.00	0.00	100.00
BAND2		59.24	9.27	3.36	0.00	0.91	2.11	5.19	1.48	2.51	3.61	1.41	0.00	0.90	0.00	100.00
BAND3		44.49	26.39	0.84	0.00	9.46	0.00	8.56	0.32	0.00	4.90	0.34	2.52	2.19	0.00	100.00
BAND4		16.30	11.34	0.87	0.00	48.40	0.00	2.97	1.53	1.48	10.72	0.74	0.00	2.16	3.49	100.00

Table 6.16b: 1. Pattern of expenditure by wealth group and ecological zone for 1987 (Average Z$ +/- SE). 2. Expenditure pattern for 1988 estimate (% of total cash expenditure). Codes used see text and Footnote 30.

1986/7	AGIN	HHITEMS	CLOTH	LABOUR	BDING	CATEXP	GTEXP	DONKEXP	LOBOLA	FEES	GROC	FOOD	TPORT	BEER	EXP TOT
TOTAL	2387.69	1320	1760.45	114	2290.85	3208	1125	105	1398	8998.5	17445.77	5597.25	3423.82	2204	51378.33
%	4.65	2.57	3.43	0.22	4.46	6.24	2.19	0.20	2.72	17.51	33.96	10.89	6.66	4.29	100
AVG:															
WEALTH 1	59.94	55.88	53.00	6.71	98.71	122.35	25.35	6.18	58.82	284.65	419.76	64.09	90.32	69.60	1366.22
WEALTH 2	32.43	20.47	26.65	0.00	22.18	45.18	7.59	0.00	9.41	102.91	300.74	88.63	62.07	68.00	730.25
WEALTH 3	21.33	1.10	15.88	0.00	10.79	18.00	15.25	0.00	0.00	80.45	172.42	81.48	29.52	98.15	508.54
WEALTH 4	24.43	0.00	5.56	0.00	1.25	0.00	16.25	0.00	14.88	50.06	109.31	85.72	27.23	47.00	347.97
SE:															
WEALTH 1	15.82	53.01	19.33	6.51	48.76	75.42	15.35	5.99	39.95	64.20	58.38	14.47	27.78	10.48	180.21
WEALTH 2	7.96	15.10	9.47	0.00	14.82	30.16	3.79	0.00	9.13	36.56	35.76	11.28	13.36	9.60	80.34
WEALTH 3	10.24	0.74	5.03	0.00	4.91	14.76	7.11	0.00	0.00	24.75	29.72	14.26	5.00	27.45	78.90
WEALTH 4	7.10	0.00	2.20	0.00	1.25	0.00	10.08	0.00	10.55	18.02	17.99	15.71	8.16	6.73	46.97
AVG:															
CLAY	42.09	29.39	24.63	2.78	47.26	10.49	13.63	0.00	7.56	147.28	260.39	79.62	64.26	72.00	751.03
EDGE	15.65	4.32	22.43	0.00	13.09	51.36	9.77	0.00	45.45	87.45	227.91	86.95	34.42	80.29	645.22
SAND	45.35	2.86	36.71	0.00	9.29	235.43	50.14	15.00	12.57	148.00	250.83	60.00	54.67	0.00	913.04
SE:															
CLAY	8.52	23.06	7.60	2.75	22.15	6.96	4.84	0.00	5.22	31.09	28.55	8.56	14.00	6.24	97.80
EDGE	4.59	4.22	10.21	0.00	5.09	26.29	5.74	0.00	31.31	23.85	44.80	14.04	6.26	25.76	97.85
SAND	10.03	1.40	10.03	0.00	4.55	90.18	17.73	7.35	6.16	54.32	47.77	11.11	4.56	0.00	138.24

1988	AGIN	HHITEMS	CLOTH	LABOUR	BDING	CATEXP	GTEXP	DONKEXP	LOBOLA	FEES	GROC	FOOD	TPORT	BEER	MILL	NANGA	CHEXP
%																	
RANK1	2.56	1.57	14.86	1.73	3.24	0.00	0.00	0.00	14.86	18.48	31.24	0.00	1.69	5.29	1.94	0.99	1.52
RANK2	1.86	1.56	9.14	1.72	7.35	6.07	2.41	1.62	3.24	6.57	46.16	0.00	0.55	5.44	2.49	3.06	0.77
RANK3	1.82	1.99	11.49	2.99	6.80	7.43	2.10	1.74	3.63	7.13	32.64	0.00	11.76	3.76	2.47	0.00	2.23
RANK4	1.43	3.45	2.39	0.06	0.00	0.21	1.27	5.08	17.35	7.53	41.39	0.59	9.71	2.98	4.25	0.17	2.12

Figure 6.5: Cash income patterns (1987/1988)

Codes used for income and expenditure categories are explained in the text. Also see Footnote 30.

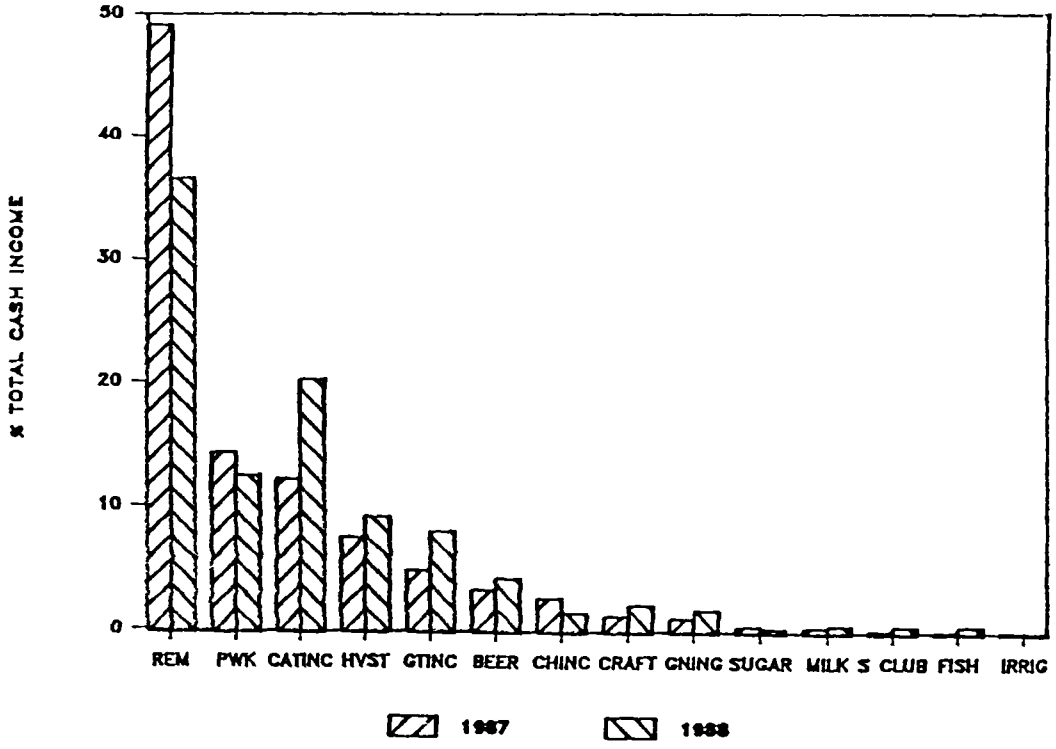


Figure 6.6: Cash expenditure patterns (1987/1988)

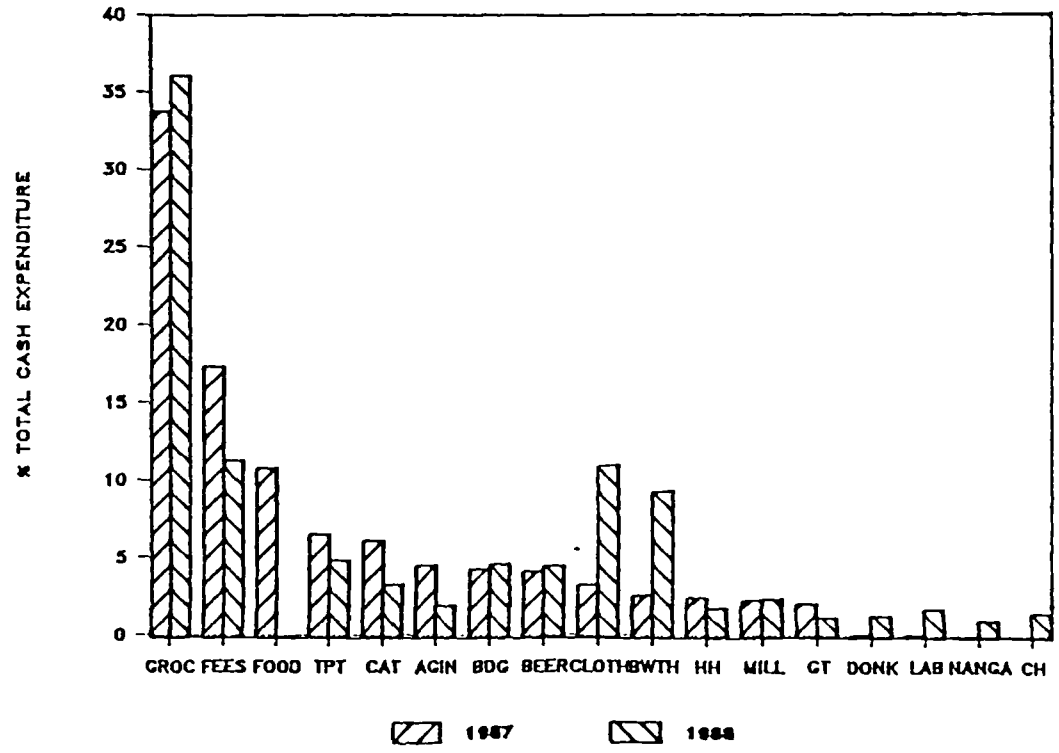


Figure 6.7: Distribution of cash income, expenditure and remittance.

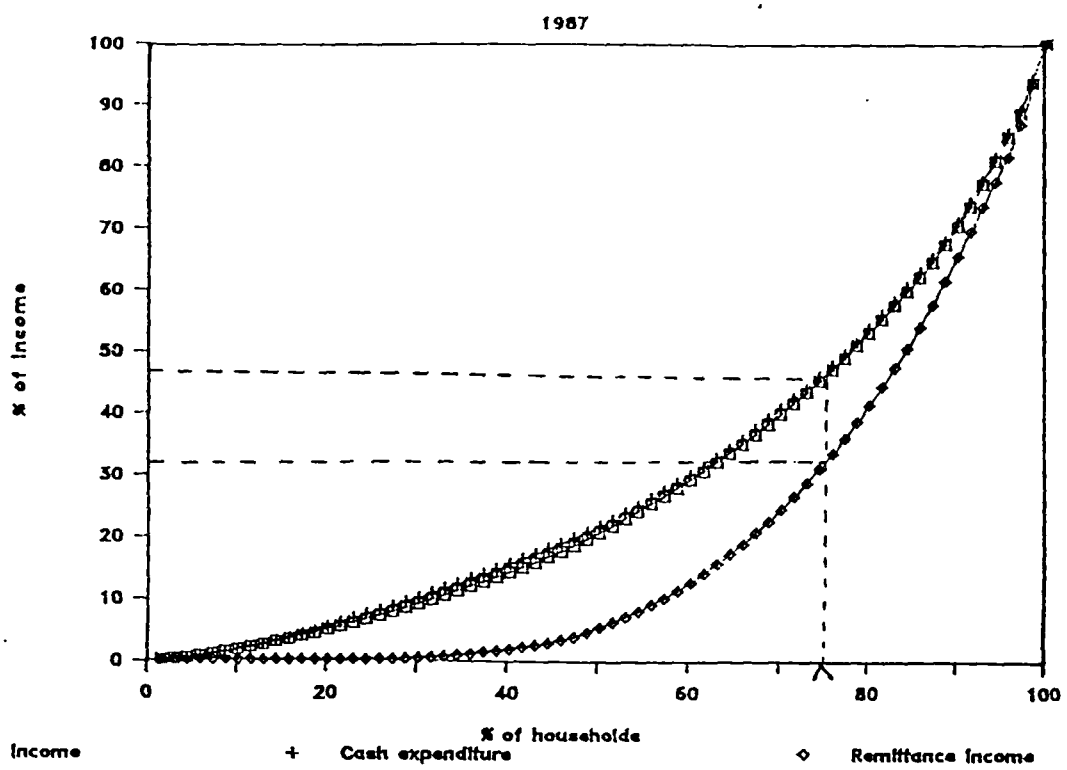
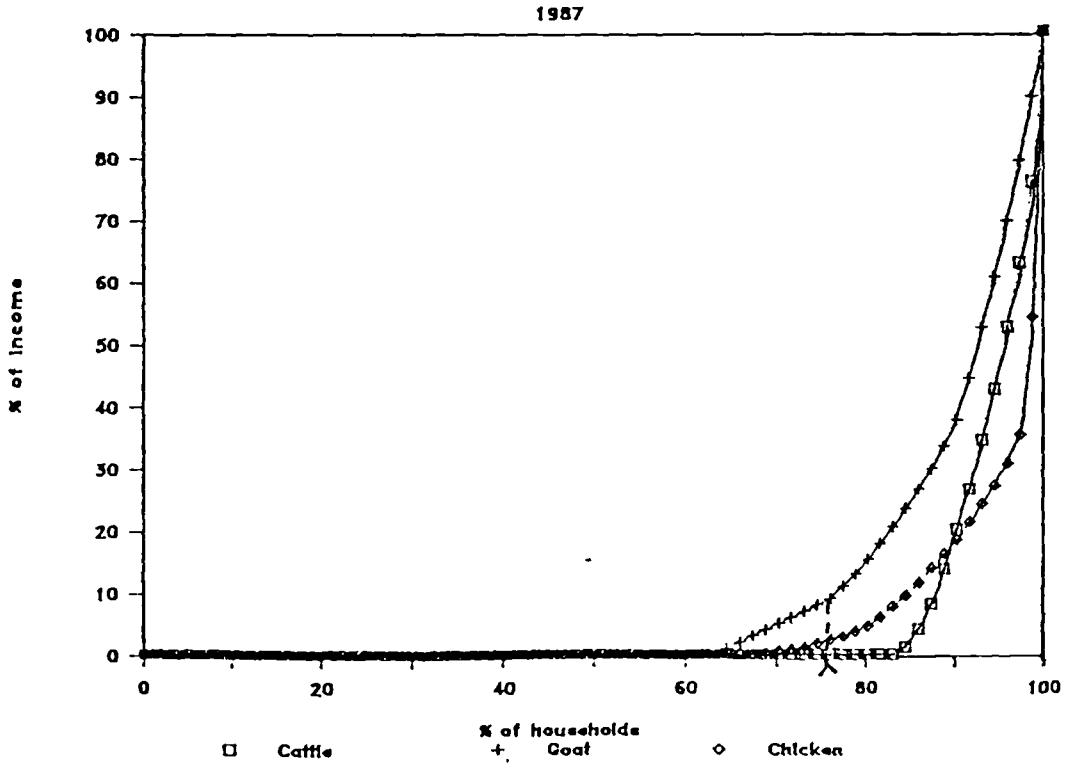


Figure 6.8: Distribution of stock income



Tables 6.16a-b show the variation in cash income levels per household from different sources for 1986-7 and 1988 for each wealth rank. The data shows that remittances dominate the cash income sources in all wealth groups in percentage terms (31). However the amounts vary; Figure 6.7 shows that nearly 70% of all remittance income is received by the top quartile of households. Remittances are complemented by cash income from stock, but again this is highly skewed in distribution (see Figure 6.8), with more than 90% of cash income from goats and chickens and 100% of cash income from cattle being received by the top quartile of households during 1987. The only other income sources accounting for more than 5% of total cash income in 1987 (for all ranks) were piece work (including a range of activities) and harvest income (32).

Cash expenditure is dominated by the expenses of groceries, food (grain/meal) and school fees. On aggregate these expenses accounted for more than 60% of total cash expenditure during 1987.

Contrasts in income patterns: wealth groups, ecological zones and household age categories

Differences in total cash income between wealth groups, ecological zones and household age categories will be investigated in detail below. First, differences in total cash income and expenditure will be explored, then particular income sources will be examined, focussing on livestock and remittance income sources.

Total cash income and expenditure

As Tables 6.16a-b show cash income and expenditure are differentiated according to wealth rank for both periods of household budget monitoring. For the 1986-7 period, wealth group 1 shows significantly higher income and expenditure levels compared to all other wealth groups (T-test, 2-tailed significance, $p < 0.01$). Wealth rank 2 shows higher

levels than both groups 3 and 4 ($p < 0.05$), but wealth groups 3 and 4 show no significant difference in levels ($p > 0.05$).

A comparison between zones (see Table 6.16) shows that the sand veld area has higher income and expenditure levels than either the clay veld or edge zone. This is significant at the $p < 0.001$ level. Significance levels are reduced if cash income per AEU is considered, as the sand veld households are on average, of larger size (see Table 6.2). The clay and edge zones show no significant differences in cash income and expenditure levels.

Cash income levels also change with the age of the household head. This is shown in Table 6.17 in terms of total cash income and cash income per AEU.

Table 6.17: Cash income and remittances (Z$) and the demographic cycle.

Age cat	Income		Income/AEU		Remit/AEU	
	Avg	SE	Avg	SE	Avg	SE
21-30	660.5	86.1	275.6	64.5	233.6	34.7
31-40	686.6	83.9	226.1	48.4	158.2	50.8
41-50	941.9	155.9	146.8	23.0	94.1	26.0
51-60	1126.3	295.6	144.6	37.0	35.4	11.9
61-70	903.1	263.2	143.5	34.3	57.4	22.8
71-80	806.3	441.5	104.4	31.0	57.5	34.1
80+	1236.3	231.1	155.0	49.0	36.7	18.5

Total cash income from all sources increases until the 51-60 age category, but in terms of income levels per AEU, income declines until the 71-80 age category. The data suggests that cash income for livestock investment (ie that surplus to household maintenance requirements, which can be assumed to be related to income/AEU) is highest in younger households.

Remittance income

Cash income is highly influenced by the amount received through remittances. Remittance income represents 49% of total cash income and is received in varying amounts by 73% of households. The average remittance level is $427 and the median $240, showing a large skew (see Figure 6.7).

Differences in remittance incomes between different wealth groups and ecological zones is shown in Table 6.16, for both periods of household budget assessment. Taking the 1986-7 data, remittance income shows significant differences between wealth groups 1-2 and 3-4. Groups 1 and 2 vs 3 and 4 show no significant difference in remittance level ($p > 0.05$), but wealth groups 1 and 2 show significantly higher levels than both groups 3 and 4 ($p < 0.02$). There are no significant in remittance income shown between ecological zones.

Remittance income is highest in age categories 21-30 and 71-80 (see Table 6.17); these are the households where either the young husband is working away or adult sons are working away and sending money back to older parents. In terms of available remittance income for livestock investment (indicated by remittance/AEU) there is a decline as the household ages.

Within the household sample of 71 households, 72% received some form of remittance income during 1987. Some households received money or gifts from more than one source and a total of 53 sources were identified during interviews. The distribution of these sources is shown in Table 6.18.

Table 6.18: Sources of remittance income

Type of job	% of all sources
Teacher	24.5
Miner	20.7
Company	15.1
Govt worker	9.4
Devt worker	9.4
Prostitute	9.4
Army	7.5
Domestic worker	1.8
Shop keeper	1.8

It is important to understand the nature of differentiation in the off-farm employment sector in order to understand the differing access to remittance income sources across households. Different wage rates in the off-farm employment sector will influence the amount of potential remittance income available for reinvestment in the rural economy (33). Since the contribution of remittance income to the total cash income level and the local wealth ranking is so important, differentiation processes in the urban employment sector are particularly significant to the overall dynamics of rural socio-economic change. Historically this has also been the case (34).

The availability of remittances will affect investment in stock. As already described, remittance income is the major source of cash for initial acquistion of cattle (54.8% of all first purchases recalled) and ongoing purchases (55% of purchases during 1987). Remittance income is the second most important route for the purchase of donkeys, representing 27% of all recorded purchases. Most goats owned by men were first acquired through remittance income, and remittances continue to be the dominant route for purchase (1987 data) in all wealth categories (35).

The securing of remittance income is thus seen as a critical component of rural livelihoods, allowing investment in rural based assets and production. The

importance of education as a route to employment in the off-farm sector, particularly as teachers, is seen as critical. Remittances therefore are spent either directly on education of children or on livestock which then can be used to increase agricultural incomes (see section 6.5) or sold for the raising of school fees.

This link between remittance income, stock investment and school fees expenditure is relatively recent, following the expansion of schooling and skilled employment opportunities since Independence. The future is uncertain, as employment options for school leavers are increasingly being constrained by the contracting employment market.

Stock income

Total livestock cash income (cattle, milk, goat, chicken) during 1986-7 is shown in Table 6.16 by both wealth groups and ecological zone. Wealth group 1 shows significantly higher total livestock cash income compared to other wealth groups (t-test, 2-tailed significance, $p < 0.02$). Wealth group 2 is insignificantly different to both wealth group 3 and 4, but wealth group 3 shows significantly higher income ($p < 0.05$) compared to wealth group 4. There are no significant differences in livestock cash income shown between ecological zones.

Stock income is important in all areas as the sale of cattle or goats results in the easy mobilisation of cash for particular needs. Goats are preferred for this purpose, because of their small unit size and the need to retain cattle for their service functions (see Chapters 4 and 5). Cattle may be sold at official sales pens or to local farmers. Goat marketing is more problematic as there is little local demand, transportation of goats to other areas is illegal and official marketing channels are limited. However, for both cattle and goats their sale can occur at any time in any year; income is thus largely independent of climatic variation and ecological zone.

Other income sources

An investigation of other income sources for the 1986-7 data (see Table 6.16) shows some further differences between wealth group and zone. Piece work shows no significant differences between wealth groups and ecological zones, while income from beer brewing shows no differences between wealth groups, although the edge zone received significantly higher income ($p < 0.05$) than other areas. Income from beer brewing was linked to a savings club arrangement in this area (36). Craft income shows higher levels in wealth groups 1 and 4, but similar levels between ecological zones. Fishing is carried out by a few skilled individuals mostly in the clay veld with access to the Runde river.

Despite the differences in absolute terms noted here, in percentage terms, the importance of other income sources such as piece work, craft sales etc is more important for the poorer wealth groups.

These other income sources do not raise large amounts of money (except for some builders), but are important for those without significant remittance sources or when crops fail.

Seasonal patterns

The regular monitoring of household income and expenditure allowed insight into seasonal patterns of cash flow. Income sources and expenditure outlays can be classified into those that are predominantly wet season, those that are predominantly dry season and those that occur throughout the year.

The general pattern shown is of course not exclusively followed, but provides a framework for understanding how the seasonal flows of cash are determined by the

availability of different income sources and the demands of particular expenditures.

Cash income and expenditure - Seasonality

Income: Wet season	Dry season	All year
Fishing	Piece work	Remittance
Milk	Cattle income	Savings clubs
	Donkey income	Sugar exchange
	Harvest	Goat income
	Gardening	Chicken income
	Beer brewing	
	Craft work	
Expenditure:		
Wet season	Dry season	All year
Agric inputs	Building	Groceries
Labour	Cattle exp	Fees
	Chicken exp	Hhold items
		Beer
		Goat exp
		Clothes
		Bride wealth
		Transport
		Milling
		Nanga

Patterns of expenditure

Much of the problem of household finance management is the guaranteeing of a stable cash income to supply money for the regular household expenditure requirements. This is particularly why the remittance income sources are so critical, as they are generally supplied on a regular basis.

Those with remittance incomes are able to buy groceries, either locally or, by spending money on the bus, in Zvishavane town. Most homes purchase some sugar, tea, salt

and oil; the richer homes will also buy bread, margarine and jam regularly. The other key expenditure is school fees. For those with secondary school children this is a major outlay and one that people hope a relative working in town will contribute to (37). Education is regarded so highly that important assets, such as cattle and goats, are disposed of.

Other expenditures recorded are less significant in relation to the overall total. Very little cash income is invested in agriculture; small expenditures on maize seed, plough maintenance and some labour were recorded. Only two farmers purchased fertiliser; most regarded the investment as too risky (38). Direct competition for cash resources between agriculture and livestock investment does not therefore exist to any great extent.

Certain expenses are only occasional, when sufficient cash becomes available (eg through a remittance, the sale of crops or some asset, such as livestock, or through a savings club arrangement). Expenditures of this sort include buying of household items (eg furniture, cooking utensils etc), buying clothes, building of a hut or house, and the purchase of livestock. Other expenditures are more regular. These include transport expenses, beer drinking and milling costs. Other expenses result from unexpected occurrences, such as illness, when a traditional healer (n'anga) may be visited.

Differential control of income and expenditure flows within households was a subject that this research did not attempt to uncover in detail. General discussions indicated a pattern whereby women often had control over small amounts of money for regular expenses, but men tended to be involved in larger investment and sale decisions. This is variable, and dependent on particular household circumstances and the degree of presence of the man. In most cases, women had independent sources of income; even though small these are important in terms of the acquistion

of goats and chickens by women (6).

Income and expenditure patterns: a summary

Different wealth groups employ different livelihood strategies and livestock enter into this in different ways. Richer households rely on a combination of remittances, cattle income and crop incomes (especially in the sand veld zone during 1987, but in better rainfall years also in other zones. This is supplemented by a range of other activities.

Poorer households similarly derive a significant proportion of their cash income from remittances, which is supplemented by income from crops and stock. They rely more on such activities as beer brewing, craft work and piece work jobs.

Expenditure patterns are similarly differentiated. Amounts spent on groceries, school fees, clothing, household items, building, agricultural inputs and cattle increases in the richer wealth groups, although in the case of groceries, agricultural inputs and school fees the percentage contribution in relation to overall expenditure is fairly even across all groups. Goat expenditure and beer are the only items of expenditure that appear to increase as a proportion of total expenses with decreasing wealth.

6.9 Total income composition

The previous sections have looked at the various components of total income - livestock, remittance, other cash sources and crop income, both consumed and marketed. These combine to make up the total income level of the household. If market values are assigned to non-marketed goods, as has been done in the previous sections, then a total income value can be arrived at.

Total income is computed as:

TOTINC = CONS + YSOLD + REM + PWK + LSTOCK + OTHER

Where: CONS = value of unsold crops produced in the season which are either consumed or stored; YSOLD = value of crops sold; REM = cash remittances received; PWK = cash income from local off-farm work (self-employed and labouring); LSTOCK = cash income from livestock (cattle, goats, donkeys and chickens), this does not include the value of services nor a consideration of the changed asset value of the stock holding due to births/deaths etc.; OTHER = the sum of other cash income sources noted in the income survey (combining fishing, beer brewing, savings clubs, gardening, sugar exchange and handicrafts).

The distribution of total income across all households in the sample (N = 69) for 1987 season is shown in Figure 6.9. Again a pattern of inequality is exhibited. The average total income Z$ 1141 and the median value $780.

Data for all but the crop income component exists only for the season 1986-7, so total income can only be accurately calculated for this year. The results are shown in Table 6.19. The relative contribution of these different components of total income are shown diagrammatically for the whole sample in Figure 6.10 (40).

The results show how, in relative terms, crop income is particularly important in the sand veld zone, while remittances are of dominant importance in all other categories. Livestock income appears to be significant in the richer wealth categories of the clay and edge zones, particularly in the latter, where crop incomes are so low.

Sections 6.6 and 6.7 have shown how the crop income component of total income is highly dependent on differences in savanna zone and interannual variations in rainfall. The importance of climate independent sources of income is critical, particularly in the clay and edge zones where crop incomes are so variable.

Table 6.19: Total income composition by wealth group and ecological zone (1987; Z$). For codes used see text.

	(Z$)	CONS	CROPSALE	LSTOCK	REM	PWK	OTHER	TOTAL
AVG	WEALTH1	690.45	304.63	558.82	610.18	93.65	27.65	2285.37
	WEALTH2	171.37	3.30	47.00	652.06	100.71	37.09	1011.53
	WEALTH3	82.97	0.00	99.88	249.15	164.90	35.12	632.01
	WEALTH4	90.87	3.70	22.44	215.06	139.31	30.00	501.38
SE	WEALTH1	243.91	263.59	135.76	137.68	49.62	12.40	461.49
	WEALTH2	34.83	3.20	16.80	124.92	29.07	23.80	129.61
	WEALTH3	14.71	0.00	31.68	86.09	43.43	10.82	91.65
	WEALTH4	24.55	3.47	7.72	78.97	20.89	13.50	75.71
AVG	CLAY	182.31	11.86	161.87	452.05	131.44	24.74	964.27
	EDGE	93.50	0.00	195.59	417.27	128.45	54.24	889.05
	SAND	1176.07	686.82	245.14	309.71	88.00	10.71	2516.46
SE	CLAY	39.16	7.49	58.66	76.95	26.44	7.42	123.32
	EDGE	23.40	0.00	68.15	118.84	33.81	19.92	145.50
	SAND	506.83	610.48	143.65	102.68	55.51	9.92	1048.47
AVG	CLAY 1-2	285.52	24.31	271.30	679.00	119.00	13.53	1392.65
	CLAY 3-4	84.02	0.00	57.64	235.90	143.29	35.43	556.28
	EDGE 1-2	147.36	0.00	394.63	717.50	66.00	94.38	1419.86
	EDGE 3-4	62.72	0.00	81.86	245.71	164.14	31.31	585.74
	SAND 1-4	1176.07	686.82	245.14	309.71	88.00	10.71	2516.46
SE	CLAY 1-2	72.49	14.85	113.18	115.70	43.47	6.69	199.49
	CLAY 3-4	11.40	0.00	20.40	74.86	29.90	12.28	73.31
	EDGE 1-2	54.95	0.00	152.11	239.28	26.94	47.79	255.16
	EDGE 3-4	13.41	0.00	37.06	101.98	48.33	11.44	113.77
	SAND 1-4	506.83	610.48	143.65	102.68	55.51	9.92	1048.47

Figure 6.9 Distribution of total income

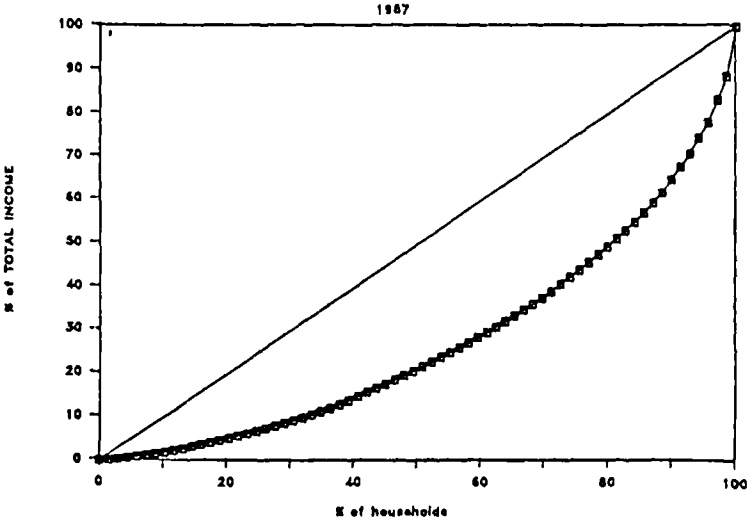
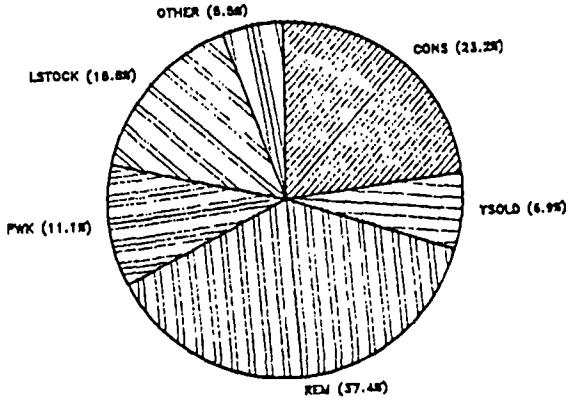


Figure 6.10 Components of total income



The income derived from piece work or livestock may be independent of crop income, since in dry years goats can be sold and time is available for piece work. However, such activities as beer brewing are dependent on a good harvest. Remittances are particularly significant because their receipt is largely independent of conditions in the rural area. The combination of different activities to reduce income variability can be seen as advantageous, especially for the poorer wealth groups.

6.10 The household economy and patterns of livestock investment and disposal

This Chapter has demonstrated the need to look at the local economy in a disaggregated way in order to understand the different constraints and opportunities of different groups of households. Different patterns of income and expenditure and different opportunities for investment exist depending on the stage in the development cycle, the wealth status and the zone of residence of the household. In order to understand fully the dynamics of livestock populations (see Chapter 4) an investigation at this level of disaggregation is required.

Sections 6.3 to 6.9 have explored the general hypotheses about differentiation presented in section 6.2. Differential asset ownership (livestock, equipment, land and labour) results in variations in returns from agricultural production. This is mediated by the effects of savanna type and rainfall levels. Cash income levels are also influenced by the availability of non-agricultural income. This may be generated locally (sales of livestock products, labour etc), but is in particular influenced by remittance income from non-local sources. Different groups (defined according to wealth category, zone of residence or household age) thus have both different sources of income and different total incomes. This in turn affects expenditure patterns and the need to compensate for food

deficits. These differences in income and expenditure patterns influence the opportunities to invest in livestock and the likelihood of their sale.

This section examines the actual patterns of investment and disposal of livestock in the household sample with data primarily from 1987 during a drought period; this is contrasted with the 1984-5 situation following a good harvest. The detailed investigations of the previous sections are used to interpret the data and postulate patterns of economic decision-making; again contrasting different wealth groups, different savanna zones and different household age categories.

Livestock investment

The sources of income used to purchase livestock are shown in Table 6.20 for the 1987 data. This reflects the patterns discussed for initial acquisitions.

Table 6.20: Income sources for stock investment (1987 data): for distribution of goat income sources see Figure 6.11.

Cattle	Goats
1. Remittance (55%)	1. Remittance
2. Crop sales (30%)	2. Local work
3. Stock sales(10%)	3. Cash for Work
4. Local work (5%)	4. Beer brewing
	5. Crop sales
	6. Stock sales

These income sources are differentiated according to wealth group, ecological zone and stage in the household development cycle. To summarise the conclusions of previous sections of this Chapter:

Remittances: These are important in all groups, but proportionately more significant in Wealth ranks 2 and 3

and in the edge zone. Remittance income is the dominant route for men's first acquistion of cattle (54.8%) and goats (38.5%). Cash sent from the husband is also noted as an important route to acquiring goats by women (10.8%). Remittances are received by all groups, but levels change between stages in the household development cycle. The availability of remittance income for investment in livestock is dependent on both the level received and the other committments of expenditure; these may be high in food deficit households, in years with low crop income and in households with large school fee expenditure requirements.

Crop income: In most years, surplus crops for sales are only available to sand veld households. But in good years, Clay veld households in wealth groups 1 and 2 market surplus. Initial acquisitions of cattle (20.9%) and goats (25.6%) are often through crop sales. This is the dominant route by which women first acquire goats (26.1%). Opportunities for expenditure of crop incomes on livestock is seen to be particularly variable between years, ecological zones and wealth groups.

Piece work: Local work contributes most to total cash incomes in wealth categories 3 and 4. Various categories of local work are mentioned by men and women as important routes for initial acquisition of goats; this is less common for cattle (1.6%). During 1987, piece work and Cash for work payments were important sources for goat investment; this was particularly significant for those without access to remittance incomes.

Livestock income: Income from the sale of cattle and goats is concentrated in wealth categories 1 and 2; amongst those with larger herds or flocks. Sales of fowls is mentioned by women as a route to goat acquistion.

Beer brewing: In terms of percentage total cash income, beer brewing is highest amongst the wealth categories 2-4.

Beer brewing was mentioned as a route to first acquistion of goats by men. During 1987 cash raised from beer brewing was invested in goats; the amounts raised were too small for cattle purchases.

Differences in income sources between zones and years is dominated by the interannual variability of crop income. Differences between wealth groups and household age categories are found for most income sources investigated here. These factors will influence the pattern of investment in livestock. Contrasts between wealth group and ecological zone are shown for 1987 in Table 6.21.

Table 6.21: Livestock investment (1987): Numbers purchased per household per year and (SE), for sample (N = 69).

	Cattle Purchase/hh/y	Goat Purchase/hh/y
Wealth 1	0.71 (0.35)	0.47 (0.30)
Wealth 2	0.13 (0.13)	0.60 (0.26)
Wealth 3	0.30 (0.25)	0.15 (0.28)
Wealth 4	0.00 (0.00)	1.00 (0.39)
Clay veld	0.12 (0.12)	0.78 (0.47)
Edge zone	0.27 (0.13)	0.45 (0.18)
Sand veld	2.25 (1.08)	0.85 (1.64)

Numbers of animals purchased by households of different wealth groups and resident in different ecological zones show large variations between households as evidenced by the high SE levels shown in Table 6.21. No significant differences in numbers of cattle or goats purchased (t-test, $p > 0.05$) between wealth groups were shown, although the numbers purchased were highest in wealth group 1, as predicted. The sand veld households showed significantly higher numbers of cattle purchased ($p < 0.002$) compared to the other zones. The numbers of goats purchased by wealth group showed no pattern, similarly, no significant differences in goat purchases between ecological zones are shown.

Figure 6.11: Income sources for goat purchases

Income sources are: Remittance, Food for Work, Building, Beer brewing, Bicycle sale, Crop sale, Carpentry, Cattle sale, Plouging, Work/labouring, Relative gift, Goat sale, Exchange.

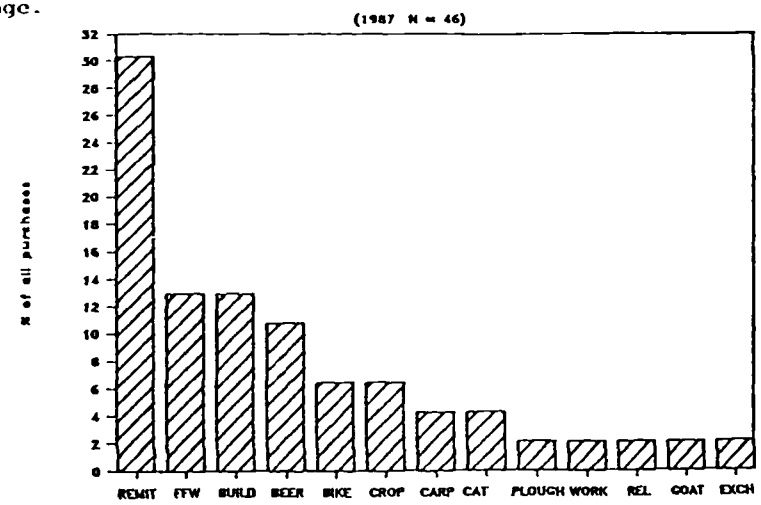
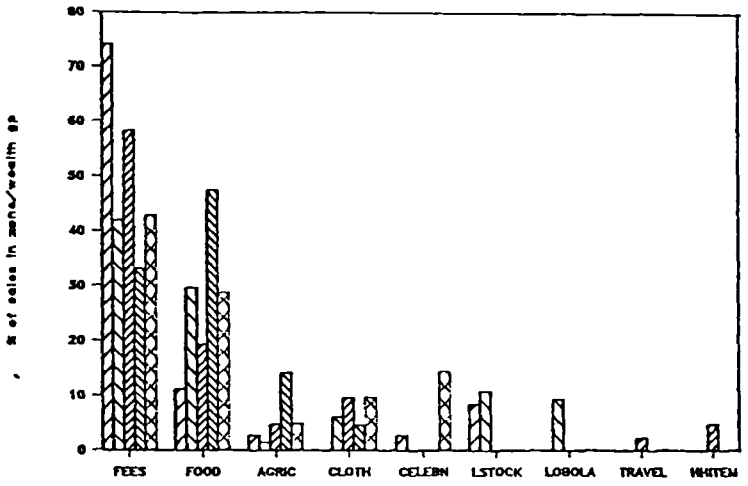


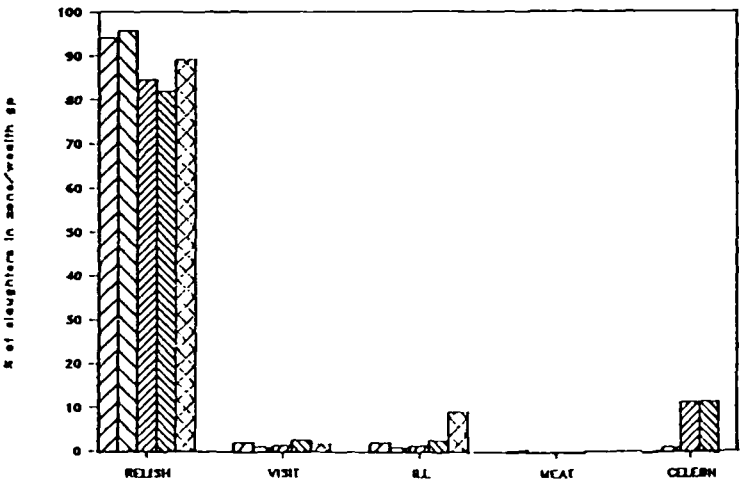
Figure 6.12: Reasons for goat sales and slaughters by wealth category and zone

Reasons for sale are: School fees, food purchase, Agriculture: input purchase, including plouging, clothing, celebration money raising, livestock purchase, lobola (bridewealth), travel money, household item purchase.

Reasons for slaughter are: Relish/food, visitor, illness, meat for sale, celebration.



Clay 1-2 Clay 3-4 Edge 1-2 Edge 3-4 Sand 1-4



Clay 1-2 Clay 3-4 Edge 1-2 Edge 3-4 Sand 1-4

The pattern of stock purchases observed can be related to differential patterns of income between groups.

- Sand veld households of richer wealth groups invested in cattle using crop income derived from good and stable harvests over some years resulting in a healthy food security situation and a high level of marketing. This was also a route to goat purchase during the year.

- Cattle purchases in the clay and edge zones were through remittance income.

- Despite poor harvests and food deficit/scarcity, but because of remittance incomes and local work, wealth category 3-4 households in the edge and clay veld areas were investing in goats during the year.

Purchases were distributed in different herd and flock size categories. Cattle were being purchased by households with all herd size groups, except 16-20. Goats were purchased by households with flocks in all size categories, except 20-29. Cattle herds were being rebuilt during 1987 following the decline in herd sizes in the drought period of 1982-4. Numbers purchased were however small. Goat purchases were higher in those households with smaller flock sizes, indicating a pattern of flock accumulation.

Table 6.22: Purchase levels and herd and flock size.

Herd size	Ave no of purchased/herd	Flock size	Nos per flock
0-5	0.2	1-9	1.0
6-10	0.2	10-19	0.6
11-15	1.2	20-29	0.0
16-20	0.0	30-49	0.3
20+	0.3	50+	0.4

Investment in livestock from crop income is important, but

is very variable between years. In the clay and edge zones surplus production is only achieved perhaps one year in five (eg 1984-5), so the opportunities for investment are limited. This contrasts with the sand veld system where crop production is viable and generates regular surpluses.

During 1987 all cattle purchases derived from crop sales were from vlei land production in the sand veld zone, representing 30% of all purchases (N = 20). Crop sales only represented 5% (for wealth 3-4) and 6% (for wealth 1-2) of the total purchases of goats in 1987.

Of those households that purchased livestock, 36.6% bought cattle, 18.2% bought donkeys and 45.6% bought goats. 75% of the cattle purchasers were in wealth category 1 and resident in the sand veld.

Following the 1984-5 harvest, households from wealth groups 1 and 3 invested in cattle and goats, while only households in wealth groups 2 and 3 purchased donkeys with cash income from crops. There were no significant differences in numbers of cattle, goats or donkeys bought between wealth groups (t-tests, $p > 0.05$). Differences in numbers of goats and donkeys purchased between ecological zones was not significantly different, but sand veld households purchased significantly more cattle following the 1984-5 harvest ($p < 0.000$).

The 1984-5 good harvest followed three years of drought and many people stored much of their grain (see section 6.7); little money was available for livestock investment. This was particularly so for the poorer, younger groups of the clay and edge zone, where storage of good harvests is important and debt repayment requirements were largest. However, some households in the clay veld invested in goats and donkeys. Cattle investment was concentrated amongst the richer groups of the clay and sand veld, where food surpluses and cash from crop sales the highest.

The pattern of crop sale and livestock investment following the good harvest of 1984-5 is investigated in Table 6.23. The data bears out the contention that households in older age categories (up to 71-80) invest in livestock, while younger age category households both sell a smaller percentage of their yield and purchase fewer livestock.

Table 6.23: Percentages households of different age categories that sold agricultural produce and purchased livestock in 1984-5 harvest.

Age cat	% Sold	%Purchased stock
21-30	25	0
31-40	51	0
41-50	80	13.3
51-60	87	28.5
61-70	63	25
71-80	75	75
80+	100	0

Households that managed to invest in livestock following the 1984-5 harvest (only 16% of all households) were concentrated in the older age categories (age 50+). The good harvest was therefore not one that the younger groups could capitalise upon in terms of investment in livestock assets. They had to spend the money on general consumption goods (groceries, clothes, blankets etc) (cf. Behnke, 1987 for a Botswana comparison).

Patterns of livestock investment are best understood in terms of the interannual variation in income derived from agricultural and non-agricultural sources. Non-agricultural sources are dominated by remittance income, but piece work, stock income and beer brewing may be important. Agricultural income is very dependent on rainfall variation; it is also highly differentiated according to ecological zone and wealth rank. Non-agricultural sources are not so variable between years and ecological zones. Although there is considerable inequality in, for instance, remittance distribution, this is not as large as seen for

crop income (cf. Figures 6.3 and 6.7).

Remittances, as a source of income independent of the rural production base, are therefore vital to the understanding of livestock investment patterns. This is especially so in the clay and edge zones, where opportunities for livestock investment from agriculture are highly variable,

Livestock disposal: sales and slaughter

The reasons people gave for the sale of cattle and goats during 1987 are shown in Table 6.24.

Table 6.24: Reasons for sale (1987 data): % of all cattle sold; for pattern of goat sale/slaughter see Figure 6.12.

Cattle		Goats
1. School fees	(45.4%)	1. School fees
2. Lobola	(22.7%)	2. Food/groceries
3. Drought/food	(18.2%)	3. Livestock purchase
4. Stock purchase	(13.6%)	4. Lobola/celebrations
		5. Agricultural inputs
		6. Clothes

The reasons for sale will be differentiated according to zone, wealth and age group, as the investigation of expenditure requirements in this Chapter has shown.

School fees: Secondary school fees are required by all households in all wealth groups and ecological zones. This is likely to be in households classified as age category 40+. The need to raise cash locally through the sale of animals increases with the reduced availability of remittance sources for expenditure on school fees. The investment of remittances in livestock can also be seen in relation to their subsequent sale for raising money for school fees. Livestock are thus closely linked into the relatively recent cycle of expenditure on school fees for investment in childrens' future employment prospects and

the later reinvestment of remittance income sent by working children in stock.

Food/groceries: The need to sell livestock to raise money for food in drought is highest in households without a remittance source, with high dependency ratios and in food deficit situations. This combination of factors is most likely in wealth group 3-4 clay and edge zone households.

Stock purchase: The sale of stock in order to buy more may occur in all groups. Sales of goats by poorer households to raise money for cattle acquisition or the sale of cattle in the clay veld for exchange with less drought susceptible donkeys are both possibilities that occured during 1987.

Lobola: Sales of animals for lobola payments may occur among any group. It is most likely amongst wealthier and older households who can support the expense of sons' marriages.

Agricultural inputs/clothes: Raising cash for these items may occur in any group, but is most likely in households without remittance income access. Overall expenditure on these categories is small compared to other commitments.

The pattern of livestock disposals is investigated in Table 6.25 in relation to patterns between wealth group and ecological zone for the 1987 data. These can be related to the differences in expenditure requirements of the different groups outlined above.

Table 6.25: Livestock disposals per household per year (average and (SE)): 1987

	Cattle Sales/hh	Goat Sale/hh	Goat Slt/hh
Wealth 1	1.00 (0.28)	2.88 (1.00)	10.82 (1.54)
Wealth 2	0.07 (0.06)	2.73 (1.50)	4.13 (0.97)
Wealth 3	0.15 (0.08)	3.10 (1.16)	4.00 (1.15)
Wealth 4	0.07 (0.06)	1.33 (0.61)	2.40 (0.59)
Clay veld	0.17 (0.10)	2.37 (0.74)	5.39 (0.94)
Edge zone	0.58 (0.14)	2.14 (0.77)	4.00 (0.84)
Sand veld	0.57 (0.40)	7.00 (3.04)	13.25 (2.48)

The numbers of cattle sold was significantly higher in wealth group 1 compared to all other ranks (t-tests, $p < 0.005$). No significant differences in levels are shown when other wealth groups are compared (all $p > 0.05$). The sand veld and edge zone show significantly higher numbers of cattle sold per household compared to the clay veld ($p < 0.05$).

No significant differences in goat sale numbers are seen when households of different wealth rank are compared ($p > 0.05$), but sand veld households show significantly higher numbers sold compared to the edge zone ($p < 0.05$), but not the clay veld.

Goat slaughter levels are significantly higher in wealth rank 1 compared to all other wealth groups (t-tests, all $p < 0.002$). No significant differences in slaughter levels are seen when wealth groups 2, 3 and 4 are compared (all $p > 0.05$). The sand veld households show the highest numbers of goats sold and slaughtered. The numbers sold are significantly higher compared to the other zones (all $p < 0.01$).

These observed patterns can be explained in terms of the understanding of different patterns of household economy developed in previous sections of this Chapter:

- Cattle sales were low overall, but high in the sand and edge zone households. Edge zone sales may relate to the poor food security situation, where overall income had to be increased to cover increased food purchases. Sand and clay veld sales were mostly associated with raising money for school fees, but several clay veld households sold cattle in order to purchase donkeys. Sales of cattle was dominated by wealth group; the only group with sufficiently large herd sizes to allow sale for raising school fees.

- Goat disposals (sales and slaughters) showed a pattern that is difficult to explain simply in terms of overall income or food budgets. Disposals in the sand veld were high because of the increasing threat from the drought to goat flocks there (see Chapter 7). Slaughters were higher in the richer wealth categories, where larger flock numbers allowed a higher offtake, without jeopardising the breeding flock. Sales were seen in all wealth groups, reflecting the widespread requirement of raising money for school fees in all groups.

Data from the cattle sales recorded (N = 22), support the hypothesis put forward in Chapter 4 that it is only when a herd has increased over a certain size, and the economic service functions (draft, transport etc) have been satisfied, will an owner be tempted to sell; unless for urgent and immediate cash needs (Table 6.26). Large cattle herds are owned predominantly by wealth group 1.

Table 6.26: Sales levels and herd size

Herd size	No of herds	% that sold
1-5	14	14
6-10	16	25
11-15	5	60
16-20	1	100
20 +	3	100

Similarly, the numbers of slaughters and sales per goat flock tends to increase as the flock size increases (although greater percentage offtakes may be removed from smaller flocks).

Table 6.27: Slaughter, sales, purchases - numbers per flock

Flock Size	Slaughter	Sale
1-9	2.2	0.8
10-19	4.5	2.9
20-29	12.5	2.8
20-49	8.1	3.9
50+	14.4	7.8

The sale of livestock is dominated by the need to raise school fees, which are a significant proportion of the household's expenditure. This is particularly so in a drought year, but remains so in other years because of low agricultural incomes among all except the sand veld vlei farmers. Stock sales are limited by available herd/flock sizes. Cattle are sold reluctantly as they are preferentially retained for their service functions (Chapter 5), except in larger herds. Goats are sold in larger numbers, but market saturation and restrictions limit the opportunities for raising cash through this route (40). Remittances are therefore seen as of particular importance as an alternative source of income for paying school fees. The expenditure of these limited remittance flows thus restricts the opportunities for stock investment.

This Chapter has demonstrated that understanding the patterns of livestock investment and disposal requires a disaggregated analysis. Differences exist between wealth groups, ecological zones and stages in the household development cycle. These contrasts interact with

interannual variations that affect crop outputs and so the composition of total income and income and expenditure patterns. The general investment criteria for different stock types discussed in Chapter 5 are thus mediated by these factors.

Changes in livestock populations investigated at the aggregate level in Chapter 4 are affected by the composite effect of these interacting factors. To fully understand the variation around generalised economic models of price response and population change, differentiated patterns at the local level need to be uncovered.

The pattern of stock investment and disposal discussed here has been largely restricted to the situation during 1987. This does not necessarily reflect the situation in all years, as data from the period of the good 1984-5 harvest shows. The household economy is dynamic and changes between years. There is the long term dynamic of the demographic cycle and shorter term variations in access to resources, dependant on changes in sharing and loaning relationships within and between lineage clusters. This variability combines with interannual fluctuations in rainfall which determine the level of crop output and hence food security situation in different zones.

Understanding the impact of inter-annual variations of rainfall is vital in exploring the linkages between the household economy and livestock population dynamics. This theme is pursued in the following Chapter where the effects of the droughts of 1982-4 and 1986-7 on livestock populations are examined in detail.

Footnotes

1. Models of demographic change often assume a nuclear unit where cross-sectional data can identify the phase of development and where polygamous households with parallel patterns of development going on simultaneously do not exist (Ellis, 1988). The Chyanov model expects there will

be greater labour inputs into agricultural or other activities when the consumer/worker (c/w) ratio is high in the younger and older households to cover for high dependency ratios. This prediction was tested for agricultural producers in Kenya (Hunt, 1979: 262) and is supported by data presented by Low (1986). It is expected that younger households will work particularly hard for investment since the present value of future returns on productive investment is greatest when the household is younger (Low, 1986). The migrant labour situation of southern Africa requires adaptations of the Chyanov model (notably the assumption regarding the absence of labour markets). Low's (1986) household economics model dissaggregates according to people with different income earning opportunities and accounts for the practice of food deficit households hiring out labour. Data supporting the Chyanov model prediction of increased land area with increased household size has been shown in Swaziland (Low, 1986: 76), Lesotho (Murray, 1980: 16), Botswana (Kerven, 1979: 46), Zambia (Low, 1986: 87) and Zimbabwe (Collinson, 1982).

2. The wealth ranking exercise was carried out on the suggestion of Sam Jackson. The wealth discussions and ranking workshops were held on successive days at the home of Mathou Chakavanda and I am grateful to his family for providing food and hospitality. Billy Mukamuri, Abraham Mawere and Simbisai Makumbirofa helped to facilitate the workshops (see Appendix 7).

3. The sources for components of wealth investigated for the household sample are shown below:

- Ken Wilson collected demographic data on the household sample during 1986/7 and changes were monitored between 84/5 and 86/7. The calculation of household size was based on the number of people present at the home (including fictive relatives) and was weighted by presence at the rural home. Those who were present all year = 1, those absent for a portion of the year = 0.5 and those who were occasional visitors = 0.1. Other indicators of demographic structure are presented in Footnotes 12 and 13.

- Cash income and expenditure patterns were monitored during 1986/7 on a quarterly basis.

- Field areas were assessed by Ken Wilson during 1987 on

the basis of discussions with farmers and the delimitation of field boundaries on aerial photographs. Field area refers to the situation in 1987 and includes land officially allocated, borrowed or appropriated. The area represents total potential arable area; in any year some may be fallow. Relating the 1987 situation to 84/5 yields introduces some error as access to land does change, but it is felt the general comparative picture is sufficiently accurate for the present discussion.

- Grain yields and sales were assessed through recall interview largely carried out by Ken Wilson. The data was recorded in local units - yields and local sales refer to local bag measurements (118.3kg), wheras the GMB sales refer to GMB bags (91kg). Amounts less than a bag were assessed in terms of buckets, tswanda etc and converted to a proportion of a local or GMB bag.

- The assessment of equipment assets was carried out over the period of fieldwork by Ken Wilson and myself.

- Age of 'household heads' were estimated according to age categories of 10 year intervals with the help of Abraham Mawere and interviews with sample members. Exact ages are difficult to assess as registration cards often give false information.

- Ownership refers to all animals owned by members of a particular household. This may include a number of different individual's animals both held at the home kraal and loaned out at other sites. Access refers only to those animals held at the home kraal, these may include owned and borrowed animals. The distinction between ownership and access is important in terms of access to the means of production and is not always explicitly addressed in surveys.

4. The interaction of different factors making up the composite wealth rank could be investigated further with statistical techniques that account for the high correlation of the variables.

5. Local people are unanimous in their assertion that cattle are essential to rural production; the declining per capita availability of cattle is a serious concern. One informant summed up the consequences of stocklessness:

"If you don't have cattle your way of life is very difficult. You normally must survive on piece-work, if not, drought relief." (Mr Masoche, Gundekunde, Mazvihwa, 9.8.87).

6. The following quotes give an impression of the type of tactics used by women in the acquisition of stock:

"It was the women who used to own goats. Some were exchanged for cattle. For instance, VaDamba exchanged 5 goats for a heifer long back. She then started selling clay pots and got another heifer. These multiplied and were used to pay the lobola of the late Mudhomori's first wife." (Mrs Mudhomori, 10.87)

"Mai Regai picked up a 10c piece left on the ground and bought a chicken. Her chickens multiplied and bought a goat. Her goats multiplied fast and she bought a heifer, leaving 5 goats still in the kraal." (Mrs Saul Jim, Mazvihwa, 9.87)

"Mai Dzabvu used to buy soap and cut the bar into 4 small pieces. Each piece was then swapped for a bucket of millet. When these accumulated she would swop several sacks for a heifer from Mangada. The cattle were kept at Matyokwa for ploughing. When he got cattle himself, Mai Dzabvu took them and paid 7 beasts un lobola for her son Stephen." (Mrs Saul Jim, 9.87)

"It was around 1969... I was given $1.50 by my sister.. later I met people playing cards at Dewa's place and I gave the money in exchange for a young female goat to a gambler in desparate need of cash!" (Mrs Peto, 9.87)

7. The age of household head was assessed according to ten year age groups. This refers to the older (usually male) 'owner' of the home.

8. It is important to investigate ownership at the individual level as this has implications for decisions over management and disposal. Decisions to sell or slaughter animals owned by individuals within the household is supposed to rest with the formal owner. In practice the situation is different. If present, the male household head tends to be dominant in such decision making. Women often complain that men sell their goats to get money for beer without their approval. However, if men are absent in town, women have an increased responsibility for small stock disposal decisions, and the husband may not be consulted. The precise pattern depends on individual household circumstances; what is important to recognise is that formal obligations are not necessarily adhered to.

The complexity of intra-household access and ownership rights warns against any simplistic assessments of stock ownership levels and inferences made about control of products. One old man in Mazvihwa explained the details of the cattle 'ownership' arrangements at his home, demonstrating the complexities of within household decision-making:

> "Before the drought the cattle were allocated to each wife and her sons. The sons would then plough their mothers' fields. If the wife had no sons or older children then I would do the ploughing. When the sons set up their own homes they would take the cattle with them and they would become theirs. Before then they were all in one kraal and were mine, although allocated to each wife. If the cattle were sold some money would go to the wife who was holding it. The cattle would also help to pay for the lobola of each of the wife's sons. Some of the cattle in the kraal were always retained by me and I would then sell them and spend the money as I wished." (Jim Snr, Muringi, Mazvihwa, 1.87)

9. The relationships between different households in terms of livestock and equipment sharing was carried out for all clusters in early 1987. Appendix 9 provides a case study approach towards understanding the relationships and dynamics of the lineage mode of production.

10. Equipment used in the calculations for Table 6.2 included: ploughs, harrows and cultivators.

11. Local wage labour was investigated for the household sample during 1986-7. During the 86-7 season, 53% of households hired someone for agricultural activity (weeding (32%, ploughing (23%), harvesting (23%), coppice cutting (18%) and fencing (4%). 14% of households employed someone for herding (see Chapter 8).

Despite evidence for local wage employment, people comment that "the rich have not abandoned the poor". There remains a significant amount of cooperative agricultural activity. 51% of households interviewed had held a communal work party (humwe) during 1986-7 (weeding (54%), ploughing (25%), coppice cutting (7%), threshing (7%), harvesting (4%) and fencing (4%)). Cooperative arrangements for herding are also important (see Chapter 8).

12. The definition of household size for this analysis went beyond the purely kin relations of household members (often children from other homes (usually relatives) are

resident). The level of dependency of even older households is often quite high, with continuing obligations to support children in food, clothing and school fees. This is especially so for 'richer' homes.

13. A consumption index, based on Latham's weightings, was also calculated in terms of Adult equivalent units (AEU), where:

Age	Male	Female
0-2	0.4	
3-4	0.48	
5-6	0.56	
7-8	0.64	
9-10	0.76	
11-12	0.8	0.88
13-14	1.0	1.0
15-18	1.2	1.0
19-59	1.0	0.88
60+	0.88	0.72

Source: Collier et al (1986).
This was again weighted according to presence/absence (see Footnote 3), but not weighted by household size to account for economies of scale considerations.

14. Consumer producer ratios:
* 1 : (C+P1+P2+P3)/(P1+P2+P3)

*2 : (C+P1+P2+P3)/(W1+W2+P1+P2+P3)

W = Workers away: permanent (W1) (presence class 3= Score = 1) and semi-permanent (W2) (presence class 2 = Score 0.5)

P = Producers at home (adults (P1) (presence class 1 = Score = 1); older children (P2) (Ages: 11-20: presence class 1: Score = 1); adult semi-permanent workers (P3) (presence class 2: Score = 0.5)

C = Consumers at home: all children (ages 1 - 10: Score = 0.5); all producers (P1 and P2) (presence class 1: score = 1); semi-permanent producers (P3) (presence class 2: Score = 0.5)

15. Dependency ratios are assumed to decline in older households as children leave home. The reasons this does not occur here may relate to the fact that children often reside in older people's homes, especially if parents are away. Also older men may have a number of wives with young children.

16. The ownership and holding of agricultural land is

complex. Formal title exists to those who were allocated land as part of the Native Land Husbandry Act implementation, inherited land granted in this way or were allocated land subsequently by the local authority (the sabhuku prior to independence or the Councillor/VIDCO with authority from the District Council since). Others may acquire land through borrowing areas from others, by appropriating illegally land that is not supposed to be cultivated or by being granted parcels of land by a title holder (eg. to wives or younger sons).

17. The Zimbabwe National Household Survey Capability Programme report for Midlands province (ZNHSCP, 1985) indicates an average land holding per household of 2.4 ha; about half the amount recorded here. This disparity probably reflects a number of factors. These include: the relative lack of land scarcity in Mazvihwa (particularly the sand veld hill zone) compared to other areas of Midlands Province, the inclusion in this assessment of all land held, including scattered blocks like home fields, borrowed land and illegally appropriated land and measurement inaccuracies in farmer estimates used in other surveys.

18. Land areas per AEU are quite equitable across different groups divided by wealth and zone (average c. 0.1ha/AEU).

19. Total crop income was calculated by estimating kg yields (converted from local or GMB bag measurements) and multiplying by price for that year. This was done for all crops excluding nyimo and nyemba, but including maize, sorghum, bullrush millet, finger millet, groundnuts and sunflowers. Sales combine local and GMB sales. The crop production data is derived from the surveys carried out with the household sample by Ken Wilson and is based on recall data.

20. Prices used refer to the producer selling price for grade A grain set annually by the Grain Marketing Board and reported by the Ministry of Lands, Agriculture and Rural Resettlement. I am grateful to M. Drinkwater for providing me with this data. I have taken GMB producer prices without deducting transport and bag costs. The income levels are therefore a slight overestimate in this regard. However the failure to account for local prices for local sales is perhaps more significant. Local sales are more important in drought years where farmers sell in small quantities and

add considerable value to the product.

Prices: Z$/tonne

	84/5	85/6	86/7
Maize	140	180	180
Sorghum	140	180	180
Mhunga	250	250	250
Rapoko	300	300	300
Groundnuts (sh)	500	750	900
Sunflower	285	320	340

21. Since groundnuts are often harvested by Dec/Jan because of early planting in vleis, there is an opportunity of capitalising on the early market when supplies are scarce and prices high. Several farmers marketed groundnuts in Zvishavane, selling to vendors at the bus terminus. Despite the large transport costs this was a very profitable enterprise. In 1988/9 the marketing authorities clamped down on this practice (GMB has an official monopoly) and prevented farmers travelling to Zvishavane with produce. Instead the buyers travelled in numbers to the remote hill villages to purchase.

22. Production function analyses of agricultural output have been carried out for Zimbabwean producers by Massell and Johnson (1968) for Chiweshe and Condere and Marijsse (1988) for Mutoko. They both found that the marginal productivity of land is high, but there are limited opportunites for increasing land areas (without land reforms). The results show limited options for increasing the efficiency of factor allocation.

23. The relationship between crop production and cattle ownership has been demonstrated by a number of researchers (eg. Collinson, 1982; Shumba, 1985 and GFA, 1987).

24. A number of reasons could contribute to the different patterns shown from expectations. First, the data set for this zone is limited, as a number of households did not provide sufficient information to calculate harvests or field area; these included three households where large harvests are known to have been reaped. This therefore brought the average down. Second, alternative sources of income may be more important in the edge zone; in particular remittance income. This reliance on alternative

income sources may have resulted in less concentration on agriculture.

25. The grain flow model was developed jointly by Ken Wilson and myself using the crop production data in order to carry out different analyses. The focus of the analysis here is the investigation of the relationship between the household food security situation and livestock investment and disposal strategies.

26. A zero start point seems reasonable since the previous years of drought had resulted in the consumption of most local stores and the government had to intervene with a large food aid effort during the previous year.

27. Consumption is estimated by regressing observed consumption levels against AEU levels for selected households (all $p < 0.01$). For 1984-5 and 1985-6 no wealth category differences could be detected between households and a standard amount of 158kg/AEU/year was given as the consumption level. For 1986-7 significantly different regression relationships were discovered and two consumption levels were used - 205 kg/AEU/year for wealth ranks 1 and 2 and 169kg/AEU/year for wealth ranks 3 and 4.

Consumption studies were carried out by Ken Wilson during 1987. For 1985 and 1986 estimated consumption levels were gained by relating estimates of bags of grain taken to the mill with AEU levels.

Beer consumption was assumed to be concentrated in the 1984-5 season, following the good harvest. Estimates of beer consumption were made based on recall of the number of beer brews carried out between the 1984-5 harvest and the end of 87. A single brew was assumed to be 3 buckets of grain or 55.8kg. The overall average consumption of grain for beer was therefore estimated at 367.5kg. There was no significant difference in consumption levels between wealth groups.

28. The half life of grain in the granary is assumed to be 6 months if the household remains in surplus, therefore for an annual loss of 10%, a 5% loss can be expected for grain. The half life of the grain is half of the time taken to finish the grain; this is the ratio between [yield-sales] and [consumption]. A 10% loss rate is again assumed over the half life period of the grain in the storage granary.

Grain that still remains in the granary following consumption is assumed to suffer a 10% loss.

29. Althought not actually in deficit, the average surplus level (Stor87) is very low for most groups, except the sand veld population and the clay veld wealth category 1 and 2 group, Even these groups show large standard deviations on the mean levels. Some households indicated that they purchased food before their granaries were empty, saying that it was best to retain some grain in case commercial or food aid supplies became unreliable; others said that they would retain good storing bullrush millet grain and purchase maize or maize flour so that a mix in the diet could be assured.

30. The income/expenditure survey was carried out on a quarterly basis. Regular and occasional expenditures were estimated separately. Expenditure on transport, beer and mill fees were also assessed on separate occasions because of suspected underestimates in the other survey. The expenditure on school fees was also cross-checked with a focussed survey for all households. Other income and expenditure categories could be cross-checked through other interviews asked at various times throughout the year. The regular stock monitoring covered all livestock incomes and expenditures, crop inputs and sales were also discussed as part of separate interviews. The same applied to savings club returns and remittances. The degree of cross-checking, and the consistencies that arose as a result, suggest that the picture is accurate for the present analysis. Those areas of income and expenditure that have been missed include the informal exchange economy, the 'illegal' economy and the small, casual expenditure that is not easily recalled.

Intra-household patterns of income and expenditure were not assessed. This study assumes that the household has a 'common purse'. This is not the case, as individuals have separate income sources and expenditure patterns. Women comment that the most important advance they can hope for in terms of economic independence is to own their own buidling society or bank account and some women do (Andrea Cornwall, pers. comm.). However, often the amount of cash coming into the home is very small and it is regularly commented that it is the wife's role to look after the purse, less the husband misuses it (This was highlighted in the wealth ranking discussions). This does not mean that

the woman necessarily has control over the cash resource, but this independence generally increases if the husband is working away.

The income source categorisation was: Remittance, Pwk (piece work including all local paid employment including government public works), Harvests (income from crop sales - local and GMB sales), Irrigation (income from irrigation crop sales), Catinc (income from cattle sales), Milk (income from milk sales), Gtinc (income from goat sales), Chinc (income from chicken/egg sales), Fish (fishing income), Beer (beer brewing income), Craft (income from sales of craft work - mats, pots, wooden items, knitting etc), Savings Club (profits from savings club returns), Gardening (income from gardening), Sugar exchange (profits from sugar-grain exchange)

Expenditure sources were categorised as follows: Agin (agricultural inputs), HHitems (household items such as furniture, cooking pots, stirring sticks etc.), Cloth (clothes), Labour (hired labour), Bding (building - materials and labour), Catexp (Cattle purchase), Gtexp (goat purchase), Donkey exp (donkey purchase), Lobola (bridewealth payments), Fees (school fees), Groc (groceries - all food items except grain eg. tea, sugar, soap, bread, jam, drinks etc.), Food (grain/meal), Transport (bus fares etc), Drink (beer), Mill (grinding mill expenses), Nanga (local traditional healer), Chexp (chicken purchase).

31. Total cash income is assessed as the sum of all cash income received over the period to the rural home. This is made up as follows:

TOTCSHINC = REM+PWK+HVST+IRRIG+CATINC+MILK+GTINC+CHINC +FISH+BEER+CRAFT+CLUB+GDNING+SUGAREXCH

32. Other income sources amalgamated under piece work include: building, cash for work schemes, agricultural labour. Most options for local off-farm employment result in low returns (c. $2/day), only skilled labouring such as major building can realise significant amounts comparable to levels acheived in the formal sector (minimum wage c. $180/month).

33. Variatons in the wage levels of the formal sector sources noted here are large, ranging from c. $150/month (domestic worker, labourer) to well over $1000 (junior management). Teachers, who dominate the remittance sources, may earn between $500 and $850/month. The comparative returns from most off-farm jobs and rural based incomes are biased heavily in favour of migrancy. However this option may only be open to a subset of society (mostly men and

more likely with schooling). This introduces a distortion into the labour force remaining at the rural home. Low (1986) suggests this is one reason why low agricultural returns are seen in migrant labour societies in southern Africa.

34. Arrighi (1970) documents the process of incorporation of the rural peasantry into the wage labour market in the early part of the century. He shows that by 1920 around 20% of indigenous African males over age 14 were in wage employment. This rose to around 40% by 1945 and to 55% by the mid-60s. Although the structure of the off-farm economy has changed dramatically over this period, it is important to note that the importance of remittance income has been evident since the 1920-30s. Johnson's (1968) study shows remarkable similarities with the patterns shown here, where off-farm wages represented on average 23% of total income. This relative historical stability in the structure of the local economy is reflected in the comments made in interviews on the pattern of acquistion of cattle.

35. Increasingly, remittances are spent on school fees, clothing and groceries. This is noted by local people as one reason for the decrease in investment in stock:

> "Long ago money was only centred on buying stock, but these days men think of buying clothes for their children as well as paying school fees. This also hinders women in their desire to own stock." (Mai Florence, Mazvihwa, 9.87)

36. Saving clubs centred on beer brewing exist (baroni) where members brew in turn and pay a set amount for each party; the sum of all members contributions (perhaps $100 from 10 members) being taken by the brewing household on that occasion. This is an important method of realising sufficient cash at one time for larger investments. During 1987, 23% of the sample households were members of such a club. Others had been in the past, prior to the recent droughts, when more liquid cash and grain for beer was available. Another form of savings club (kandirana) is more common amongst groups of women, where small sums of cash are contributed on a rotating basis, realising around $30-40 for each member during the year. During 1987, 32% of the households were linked to a kandirana savings club group. Overall 45% of the sample households were not engaged in any form of savings club, yet many indicated that they had been in the past.

37. A single child's fees in a non-exam year (c$130) represents 15% of the estimated average total cash income of a sample family.

38. This had followed bad experiences with loan repayments for agricultural fertiliser/seed packages promoted in the area in previous years.

39. These figures can be compared with two other income studies carried out in Zimbabwe. Johnson (1968) surveyed households during 1960/1 in Chiweshe and Jackson et al (1988) carried out a national survey for the 1984/5 season.

Income source	Johnson (1968)	Jackson (1988)
Crop income	38.3	50.35
Livestock income	12.5	5.41
Remittances	33.4	18.51
Local off-farm		14.71
Local farm wage	7.4	1.00
Self		7.88
Other	8.4	2.5

Although different methodologies were used to assess income levels, the general pattern is clear. The importance of crop income at a national level even in the good year of 84/5 was only 50% and in the poorer season 29 years ago, the importance of remittance income was clear. Indeed a cross-comparison of the data shows that the basic structure of the rural economy is little changed, although regional differences (my data for 84/5 vs the national sample) and interannual differences are obviously important.

40. Goat marketing is limited by vetinerary restrictions on the transport of animals to other areas, including urban markets. In addition the high cost of transport (on buses) reduces incentives.

7. DROUGHT: IMPACTS ON LIVESTOCK POPULATIONS

7.1 Introduction

This Chapter explores the local level responses to drought in the Mazvihwa study area. Chapter 4 has already highlighted the impacts on livestock populations of variable environmental conditions, but these could only partially be examined with the aggregate time series data presented there. This Chapter builds on the local level understanding of the role of livestock in the household economy developed in Chapters 5 and 6, and explores how local differences in savanna type, livestock population structure and socio-economic differentiation affect the responses of cattle and goat populations to drought (1).

Following an attempt to define the nature of drought and a brief exploration of its impact on livestock in the past, the Chapter focusses on the impact of the recent droughts of 1982-4 and 1987-8 on the stock populations of the Mazvihwa study area. The collapse and recovery of cattle and goat populations is investigated in relation to patterns of savanna ecology and strategies of management.

7.2 The nature of drought

Drought is a difficult concept to define. Popularly it refers to a severe rainfall deficit, but years when rainfall has been below 25% of the long term mean have been quite frequent within the regional study area (see Chapter 4), yet in these years the consequences for human and animal populations have been very different. There is no simple relationship between seasonal rainfall and impact on crop or animal production. Comparing their experience of droughts local informants comment:

> "Some droughts affect the crops and the humans suffer, like 1947; others only affect the cattle."

> "In the past there were only local shortages of grass

> and cattle remained at home. There was always grass because of rain.. with restricted grazing areas the grass now runs out." (Discussion on the history of droughts, Zihove, Chivi, 28.5.87).

Sandford (1979) suggests an economic definition of drought:

> "We should define drought as a rainfall-induced shortage of some economic good (eg livestock fodder) brought about by inadequate or badly timed rainfall. By this definition the future incidence (frequency and severity) of drought depends not only on rainfall but also on trends or fluctuations in requirements (demand) and on the factors other than weather which influence supply."

This definition focuses on the consequences of drought and leaves open the question of the causes of deficits in fodder; they may be simply drastic rainfall deficits or may be combined with excess stock populations or decreasing land productivity. Farmers have to respond to this combination of causal factors and so a wider definition is helpful in understanding the link between rainfall deficit and farmer response strategies under different conditions.

In Zvishavane District annual rainfall varies enormously between years. Over the period examined for Zvishavane town (1923-1986), the maximum was 1144.2mm in 1925 and the minimum 175.6mm in 1973. The mean level is 571.89mm and the median 554.75mm. The coefficient of variation for annual rainfall for this period is 0.36. The data shows no apparent downward trend in average rainfall, unlike other areas of dry Africa (see Appendix 1). Rather a cyclical pattern of dry and wet phases is exhibited (Tyson, 1978). This is on an approximately ten year cycle. Interannual variability is the norm in such an environment; levels of rainfall well below the average are a regular occurrence.

It is important to remember this long term dynamic element of the environment when considering patterns of ecological change or the changes in livestock populations. Oral histories recount the incidence of drought over the last 70 years and a number of themes emerge. First droughts in the

past did not apparently affect livestock to any significant extent. Secondly the local responses to drought survival have changed over time. Thirdly, there is a universal view that rainfall has declined, even within a cyclical pattern.

The local perception, shared by African elders and European commercial ranchers alike, is inaccurate, as the climatic data reveals. However it does suggest that other changes have occurred that affect the proximal indicators used to gauge the level of rainfall (eg grass growth). The incidence of drought, as defined by Sandford (1979), may have increased, yet the actual rainfall has not declined over time. Observer bias may be a cause because the heavy rainfall of the 1970's may give an impression of current rainfall scarcity and so decline. This may be so for younger informants, but many were older and have lived through several dry and wet phases.

A real possibility is that the pattern of annual rainfall has changed. This remains to be fully investigated for the Zvishavane situation. Local observers certainly agree that there has been an increase in mid-season dry patches (January) that would have a serious impact on grass or crop growth. Certainly many researchers have emphasised the importance of the pattern of rainfall (in terms of timing and intensity) availability for plant growth and hydrological recharge. Another possibility is that changes in the environment such as increased run-off and decreased infiltration have reduced the rainfall amount that finally becomes available to plants. In certain patches of the landscape this is certainly the case (see Chapter 9).

Understanding the historical pattern of response to drought helps us to comprehend why recent drought years in southern Zimbabwe have been so different in impact and resulted in a different response. However there are also similarities and these are important in pin-pointing critical elements of the local drought response. In the following section I will offer a sketch of the characteristics of a few key drought

years prior to the 1980s, based on the impressions of informants in the study area (see also Chapter 3).

Some older people remember the droughts early this century when government supplied food on credit. There is no recollection of any impact on the cattle population at this stage as surplus land and grazing always existed.

> "In 1916 people survived off loans of food, but the cattle did not suffer" (Interview, Mr Mabomba, Murowa, Mazvihwa, 17.10.86)

Droughts in the 1920s and 1930s (eg 1922, 1933) are remembered as times of crop failure and food deficit. The local responses included purchasing grain or exchanging livestock or sometimes daughters with the successful agricultural entrepreneurs (hurudza). Wild game resources were particularly important at this time. Following the decline in game populations alternative wild resources were used during drought periods.

> "After the influenza [1918] there were many droughts. People were given maize or they sold cattle. But the droughts were mild by comparison to these days... those who did well had farms on the vleis, the others in the plains suffered. The hurudza succeeded because of good rainfall in the years between." (Discussion, Zihove, Chivi, 28.5.87)

> "In 1922 grain was brought, but it was for sale. In those days people used to organise hunting parties in times of drought and round up wild animals for slaughter. Also you had to rely on the hurudza or relatives in distant places where there had been rain and food was plentiful" (Discussion, Maringire, Chivi, 29.5.87)

The drought of 1947 was catastrophic for food resources, the role of the hurudza had declined and people had to increasingly rely on the links with the urban economy in order to obtain food. Despite the dramatic effect on food crops, cattle mortalities were not massive, but some movement in search of alternative fodder supplies is remembered.

> "In 1947 the hurudza had to be secret to stop people flocking in numbers to their homes and forcing them to give up the whole granary. People generally had to buy food at the mines with cash. You always find a relative working - otherwise you would just starve.." (Chedume, 3.7.87)

From 1947 the effect of droughts on cattle is increasingly remembered; movements to other areas or cattle deaths are recalled.

> "In 1947 cattle were driven here [Masinire, Chivi] and again in 1950. In 1960 alot of cattle were loaned here and some people came and built camps in the forest. Plenty also came around 1965 to find grass.." (Group discussion, Masinire, Chivi, 26.8.87)

> "In 1965 the drought affected the cattle. They were taken to Shabani area and further to Mapanzure; many died." (Discussion, Chedume, Mazvihwa, 3.7.87)

> "Cattle suffered in 1973; some died and others were taken across the river to Chivi (Interview, Mototi 15.7.87)

Historical information from informant interviews and supported by archival material suggest that the consequences of rainfall deficits have increasingly been felt by cattle over time. Small stock and donkey populations are not remembered as having been affected to any significant extent. The droughts of the 1980s resulted in the most serious impact on cattle populations ever. This is reflected in the regional livestock population data presented in Chapter 4.

The remainder of this Chapter will concentrate on a detailed case study of the two most recent droughts: 1982-4 and 1987-8. A detailed study of the impact of particular drought events will provide additional insight into the time series data for the regional level presented in Chapter 4. The effects of drought on mortality, fertility, movement patterns, sales or slaughters has never been fully studied in Zimbabwe. Knowing the gross levels of herd reduction and general relationships of economic or biological parameters with rainfall levels does not reveal

the underlying biological and economic processes. With micro-level data, explanations for local drought response strategies by livestock and their owners will be sought. This discussion attempts to investigate the consequences of inter-annual variability in some detail, comparing the impact of droughts on goats and cattle, the impacts of a sustained two year drought and a one year drought and the impact on livestock resident in different ecological zones. Details of methods used are given in Footnote 1.

7.3 The phases of drought and the impact on stock populations

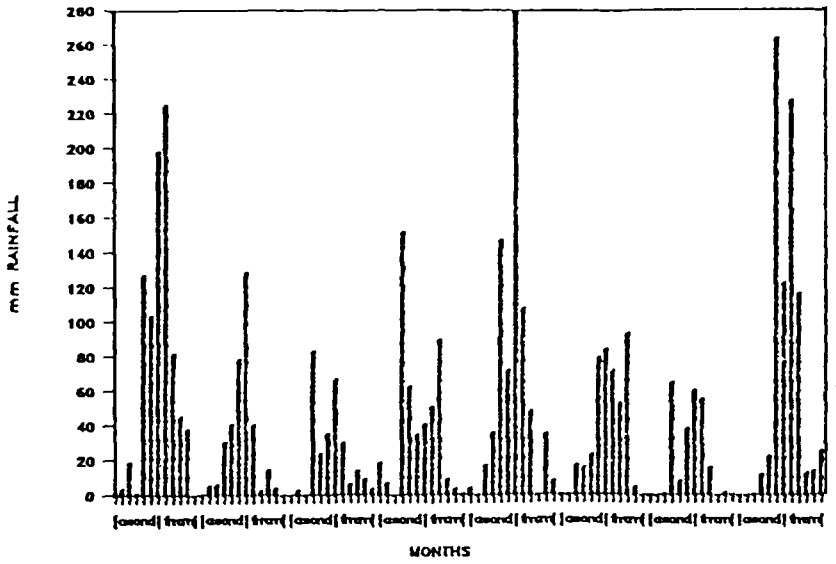
Monthly rainfall data for the two droughts is shown in Figure 7.1. Annual rainfall data is presented in Table 7.1 for the period between 1980 and 1988, showing the percentage reduction from the long term mean.

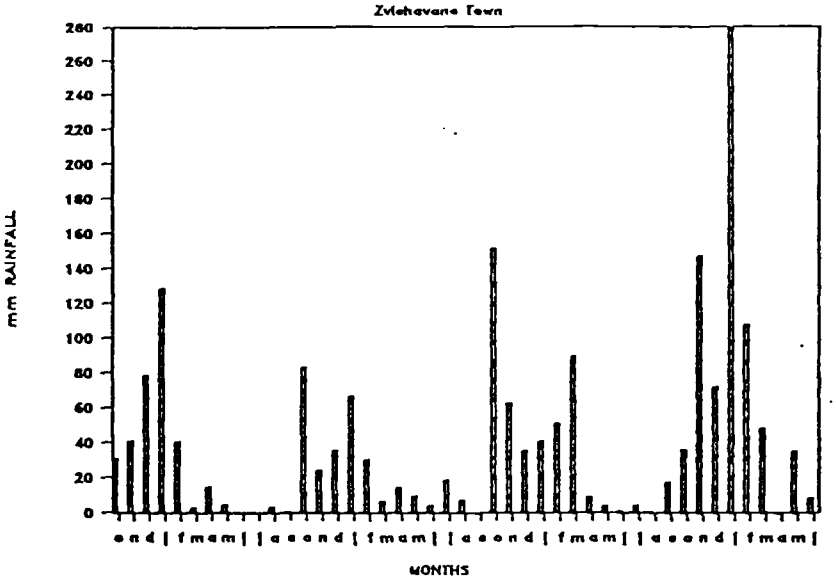
Rains were below the long term mean in 81-2, 82-3, 83-4, 85-6 and 86-7. Although in each case some grass grew, germination and growth was poor. The pattern of rainfall incidence was such that over wide areas there was a shortfall in available forage during the dry seasons that followed. In 1983-4 the rains were low for a third year, after a particularly severe deficit the previous year.

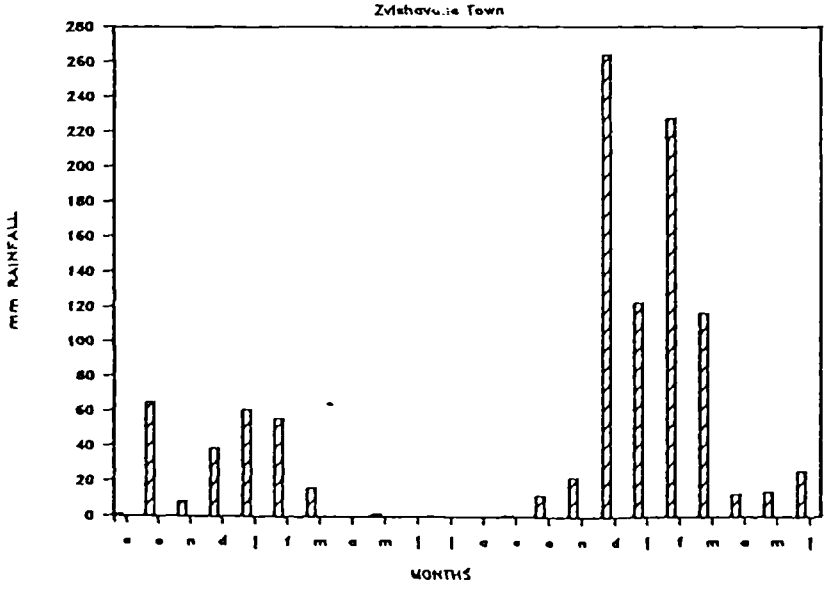
Table 7.1: Seasonal rainfall (July - June) Zvishavane town and deviation from 1923-1986 mean.

Season	Rainfall (mm)	Deviation from mean (%)
1980/1	855.4	50
1981/2	360.4	-37
1982/3	285	-50
1983/4	476.4	-17
1984/5	762.4	33
1985/6	451.3	-21
1986/7	253.4	-55
1987/8	825.7	44

Figure 7.1: a. Monthly rainfall variation, Zvishavane town: July 1980 to June 1988. b. October 1981 to June 1985. c. September 1986 to June 1988.







The progress of the 1982-4 drought and its effect on grass production was explained to me by Mr Mukamuri of Mototi, Mazvihwa:

> "In 1983 there was no grass; in 1984 it was worse, grass germinated alright but rapidly dwindled to nothing, because of the patterning of the rains. Even with no cattle around ther was no grass until the good rains of 1984/5. It is the daily rainfall pattern that explains why grass fails to produce in a season." (Interview, Mototi, 17.7.87)

Interviews in Mazvihwa and surrounding areas and an examination of local Agritex and Veterinary Department monthly records indicate that there were definable phases in the progress of the droughts. Movements of animals are shown in Figure 7.2.

The 1982-4 drought

Dry season of 1982 up to November. This phase saw the first cattle mortality in the clay veld areas of Mototi Ward. Cattle were still resident in Mazvhiwa, but were moved from the clay veld areas to the sand veld during this period.

> "Cattle came from all over the deve (clay veld) to find grass here. They came in numbers; some were left with relatives and some were just left to wander in the hills. Soon the grass was finished." (Interview with Mr Fani, Bungowa hills, 7.87)

> "Mazvihwa-Bungowa is our worst drought affected ara and Mazvihwa dip may be forced to close down because of lack of water" (Veterinary report, Buchwa, June 1982)

> "Grazing started to become short as early as March, where in some parts there was just soil and leaves of trees left for cattle to feed on." (Veterinary report, September 1982, Buchwa)

November 1982 to July 1983. Mortality rates increased during this phase. Poor dry season condition was exacerbated by the lack of grass production due to insufficient rainfall. What rain did fall destroyed available forage (dried grass or leaf litter). A significant increase in mortality occurred at the onset of

the rains. A number of farmers commented on this:

> "The coming of the rains is the most dangerous time of drought, but the Mopane can rescue the animals as it can come out with the rains. Grass will only be available after three weeks." (Tsaurayi, Gudo, Mazvihwa, 11.11.86)

Cattle began to be moved out of Mazvihwa during this period. This was initially from the clay veld areas, but increasingly sand veld cattle were moved. The fodder availability in these areas declined as more cattle were transferred there from the clay veld. Most of the movement was first to Zvishavane town and then up to Mapanzure in Runde CA or beyond to the commercial farms of Shurugwi District. Some cattle were moved south east to the abandoned ranches of Gwaai (see Figure 7.2).

> "The shortage of grazing in Runde and Mazvihwa CAs led to an invasion of cattle into Zvishavane town.." (Veterinary Dept, Midlands Annual Report 1982)

> "The drought of last year was followed by one of equal severity.. in the CAs there are virtually no crop residues or grass and people are chopping down trees for their stock... the lack of grazing forced numerous CA cattle onto neighbouring ranches, into the town of Zvishavane and a vast migration took place to Gokwe." (Vet Dept., Midlands Annual Report, 1982/3)

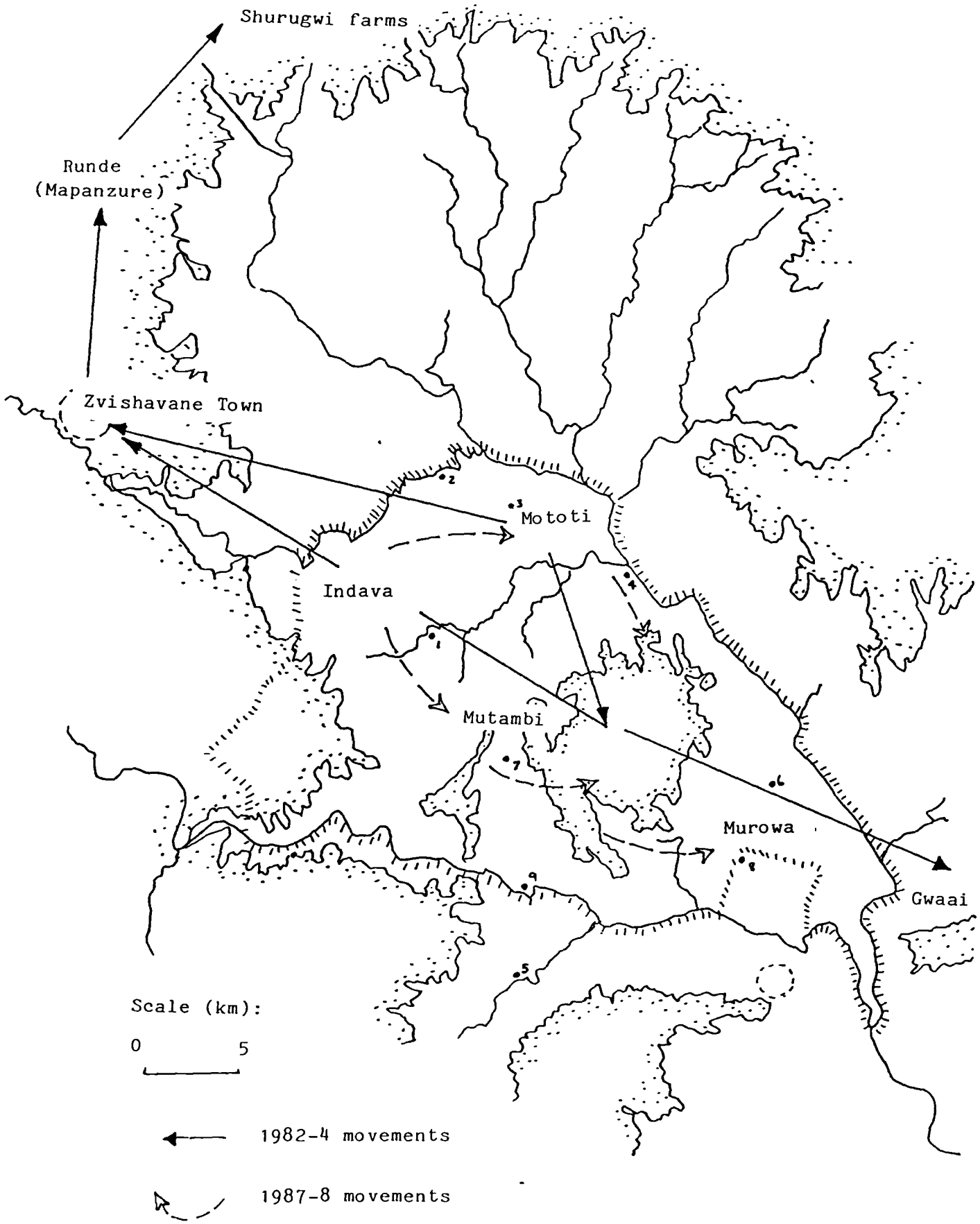
August 1983 to November 1984. Large scale cattle mortalities were occurring in Mazvihwa with the failure of the second rainy season. More cattle were moved out of the area.

> "In the Chivi CA no grazing whatever exists and stock are totally dependent on browse.." (Veterinary Dept.,Masvingo, 83/4)

December 1984 through 1985. The good rains prompted a rapid recovery of grass cover and by the end of 1985 birth rates were rising and mortality negligible.

> "In 1984/5 the grass returned very quickly. People were surprised by this as the place was completely bare only just before.." (Interview, Mawere, Mazvihwa, 9.5.87)

Figure 7.2: Location of Mazvihwa dips and patterns of drought movement by cattle



1 = Makovora; 2 = Gwamadube; 3 = Mazvihwa; 4 = Gwenombe; 5 = Solomon; 6 = Kwata; 7 = Zerubi; 8 = Murowa; 9 = Chibvumba

The 1987-8 drought

June 1987 to October 1987. Lack of topland grass meant that cattle became reliant early in the dry season on 'key resource' patches (see Chapter 8). Lack of surface water for drinking also meant increased energy expenditure in trekking for drinking water. By the end of the dry season cattle were in poor condition in the clay veld of Mototi ward and began to be moved to the sand veld areas. In the adjacent clay veld of Indava ward this phase had started earlier and many cattle had been moved to Mototi Ward and into the sand veld areas of Mutambi and Murowa wards by March/April.

November 1987 to January 1988. Mortality rose dramatically in this period. First to be affected were the clay veld herds, either resident there or moved in poor condition to sand veld sites. Later the herds resident on the edge of the two zones suffered some mortality. The sand veld herds survived due to the availability of vlei grazing and browse in this period.

> "The cattle that are dying are the ones brought into the valley from other places. They are dying because they were already thin when they arrived" (Mr and Mrs Kembo, Bungowa hills, Mazvihwa, 18.11.87)

January 1988 onwards. Grass cover was restored by the incidence of good rains; cattle quickly regained condition.

The phases of drought

A common pattern can be discerned that distinguishes between four phases:

- Loss of condition particularly in clay veld areas

- Movement of cattle from clay veld to sand veld zones

- Late dry season/early wet season mortality, particularly of clay veld cattle.

- Rapid recovery of grassland and cattle condition, particularly on the clay veld.

The sustained two season drought of 82-4 repeated the second and third phases, where cattle were first moved within Mazvihwa and suffered mortality locally and then were moved out of the area during the second season.

7.4 Savanna ecology and the impact of drought

This Chapter will pursue the distinction between responses in the clay veld and the sand veld. The following discussion of the data will illustrate how fundamental differences in the dynamic properties of the different savanna ecosystems affects the population dynamics of livestock and so moulds the human response to drought.

Contrasts in savanna ecology between different zones lead to expectations about the responses of animal populations to the impact of drought (see Chapter 2). These can be investigated with quantitative data from the sample household and dip stock populations in Mazvihwa. These can be divided into clay, edge and sand zones.

Figure 7.2 shows the position of the nine dips in the Mazvihwa area. The dip sites can be classified into three savanna zones with reference to the regional soil map (Chapter 1; (2)). The classification is not ideal, as some dips serve wide areas comprising sections of all zones (eg. Gwenombe). However for the purposes of the current discussion the argument will concentrate on a comparison between sand veld areas and clay veld areas. The classification is given in Table 7.2.

Table 7.2: Mazvihwa dip sites and ecological zone

Dip name		Zone
Makovora	Indava	Central clay veld
Gwamadube	Indava	
Mazvihwa	Mototi	
Gwenombe	Mototi	Edge zone
Solomon	Mberengwa CA	
Kwata	Murowa	Sand veld
Zerubi	Mutambi	
Murowa	Murowa	
Chibvumba		

Changes in livestock populations in these areas can be related to constrasting savanna ecology, rather than differences in population density. A 1982 census that compares the stocking rates of Mazvihwa (basically the clay veld zone comprising Indava and part of Mototi Wards) and Bungowa (Murowa, Mutambi and part of Mototi) shows that the stocking rates are similar in all areas, but marginally higher in the sandveld (Table 7.3). A more recent ward level survey echoes this conclusion (Agritex survey, 1987).

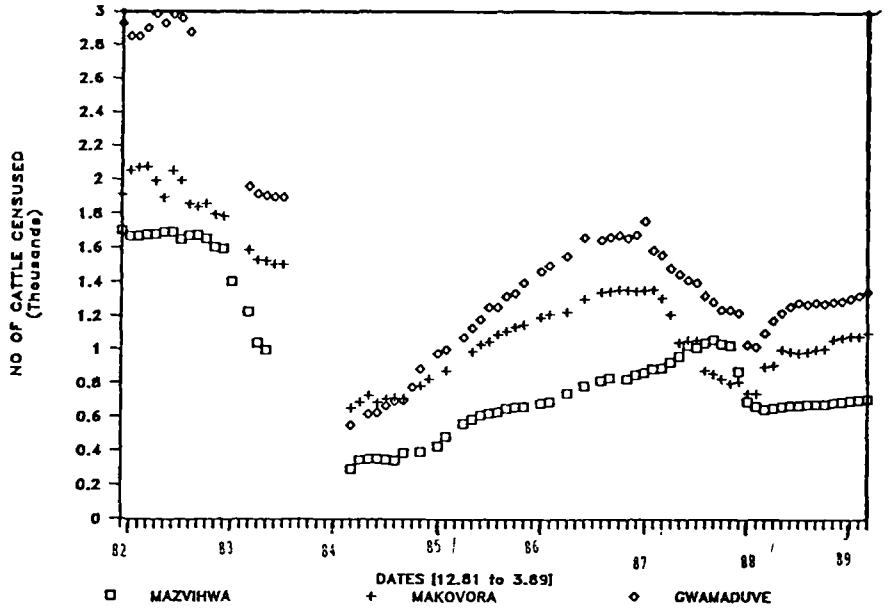
Table 7.3: Stocking rates in Mazvihwa

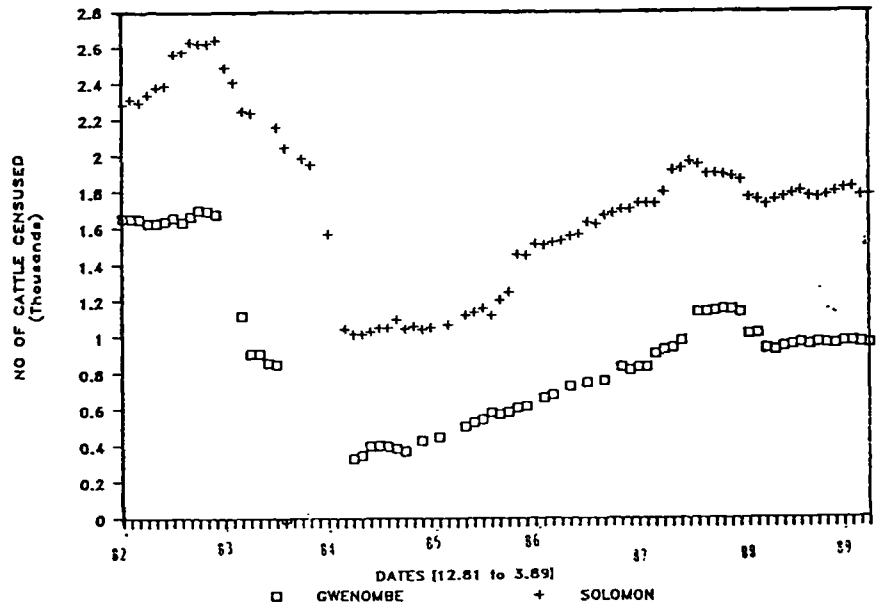
	Area	Cattle Nos	Stocking rate
Mazvihwa	14500	3137	4.6 Ha/animal
Bungowa	37300	9563	3.9 Ha/animal

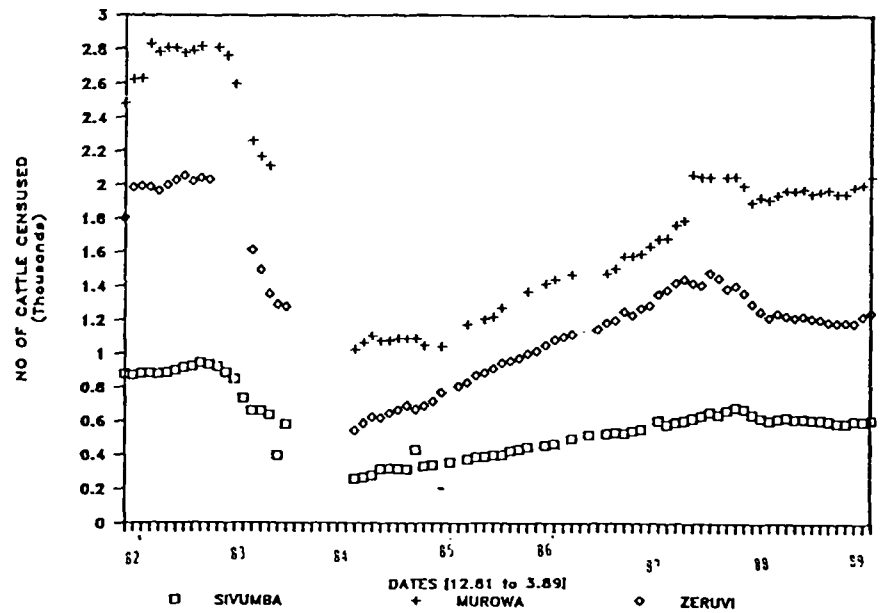
(Source: Agritex files, Zvishavane office).

Local factors probably do result in differences in stocking rates, but stocking rates at a local scale are impossible to determine as stock move freely across quite wide areas. There is no way of relating stocking rates to specific dip populations as dips do not represent any defined geographical area.

Figure 7.3: Cattle population change: clay veld dips (12/81 to 3/89 - monthly census levels) 7.4: Edge zone dips. 7.5: Sand veld dips







The changes in cattle populations for the dips in the Mazvihwa area between December 1981 and March 1989 are shown in Figures 7.3 to 7.5. Several phases can be seen. The collapse during 1982-3 is followed by recovery during 1984-6. The impact of a further drought period is seen in 1987-8, followed by a further phase of recovery (3).

Savanna ecology predicts differences between the patterns shown by populations of different ecological zones and between different livestock species. A series of hypotheses can be outlined that will serve as the basis for investigating the data in detail:

-The drought phases will be different in the different zones; drought will affect cattle in the clay veld areas first because of the early collapse in grass production.

- The percentage cattle mortality will be highest in the clay veld areas, less in the edge zone and lowest in the sand veld.

- The movement pattern of cattle will be from the clay veld to the edge zone to the sand veld areas and finally out of the area to other sand veld areas.

- Recovery of populations will be rapid and especially pronounced in clay veld areas.

- Patterns of population change of cattle and goats will be different due to different resource requirements. The browse resource of the clay veld will tend to support goats there.

7.5 Collapse and recovery of cattle populations (dips)

Decline in numbers

The decline during the 1982-4 drought (from the peak population in 1982 to the level when dip recording

restarted in March 1984) and the 1987-8 drought to December 1988 was higher in terms of % change for the clay veld populations. This is shown in Table 7.4.

Table 7.4: Percentage change in cattle populations (% of starting population).

	1982-4 %	1987-8 %
Clay veld		
Makovora	68.34	30.47
Gwamadube	81.40	27.66
Mazvihwa	82.47	38.78
Edge zone		
Gwenombe	80.41	22.82
Solomon	61.43	12.17
Sand veld		
Kwata	63.36	18.87
Zerubi	73.57	20.27
Murowa	63.86	8.26
Chibvumba	72.63	14.45

Two patterns emerge that distinguish the Indava clay veld populations from the rest. The Indava populations crash early in both droughts. The clay veld site at Mazvihwa does not follow the same pattern (4). In percentage terms the collapse of all clay veld populations is higher than for the sand veld for both droughts.

Recovery of numbers

A comparison of different areas during the period of recovery can also be investigated in relation to predicted differences in the dynamics of cattle populations in the clay and sand veld areas. The percentage increase over two seasons in cattle populations after the 1982-4 drought from October 1984 to September 1986 is illustrated in Table 7.5.

Table 7.5: Cattle population recovery 1984-6

Dip tank	% increase
Makovora	228.29
Gwamadube	111.26
Mazvihwa	108.35
Gwenombe	90.5
Solomon	57.65
Kwata	69.67
Zerubi	77.81
Murowa	35.99
Chibvumba	24.70

The data shows the clay veld populations recover at a faster rate from the drought impact than the sand veld populations. The population recovery was in part due to the return of cattle from other areas, but also may be explained in terms of the resilience of the high nutritive quality clay veld herbaceous vegetation, which returned with the good rains of 1984-5.

Biological population parameters

Using the same dip record data this contrast is investigated further by examining biological population parameters. Makovora and Gwamadube dips are taken as representative of the clay veld zone and Kwata and Zerubi as representative of the sand veld zone. Figures 7.6 and 7.7 show the different patterns of mortality between the two zones in the two droughts under study.

Figure 7.6 shows how the clay veld mortality is at a peak in March 1983 (or possibly before; unfortunately there is no mortality data for the previous period), whilst the sand veld dip mortality does not peak until May. The clay veld peak mortality is twice that of the sand veld. Data is incomplete after July 1983.

Figure 7.6: Cattle mortality patterns, 1982/4 drought (clay vs sand veld dip populations): 3/83 to 1/84.

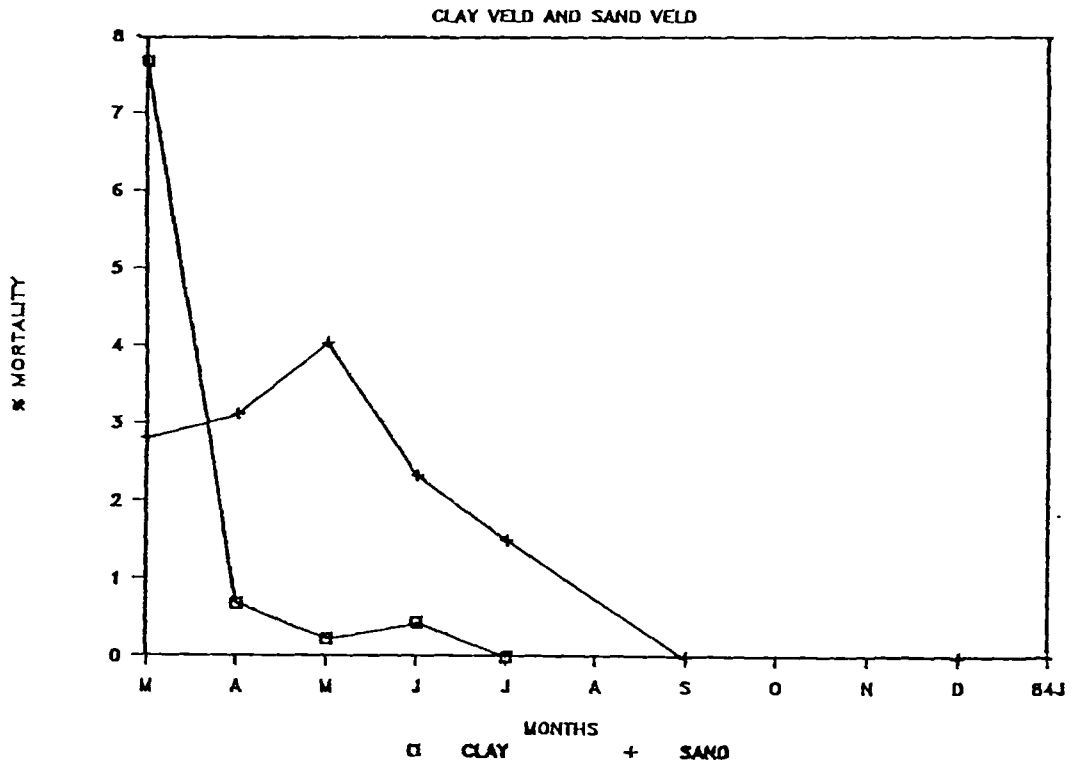


Figure 7.7: Cattle mortality patterns, 1987/8 drought (clay vs sand veld dip populations): 6/87 to 5/88

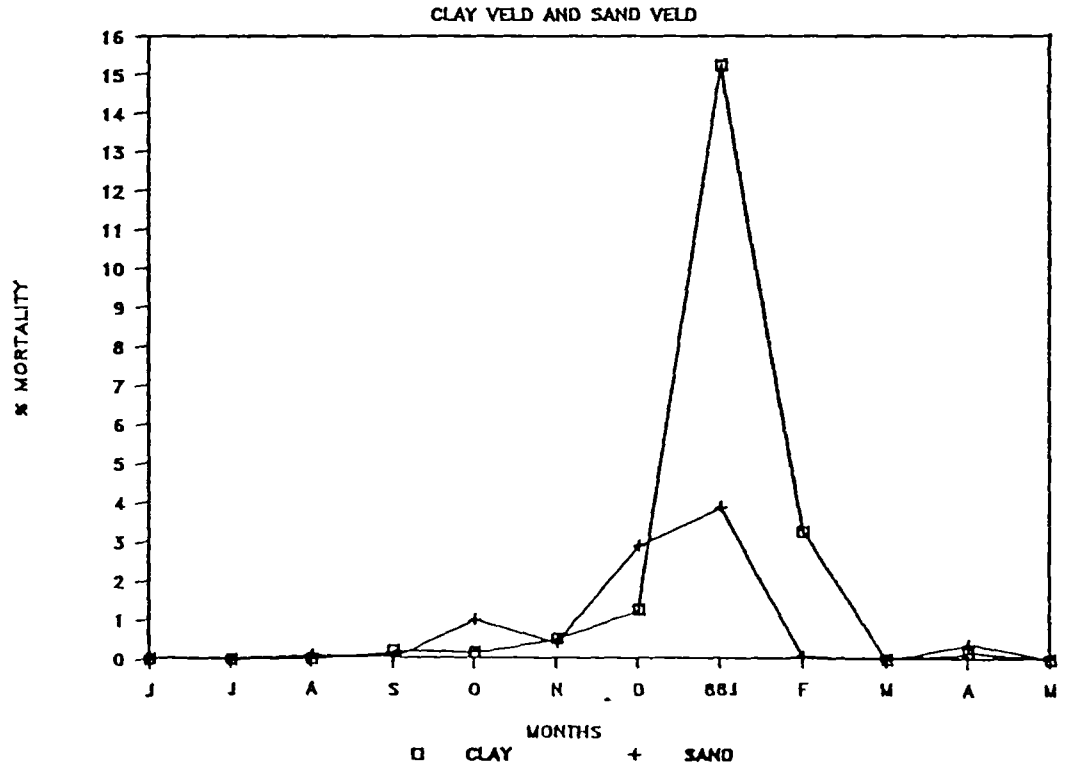


Figure 7.8: Cattle birth patterns (all dips)

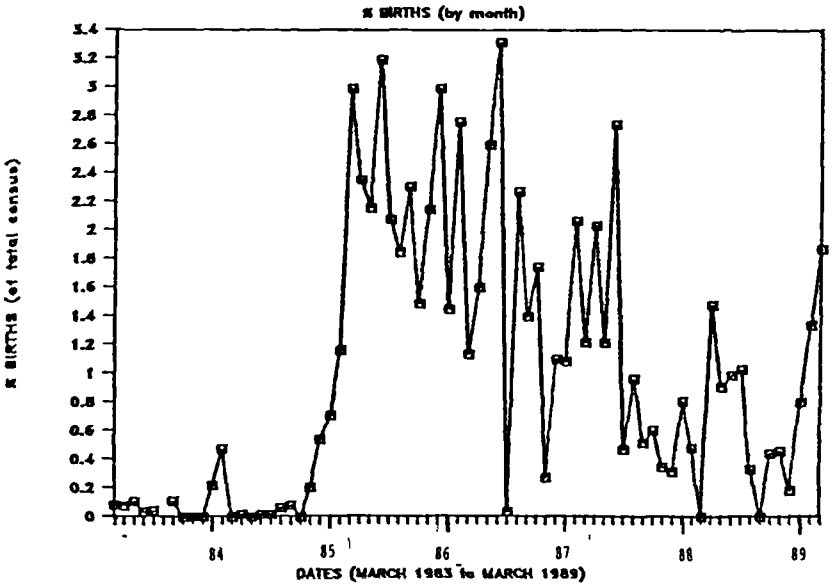


Figure 7.9: Cattle sale patterns (all dips)

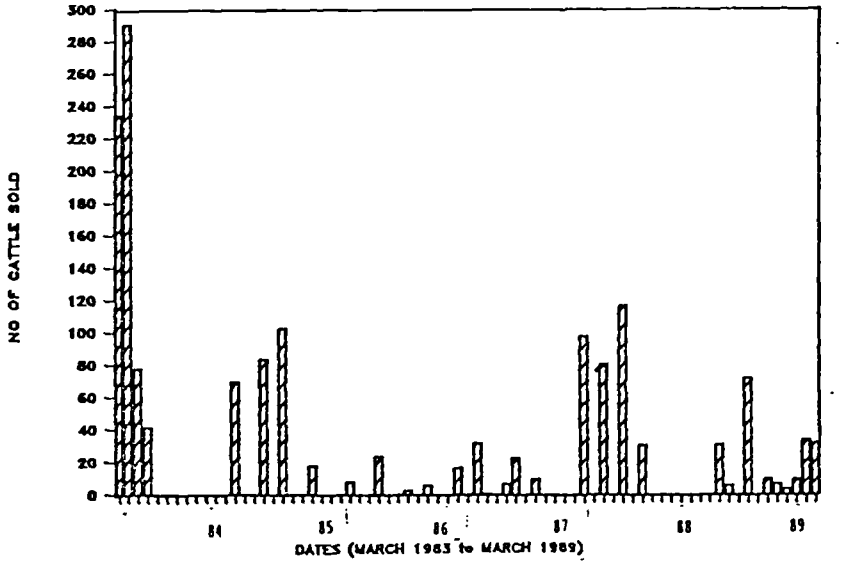
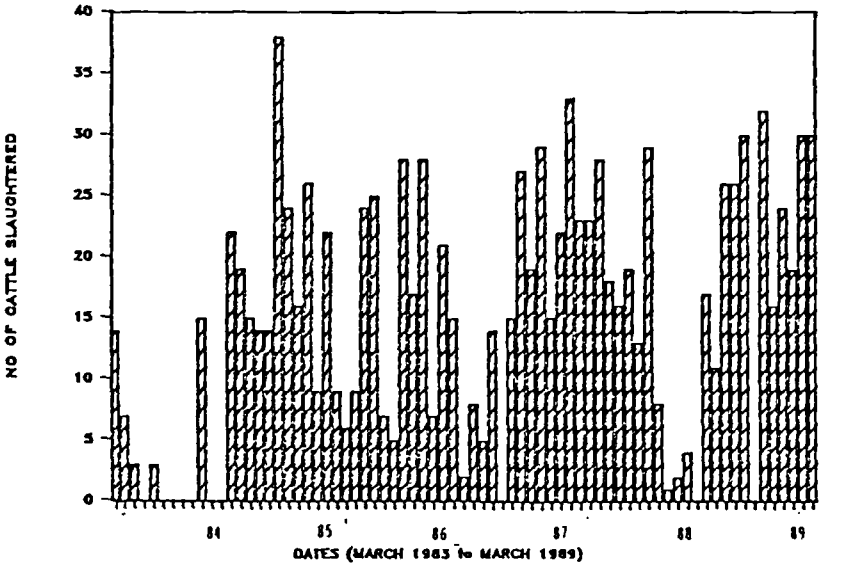


Figure 7.10: Cattle slaughter patterns (all dips)



A more comprehensive data set is shown for the 1987-8 period in Figure 7.7. Here the peaks are coincident in January 1988, with the clay veld mortality being nearly four times higher.

The annual death rates estimated from this data as a percentage of the total census at the beginning of the year (starting October) give a picture of inter-annual variation (see Table 7.6).

Table 7.6: Annual percentage birth, death, sale and slaughter rates - average for 9 dip tank cattle populations. All parameters estimated as number as percentage of starting population.

Dates	Birth %	Death %	Sale %	Slaughter %
10/83 - 9/84	0.2	8.0	2.7	1.7
10/84 -9/85	18.3	0.3	0.8	2.6
10/85 - 9/86	19.6	0.6	1.1	2.1
10/86 - 9/87	18.6	0.5	3.2	2.4
10/87 - 9/88	7.37	11.8	0.9	1.3

Figure 7.8 shows the pattern of births for all the Mazvihwa dips between March 1983 and March 1989. When the dips are analysed separately, the only discernible difference between savanna types was that the rate of birth dropped off quicker in the mid 1987 period in the clay veld populations. The pattern of increase in birth rate following both droughts was similar in all areas. The increase was from virtually zero birth rate in October 1984 to about 3% increase of total population in a month in March 1985.

The general pattern of changes in biological parameters showed a higher overall clay veld mortality rate which peaked earlier than in the sand veld in the 1982-4 drought. There was less differentiation in birth patterns, both areas showing depressed birth rates during droughts,

although the decline in monthly rates is not seen until well into the drought period. All areas showed a rapid recovery of pre-drought birth rate levels once the drought ceased (5).

Sales and slaughters

Figures 7.9 and 7.10 show the pattern of sales and slaughters between March 1983 and March 1989 for all nine dips. Sales are concentrated in the dry season and are greater in dry years (1983 and 1987). However the sales rate remains low (see Table 7.6). Slaughter levels are also low. Slaughters are spread throughout the year and no major differences between years is observed, except a particularly low level in 1983-4. The pattern of sales and slaughters between dips is basically the same; there are no discernible differences between ecological zone.

Movement patterns

Data on the movement of cattle in and out of dip tank areas (official transfers between dip registers) is documented below in Table 7.7.

Table 7.7: Movements in and out of Mazvihwa dip tank areas (total between 3/83 and 3/89)

Dip tank	In	Out	Net In
Clay:			
MAZVIHWA	579	475	104
MAKOVORA	698	743	-45
GWAMADUBE	1016	782	234
Edge:			
SOLOMON	768	401	367
GWENOMBE	740	460	280
Sand:			
KWATA	813	461	352
MUROWA	966	182	784
ZERUBI	1219	738	481
CHIBVUMBA	488	359	129

The data does not include unofficial movements which are common, especially during the drought years. When dipping was abandoned due to the lack of water in the 1982-4 drought cattle had been redistributed all over the area. However even the official records give some idea about the relative movements in and out of different zones. The data supports the suggestion that cattle tend to move out of clay veld areas and into sand veld areas.

7.6 Collapse and recovery of sample cattle populations

The data presented in this section is based on the herds of the sample households under study in Mototi Ward, Mazvihwa CA. The detailed case study allows for the investigation of the patterns of drought impact in much more detail, where changes in population levels can be related to herd structures, more precise residence areas and recorded management strategies of owners.

Changes in herd size

The mortality level of cattle populations in the three agroecological zones was assessed by comparing the herd sizes and structures before and after the droughts, taking into account changes due to births, purchases, sales, slaughters and loans (6).

The changes in the pattern of cattle holding is examined in Figures 7.11 and 7.12. These refer to the net changes due to mortality, births, sales, slaughters and changes in loaning relationship. It can be seen that in both cases there is a general shift towards smaller herd sizes following drought. Stocklessness doubled during following the 1982-4 drought. The impact was far less during 1987-8; indeed two stockless households acquired cattle as a result of loaning arrangements established during the drought (see Chapter 6).

Figure 7.11: Cattle holdings pre- and post 1982-4 drought

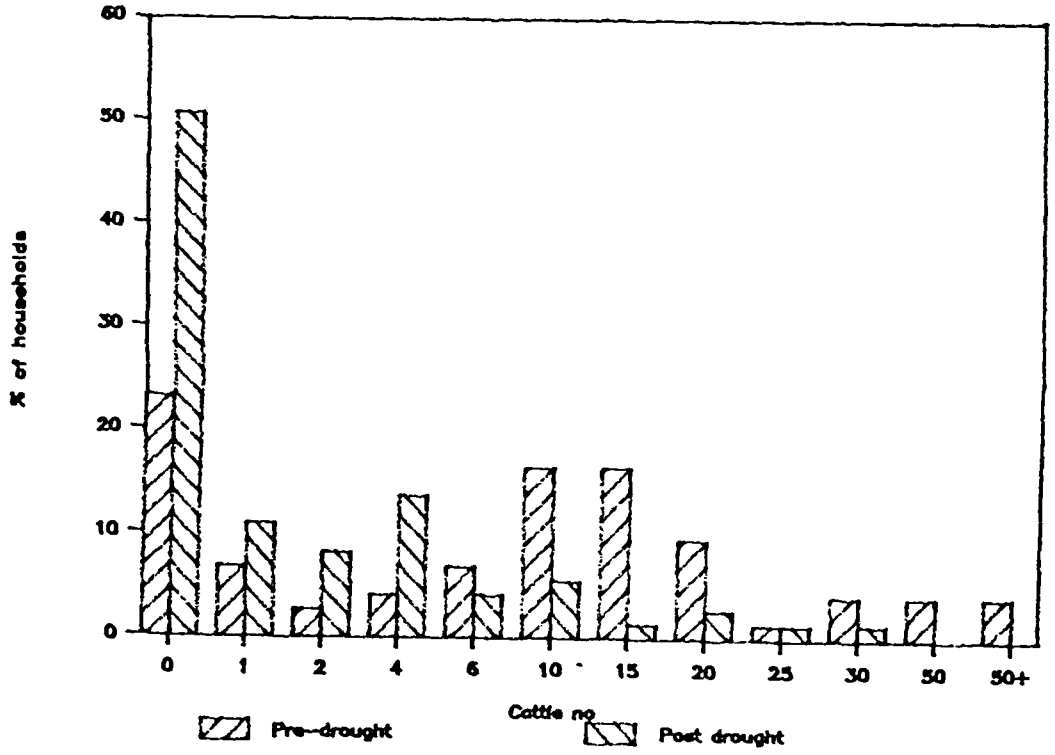
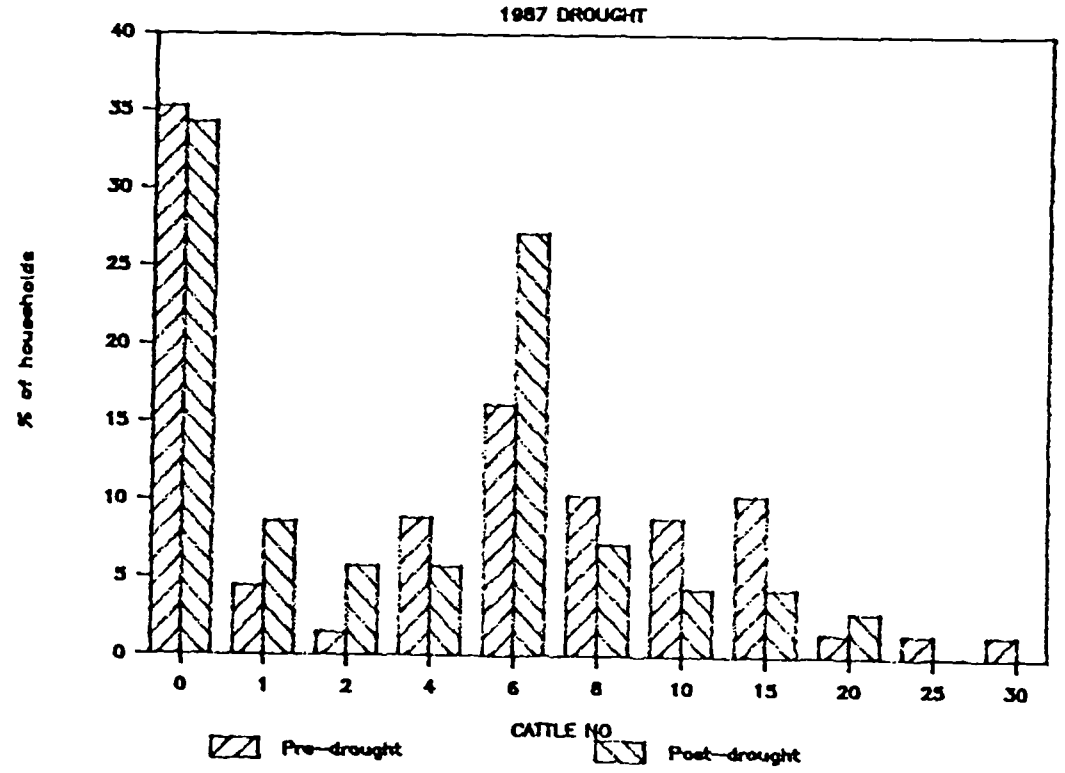


Figure 7.12: Cattle holdings pre- and post 1987-8 drought



Tables 7.8 and 7.9 present data on the changes in herd size in different ecological zones during the drought. The figures represent the size of herds post-drought as a percentage of pre-drought size. Aggregate changes of the total population of the zone are given alongside average levels for household herds.

Table 7.8: 1982-4 herd size change

Zone	Zone avge	Herd ave	SE	N Herds
Clay	17.81	13.73	2.88	41
Edge	28.42	24.75	4.84	25
Sand	35.67	33.70	13.19	7

N = 385 cattle in total.

Table 7.9: 1987-8 herd size change.

Zone	Zone ave.	Herd ave	SE	N (herds)
Clay	68.62	72.82	4.99	24
Edge	80.53	86.04	3.45	15
Sand	104	101.42	1.27	5

N = 988 cattle in total.

The pattern is clear. The changes in herd size of cattle during drought are lowest in the sand veld zone and highest in the clay veld zone, with the edge zone showing an intermediate level.

If the data is analysed in terms of the numbers of cattle that survived and died, a Chi-squared test can be applied to investigate whether there are any significant differences between zones. In both the 1982-4 and 1987-8

drought, significant differences to the p = 0.0000 level are found between savanna zones.

Almost all losses from the population can be attributed to death due to lack of food. Sales and slaughters represent a small percentage of total losses. In 1987 (January to December in the sample only 22 cattle sales were recorded). During 1982-4 virtually all sales were of animals on the verge of death.

These losses from the population were unevenly spread between different age and sex categories of animal.

Table 7.10: Percentage survival: all animals

	1982/4	1986/7
Bulls	20.00	90.63
Oxen	30.95	96.00
Cows	15.69	71.30
Heifers	32.69	76.36
Male calf	24.64	81.36
Female calf	24.53	58.33

There are significant differences in survival between livestock type during both droughts. For 1987 X^2 = 25.81; df = 5; Sig 0.0001 and for 1982-3 X^2 = 19.4; df = 5; Sig = 0.0016. In both instances, the major impact is felt by mature female cows. This obviously has a significant impact on the ability of the population to recover after drought, as prior to the droughts 55.3% and 60.5% of the total cattle population in the sample were cows or heifers in 82-4 and 87-8 respectively.

Table: 7.11: % survival of cows by zone

	1982/4	1986/7
Clay	12.50	53.57
Edge	13.55	86.11
Sand	40.00	100.00

Differences in population change between ecological zone is clearly an important factor in the overall dynamics of cattle populations. Similarly, population dynamics is affected by age and sex structure effects. Both these factors were not included in the simple analysis of aggregate population change presented in Chapter 4, due to lack of data, but would have to be considered in the future development of understanding of population dynamics.

Timing of births, deaths and sales: 1987-8

The timing of cattle mortality is illustrated for the 1987-8 drought in Figure 7.15. No data is available for the 1982-4 drought, as recall on time of death was not consistent after cross-checking. For the 1987-8 drought the peak clay veld mortality was found to be in November 1987 while the edge zone mortality peaked in January 1988. There was no mortality in the sand veld zone. The general hypothesised pattern, where the mortality phase of the drought is earlier for clay veld resident herds, is demonstrated.

The seasonal pattern of births is illustrated in Figure 7.13. This shows the number of births by month between 1984 and 1988. This data is based on cow histories, where the calving history of each named cow in the household sample was ascertained through interviews. A similar pattern as that shown for the dip data is shown, with a wet season peak and a dry season trough in births that is accentuated by drought and without ecological zone differences.

Figure 7.13: Number of births recorded (1984-88)

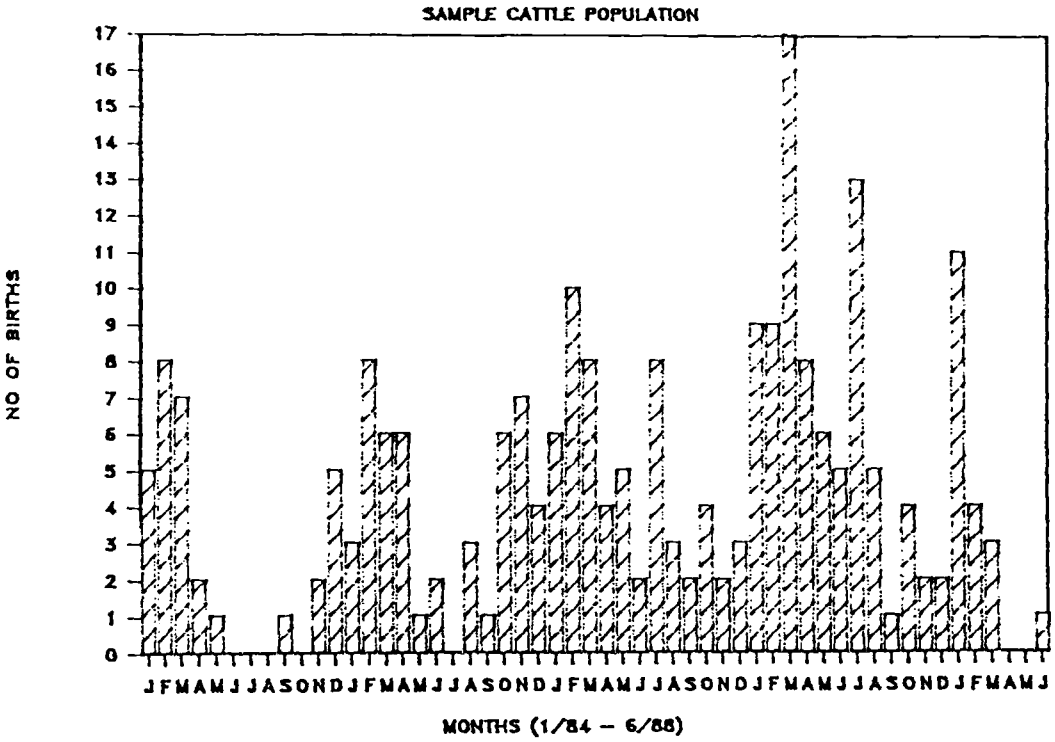


Figure 7.14: Percentage of all births recorded by month

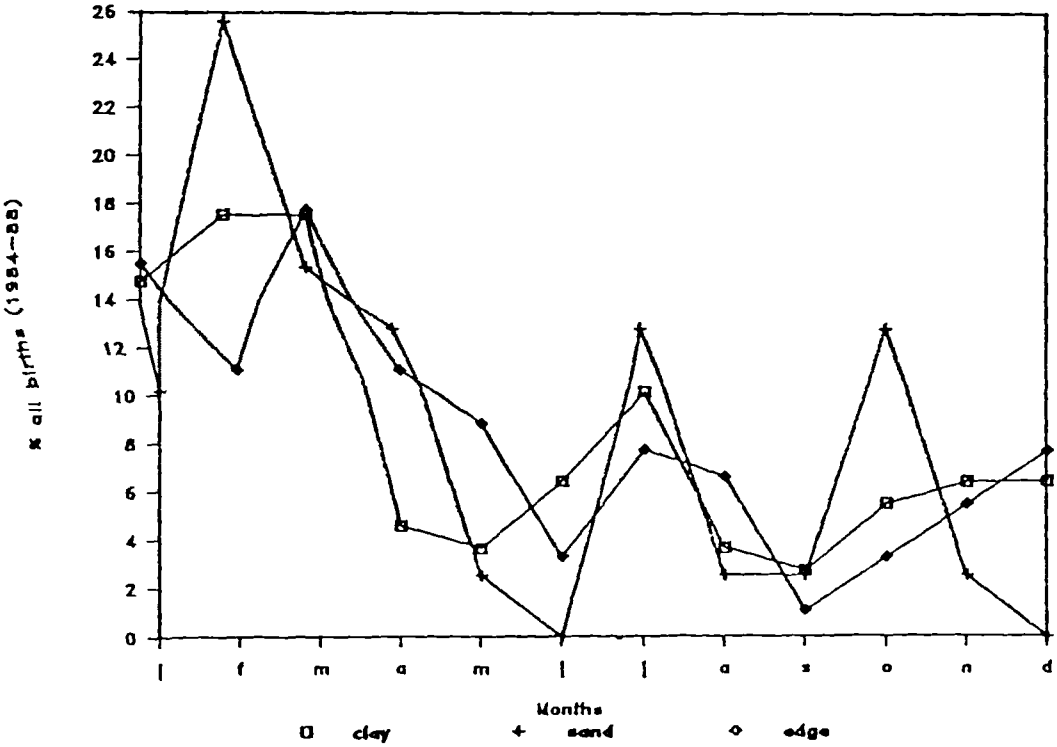


Figure 7.15: a. Pattern of cattle deaths (1984-88). b. Cattle deaths (1987-88) by zone

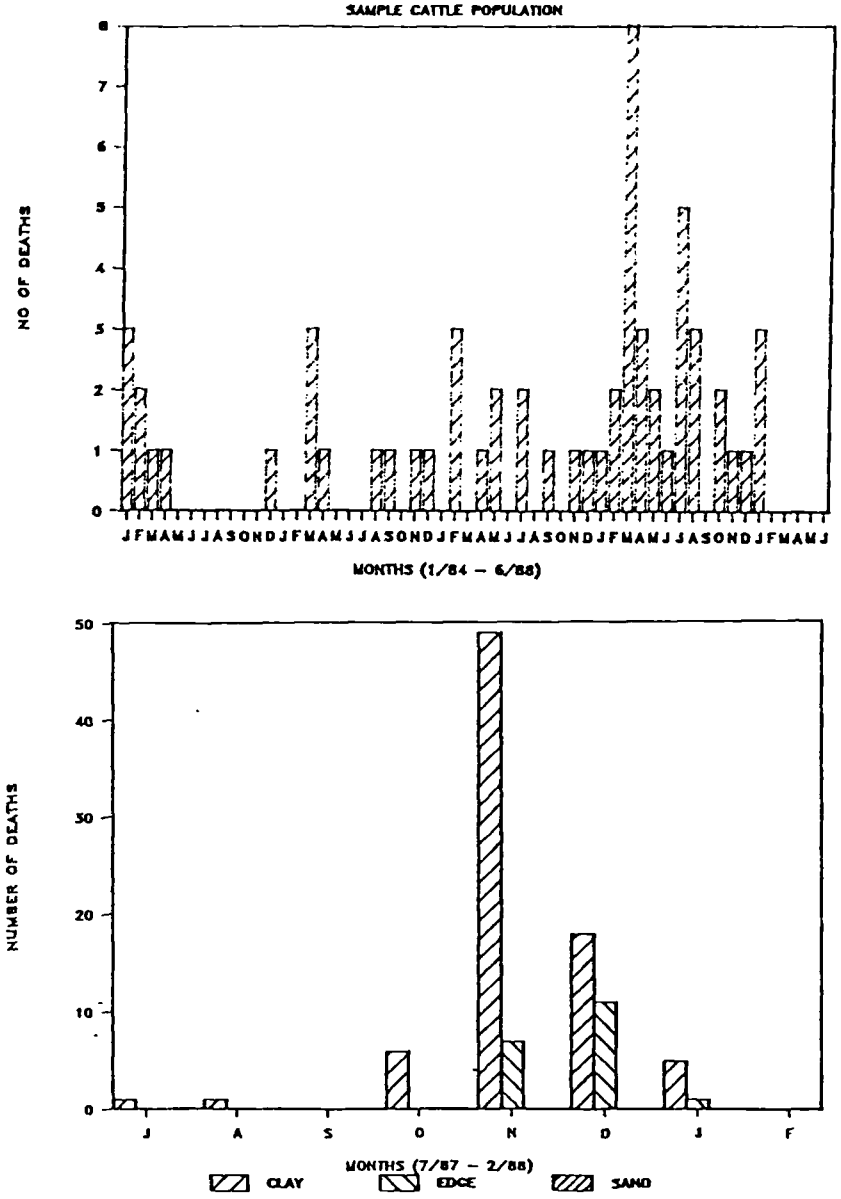


Figure 7.16: Seasonal pattern of cattle sales: 1987

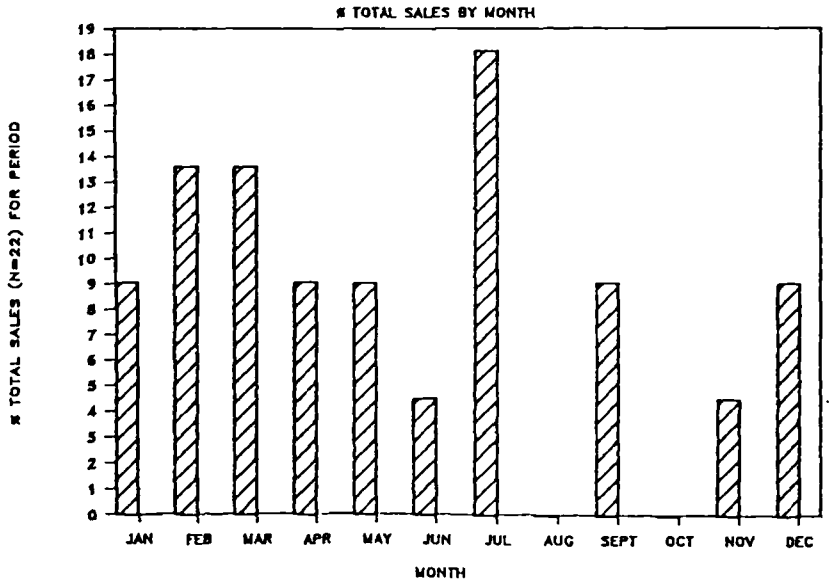


Figure 7.14 combines all the data between 1984 to 1988 and shows the proportion of all recorded births by month.

The pattern of sales during 1987 (both local sales and exchanges and sales at official markets) is shown in Figure 7.16. The seasonal pattern shows most sales in the post ploughing (Feb/March) and dry season (July). Chapter 5 discusses the reasons for sale. Drought stress sales are concentrated in the latter portion of the year (September to December), but only contributed to 13.6% of all sales. Most sales were in order to raise money for school fees and not explicitly drought related. No slaughters were recorded during the period of study.

7.7 Movement of cattle and drought survival

The movement of cattle to alternative grazing areas dominates the strategies used by farmers to ensure cattle survival. Movement in response to drought induced shortages of fodder occur at different scales and in relation to the availability of different savanna types. Local movement occurs between clay veld and sand veld savanna and from topland grazing resources to 'key resource' patches. Such local level movements during 1987 will be investigated in more detail in Chapter 8. Larger scale movements can occur under conditions of severe drought to areas with less drought impact (often sand veld savanna areas) or to areas with fodder surpluses (eg commercial ranches or resettlement areas (7)).

As the dry season progresses cattle are moved increasingly to the sand veld areas where residual grazing exists in the vleis. If the drought continues into a further season and local grazing is exhausted longer, transhumant movements have to be attempted to distant CAs or commercial ranches. This was the case during the 1982-4 drought. The cattle movements in the Mazvihwa area during 1982-4 and 1987 are shown in Figure 7.2.

The 1987 season resulted in localised fodder shortages, particularly in the clay veld areas. Forage was scarce as early as April in Indava and cattle were moved to the sand veld areas of Murowa and Mutambi wards. Some also were loaned to relatives in the Mototi area. One cluster in the household sample were guardians of around 60 cattle from relatives in Indava between April and September (see Chapter 6). By August similar scarcities had arisen in the clay veld areas of Mototi ward and some cattle were moved to the Murowa area until the arrival of the rains.

In 1982-3 a similar pattern of movement is recalled for the early phases of the drought. Cattle owners in the sample households from the clay veld area moved cattle into the sand veld area during the dry season of 1982. There were large concentrations of cattle feeding from the vlei and hill grassland and browse resources during this period. The available biomass was insufficient to support this population and by November some cattle were beginning to die. It was at this stage that some cattle owners decided to move their cattle out of the area. Others followed later during the dry season of 1983, following the failure of the rains.

Cattle were moved initially to Zvishavane town where they were grazed on the nearby hills. The Veterinary department complained about the contraventions of the laws and tried to move the animals out of the area. Cattle were then moved north to Mapanzure area of Runde CA and beyond to commercial farms in Shurugwi district. An alternative direction of movement for people from Mototi ward was to the south east, towards Chiredzi, where there were large abandoned commercial farms. These had extensive grazing and many people from Chivi and Mwenezi districts used these areas during 1982. Others sent their cattle even further south to Matibi 2 area.

The loaning system (kuronzera) is central to the redistribution of grazing pressure in the CAs. Cattle may

be loaned on a temporary basis for the duration of a local crisis to relatives or friends or on a more long term arrangement, which helps in reducing grazing pressure for the herd still resident at the owner's home. Large herd owners rarely keep more than 10-15 cattle in their home kraal but prefer to loan out to a number of miraga sites. This not only lowers the risk of local overgrazing but reduces herding and management requirements at the same time as assisting stockless relatives.

In the case of the 1982-3 crisis the situation was too severe for local redistribution and the loaning system to cope. Many adopted a transhumant existence for the duration of the movement; often living with their cattle in distant grazing areas or on commercial farms. Others left their cattle with relatives and friends resident outside the area.

Despite the lack of any formal institutions for transhumant movement, the lack of exclusion rights from communal grazing and the existence of family ties between areas allows the potential for movement in drought in the Zvishavane area, despite government regulations that discourage it.

Amongst the sample households three different strategies can be discerned:

Strategy A: Movement out of Mototi ward during 1982 (usually around November).

Strategy B: Movement during 1983 (mostly in the dry season between August and October).

Strategy C: No movement outside the area.

A comparison of the change in herd size of herds owned by different households following one of these three strategies is shown in Table 7.12.

Table 7.12: Cattle survival according to movement strategy

Movement	A	B	C
Survival %	40.1	22.9	3.3
Numbers	287	402	181

Statistics: X^2 = 82.13, df = 2; Significance = 0.0000.

During the 1982-3 drought the adoption of a movement strategy significantly increased the probability of cattle survival. The movement of animals in response to changing availability of fodder resources is central to the opportunistic grazing management strategy of CA cattle owners.

7.8 Household characteristics and cattle management in drought

Movement is clearly an important management strategy for drought survival. The ability of a household to actually move cattle to distant places will be dependent on the ability to mobilise herding labour. This relates to the demographic structure of the household, the opportunities to hire labour and cooperative herding arrangements with other households. In addition drought survival can be increased with investment in supplementary feed resources.

The wealth rank serves as an indicator of cash availability (see Chapter 6). This ranking relates to the situation in 1987-8. No equivalent ranking exists for the 1982-3 period, but as a general indicator of relative wealth the 87-8 ranking can be used to investigate the patterns of herd survival according to wealth rank during the two drought periods.

Table 7.13: Cattle survival and wealth rank

Rank	1	2	3	4
Survival % (87)	81.8	69.9	74.6	77.3
Survival % (84)	30.4	15.4	16.5	21.3

Statistics: For the drought of 1987-8, $X^2 = 5.04$, df = 3; Significance = 0.16.
For 1984, $X^2 = 21.84$, df = 3; Significance = 0.0001.

From this data it appears that the importance of 'wealth' was more significant in the 1984 drought, with the top wealth category showing significantly higher herd survival rates. Because of length of drought there was probably an increased need to mobilise resources for movement to more distant pastures. With larger herds those in the wealthier category felt it worthwhile to invest more in the maintenance of their herds and were able to mobilise labour for ensuring survival. The interaction of zone and wealth rank is highlighted in Table 7.14.

Table 7.14: Survival, wealth rank and ecological zone

	C1-2	C3-4	E1-2	E3-4	S1-4
Survived % 84	20.4	8.8	31.2	22.6	35.7
Survived % 87	79.6	91.2	68.8	77.4	64.3

Statistics: For 1984, $X^2 = 28.12$, df = 4, Sig = 0.0000
For 1987, $X^2 = 32.04$, df = 4, Sig = 0.0000

Income access

The access to sources of income that are independent of drought might be an alternative strategy for keeping animals alive through supplementary feeding. However correlations of survival rates with income levels (1987 data) and remittance levels show no significant

relationships; indeed the remittance level shows a slight negative correlation. During the 1987 drought, only one person purchased extra feed for supplementing young calves, indicating the lack of prevalence of this form of drought survival management mechanism.

Table 7.15: Cattle survival and income/remittance levels

	Income (87) r 1-tailed sig	Remittance (87) r 1-tailed sig
Survival 87	0.17 (p=0.15)	-0.096 (p=0.29)

Labour availability

A more specific assessment of the impact of labour availability can be gained by relating household demographic data to herd survival for both droughts. The Adult Equivalent Unit (AEU) indicator can be taken as relating to labour availability and correlated with percentage survival of cattle in the two droughts. A more accurate reflection of the availability of herding labour is the value that combines the total resident adult population (including part time migrant visitors taken as 0.5 adult resident) plus children aged between 10 and 20 (P1+P2). This indicator is available for the 1987 period only.

Table 7.16: Labour availability and cattle survival

		r	1-tailed sig
Survival 84	AEU84	0.214	0.10
Survival 87	AEU86	0.032	0.42
Survival 87	P1+P2	-0.045	0.40

Labour availability at the household level does not appear to relate strongly to cattle survival in drought. Although

it is notable that in the prolonged drought of 82-4 the relationships are stronger. This could relate to the need to mobilise labour for transhumant movement.

Herding organistation

The organisation of herding labour is a critical component of of cattle management. During 1987 68% of cattle holding households had a cooperative herding arrangement and a further 20% hired herding labour for at least some of the year. Only 12% of households had to rely on purely their own family labour for all herding. Table 7.17 relates survival rate to these three types of herding organisation.

Table 7.17: Cattle survival and herding arrangement

	Coop herding	Individual	Hired
Survival % (87)	76.6	79.1	75.0
Statistics: X^2 = 0.32, df = 2, ns			

The data does not show any differences in herd survival between different types of herding organisation for the 1987-8 drought.

Supplementary feeding

The supplementary feeding of animals during drought is primarily through the use of crop residues and browse fodder. During the 82-4 drought crop residues soon ran out and all cattle owners in the sample fed their cattle with additional feed collected locally.

During 1986-7 stover was collected for feeding cattle during the late dry season by 83% of cattle owners interviewed in the sample (see Table 7.18). A few people lopped trees, especially the early shooting miombo species

around September.

Table 7.18: Stover collection

Type collected	% Cattle owners
Maize	65.2
Mhunga	50.0
Sorghum	15.2
Groundnuts	13.0

The most common practice was the lopping of trees and a wide variety of trees were used for this purpose (see Table 7.19). A few collected grass from the inaccessible hill areas.

Table 7.19: Trees lopped during 82-4 drought for cattle

Shona name	Botanical name
Mupanda	Lonchocarpus capassa
Mubondo	Combretum apiculatum
Mubvumira	Kirkia acuminata
Mumveva	Kigelia africana
Mukamba	Afzelia quanzensis
Mutondo	Julbernadia globiflora
Muzeze	Peltophorum africanum
Mupani	Combretum mopane
Mutechani	Combretum hereroense
Mudyahudo	Strychnos potatorum
Dhorofia	Euphorbia sp.
Mudohonya	Ficus soldanella
Mumbuzhe	Brachystegia glaucescens
Muchecheni	Ziziphus mucronata
Muchokochiana	Rhus sp.
Mutehwa	Grewia monticolor
Mudhuvu	Combretum erythrophyllum
Mupangare (pods)	Dichrostachys cinerea
Munyera	Commiphora spp.
Mupfura	Sclerocarya birrea

7.9 Patterns of goat population change during drought

The patterns of goat population change are locally

specific, as conditions in the immediate area of the kraal are the critical determining factors. Short foraging distances and minimal management through herding mean that local environmental factors are likely to be the most important in explaining goat population responses.

The impact of drought on goat populations can be investigated with data from the household sample and dipping records for the 1987-8 drought. Dip data for Mazvihwa (9 dips combined) provides a picture of aggregate population changes for the period between May 1985 and March 1989. Figure 7.17 shows a cyclical pattern of overall population size with peaks in mid 1986 and 1988 and troughs in late 85, early 87 and 89.

When the patterns at individual dip scale are investigated (Figure 7.18) it can be seen that the aggregate data is a composite of many different local patterns. In the case of Gwamadube area a population collapse is observed, while at Zerubi the population holds reasonably constant. In the clay veld areas populations hold relatively constant (with the exception of Gwamadube), while in the sand veld populations, collapses in early 1987 and 1988 are shown (with the exception of Zerubi). Local information for this period is required to gain insight into the specific determinants of population change and data from the sample households can help in exploring local dynamic patterns.

The sample population represents broadly three dip areas. Mazvihwa dip is in the clay veld sample area, Gwenombe the edge zone and Murowa the sand veld area. A closer examination of data for these dips shows that the clay and edge zone populations increased into 1986, held relatively stable during the 1987 drought and showed a slight decline, but rapid recovery in 1988-9. The Murowa sand veld population by contrast collapsed during the drought of 1987 and has only recovered recently.

Figure 7.17: Goat population change (all dips: 5/85 to 3/89)

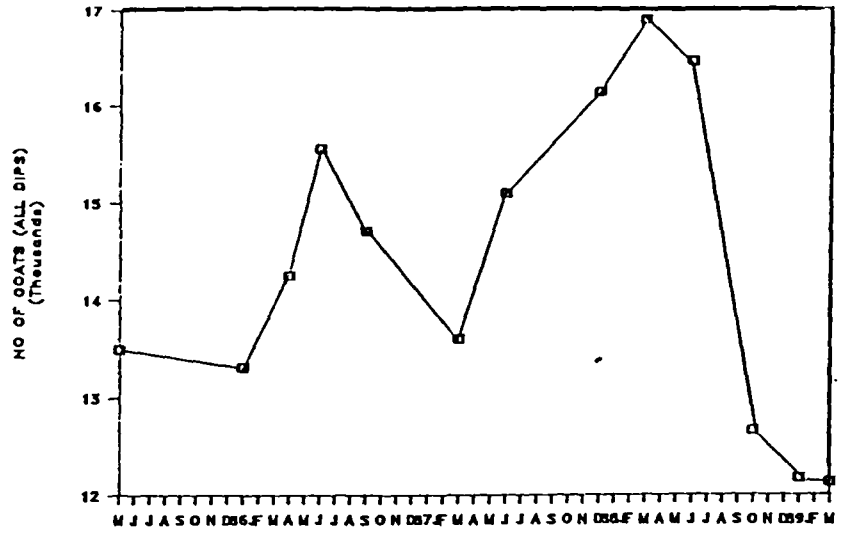
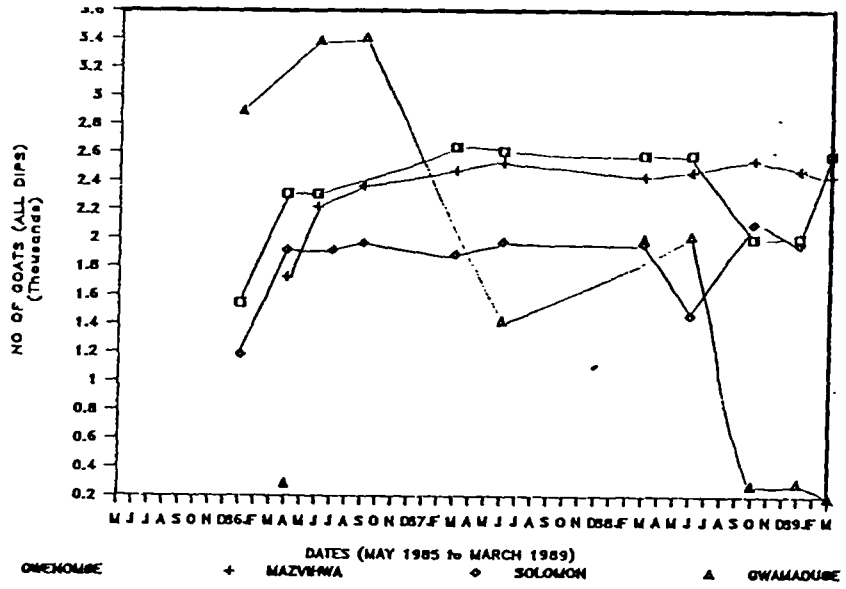
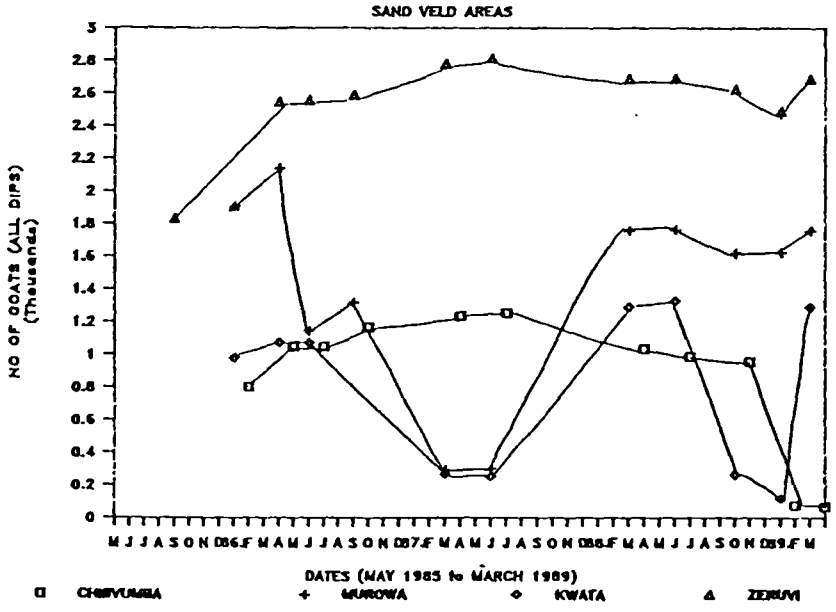


Figure 7.18: Goat population change: a. clay veld b. sand veld (5/85 to 3/89)





This general pattern is reflected in data for the household sample goat population for the period between December 1986 and January 1988. During this period the goat holdings in each household were monitored on a monthly basis. The estimated patterns of goat population change takes as a starting point the flock size at the end of 1986 and calculates changes in size according to recorded levels of births, deaths, sales and purchases. The pattern of change for the household sample goat population aggregated for the three ecological zones is shown in Figure 7.19.

The data shows that the sand veld and edge zone populations increased from February until June and thereafter declined to a level in January 1988 below that in February 1987. The clay veld population, on the other hand, continued to increase until September 1987 and then declined to a level higher than the start point.

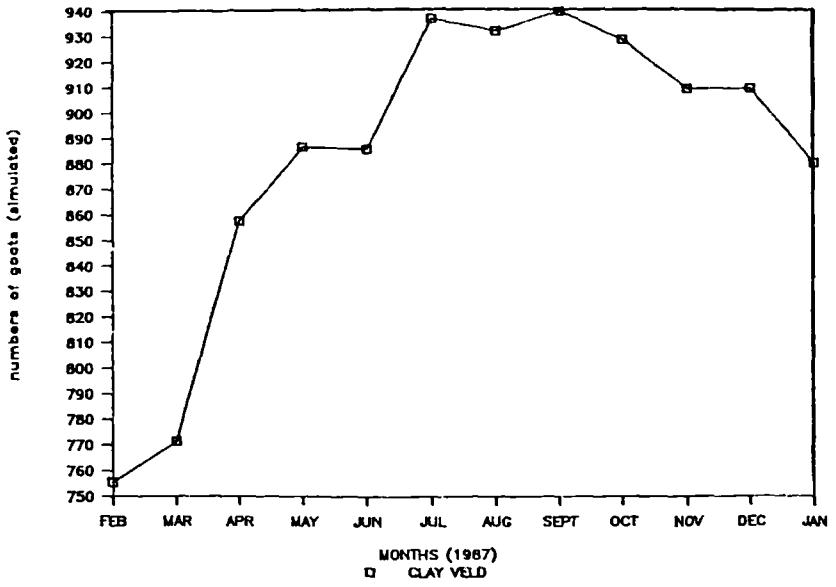
Table 7.20: Aggregate sample population change

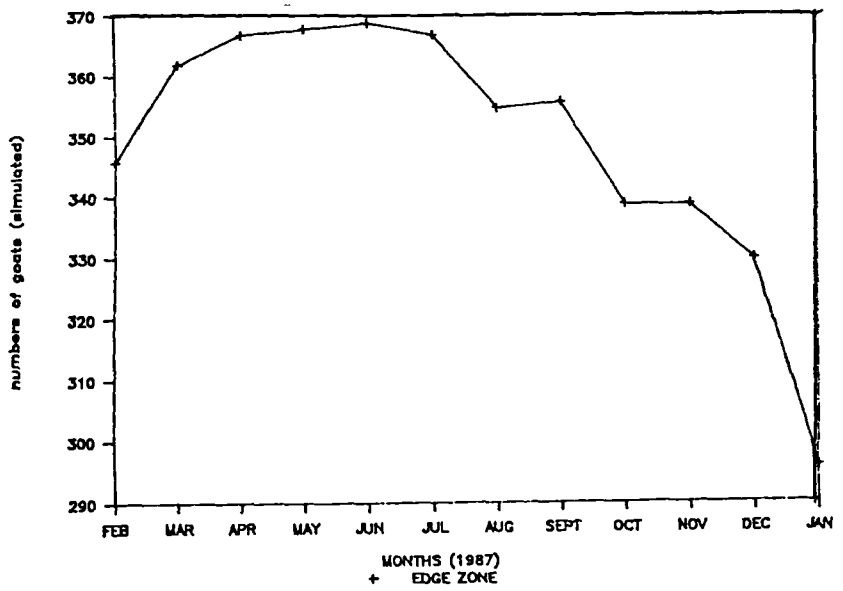
	Clay	Edge	Sand
Change over period	17%	-14%	-42%

From the overall figures for these three populations, it appears as if the impact of the 1987 drought was felt far more by the sand and edge zone populations. The clay veld population actually increased over the period.

The pattern of goat flock size by individual households in relation to ecological zone is summarised in Table 7.20. This provides an average (+/- SE) figure for flock size change based on the percentage change in flock size for all flocks in a particular zone, based on the simulated changes in household flocks over 1987. The figure therefore is the net result of all births, deaths, sales, slaughters and purchases over the period.

Figure 7.19: Goat population change in the sample households (simulated from February 1987 baseline)





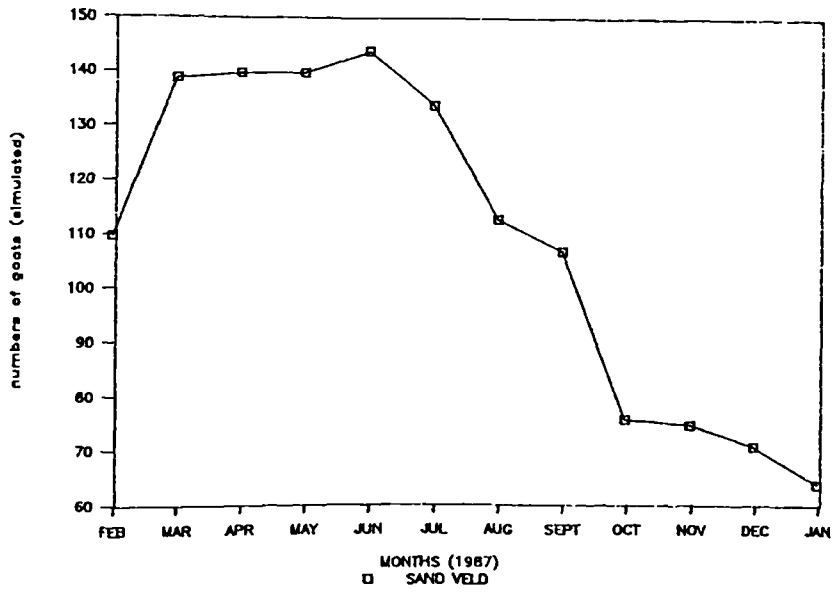


Table 7.21: Survival rates of goat flocks by ecological zone

		Clay	Edge	Sand
% Survival	Avge	-2.6	0.83	-63.21
	SE	8.43	13.02	22.72

Significant declines are observed in the sand veld, clay veld and edge flocks do not show much change. When an average of flock performance is calculated as here (rather than the overall aggregate simulation as in Table 7.20), the edge zone has the highest survival rate.

The reasons for these patterns can be investigated by a closer study of fertility, mortality and economic use patterns of goats in the household sample.

Fertility and mortality patterns of goats

The pattern of fertility is shown in Figure 7.20. It shows that the birth rates of both the sand and edge zone populations continued to increase into the dry season with an October peak. This is followed by a virtually complete cessation of births from November onwards. The clay veld birth rate is overall lower and less seasonally varied.

When the mortality figures are investigated (Figure 7.21) it can be seen how the sand and edge zone populations declined so sharply from July onwards despite a large birth rate. A large proportion of births recorded for this period end up as young kid mortality, especially in the sand veld area. The death rates in the clay veld area are relatively low by comparison, and only increase slightly in the late dry season.

Figure 7.20: Seasonality of goat births (3/87 to 1/88)

Figure 7.21: Seasonality of goat deaths (3/87 to 1/88)

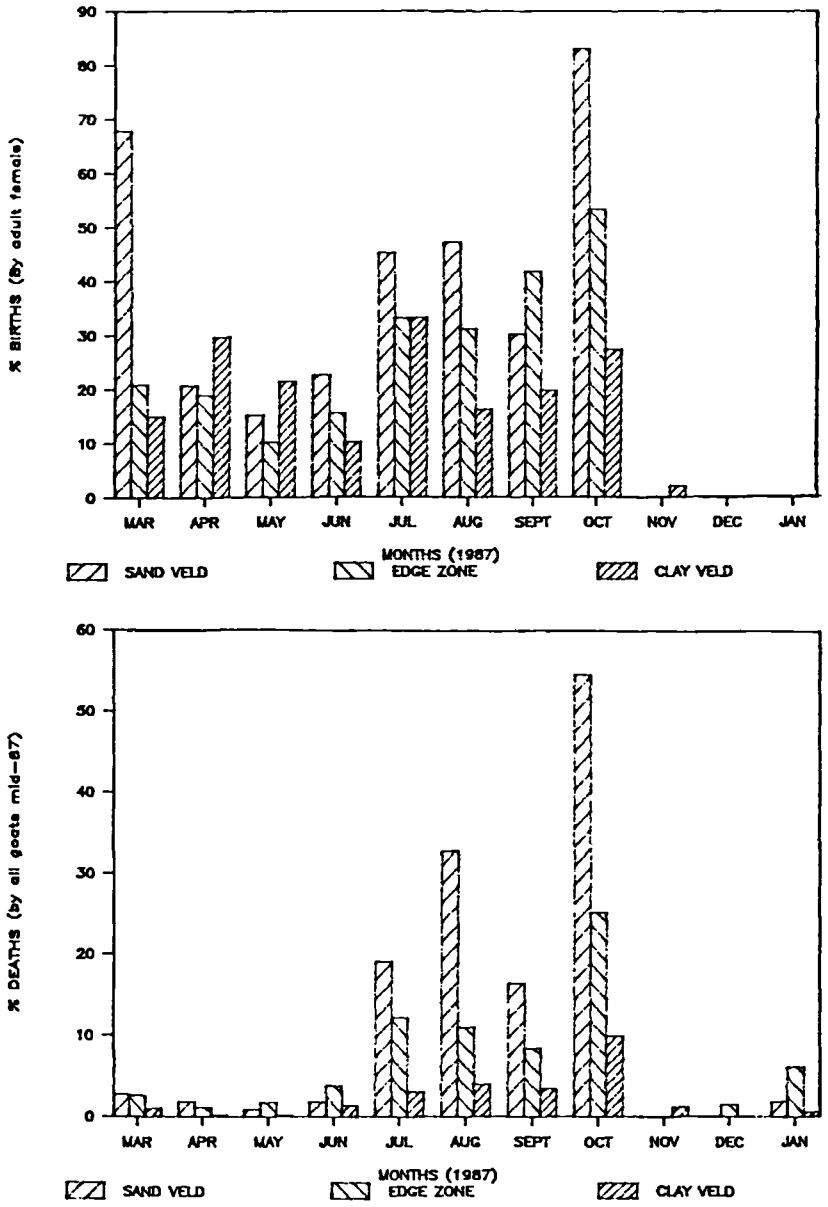


Figure 7.22: Causes of goat deaths by zone (3/87 to 1/88)

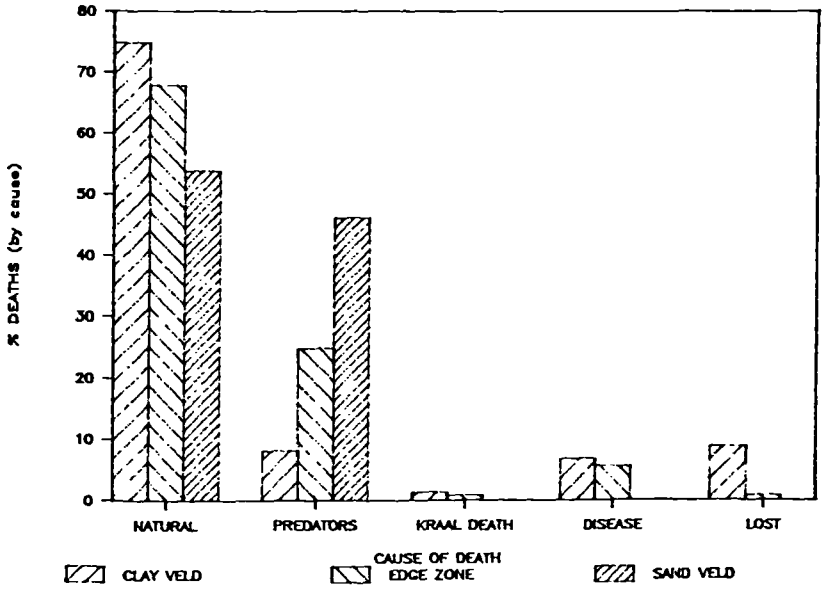


Figure 7.23: Seasonality of goat sales (1/87 to 1/88)

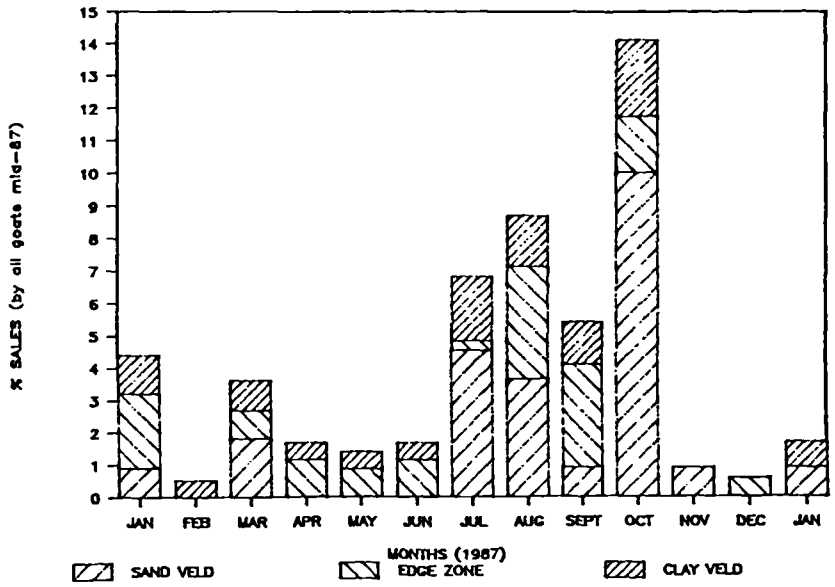


Figure 7.24: Seasonality of goat slaughters (3/87 to 3/88)

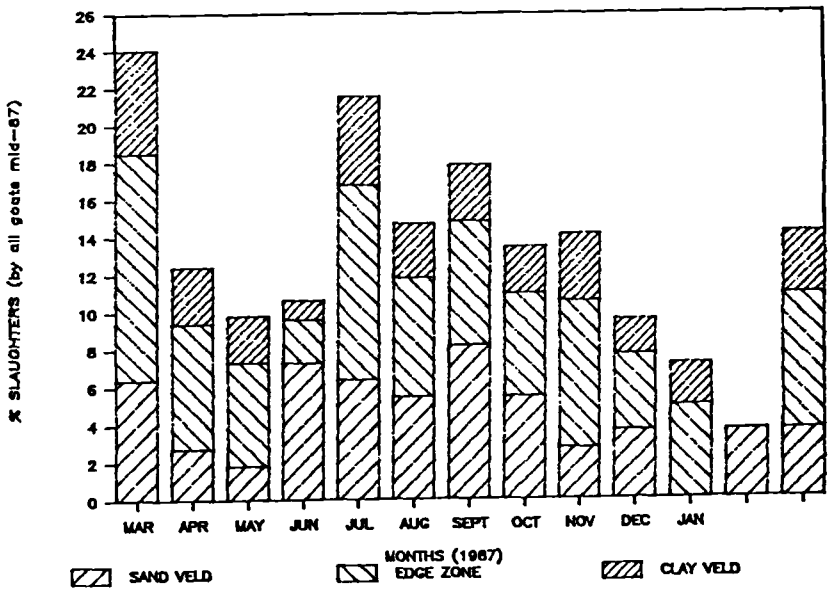


Figure 7.25: Seasonality of goat purchases (1/87 to 1/88)

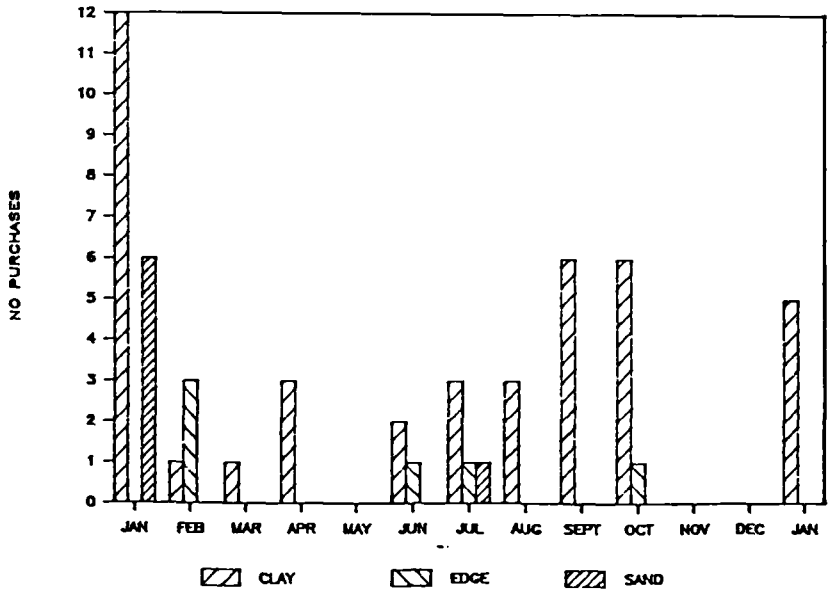


Table: 7.11: % survival of cows by zone

	1982/4	1986/7
Clay	12.50	53.57
Edge	13.55	86.11
Sand	40.00	100.00

Differences in population change between ecological zone is clearly an important factor in the overall dynamics of cattle populations. Similarly, population dynamics is affected by age and sex structure effects. Both these factors were not included in the simple analysis of aggregate population change presented in Chapter 4, due to lack of data, but would have to be considered in the future development of understanding of population dynamics.

Timing of births, deaths and sales: 1987-8

The timing of cattle mortality is illustrated for the 1987-8 drought in Figure 7.13. No data is available for the 1982-4 drought, as recall on time of death was not consistent after cross-checking. For the 1987-8 drought the peak clay veld mortality was found to be in November 1987 while the edge zone mortality peaked in January 1988. There was no mortality in the sand veld zone. The general hypothesised pattern, where the mortality phase of the drought is earlier for clay veld resident herds, is demonstrated.

The seasonal pattern of births is illustrated in Figure 7.14. This shows the number of births by month between 1984 and 1988. This data is based on cow histories, where the calving history of each named cow in the household sample was ascertained through interviews. A similar pattern as that shown for the dip data is shown, with a wet season peak and a dry season trough in births that is accentuated by drought and without ecological zone differences.

Clay veld mortalities are reported to be largely 'natural' (ie nutritional deficits resulting in kid mortalities). The same is the case with the edge and sand veld zones (Figure 7.22). However these areas also have significant mortality from predation. This is especially so for the sand veld zone where nearly 50% of all goat mortalities were due to predation; in this case exclusively due to baboons.

Sales and slaughter patterns

The pattern of sales is illustrated in Figure 7.23. This shows the seasonal dry season peak of goat sales between July and October. This is the period when agricultural produce is low, relish is lacking, cash is short and school fees are needed. Goats are therefore sold for cash to those who require meat for relish. The rate of sale is particularly pronounced in the clay veld area. It is here that goats are a very important source of supplementary income, especially in a drought year where the clay veld agricultural returns are poor. This requirement is not so great in the sand veld area where agricultural income is sustained during drought. In addition the saleable quality of clay veld goats is higher with their greater carcass weight and larger structure (see Chapter 5).

The patterns of slaughter are different, with a peak stretching between July and November (Figure 7.24). This again relates to the demand for dry season relish resulting in increased consumption of meat when collected or cultivated vegetables, insects and other sources or relish are unavailable. Particular events also result in a lot of goat slaughters. The peaks surrounding Christmas/New Year and Independence Day (April) are evident. Large funerals or marriages also result in the slaughter of many goats. Slaughters are higher in the edge and sand veld zones; the reason for this is unknown.

7.10 Economic factors and goat management in drought

The economic/wealth status of the household may be influential in determining differential changes in goat flocks between households. For instance, particular households may be able to tender more care and introduce controlled management of their goats so increasing survival rates. The patterns of goat flock change, slaughter, sale and purchase across wealth ranks is illustrated in Table 7.22. Slaughter, sale and purchase rates are calculated as the total in the year as a percentage of the starting flock (Census Feb 87).

Table 7.22: Flock size change, slaughter, sale and purchase and wealth rank.

	RANK	1	2	3	4
Flock size change	avge	-19.97	-10.71	4.53	0.55
	SE	13.68	11.48	16.72	11.94
% Slaughter	avge	42.28	35.00	36.13	36.81
	SE	9.44	9.76	10.88	14.53
% Sale	avge	15.47	14.92	31.70	13.00
	SE	6.76	4.95	18.91	6.82
% Purchase	avge	2.94	11.98	10.55	24.35
	SE	2.37	7.20	4.16	14.31

As a percentage of starting flock size (which itself varies according to wealth rank), the higher wealth groups show a larger decrease in flock size. Slaughter percentage rates are reasonably evenly distributed, but with the top wealth group showing higher offtake rates. Sales rates, though, are highest in the third wealth group and purchases are concentrated among the lowest wealth group.

7.11 Explaining changes in goat populations: economic and ecological factors

Different factors, both biological and economic, affect the goat populations in the different savanna zones of the study area. In the clay veld zone, birth rates are apparently unaffected by seasonal changes, but remain at a relatively low level (10-30% per month). Seasonal changes in natural mortality reduce the population in the late dry season. This is complemented by large offtake around October. The overall trend is an increased population through the drought period. The availability of good browse (especially Acacia spp) in the clay veld clearly helps with nutritional status and so maintaining birth rates, as well as reducing mortalities through the drought. The lack of predators (except for a few deaths by jackals) is also a contributory factor to the relative success of the clay veld population.

In the sand veld and edge zones birth rates increase through the dry season, but so does mortality induced in large part by baboon predation. Sales and slaughters also increase during this period. The overall result is a downward population trend over the course of the drought period. This can be attributed to the lack of suitable goat browse in the miombo woodland, combined with the high risk of juvenile and adult mortality from baboons. This is particularly characteristic of a drought year in these areas. When alternative food sources for the large baboon population in the hills are absent there is a dramatic increase of attacks on domestic animals. This is combined with the high slaughter offtake which is also a drought related response. The edge zone population does not decrease dramatically; goats in this zone have the option of switching to clay veld resources during the drought period.

In the study area, the clay veld population is thus characterised by relatively stable production through

drought, with the population showing high resilience to drought impact. By contrast, the sand veld goat populations show high variability induced by collapses in birth rates and high levels of predation. The edge zone shows an intermediate situation, with characteristics of both clay and sand veld populations.

The characteristics of the sample populations should not be taken as representative of a wider situation. The dip data has illustrated different patterns for other populations. For instance, the collapse of stock populations in Gwamadube will require a local explanation. It might relate to disease which is known to have important but irregular impacts on goat populations (see Appendix 6). The household study is based on a local scale of analysis. It is at this scale that explanations for the patterns of goat population dynamics must be sought, because it is local specificities that are the key influences on goat population parameters.

7.12 Cattle and goat population changes in drought compared

The drought responses of cattle and goat populations within the study area are very different. The impact of drought is felt in different ways, mediated by the type of environment and management of the stock.

Cattle's forage requirements include a significant intake of grass. Although browse is an important supplement at the time of drought the nutrition of cattle is principally dependent on the success of grass production. This is highly correlated with rainfall incidence. The lack of rainfall in a drought will therefore have a larger impact on cattle than the predominantly browsing goat. The spatial scale over which cattle forage is also significant; especially in times of shortage the seeking out of fodder sources is critical. This requires particular inputs from herding. With movement between zones the fluctuation of the grass resource induced by rainfall variation can be

dampened somewhat and the ability to move is therefore critical (see Chapter 8). Other management inputs such as lopping of browse are also significant in severe droughts.

The savanna type will also have an impact on the interannual variation of fodder resources for cattle. The dystrophic system of the sand veld has grass production levels that are relatively stable and browse resources that are particularly timely in drought. In the clay veld the herbaceous production levels are very variable resulting in population crashes in drought, yet relatively rapid recovery (see Chapter 2).

The survival of goats in droughts is more dependent on factors at a smaller spatial scale. Environmental factors in the vicinity of the goat kraal are critical; in particular the availability of browse. The clay veld offers the best opportunities in this respect with its abundant, low Acacia bush. At this scale the resource availability between years is relatively stable and survival is possible for clay veld populations during drought, even if birth rates drop. In the sand veld available forage resources are more variable and not as high quality; sand veld goats are more reliant on grass. This population instability is further affected by the fluctuating incidence of predation, with dramatic increases in the drought periods. The edge populations do not appear to be affected in the same way as the sand veld; they are able to opportunistically use the clay veld resource in times of drought.

The relationship of drought survival and 'wealth' appears to be significant in severe droughts for cattle. This is because in order to maximise drought survival, labour must be mobilised to care for the herds and in extreme cases move them over some distance. This is only feasible for the richer households, or those that have strong ties with them. Goats require much less management input and there is little that is done in terms of changed management practice in drought. 'Wealth' therefore has less of an effect on

flock survival; indeed the lower wealth ranks had lower percentage changes in flock size. This may relate to the fact that lower wealth categories have smaller flock numbers and so the chance of survival in a particular kraal is increased (due to less crowding and more local fodder resources) or that the owners afforded extra care to their small flocks since their value to a poorer household is particularly great.

Chapter 6 has shown that changes in livestock population size due to sales, slaughters and purchases differ between households of different wealth rank and resident in different ecological zone. For instance, cattle are rarely sold by poorer households with small herd sizes, except when under extreme stress, while slaughters were absent among all groups in 1987. Purchases are found in all groups, but routes to investment differ widely. Economic factors that influence goat populations are similarly differentiated. To develop a realistic understanding of how aggregate population trajectories arise, the disaggregated perspective gained here and in Chapter 6 must be applied to the macro-level understanding of population dynamics developed in Chapter 4.

Due to the nature of the resource base and the availability of different fodder resources in the three ecological zones the survival of cattle and goats in droughts show opposite patterns - survival of cattle is enhanced in the sand veld, while goat survival is highest in the clay veld. Resource type (ie. grass, trees etc) combines with the differing stability of production between years to affect cattle and goats in different ways because of the different scales of resource use and different degrees of management.

Deficits of rainfall therefore have varied consequences; it depends on what type of stock is being considered, in what ecological zone and how much active management is being carried out. Only with an understanding of the detailed dynamic patterns of drought induced population changes can

the aggregate patterns described in Chapter 4 be understood. Models of population change thus need to take account of local environmental variation, as well as the differential impacts of drought on different age/sex categories of populations and herds or flocks under different management regimes.

This Chapter has looked at the detailed impact of drought on key population parameters; it has been assumed that food deficits induced by lack of rainfall have driven these changes, but how does the patterning of the fodder resources within the landscape affect livestock nutrition, determine cattle foraging behaviour and guide local management strategies? These questions are the subject of the next Chapter.

Footnotes

1. The data is centred on the interviews done with families in the sample described in Chapter 1. The 1987 drought was investigated for both cattle and goat populations by discussing with households each month the changes in their stock holding due to births, deaths, sales, slaughters, gifts and purchases. These interviews were continuous from March 1987 to January 1988 with a follow-up in April 1988.

The 1982-4 drought was investigated primarily by recall interviews. The pre-drought cattle holding was ascertained, differentiating between owned, borrowed and loaned out stock and the post-drought holding compared by going through individually (by cattle name) all the deaths, births etc that occurred during the drought. The strategies employed by people for keeping stock alive was also investigated by interview: discussions centred on supplementary feeding, browse use and movement of stock to other areas were carried out with all sample households.

This local data is complemented by information on cattle population changes for the 9 dips in the Mazvihwa area. This data was collected by the Veterinary Department on a monthly basis and records the local census, the number of births, deaths, slaughters, sales, purchases, movements in and out each month. The census data for cattle is accurate as all stockowners have their cattle registered on a card

and regular dipping is compulsory. The accuracy deteriorates during 1983 for some months when large cattle movements and lack of water for dipping meant that the censuses were effectively abandoned. The data for goats is less precise, as it relies on cattle owners stating their small stock holding and periodic censuses being carried out by Veterinary Department staff for non-cattle owning smallstock owners. Despite these drawbacks the overall trends are apparent even if the actual numbers are suspect. The census data runs from December 1981 to mid-1988. Data on cattle births etc is only available from March 1983.

The quantitative data from the sample interviews and the dip records is added to by qualitative records (eg local Agritex/Vet Dept. monthly reports) and discussions with key informants aswell as direct observation during 1987-8. Discussions with Agritex and Veterinary Dept. personnel and with many local farmers helped to build up a broader picture and an interpretive foundation for understanding the information revealed in the quantitative data.

2. The classification of dip areas into savanna types relies on information from the geological map of the area and local knowledge of the catchment area for each dip. Sand veld dips serve the cattle populations of the sandy, granitic soil areas, clay veld dips cover the heavier soils (doleritic/volcanic intrusions) and edge zone dips have a catchment area with a variety of soil types.

3. The pattern of mortality during the 1982-4 drought is reflected in observations made in national parks in South Africa where there were key peaks in herbivore mortality and movement (Walker et al, 1987). In a pastoral area of Kenya, Homewood and Lewis (1987) have observed sequential phases in the progress of a drought (1983-5). This started with an initial phase of movement, followed by high mortality, but continued high fertility, and ending with a final phase of decreased mortality but no calving of cattle.

4. Perhaps its relative proximity to sand veld means that opportunistic use of these areas is feasible. Another possibility is the option of 'grass poaching' from the neighbouring commercial ranch to sustain cattle longer than in the Indava ward areas. The edge zone dip populations show no real difference to the sand veld dips. This is because in a drought year they effectively become sand veld

herds by switching to use the drought resistant resources of this zone.

5. This pattern of sequential phases of seasonal mortality in extended drought and a delayed response in terms of reduced birth rates is similar to that recorded for the Baringo case study in Kenya (Homewood and Lewis, 1987).

6. For the 1982-4 drought this was on the basis of recall. For the 1986-7 drought the mid-1987 census was taken as the baseline and the changes to April 1988 assessed. The percentage survival is calculated on the basis of an aggregate herd of all households resident in a particular zone and by the average (+/- SE) by household herd for each zone. The herds represent 'management herds', that is herds held by a particular households. This includes cattle lent to that home and not those lent out. In the case of the 1982-4 drought most ronzera animals were recalled so it represents more or less formal 'ownership'.

7. Large scale movements of the type experienced in 1982-3 in Mototi ward have been rare, although a similar exodus is recalled for 1964-5. In the nearby areas of central Chivi people recall movements from the eutrophic plains areas around Takavarasha into the nearby hilly areas during the droughts of 1947, 1965, 1973 and 1982. In the low veld CAs further south, where grass production is even more variable and there are no nearby dystrophic zone refuges, NCs report having to make frequent arrangements for large scale migrations of cattle. For instance, the NC of Gwanda reports between 1925 and 1948 the necessity for moving thousands of cattle in 1938, 1941, 1942 and 1947. Patterns of transhumant grazing have been recorded for Mtabeleland. Cobbing (1976) emphasises the regular movement between sour and sweet veld during the nineteenth century, while Prescott (1961) records the dry season movements for flood retreat grazing along the Nata river valley in Nyamandhlovu SNA.

During both droughts the people of Runde CA were making use of the neighbouring commercial ranches. In 1982-4 free grazing was possible, but by 1987-8 the owner was putting restrictions on CA cattle use. Some owners with alternative sources of income placed their animals there for a grazing fee paid to the ranch owner (Richard Ndatschana pers. comm.). A similar pattern of increasing restrictions to flexible drought responses is reported in Shurugwi

(interviews during CSC/FC training course, 1988). In 1982-4 the neighbouring ranches were largely abandoned and animals could use the area without arrest. Since then the ranches have either been reoccupied or transferred to resettlement land; stray cattle from the CA are usually impounded. The only option today is illegal night time grazing, grass collection or the transfer of cattle to resettlement farmers for grazing.

8. LIVESTOCK FORAGING: EXPLOITING A PATCHY ENVIRONMENT

8.1 Introduction

The impact of the macro-level distinction between clay and sand veld savanna on the economy and ecology of livestock production has been discussed extensively in the previous Chapters. This Chapter focuses on the micro-level patterning of resources in space and time and explores the influence this has on livestock foraging behaviour and local management practices. For it is the availability of specific forage resources in the different ecological zones that ultimately affects the dynamics of stock populations. The availability of such resources at particular times is crucial in understanding the survival strategies of stock and the management practices of the stock keepers in such a temporally variable environment.

This Chapter will therefore relate the understanding of the production dynamics of the vegetation resource developed in Chapter 2 to the responses of livestock and herders. Chapter 2 has demonstrated the spatial heterogeneity of grass production and the differential availability of the browse resource in the savanna types. The way the forage resource responds to rainfall variation is also significant in understanding the dynamics of the stock populations that survive on it. To the grass and browse resource must be added the crop residue fodder resource. The availability of crop residues is related to the grain yields shown in the different zones and mirrors the responses of the herbaceous layer to rainfall variability (Chapter 2).

The foraging behaviour studies carried out on cattle and goats reported here refer to a low rainfall year (1986-7). The results that are presented are not typical - no year is. However the study of a drought year offers an important opportunity to examine how animals survive under the extreme conditions of drought. As the population dynamics analysis of Chapter 4 has shown, it is drought (stress)

years that particularly affect the long term population trends (in terms of numbers), and it is these years that must be examined closely to answer the question: why do so many animals survive in the intensive use systems of the communal lands?

8.2 Investigating cattle foraging behaviour and management

Methods used for the cattle foraging study

Herds from four household clusters, representing different positions on a gradient from clay veld to sand veld, were studied between November 1986 and November 1987 (Figure 8.1; 1). Each herd was followed for a full day from the time of kraal release to the herd's return (approx. 6am to 6pm, but variable) once each month. Daylight feeding was usually recorded in full, however when cattle were not night kraaled (as happened at the end of the dry season for two herds) some time was spent locating the animals within the grazing areas. The days of the week were varied so that a general pattern was observed.

Four or five animals were selected from each herd, representing a range of age/sex types, and recordings were made of these individual animals every 15-30 mins. The position of each animal (according to a habitat type classification) and the activity of the animal was recorded. The habitat classification was derived from the vegetation resource study and discussions with farmers, while the activity classification was based on what was feasible to recognise without observer interference. It was therefore limited to general activities of grazing, browsing, stover eating, resting, drinking and moving. The frequency of recording was limited by the fact that the herd often split up if unherded and the recording involved moving between different groups of animals. However the time interval between recordings was found not to be incompatible with the general pattern of behaviour bouts,

as switching between different activities was quite infrequent when feeding and especially when ruminating (2). No attempt was made at recording bite counts or other consumption indicators after the failure of some test runs.

It is therefore assumed in this study that feeding time relates proportionately to intake. This is not necessarily the case as the availability of forage will also affect intake - as the season progresses and less food is available, more time is spent eating. However as a general indicator time feeding is thought to be adequate (De Leeuw, 1979).

Species choice was recorded for browse trees, since these could easily be identified. However grass species choice proved impossible as the identity of a grass was difficult to discern from a distance as soon as the flowering heads were eaten and the sward grazed down. However the species composition of grasses for different habitat patches was assessed (see Chapter 2; Appendix 4), but no quantitative data is available on micro-level selection.

The availability of the different habitat types in the four locations was assessed using aerial photographs (1985). The area of each habitat patch (according to a local classification) was assessed within a 2 km radius of the kraals (representing an approximate 'normal' grazing radius). These radii are shown in Figure 8.1.

Studies of herding and forage resource management were an integral part of the cattle foraging behaviour study. Actual kraaling patterns were observed when visiting the study herds and herding was also observed and discussed at length with adult herders and herd boys while carrying out the foraging behaviour studies. Whole days in the bush observing animals and discussing with herders is perhaps the best way of gaining some of the insight held by the most experienced stock keepers. A seasonal perspective is also realised by repeating this experience on a monthly

basis. This was complemented with many interviews on the subject with the sample households and in more general discussion workshops.

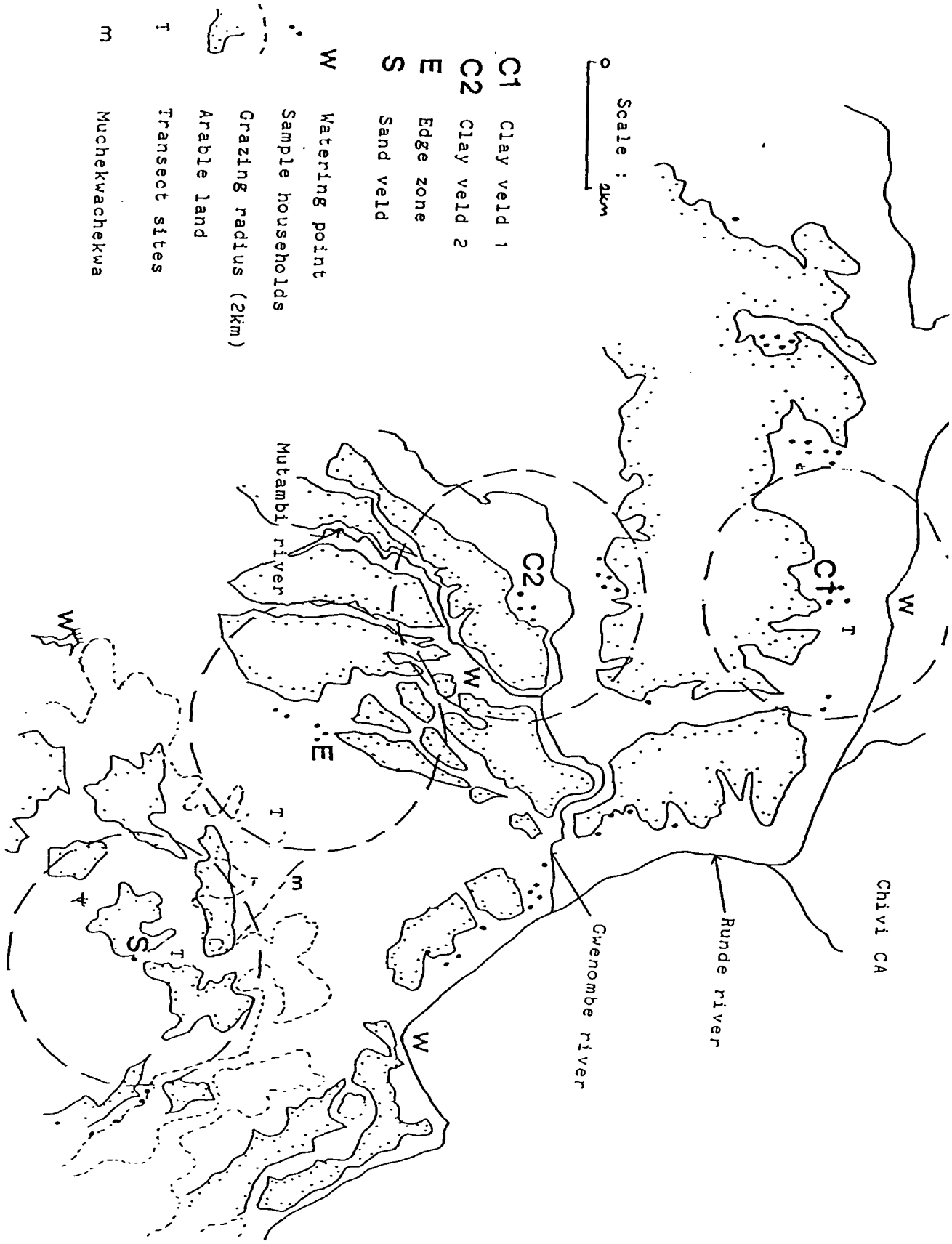
The age/sex/size characteristics of the study herds is shown in Table 8.1. A range of different animals were chosen for the study to reflect the age/sex composition of the local herd.

Table 8.1: Age, sex and size characteristics of study herds

Name	Breed	Sex	Age	Height cm	Girth cm
Clay veld herd 1:					
Captain	A	O	11	143	-
Faruteni	A	O	9	153	-
Mangaruve	T/K	C	7	143	150
Malaria	K	C	6	130	
Clay veld herd 2:					
Busuman	K	O	8		
Highcourt	K	O	6	No Data	
Muchigwe	T/K	H	3		
Ch'muchena	T	C	2		
Edge zone herd:					
Scoonery	T	O	5	135	170
Bloom	T	O	5	140	185
Mhesisi	K	C	8	120	140
Miss	T/K	C	7	136	150
Bullock	K/A	Bl	2	115	120
Sand veld herd:					
Starch	K/T	O	5	125	157
Sinoia	K	C	11	115	100
Jumbureni	K	Bl	1	110	120
Phone	K	C	15	116	153

Key: Breeds: A = Afrikaander; T = Tuli; K = Karanga
Sex: O = Oxen; C = Cow; H = Heifer; Bl = Bullock
Height: height to shoulder; Girth: maximum.

Figure 8.1: Position of study herds' kraals and permanent watering points in relation to land use patterns.



8.3 Habitat patch availability

The detailed habitat classification that was offered in Chapter 2 was aggregated to assist in analysis. The important distinction between grazing area and cropland grazing and topland and 'key resource' grazing is retained. Topland grazing refers to upper catenal areas within the demarcated grazing area; riverine areas include the area of rivers or streams plus a 30m strip either side; vleis refer to unfarmed vlei areas recognised by their darker colouration on aerial photographs and local observation; drainage lines are non-cultivated areas in the arable block or drainage strips within the topland grazing area; contour ridges are non-cultivated soil conservation bunds estimated as 10% of the arable area; home sites are all areas of settlement including houses and compounds.

'Key resources' are defined as those areas that offset critical seasonal constraints of fodder quality (especially in the sand veld) or quantity (especially in the clay veld) (Scoones, 1987). These include vleis, river banks and drainage lines and arguably the contour ridge grazing as well. The justification for this contrast in terms of foraging response by cattle is set out below. The pattern of availability of forage resource patches in the different study herd areas in shown in Table 8.2.

Table 8.2: Habitat patch availability (%) within 2km radius from herds' kraals.

Clay veld zone:	Clay veld 1 (%)	Clay veld 2 (%)
Arable (fields)	25.7	34.5
Contour ridges	2.8	3.8
Drainage (arable)	6.3	16.8
Home sites	8.0	5.4
River (inc sand)	6.2	7.6
Topland grazing	50.8	31.9

Edge and sand veld zone:

	Edge herd (%)	Sand veld (%)
Arable (fields)	32.3	12.3
Contour ridge	3.6	1.4
Drainage (arable)	15.7	-
Vlei grazing	1.0	4.8
Home sites	5.8	1.0
Topland grazing (inc bare rock).	41.6	80.5

Note: Area estimates used 1:25000 photographs and no allowance was made for topographical effects on area calculations.

As these four examples show, the local availability of grazing resources is very variable. Reference to the map of land use (1985) and the discussion of land use change in the area will illustrate why this variability exists (see Chapter 3). To gain a full range of local situations would require a massive sample and was well beyond the scope of this study. However the four case sites do give a reasonable representation of the three zones in the Mazvihwa area.

Seasonal variation of key resource availability is significant to this discussion. In the cropping season, when the arable block is excluded from grazing, vleis/river bank resources constitute only between 2% and 17% of available grazing land (the upper limit is high because of the inclusion of the river bed in the calculation of riverine area). In the dry season when arable key resources are included (drainage lines/contour ridges), 'key resources' account for between c. 6% and 28% of total available grazing area.

Clay veld resources

The availability of grazing resources in the clay veld is very much dependent on the historical pattern of settlement and centralisation, as well as the degree of encroachment on designated grazing land in the late 1970s. Clay site 1

is close to the Runde river and has a fairly well defined arable-grazing boundary (this area coincides with the clay veld vegetation transects (see Chapter 2); for a detailed history of land use and habitat change see Chapter 3).

This contrasts with Clay site 2 which has had a history of more arable encroachment and, because of the area being outside the area of jurisdiction for the Native Land Husbandry Act, a less strict and later enforcement of land use planning exercises. However the general pattern is the same with a combination of arable area resources (including drainage lines and contour ridges (bunds)), riverine grazing and topland areas.

The topland areas combine a mix of Colophospermum mopane woodland (on both heavy red soils and sodic patches) and mixed Acacia woodland. Clay site 1 has a greater amount of Acacia areas, since large parts of the now grazing area were once cultivated. Clay site 2 has more original mopane woodland (although heavily disturbed, except parts of the rambo temwa area (3)) and some Acacia on old field sites adjacent to the Gwenombe river. These riverine strips have more prolific grass growth (Chapter 2) and are important 'key resources' for grazing.

Edge zone resources

The edge zone site sits on the boundary between the sandy soil hills and the clay veld plains. Most of the grazing area is in the hill zone, although there are important drainage line systems that flow from the hilly area into the clay plains. The clay zone is where the majority of fields are. The sand veld grazing area consists of open miombo woodland around large rocky, granitic outcrops. In the flatter areas where cultivation or settlement had been previously, degraded miombo/Terminalia woodland exists. The history of land use and the composition and standing crop of the grazing area vegetation is documented in detail in Chapters 2 and 3, as the sand veld vegetation transects are

found in this area. The vlei areas are critical to understanding grazing ecology and the Muchekwachekwa vlei and stream are extensively used by cattle in this area.

Sand veld savanna

The sand veld site is a further 5 kms into the hilly area. The mountainous nature of the area means that the amount of arable area is considerably less in total proportion than in the clay or edge zone. Most agriculture in the area is concentrated on the use of vleis and intensive cultivation on smaller areas secures good returns and so high, relatively stable stover yields. The large area of topland grazing should not be interpreted as a really plentiful fodder supply, as much of the surface area is bare granite rock (4). Vleis, although small in area, are an important source of fodder in this zone also (see vegetation transect data for sand veld vlei in Chapter 2).

Water resources

The distance to permanent water is also another critical variable in understanding foraging behaviour, particularly in droughts. The maximum distance from the kraal to a water source that the herds had to travel during 1987, a year when water was exceptionally short, was measured (see Figure 8.1).

Table 8.3: Maximum distance to permanent water (1987)

Clay 1	1000m
Clay 2	750m
Edge	4000m
Sand	4500m

The distances travelled on the clay veld are much shorter than in the other zones. This is because of the availability of water from perennial rivers and streams. In the case of Clay site 1 a local pool provided water through

the dry season, although by the end it was very polluted and many herders were digging holes in the sandy river bed (mifuku) for animals to drink. In Clay site 2 this practice started early on and involved considerable amounts of labour. The alternative for watering was a dam about 7km away. In the edge and sand zones the shallow water supplies from vleis and streams that normally see animals through a dry season all dried up. The alternative was to herd cattle to dams or the Runde river and this involved quite large distances. The frequency of watering was reduced during the dry season with apparently little ill effect (5).

8.4 Seasonal patterns of cattle herd management

The seasonal patterns of management are dependent on the availability of different grazing resources throughout the year. Cropping in the arable area restricts grazing there between c. November and March, while the concentration of grazing on particular patches or the switching to browse is related to the availability of herbaceous forage at different times of year. The year can be divided into three seasons that are distinguished by different forage resource use and management patterns: the cropping season (November to March), the early dry season (April to June) and the late dry season (July to October). The actual months that these three seasons apply to will vary from year to year, with differing times of the onset of the rains and different levels of rainfall.

A general pattern is described below, derived from interviews and observation. This will be explored in more detail with specific data from the four case study herds.

Cropping season

Cattle are herded all day - by adults in the morning and school children in the afternoon. In the early rains, before grass has grown, there is a reliance on browse and

sometimes controlled herding along arable drainage lines. When grass is available in the main grazing area cattle graze there; other areas being reserved for dry season grazing. In drought years, when grass production is low, there is an especial reliance on riverine strips and vleis within the grazing area.

Early dry season

When the crops have been harvested and notice has been given that the animals can be released into the fields herding ceases. This notice was traditionally given by the senior lineage elder; today regulated release of cattle for arable grazing is less common. Cattle feed off crop residues, complemented by contour ridge grass.

Late dry season

Fodder is particularly short in this period and animals must increasingly feed from stored crop residues and browse. Grazing is derived from vleis and drainage lines conserved within the arable block. In drought years kraaling is reduced and night time grazing encouraged. Herding may have to resume in order to take animals to water or particular grazing areas.

The way this generalised pattern is reflected in the actual behaviour of the four study herds is discussed in the following sections.

8.5 The seasonal use of different habitat patches for foraging by cattle

The monthly data has been aggregated into three different seasons representing the cropping period, the early dry season and the late dry season. For the period of study between late November 1986 and November 1987 these seasons refer to the months 12/86 - 3/87, 4/87 - 6/87 and 7/87 -

11/87. The feeding time spent in different habitat patches is calculated as a percentage of total daytime feeding. The results of this analysis for each of the four herds is shown in Figures 8.2 to 8.5.

Habitat use by clay veld herds

The clay veld herds spent a major proportion of feeding time during the cropping season in the topland grazing resource. Here there was a sparse covering of grass early in the season following the rains. However in both cases this was complemented by river bank grazing. This became increasingly important as the season progressed, especially in clay veld herd 1.

This herd also relied on grazing in the major drainage line that skirted the fields. This was not normally allowed in this area as the local agreement was that this area should be maintained for dry season use. However discussions quite early in the rainy season agreed that limited use by animals attended to by experienced herders was permissible. The use of the drainage line grazing tracts was also convenient early in the season when cattle were needed for ploughing and they could easily be spanned for early morning ploughing whilst the rest of the herd were nearby and watched over by those in the fields. The drainage lines were used predominantly in the early morning grazing session when the adult herders were available to keep the cattle closely monitored and prevent them straying into the fields. The grass growth in the drainage line was good, particularly in local drainage sinks (see data on grass standing crop from this drainage line/sink in Chapter 2). It was these patches that the animals were led to by the herders. In the afternoon cattle were accompanied by children and the goat flocks and moved towards the river for drinking and riverine grazing. The topland grazing observations were generally en route to the river and concentrated in the Acacia woodland areas near the river.

Figure 8.2: Use of different habitat types by cattle: Clay veld (1) herd: cropping season, early dry season and late dry season. Percentage total feeding time spent in each habitat type.

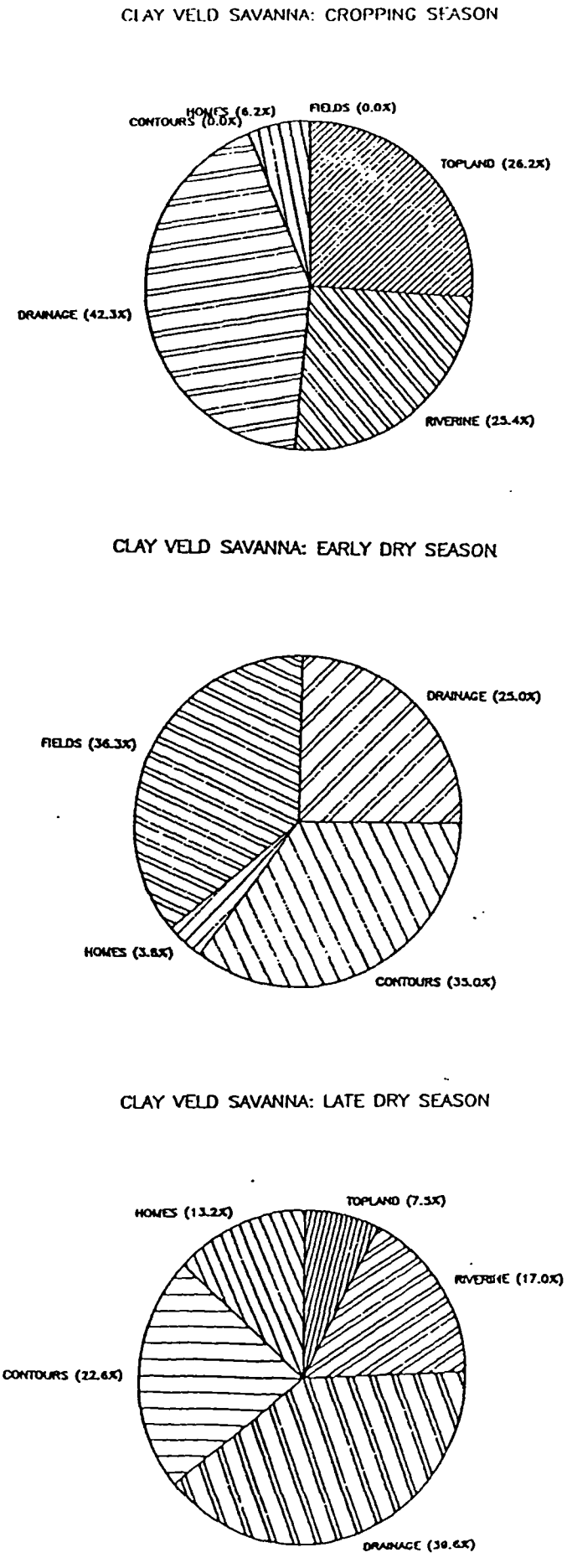
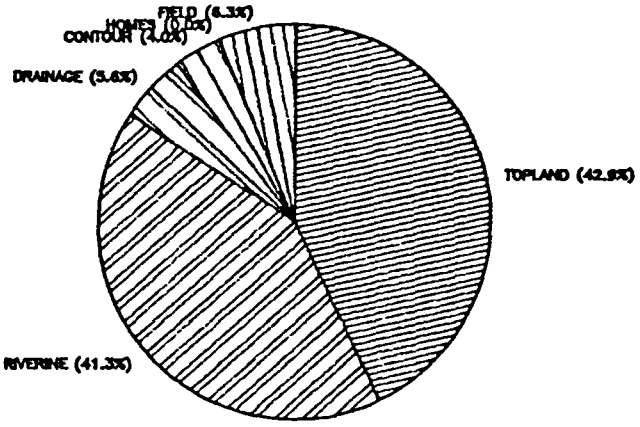
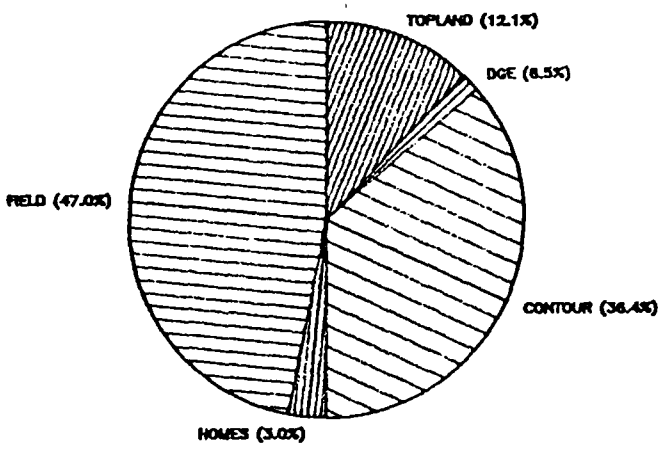


Figure 8.3: Use or different habitat types by cattle: Clay veld (2) herd: cropping season, early dry season and late dry season. Percentage total feeding time spent in each habitat type.

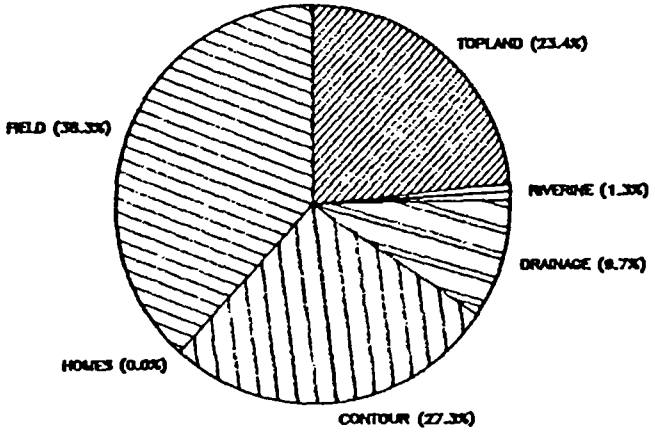
CLAY VELD SAVANNA: CROPPING SEASON (2)



CLAY VELD SAVANNA: EARLY DRY SEASON (2)



CLAY VELD SAVANNA: LATE DRY SEASON (2)



The clay veld 2 herd relied on the sweet grasses of the mopane woodland and were generally herded within this relatively small area during the cropping season. Riverine grazing was combined with drinking. This had to be organised by the herders, because the rivers (Gwenombe and Mutambi) soon dried up and mifuku had to be dug to feed both cattle and goats. This generally happened in the early afternoon prior to being taken by the children back to the grazing area. The availability of fodder by the end of the rainy season in the grazing areas was a serious source of concern in this area and as soon as some fields were harvested (in late March) cattle were herded on them to get the stover and contour ridge grass. The restrictions on the release of cattle onto the fields is not as strictly applied in this immediate area as some others and, as long as care was taken to ensure cattle did not stray onto the unharvested fields, there were no complaints.

The early dry season in both clay veld areas was dominated by arable land grazing - both on the contour ridges, where conserved grass was prolific and still sweet, and off the stover remains of maize and millet. Much stover was stored (see Chapter 7) due to fears of an impending forage shortage, but the yields were low, so the amount of residue was not extensive. However it was a significant factor in maintaining nutrition in this period.

The end of dry season saw a variety of strategies employed in the clay veld herds. By this stage there was very little grass available in the topland areas and browse became an increasingly important component of feeding. The intense use of the riverine grazing areas in the previous months had left them bare. In other years people reflected that these would be a critical dry season resource, but this clearly only applies when there is sufficient topland grass production to see animals through the cropping season without reliance on riverine areas. The arable areas continued to be important throughout the dry season. In the Clay veld 1 area the contour ridge grass production was

high (see Chapter 2) and so this resource became crucial. Stored crop residues were also important and these were fed at home sites. The drainage line areas were also used in both areas, but not extensively; they too had been heavily used in the earlier months and were not the dry season reserve that they are in other years.

In the clay veld 1 area the drainage line had been heavily used by cattle from outside the area. Cattle in search of fodder and water from the river had moved in large numbers through the drainage line trampling and eating the remaining grass. In addition, cattle from across the river in Chivi had moved in search of food, further depleting the local grazing resource. This had caused much local outrage, but attempts to control the influx failed.

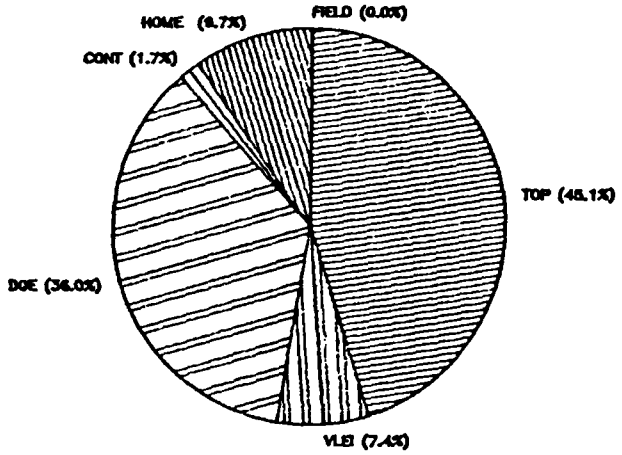
In the Clay veld 2 area the situation got very serious by mid-September and the cattle were moved approximately 5 km into the sand veld zone where hill grazing was still possible. They were moved to an area where relatives lived and they kept a general eye on them. They were visited by the owners or their children regularly and herded down to the dip tank every two weeks for dipping. They were not kraaled for several months and only brought back to plough with the early rains (November). This move is represented in the higher levels of topland grazing in this period than shown in the other clay veld herd.

Habitat use by the edge zone herd

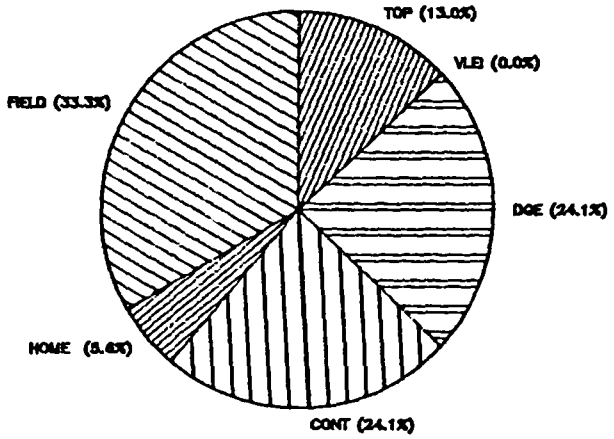
The edge zone herd was in the position of being able to switch between clay and sand veld resources at different times of year without having to transfer the whole herd as occurred in the clay veld 2 herd. The topland grazing was all basically sand veld among the hills. Here the grass was of poor quality, so early in the cropping season drainage line grazing on the clay veld (adjacent to the fields) was preferred (Dec/Jan).

Figure 8.4: Use of different habitat types by cattle: Edge zone herd: cropping season, early dry season and late dry season. Percentage total feeding time spent in each habitat type.

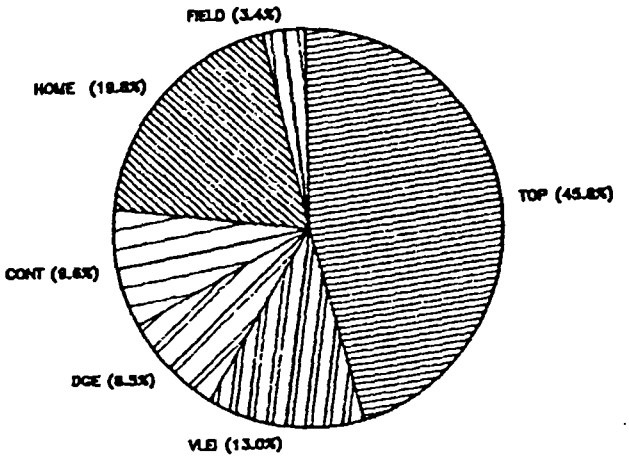
EDGE ZONE SAVANNA: CROPPING SEASON



EDGE ZONE SAVANNA: EARLY DRY SEASON



EDGE ZONE SAVANNA: LATE DRY SEASON



The hired herder explained that he will move cattle to the hills only when the other possibilities are finished. He also admitted that the convenience of the drainage line grazing was an advantage and it allowed the cattle to be spanned for morning and evening ploughing without having to bring them back from great distances.

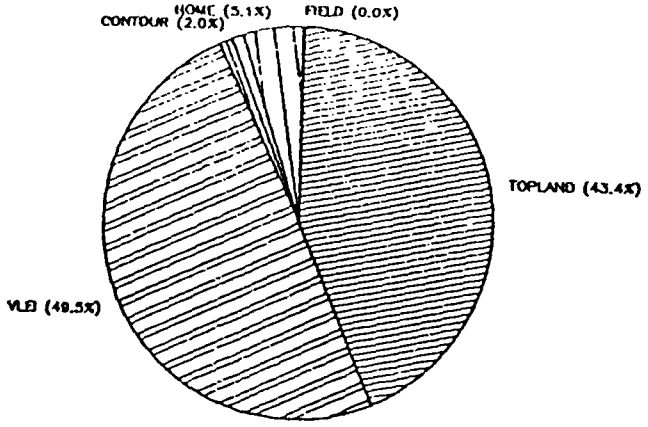
The early dry season shows a range of habitat patches used. The reliance on the arable grazing and crop residue resources shown in the clay veld herds is not observed here. This is because the options are wider and the persisting availability of topland grazing (even if low quality) allows a more flexible grazing response. Topland grazing continues into the late dry season; although by this stage additional fodder supplied at home and vlei grazing are also important. Although the topland grass existed it was sparse and distant (often up mountains). For this reason the cattle were not night kraaled from September and left to seek out grazing and only collected every 2-3 days for taking them to water or the dip tank. Day time feeding reduced fairly dramatically in October and November as a consequence; no attempt was made to monitor night time grazing.

Habitat use by sand veld herds

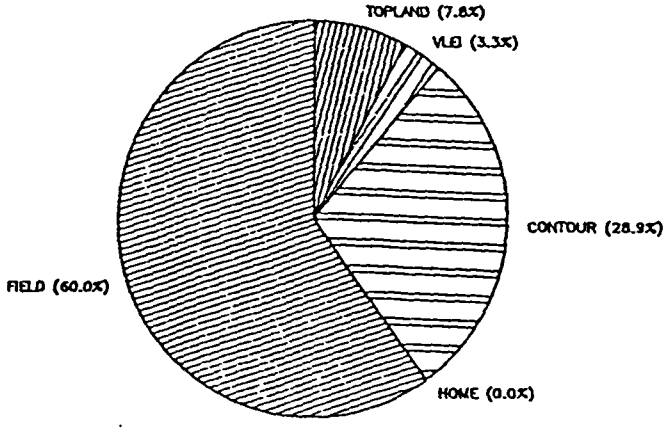
The sand veld herd showed a broadly similar pattern, with the use of topland grazing resources throughout the year. However the switch to early dry season grazing on the arable block is much more noticeable in this herd. The importance of vlei grazing to complement topland grazing in the rains and as a 'key resource' in the late dry season is also more noticeable in this herd. This can be attributed to a number of factors. The sand veld herd did not have the range of grazing resources that was available to the edge zone herd and therefore could not switch to clay veld fodder resources for high quality forage to complement the poor grasses of the sand veld topland. The vlei grasses probably compensated for this to some extent.

Figure 8.5: Use of different habitat types by cattle: Sand veld herd: cropping season, early dry season and late dry season. Percentage total feeding time spent in each habitat type.

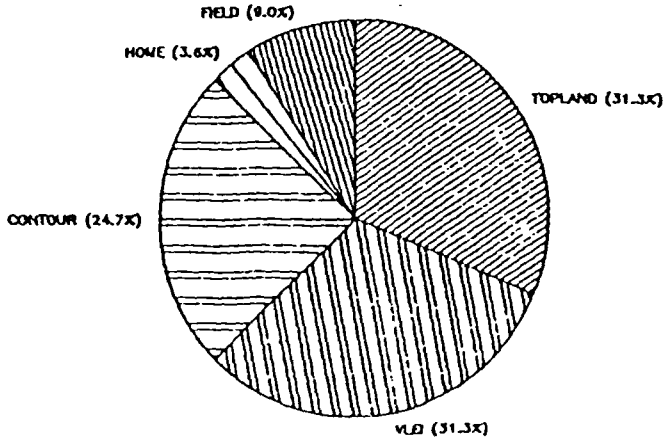
SAND VELD SAVANNA: CROPPING SEASON



SAND VELD SAVANNA: EARLY DRY SEASON



SAND VELD SAVANNA: LATE DRY SEASON



The sand veld herd was also night kraaled throughout the dry season and so did not have the opportunity of extended grazing forays. The danger of theft or injury from free grazing in the hills and the importance of manure for sand veld cultivation meant that kraaling was maintained.

Although large amounts of stover were stored here there was apparently little day time feeding of crop residues by the animals, although an amount was given when the animals were kraaled at night.

The importance of the vlei resource was also inevitably enhanced by its proximity and exclusivity. The major vlei grazing area for this herd was only c. 200m away from the kraal, compared to c. 1.5km for the edge zone herd. Although a small patch (c. 300m x 50m) compared to the large Muchekwachekwa vlei (c. 1500 x 80m) the sand veld vlei area was not used extensively by other cattle (perhaps 20 - 25 on a regular basis) and so had large amounts of standing crop (see Chapter 2). By contrast the Muchekwachekwa vlei was used throughout the rains and into the dry season for both grazing and drinking by cattle from a number of household clusters and perhaps 150 cattle used it regularly, as a consequence the availability of fodder was much less.

8.6 Habitat feeding preferences of cattle

The preference of cattle for feeding in different habitat types can be investigated by relating the feeding time spent in a patch to the overall availability of the patch. An index that describes the preference level is:

$$PI = \frac{\%\text{ feeding time spent in habitat patch x in season y}}{\%\text{ of total area as habitat patch x}}$$

The preference index (PI) is > 1 when the habitat patch is preferred PI = 1 when the area is used in proportion to its availability and PI < 1 when the patch is used less than

expected if animals were just choosing areas to feed in proportion to their availability. PI will = 0 if the area is not used at all. Table 8.4 gives the results of the preference index calculations for four herds in three seasons. The results are calculated according to total potential area (see Table 8.2). However, not all habitat patches are available all year round; an alternative calculation would account for this, separating patch availability into different seasons (cf Scoones, 1988). In addition, habitat availability was assessed within a 2km radius, therefore the proportions of patch available do not necessarily reflect situations when the cattle occasionally moved out of their local grazing area (eg. when clay veld 2 herd was moved or the sand/edge herds went on long treks for water).

Table 8.4: Foraging preferences of cattle (PI).

Season	Topland	River Vlei	Drainage	Contour	Home	Field
Clay veld 1:						
Crop	0.51	4.09	6.12	0.00	0.77	0.00
EDS	0.00	0.00	3.97	12.24	0.47	1.41
LDS	0.15	2.14	6.29	7.92	1.65	0.00
Clay veld 2:						
Crop	1.34	5.43	0.33	1.04	0.00	0.18
EDS	0.38	0.00	0.09	9.49	0.56	1.36
LDS	0.73	0.17	0.58	7.12	0.00	1.11
Edge zone:						
Crop	1.09	0.18	0.87	0.04	0.23	0.00
EDS	0.31	0.00	0.58	0.58	0.13	0.80
LDS	1.10	0.31	0.20	0.23	0.48	0.08
Sand veld:						
Crop	0.54	10.31		1.47	5.05	0.00
EDS	0.10	0.69		4.09	0.00	4.87
LDS	0.39	6.53		18.03	3.61	0.73

Note: Seasons refer to Cropping (Crop), Early dry season (EDS) and Late dry season (LDS).

The results highlight the importance of different 'key resources' for feeding in the different seasons and zones.

The two clay veld herd herds both show an important preference for the riverine grazing habitat during the rainy season. The clay veld 1 herd returns to this in the late dry season. The drainage line is particularly important for the clay veld 1 herd throughout the year. This is not highlighted for the clay veld 2 herd, where the drainage line grazing resources are more dispersed covering a larger area, and less productive per unit area. Both herds from the clay veld apparently select out contour grazing during the dry season. Neither herd prefers the topland grazing land, except for a marginal preference shown by the clay veld 2 herd in the cropping season. Although similar patterns are shown in terms of preferences the clay veld 1 herd shows a much more selective pattern of grazing, while the clay veld 2 herd spreads grazing time much more in relation to availability.

The edge zone herd shows this pattern also. This reflects an opportunistic response to changing resource availability and the ability to switch between different patch types and different zones.

The sand veld herd by contrast shows a much more selective grazing pattern where 'key resources' are preferred. These include the vlei and contour resources which are important at different times of the year. Field grazing resources are seen to be important in the early dry season (crop residues) and home sites are preferred both in the rainy season (when cattle were kept around the home for ploughing) and in the late dry season (when stored crop residues were available).

Two different strategies seem to be evident - either a reliance on particular 'key resources' at different times of the year or an opportunistic switching between habitat

types with a greater spread of use across different patches. Both require a flexible herding and foraging strategy that allows movement between patches and adaptive exploitation of a dynamically variable environment.

Interestingly, the contrasts that have been stressed between the sand and clay veld savanna systems are not reflected at this level of patch resource use. Both the clay and the sand veld populations make use of lower catenal resources (vleis/river banks) as the forage availability of the toplands decreases. However the production dynamics of these key resources differ and their role in different years will be determined by the production success of the topland grass resource, which is dramatically different between clay and sand veld (see Chapter 2).

Acres et al (1985) have recognised the importance of vleis (dambos) for grazing in Tanzania:

> "During the long dry season when upland grazing dries out and becomes nutritively poor, dambos may become the only source of grazing for large numbers of animals..... Herdsmen organise transhumance so that stock are grazing the dambo grassland as soon as possible. This early grazing of at least a small area extends the vegetation phase and keeps the herbage in a nutritive condition."

Other studies of habitat use of livestock in Africa reflect some of the patterns observed here. Coppock et al (1986) show how in Turkana district in Kenya cattle forage selectively on drainage line patches, which represent around 5% of total area. Homewood (1985) similarly highlights the seasonal importance of swamp grazing for cattle in Baringo, Kenya. Homewood et al (1987) also show the habitat preferences shown by cattle in the Ngorongoro Conservation Area in Tanzania. Van Raay and DeLeeuw (1974) note the importance of preferred grazing on valley grasslands in the early dry season in the Nigerian savanna region. Studies of wildlife habitat use have also

emphasised the seasonal importance of different habitat patches (Field and Laws, 1970; Ferrar and Walker, 1974; Sinclair, 1977).

8.7 Micro-level patch use

Patches of higher quality grazing are present in both savanna types at a scale smaller than the habitat type classification so far discussed. These include small areas where topography and run-off/on patterns, local micro-climate or nutrient conditions, particular edaphic factors, small scale physical disturbances or grazing/animal behaviour induced heterogeneity have resulted in the creation of micro-patches that influence the pattern of animal foraging behaviour. Detailed information has not been collected on this scale of heterogeneity and patch use, but it is relevant to reflect on its importance as one additional environmental factor that affects the dynamics of response of livestock populations to the variable and patchy vegetation resource.

Important micro-patches include grazing beneath trees where local conditions results in a different species composition. Swards of Panicum maximum are important in this respect, being of higher quality and sometimes higher production than surrounding grassland (Kennard and Walker, 1973; Bosch and van Wyk, 1970). Chapter 2 has already discussed the relationship between tree cover and grass biomass availability. Under certain conditions and under particular trees, there are increases in biomass and quality of the grass layer (see Appendix 3).

The micro-level dynamics of litter fall and nutrient recycling (Campbell et al, 1988 for a Zimbabwean miombo ecosystem) is also likely to be important in setting up small scale patterning that influences grass production dynamics and grazing. Because of phenological differences amongst species, spatial variation and timing of litter and pod fall results. Spatial patterning of different quality

litter is likely to causes differences in woodland regeneration dynamics and herbaceous production. Observations of litter accumulation on the vegetation transects indicated that such processes were also likely to be occurring in the clay veld areas, not so much through nutrient cycling, but litter drifts allowing establishment of grasses in otherwise open, capped bare ground.

Small run-on areas (of a few metres squared) also act as micro-patches where increased green grass growth occurs. These are frequent in the relatively flat topography of the clay veld zone. These small pans are known as makawa and may become waterlogged in good years; they serve as important grazing resources into the dry season.

The presence of patches of sodic soils (chimamhare) is also important (Dye and Walker, 1980). These serve as salt licks for grazing animals, as well as providing a short grassland that, although not productive, are likely to be important for mineral nutrition. Gammon (1976) found that a type of sodic soil grass land (Sporobulus sp. dominating) was favoured by grazing cattle during certain times of the year. The short grass layer is also favoured by donkeys. Termitaria with their particular vegetation association may act in a similar way. Belsky (1988) found that in the Serengeti grassland communities a major explanatory variable of grassland heterogeneity was the presence of sodium deposits in sodic patches or termite mounds.

These patterns remain to be explored, but are likely to be important in explaining grazing strategies of livestock in the same way as other levels of heterogeneity at the regional and habitat scales.

8.8 Travelling distances by cattle

The distance covered to seek out particular forage or water resources is also important to consider, as additional

energy expended on walking and diverted away from maintenance may be critical in the overall nutrition of the animal.

The distances travelled by the herds on each occasion that they were followed was mapped out on 1:6250 aerial photographs and the total distance calculated. No account was taken of the changes in elevation; the estimated distances are thus less than actual distances walked. Maximum vertical displacements were also estimated for the foraging movements of each herd using topographical maps. The results for the whole year are shown in Table 8.5.

Table 8.5: Travelling distances of four herds: average for the year.

Herd	Distance (m)	SE	Max vertical(m)	% FM
Clay 1	5615	659	20	11.7
Clay 2	4020	676	10	8.3
Edge	5495	1042	60	12.6
Sand	7687	868	100	18.1

Note: %FM = % of daily fasting metabolism consumed in energy on distance travelled (average).

Two patterns are observed from the data. First, the sand veld herd travelled on average the greatest distances. This was because of the wider foraging area among the hills during the wet season and the long distance down to the Runde river in the dry season, when the local water sources dried out. Second, the clay veld herds had longer travel distances in the rainy season when they were foraging in the grazing area, while the sand and edge herds travelled further in the dry season when they needed to seek out water some distance from their home kraals. This extra dry season energy expenditure can be expected to have a greater impact on condition when fodder availability was reduced.

The energy consumption as a percent of fasting metabolism that these travel distances imply can be calculated

according to the relationship suggested by Blaxter (1962). The calculation assumes 0.5 cal/kg/m is consumed on horizontal movement and 6.8 cal/kg/m on vertical movement. If the weight of the sample cattle is assumed to be on average 200kg and the fasting metabolism 5000 kcal, the energy consumed by walking ranges between 8.3 and 18.1% of fasting metabolism (see Table 8.5). This is an indicator of the extra energy required on top of maintenance. This is highest for the sand veld herds, especially because of the significant vertical displacements during foraging in the hills. However compared to the use of energy by pastoral cattle the levels are low. Western and Dunne (1979) quote a maximum rate of 35%, while Homewood et al (1987) demonstrate a range between 17% and 53%.

The foraging radius of the four herds was on average 2km, but ranged from 750m to 4.5 km according to the mapped foraging routes. Such radii are considerably less than those exhibited by cattle in pastoral situations where a 'standard' of 16 km is expected (Dahl and Hjort, 1976), although distances up to 26km have been recorded in South Africa under drought conditions (Bonsma and LeRoux, 1953). Pennycuick (1979) calculated an empirical relationship between body weight and foraging radius for a range of wildlife species ($r = 2m^{0.4}$) that would expect a radius of 16.6 km for cattle of a body mass of 200kg.

8.9 Cattle activity patterns

Kraaling management

The length of the grazing period is dictated by the kraaling practices of the owners. The length of time available for feeding observed for the four study herds during the times when they were night kraaled ranged from 8 to 12 hours (average 9.5 hrs). The division of this time into different activities is discussed below.

The effect of night time kraaling is likely to affect the grazing behaviour and nutrition of animals. Smith (1961) found that animals responded with increased intensity of grazing when kraaled at night, although this was not reflected in the findings of Wilson (1961). Smith (1961) found that there were no effects on weight gain of animals under conditions of moderate kraaling (11 hours of grazing day available), but when the grazing day was reduced to 7 hours a negative effect on weight gain was noted, but only in the dry season. Only under bad dry season conditions is the practice of kraaling detrimental to cattle condition.

Kraaling was only relaxed in two of the herds during a few months of the late dry season. The cost of reasonable kraaling times are apparently slight, in terms of loss of condition, and the benefits of manure received and the reduced risk of loss or theft are definitely high. The advantages of current kraaling practices are clear.

Activity patterns

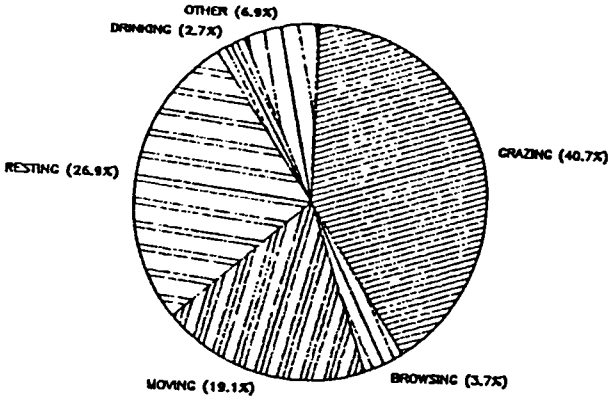
The activity patterns according to different seasons are shown in Figures 8.6 to 8.9. Activities are divided into: grazing, browsing, stover foraging, drinking, moving and resting, other (including cleaning/sexual behavíour). As in the habitat use study, the monthly data is aggregated into three seasons and is divided between four herds. The proportion of total time spent feeding is shown in Table 8.6.

Table 8.6: Proportion of total daylight time spent feeding

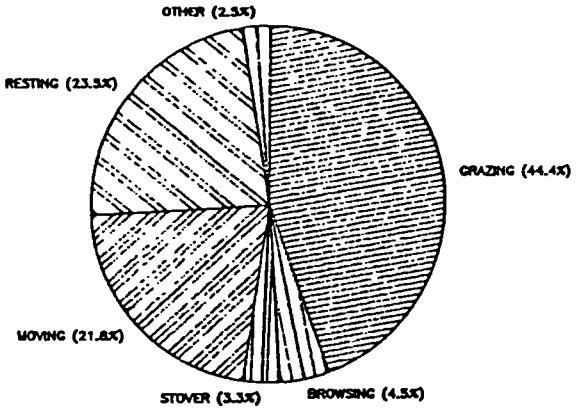
%	Cropping	Early Dry	Late Dry
Clay 1	44.4	34.6	12.3
Clay 2	52.2	36.7	40.4
Edge	55.0	31.9	39.6
Sand	52.6	38.3	46.1

Figures 8.6-7: Cattle activity patterns: 8.6: Clay veld (1) herd; 8.7 Clay veld (2): cropping season, early dry season and late dry season. Percentage of total time spent on different activities.

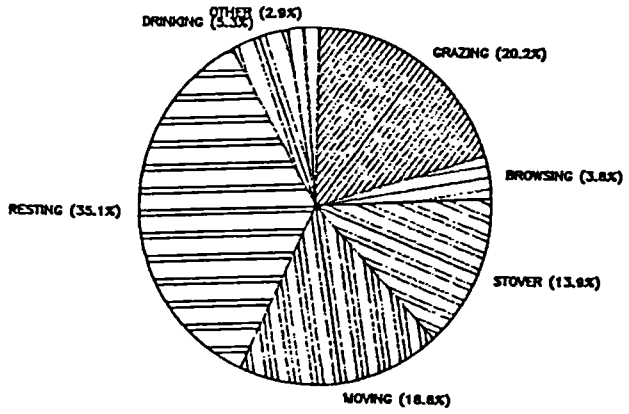
CLAY VELD 1: CROPPING SEASON



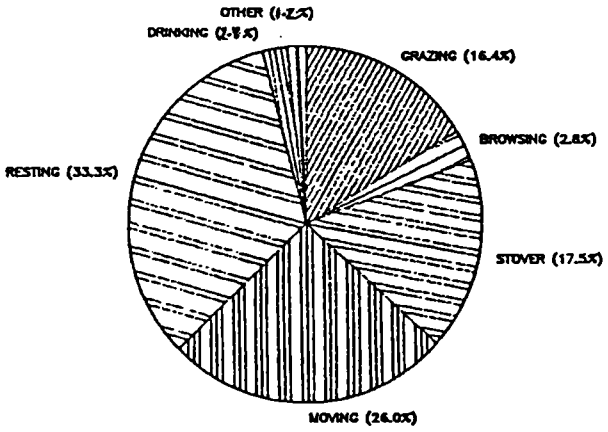
CLAY VELD 2: CROPPING SEASON



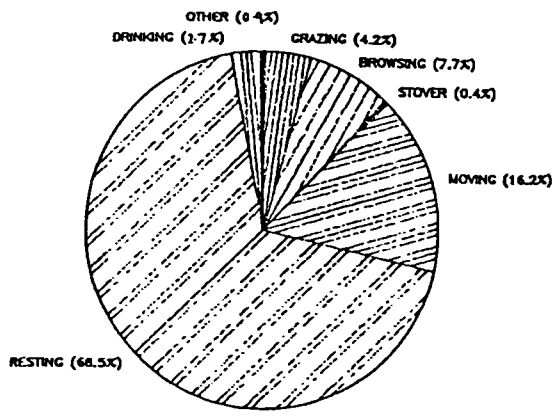
CLAY VELD 1: EARLY DRY SEASON



CLAY VELD 2: EARLY DRY SEASON



CLAY VELD 1: LATE DRY SEASON



CLAY VELD 2: LATE DRY SEASON

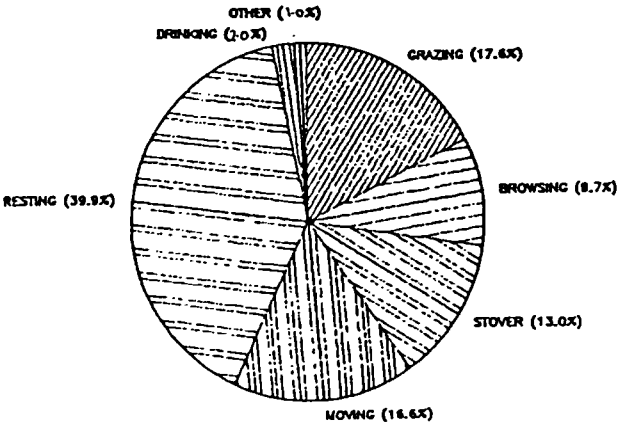
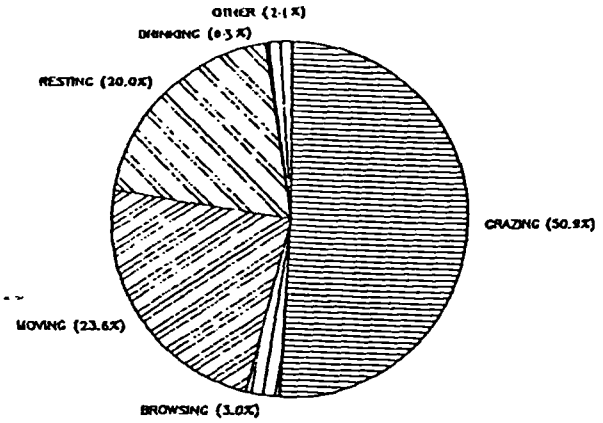
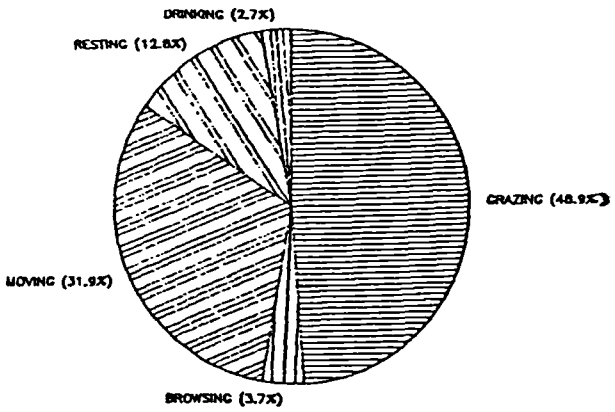


Figure 8.8-9: Cattle activity patterns: 8.8: Edge zone herd; 8.9: Sand veld herd: cropping season, early dry season and late dry season. Percentage of total time spent on different activities.

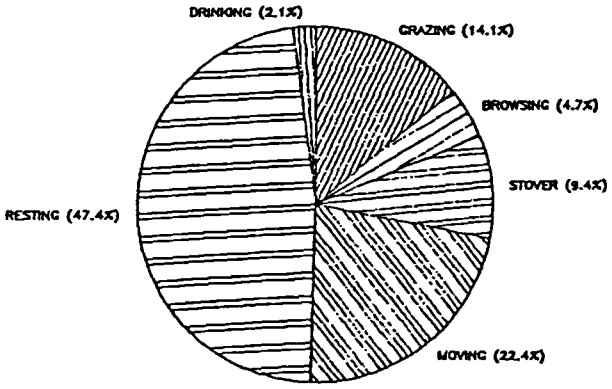
EDGE: CROPPING SEASON



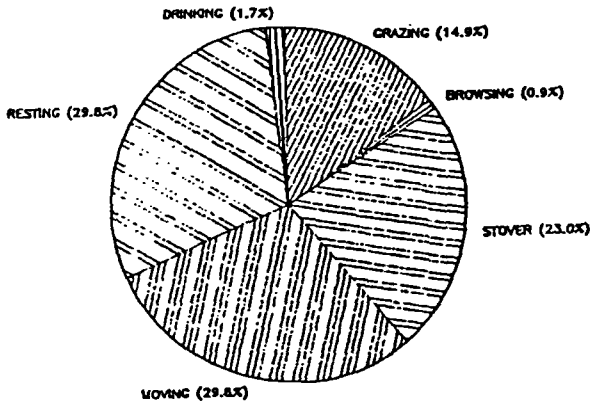
SAND VELD: CROPPING SEASON



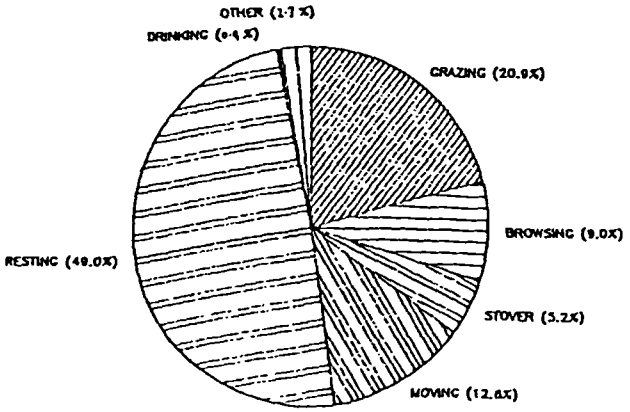
EDGE: EARLY DRY SEASON



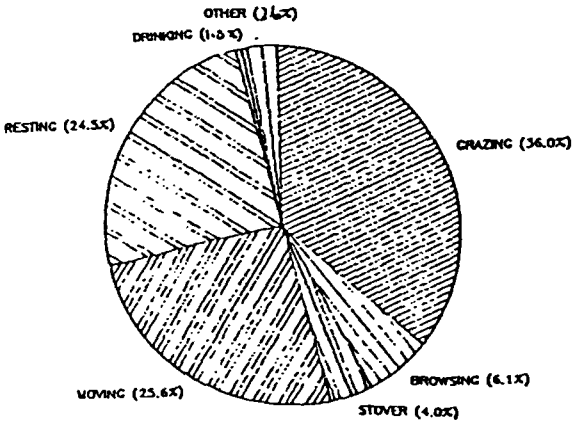
SAND VELD: EARLY DRY SEASON



EDGE: LATE DRY SEASON



SAND VELD: LATE DRY SEASON



The overall feeding time as a percentage of available time (avge 9.5 hours) reflects short times of feeding compared to other studies of free grazing animals. Arnold and Dudzinski (1982) refer to over 100 studies and indicate an average 9.5 hours a day grazing time for free grazing animals on range. Most grazing takes place during day light, but Haggar (1968 for Shika Nigeria) and Smith (1959 for Zambia) reports that up to 20 - 25% of grazing can occur at night. Other studies (eg Harker et al, 1956 and Lampken and Quartermain, 1958 for Kenya) show lower rates of 8 - 9 %. However, other studies from Africa show similarly short grazing times where crop residue feeding is significant (Bayer and Otchere, 1986 for sub-humid Nigeria) or where kraaling management is important (Wilson, 1961).

The importance of selective, patchy feeding strategies that are seasonally distinct increase in importance under peasant management conditions and stocking rates. Comparisons with free grazing animals on range under low stocking rates, minimal herding management and a grazing environment constrained by paddocks and without the arable forage resources are probably unjustified. Unfortunately most of the literature has focused on such ranching conditions as the model for grazing management in Africa.

The seasonal pattern observed showed a peak feeding time in the cropping season, a drop off in the early dry season and then an increase in the late dry season. Clay veld 1 herd did not show this increase in feeding time in the late dry season, as a considerable amount of time was spent resting. Alternative fodder supplies were provided at the kraal in the form of stover. Supplementary feeding of stover combined with night time feeding are probably the reasons why the length of end of dry season day time feeding was not as extensive as might be expected in all herds. The pattern observed in other studies of cattle activity patterns generally show an increased feeding time as the season progresses, as the availability and quality of fodder decreases (Smith, 1959; Lewis, 1977).

The dry season coincides with longer rumination times (Arnold and Dudzinski, 1982) as the quality of available fodder decreases. The amount of 'resting' noted in this study shows large increases at the end of the dry season. This may in part reflect increased rumination, as well as a strategy to conserve energy.

Grazing and browsing

The amount of time spent grazing grass reflects the overall feeding time pattern. The rains bring a flush of new green grass on the topland grazing areas and cattle respond to this with increased grazing. In the early dry season grazing is concentrated on contour ridges in the arable area. This provides bulk but little quality, especially in the sand veld zone. By the end of the dry season grass resources are scarce and 'key resource' grazing is critical. The key resource areas such as vleis and river bank strips are important not only because they provide biomass but also because the grazing is of higher quality. The contrast in quality is especially important in the sand veld zone where the topland grassland is of low forage quality which drops further during the dry season. Vlei grazing however only maintains quality and greenness by grazing through the year. The grass in vlei fields which are protected during the growing season tends to grow tall and rank and is of less use to animals in the dry season. In the clay veld the grass layer is of higher nutritive quality and even the tall contour ridge grass, dominated by Urochloa mosambicensis remains reasonably palatable.

Data was not collected on quality indicators of the grass layer, but reference to the literature on southern Africa show the trends of higher quality of clay veld grasses and large seasonal fluctuations in crude protein content. Appendix 4 provides a summary from various sources.

The distinct arable grazing resource that becomes available

in the early dry season apparently results in decreased feeding times. This is probably directly related to the increased availability of fodder, including maize stover. This option is not available for cattle feeding off open range and the pattern of increasing feeding times is not observed here. Crop residues are a critical feed resource. No studies were carried out on their feed quality, but the literature suggests that although poor in quality, crop residues are important fo bulk feeding which is particularly significant for cattle at this time of year (6).

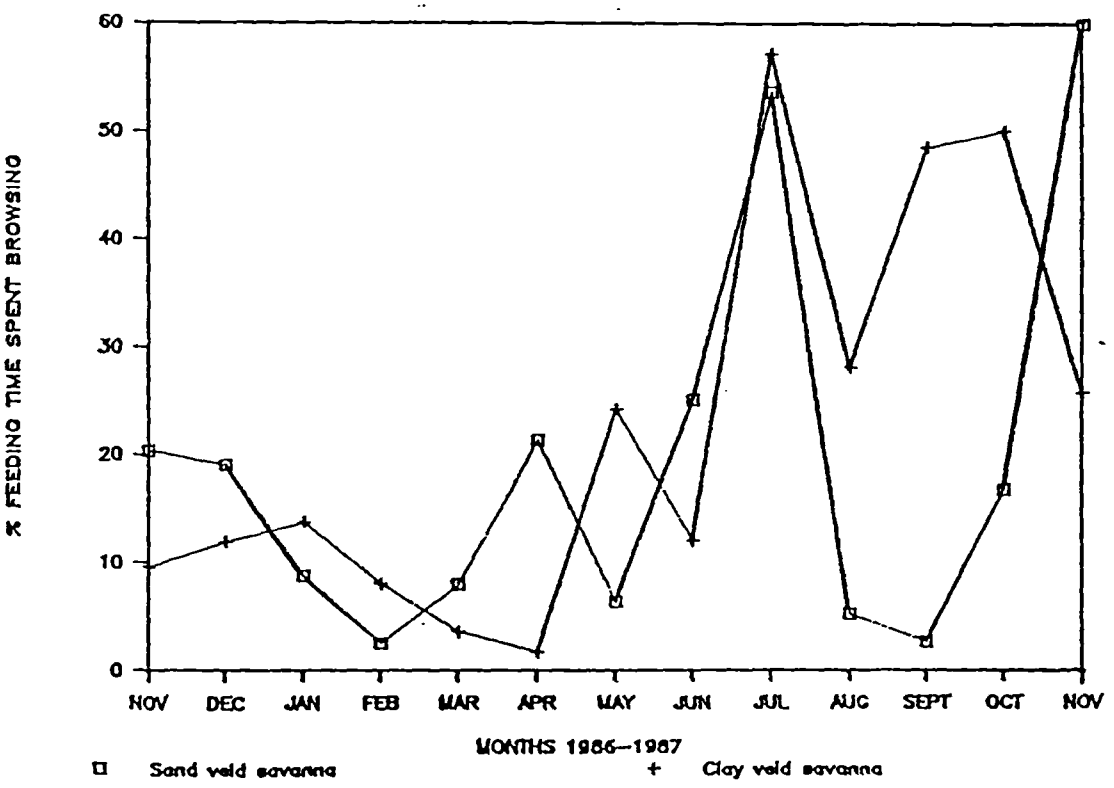
In all zones the percentage of total time spent browsing increases into the late dry season. All herds spent between 6 and 9% of total time browsing during the late dry season. The monthly browsing pattern as a percentage of feeding time is shown in Figure 8.10 for the two clay veld herds combined compared with the sand and edge herds. Dry season peak browsing constitutes 50 - 60% of total feeding time.

There is significant dry season browsing activity in the clay veld savanna between August and October. Much of this is concentrated on feeding off leaf litter during August and September (particularly Colophospermum mopane and Combretum apiculatum; see Table 8.7). With the early rains some green leaves appear, but the leaf litter resource rots and becomes unavailable. The rate of browsing thus decreases in November.

Table 8.7: Proportion of browsing time spent feeding from leaf litter.

Month	Clay veld	Edge/Sand
	(%)	(%)
June	0.0	60.0
July	0.0	47.8
August	62.5	100.0
Sept	43.8	50.0
Aug	0.0	0.0
Nov	0.0	18.8

Figure 8.10: Percent of feeding time spent browsing (November 1986 to November 1987) in sand veld and clay veld (1 and 2) herds.



By contrast, the late dry season flush of the miombo browse resource in the sand veld area prompts an increase of browsing activity in September - October, and this persists into the early rains. In general there is more browsing activity in the clay veld savanna for most of the year outside the November - December period, when the new leaves are only just emerging in the clay veld. This is the time of year when the sand savanna browsers are exploiting the new growth of the miombo trees, before any significant build up of secondary chemicals.

The use of specific species for browse was documented during the study of foraging behaviour. The trees browsed are ranked according to the time spent browsing for all herds and for the clay and edge/sand herds in Table 8.8. This can be related to the ranking of browse preferences derived from interviews with farmers (see Appendix 3).

Table 8.8: Browse species ranked by % of browse time spent.

All areas	Clay veld	Edge/sand veld
Colophospermum mopane	C. mopane	J. globiflora
Julbernadia globiflora	C. apiculatum	B. mollis
Bridelia mollis	G. monticolor	C. mopane
Grewia monticolor	J. globiflora	C. apiculatum
Ficus soldanella	S. birrea	A. quanzensis
Sclerocarya birrea	B. discolor	G. monticolor
Berchemia discolor	B. lyciodes	T. sericea
Lonchocarpus capassa	C. hereroense	Euphorbia sp.
Acacia tortilis	A. tortilis	L. cappassa
Afzelia quanzensis	D. cinerea	B. galpinii
Diospyros lyciodes	L. cappassa	D. cinerea
Combretum hereroense	G. flavescens	A. tortilis
Dichrostachys cinerea	C. imberbe	B. angustifolia
Terminalia sericea		D. mespiformis
Euphorbia sp.		F. indica
Bauhinia galpinii		S. birrea
Flacourtia indica		
Dyiospyros mespilliformis		
Boscia angustifolia		
Combretum imberbe		
Grewia flavescens		

The percentage of total browse time spent browsing particular key species is illustrated in Table 8.9.

Table 8.9: Percentage total browse time feeding from top three trees and season when browsing concentrated.

Tree species	Clay	Edge/sand	Season
Colophospermum mopane	56.1	9.4	D
Combretum apiculatum	17.1	<5	LD
Grewia monticolor	14.6	<5	D/ER
Julbernadia globiflora	-	62.5	LD/ER
Bridelia mollis	-	15.6	ER

Note: Season = D (dry), LD (late dry), ER (early rains)

This shows how in each zone a few key species are vital for browse. In the clay veld this is particularly C mopane along with Combretum apiculatum and Grewia spp., while in the sand veld Julbernadia globiflora dominates. The edge zone exhibits a mixture, illustrating the switching feeding strategy between different zones. The choice of species relates to both their availability, which relates to species composition, tree density and physiognomic structure of the woodland (see Chapter 2), and also to their provision of crude protein and other minerals. No attempts were made to measure crude protein content, but an indication of the importance of browse in this respect can be gained from the literature (see Chapter 2).

The importance of the browse resource has been noted in a number of studies in the region (Kennan, 1969; Rees, 1974; Walker, 1980) and is confirmed by this research. This importance is not always reflected in range management recommendations that often advocate the removal of bush from grazing lands (Hill, 1984). The trade-off between grass production and woodland cover has already been discussed in Chapter 2. The importance of the browse resource is particularly significant in the high use systems of the communal areas and in periods of drought.

High use means that much available topland grass production is consumed during the rainy season, especially in drought, and there is a need to rely on browse for high quality fodder to increase intake and simply for sustenance in extreme drought situations (see the discussion of lopping of browse trees in Chapter 7). The grass layer dynamics of the clay veld makes browse particularly significant in terms of its fodder contribution. Collapses in grass production are more common in this zone and browse thus plays a vital role. This view is reflected by local observers:

> "The only reason our cattle are surviving is because of the many falling leaves on the ground, mainly mubondo [C. apiculatum] and mupani [C. mopane]." (Interview: Zwamapere, Chivi, 9.87)

> "These heavy soil plains support a wonderful woodland.. these trees produce their leaves very early nice and low down for stock. The trees of the sandy soils are not as good for stock." (Mototi trees seminar, 15.3.87; Wilson, 1987).

NCs regularly commented in their annual reports on the importance of browse for cattle survival. The NC of Chivi commented in 1933:

> "In spite of the shortage of grazing and water, cattle kept in remarkable condition and very few deaths occurred from poverty. This I attribute to the leafage on bush and trees coming out well during the latter months of the year and the cattle browsing off these." (Annual report, NC Chibi, 1933).

8.10 Goat foraging behaviour

Goats use the same grazing areas as cattle, but to what extent do they overlap in their foraging resource requirements? This question can only be addressed in a preliminary manner as the data collected on goat foraging behaviour is limited. However, it is important to

investigate foraging and resource use in the context of the multi-species livestock system of the CAs.

Goat flocks from the same kraals as used for the cattle following observations were followed for full days on two occasions - August 1987 and March 1988 (7). These represent contrasting situations - dry season and free ranging behaviour vs. wet season and controlled herding. Individual goat observations proved impossible to carry out so a scan assessment method was employed (Rollinson et al, 1956). At 10 minute intervals the flock was scanned and the dominant activity (browsing, grazing, moving, resting, drinking) was noted. The habitat type was also recorded (homes, river/vlei, fields, topland) and the route travelled by the flock subsequently mapped on aerial photograph overlays.

Habitat patch use

The results of the habitat use information are included in Table 8.10. The habitat types are ranked according to the amount of time the goat flocks spent in them.

Table 8.10: Ranked use of habitat patches

Habitat	Clay1	Clay2	Edge	Sand
August 1987 (dry season):				
Homes	2	1	2	2
River/vlei	3	4		
Fields		2=	1	1
Topland	1	2=	3	3
March 1988 (wet season):				
Homes	2	1	2	2
River/vlei	3	2=	3	3
Fields		4		
Topland	1=	2=	1	1

The clay veld goat flocks show much the same pattern of habitat use in the different seasons with much feeding done

in the proximity of home sites. Little use is made of arable area feed resources, although earlier in the dry season this is more likely. The edge and sand veld flocks by contrast show different patterns of use in the two seasons. Topland grazing resources are little used during the non-herded dry season and most grazing is concentrated in the field areas. During the wet season goats are herded in the topland areas and taken to river/vlei areas. This difference is explained by the high incidence of dry season predation by baboons in the sand veld topland areas (see Chapter 7). As a result, goats fear to move away from the home/field areas. The edge zone flock was restricted to the field area towards the clay veld and did not venture into the sand veld area at all. In the wet season the level of predation is less and herdboys are able to protect goats from baboons.

In general, goats tend to forage close to the homes with small foraging radii; they switch between topland and home areas but rarely stray far. Further distances may be travelled when herded in the wet season or when taken to water. This is when the riverine feeding is observed, however it is not actively sought out in the same way as cattle. 'Key resource' habitat patches do not exist to the same extent for goats; they are more reliant on browse.

Foraging distances

Herding tends to increase the foraging distance goats move. This occurred in all flocks with the exception of Clay 1 where essentially the same route is followed throughout the year. During the herding period goats are released later in the day, on the return of children from primary school. They are then often herded with the cattle during the afternoon and will therefore move further as a consequence.

Distances mapped out on aerial photograph traces are shown in Table 8.11.

Table 8.11: Goat foraging distances

Flock	Unherded August 87 Distance (m)	Radius Max (m)	Herded March 88 Distance (m)	Radius Max (m)
Clay 1	2937	875	2812	875
Clay 2	750	250	1625	406
Edge	2000	812	3625	1000
Sand	1937	812	3437	1125

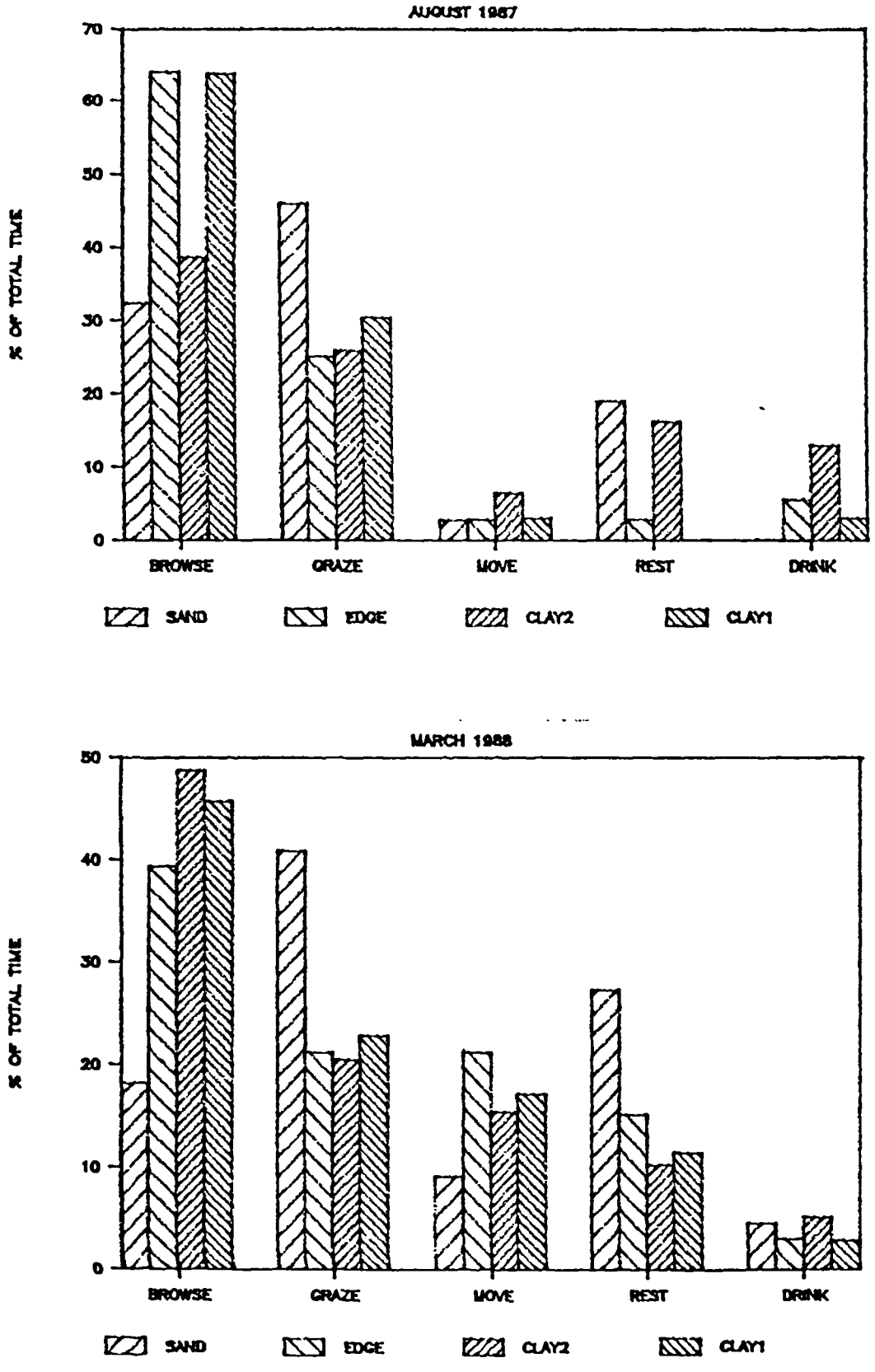
Sand/edge zone flocks show long travelling distances in the rainy season as they are herded away from the home/field areas. The longer foraging distances also reflect the different goat forage availability in the different zones - the lack of good browse in the sand veld zone means that fodder must be more actively sought than in the clay veld zone.

Goat activity patterns

Figure 8.11 shows the percentage total time out of the kraal spent on different activities. These are classified as browsing, grazing, moving, resting and drinking.

During the dry season observations (August 87), the sand veld flock spent more time grazing than browsing. This flock exhibited the lowest browsing time of all the flocks. This reflects the poor quality browse available in the sand veld area (8). The edge zone flock, restricted to the clay zone fields/home sites, essentially adopted a clay veld strategy for this period with higher levels of browsing. The clay veld flocks both browsed extensively, but flock 2 showed a lesser amount. This was due to the long time spent resting and drinking by the river.

Figure 8.11: Goat activity patterns in dry season (August 1987) and wet season (March 1988). Percentage of total time observed spent on different activities.



A very similar pattern of activities is shown in the wet season data. Due to the fact that the goats were being herded the amount of movement is increased. These findings reflect those of Sibanda (1987), where free ranging goats spent between 30% and 75% of available time browsing in Matopos thornveld (7). The trees that were observed being browsed are indicated in Table 8.12.

Table 8.12: Trees browsed by goats (observed during the goat following studies).

Sand veld	Clay veld
Brachystegia glaucescens	Colophospermum mopane
Julbernadia globiflora	Acacia tortilis
Boscia angustifolia	Combretum apiculatum
Strychnos spinosa	Acacia nilotica
Vangueria sp.	Combretum imberbe
Ficus sp.	Dichrostachys cinerea
Gardenia spatulifolia	

Although the diversity of tree species is greater in the sand veld (see Chapter 2), the quality and availability of their browse is not as high as in the clay veld. In particular the important pod production from Acacia species is absent in the sand veld. This encourages more grazing in the sand veld flocks. The breed of sand veld goats is also more adapted to a grazing habit (see Chapter 5).

8.11 Resource partioning and overlap

This Chapter has investigated the use of different habitat patches and plant types (grass vs trees) in cattle and goats. In this section the degree to which this foraging behaviour results in overlap of niche use and potential competition for forage resources will be briefly considered.

As topland forage resources decrease in quantity and

quality, cattle foraging increasingly becomes concentrated on the lower catenal key resources of riverine strips and vleis. Arable area forage, that becomes available in the early dry season, affects the switching to key resource habitats, but the general trend is clear. This pattern of resource use parallels closely that observed by Sinclair (1977) in his detailed study of the African buffalo. He notes:

> "As the grass dries out, becoming coarse and less nutritious in the non-riverine habitats, the buffalo move down the catena to the riverine habitats... Conversely, rain causes the animals to move back, but only after sufficient growth has taken place." (p. 80).

Goats show a much more localised use of habitats. Much of goat foraging is restricted to areas around homes; the use of 'key resource' areas is limited. Goats are less restricted by available plant biomass than cattle and can select browse, seed pods or fruits, as well as new green shoots in the wet season. The structure of the goat's mouth and its active foraging behaviour allows selectivity to maintain nutritional status in the face of decreasing availability of fodder and lowered nutritional value. Goats are thus able to survive in the areas around homes which are heavily grazed and browsed and unable to support cattle feeding to any significant extent.

Cattle are less selective feeders and must maintain high intake levels. Bulk feeding in the wet season and concentration of feeding in the dry season on particular patches that have relatively nutritious grass is critical to this strategy.

This parallels the feeding strategy of impala and buffalo in a mixed wildlife system (Jarman and Sinclair, 1979: 151), where potential competition increases as the impala follow the buffalo down the catena during the dry season.

> "The buffalo's strategy involves dispersion to many vegetation types in the rains, but retreat in the dry season to the only vegetation communities in which

> grasses are still long and partly green, where the animals exercise what selection they can by avoiding grasses with tough stems. Buffalo may have to leave some habitats in the dry season because the grass is too short...
>
> "...the largest species descend the catena soonest in the dry season, spend longest on the lowest catena and feed selectively on the large quantities of food available. The smallest species... utilise the upper catena longest, obtaining high quality diets by feeding selectively from vegetation left by larger species." (Jarman and Sinclair, 1979: 150)

Cattle too may also have to abandon 'key resources' if the areas get too heavily used, as happened in the clay veld riverine habitats. Donkeys are able then to use this short grassland; cattle thus act as grazing facilitators for donkeys in a grazing succession (cf. Vesey Fitzgerald, 1960). This has a negative effect on cattle forage supplies, as the short grassland is unable to recover before the next growing season with continued grazing by donkeys.

The degree to which goat and cattle foraging patterns overlap in a free ranging situation (it may be very different under paddocked conditions), is therefore quite limited. Competition may increase during the late dry season as animals congregate on the remaining lower catenal grazing resources, but the degree to which goats have access to such areas is limited by predation risk and herding patterns. The option of herded transhumance over wider areas adds further to the potential separation of resource niches between cattle and goats.

Donkeys may follow cattle onto grazing resource patches (particularly river banks) following cattle grazing and keep the sward short thus preventing further cattle feeding. This may imply some resource competition, but donkeys are very flexible feeders opting for sodic patches, home area grazing and particular browse species - resources used infrequently by cattle.

On the clay veld perhaps the most significant grazing competitor of cattle are harvester termites (Hodotermes mosambicensis). In dry years population eruptions occur and large amounts of grass are consumed (Bissett, 1981). Residents of the clay veld regularly comment on this:

> "An important reason why there is little grass in the deve (clay veld) is because of the matheza (termites). They cut huge piles of grass and leave it in heaps." (Livestock discussion workshop, Mototi, April, 1988).

The potential impact of arthropod competition and the uncertain nature of competition between stock, questions the advisability of aggregating livestock into common units for the assessment of carrying capacities.

8.12 The importance of key resources and flexible foraging strategies

The importance of responses to spatial heterogeneity of vegetation resources at different spatial scales - from micro-level patches to habitat patches to ecosystem level differences in savanna type - is critical to the understanding of livestock, and particularly cattle, survival strategies. This interaction between animal behaviour, management and the vegetation resource is the background on which the fundamental processes of population dynamics are set. This Chapter has emphasised the importance of flexible responses to habitat level variations in primary production and Chapter 7, in the context of extreme drought, has emphasised responses of movement between ecological zones.

An understanding of the ecological patterns of use of different animals therefore provides a basic rationale for local management strategies and some indicators as to where future directions in grazing management may lie. In discussions, farmers continually emphasise the importance of vlei/riverine grazing and browsing as central components of livestock management strategies. A series of discussion

workshops were held in different areas during the dry season of 1987 and the debate regularly emphasised these points. Two examples serve to illustrate the central themes:

> "Cattle like to come and graze in the vleis in the dry season. They get greener in August or so when the water starts to rise up. They really rely on the vleis for feeding. At this time the trees begin to shoot, so they survive very well." (Mapanzure workshop, Runde CA, 12.5.87)
>
> "At this time, cattle survive completely on the vleis. The cattle will remain in the vleis until ploughing. They will find plenty of bulk food, but not enough good quality to keep them strong. They will be alive though." (Mutonga workshop, Mazvihwa, 25.7.87)

Grazing management systems

Studies of wildlife ecology and increasingly pastoral herding management have emphasised the need to understand adaptive herding and grazing responses in the context of the patchy and variable environments of dryland areas (cf literature in Scoones, 1988b). However, the debate about grazing management in Zimbabwe has remained firmly in the range management tradition. The historical reasons for this have been discussed at length in Chapter 3; the practical outcome has been a concentration of research effort over 50 years on the comparative benefits of continuous versus rotational grazing and the weight gain responses of cattle to different paddocking configurations (9). The research is basically equivocal about the relative benefits of different grazing patterns (Gammon, 1978), although there has been a general belief generated that rotational systems are preferable in the long term (Gammon, 1983), but without substantive supporting evidence (10). Much of this research has been irrelevant to the communal area situation where the criterion for comparative assessment would not be weight gain but survival.

Paddock systems are designed for low intensity grazing systems where surplus fodder exists on topland areas and

the necessity of catenal shifts and 'key resource' utilisation (including browse) is not vital. It is only at higher stocking rates or in severe droughts that environmental patchiness is fully exposed. The importance of 'key resource' grazing and adaptive movement strategies in the past was much less in the communal areas (see Chapter 7). Low stocking rates meant that vlei grazing for instance was infrequently used. One farmer from a sand veld area recalls:

> "Long back the vleis were not used by animals; the grass was tall and the places wet. There was plenty of grass elsewhere." (Interview, Masinire, Chivi, 18.8.87)

The same applied to the clay veld area, where movement was rare and surplus biomass had to be cleared using fire. Only one farmer recalled movement out of the clay veld zone in Mazvihwa prior to the 1960s:

> "In 1933-4 there was no grass in the area due to the lack of rain and we had to move the cattle to Baradzamwa. Before this there was so much grass and the elders used to organise burning to get the green shoots." (Mr Chibidi, Mazvihwa, 29.6.87)

If paddocks or rotation regimes are not designed to 'fit' the scale of heterogeneity of natural habitat patches the options for adaptive resource use under higher stocking rates is severely limited. Most grazing schemes take a grid approach to design and recommend an inflexible rotation pattern. The findings of this research indicate the potential problems of such an approach. Local people often voice their own objections. A series of interviews were carried out in the adjacent Indava ward where a grazing scheme had been proposed. A number of recurrent themes emerged. These included: the need for larger grazing areas to make schemes operational, the futility of paddocking topland grazing areas where there is little grass, the importance of free movement to seek out grazing and the fear that grazing schemes were being used as a pretext for destocking. These criticisms were countered by positive suggestions that centred on the prospect of using fencing

to create improved dry season forage reserves (11):

> "The areas they want to make paddocks are very small. Also there is no grass in these areas. It's like putting a fence round this bare patch of ground here. It's better to let the animals wander free, otherwise they will stand there and die." (Interview, Manyarira, Indava ward, 5.6.87)

> "The paddocks will be there to fence the zvimhamhare soils (sodic areas), where from birth we have never seen any grass... but paddocks are just going to come, but they will not be of any use.... it is possible to fence off specific areas... where a lot of grass grows in summer ... like certain streams and other makawa (pans)" Interview, Vugwi, Indava ward, 6.6.87)

The need to consider the pattern and use of resources in the design of grazing shemes is highlighted by an example from a research station in southern Zimbabwe. An experimental grazing scheme being tested under communal area conditions at high stocking rates resulted in the death of a number of cattle. The scheme had not been designed with an idea of the local resource availability in mind. The critical 'key resource', a vlei, had been left out of the fenced areas and the grazing was constrained to topland grazing (that area formally designated as grazing land under government land use planning procedures). The fencing pattern had to be redesigned to avoid further deaths and later included a portion of the vlei area (12).

Poorly designed fencing patterns, reducing grazing flexibility in the dry season or movement between ecological zones, appear to be the major potential problems of grazing schemes. Such schemes are not wholly unpopular as they offer communities the opportunity to exclude others from their own grazing resource and to reduce the amount of herding labour by the division of the grazing and arable blocks with a fence (Cousins, 1988; 1987). However these benefits arise merely from the provision of a boundary fence rather than the subdivision of paddocks. The degree to which local grazing management committees will adapt to serious drought conditions, where movement of animals beyond a specified grazing boundary is required, remains

largely unknown.

Restrictions on movement of cattle are also imposed as a result of veterinary regulations. These have been in existence for some time, but have been recently tightened as a result of the government's beef export drive and the Foot and Mouth disease restrictions imposed by the EEC. The consequences of these limitations on movement have been discussed in the context of drought movement strategies in Chapter 7.

Bush clearance and the role of browse

Another implication of the beef management paradigm in Zimbabwean range research has been the concentration on grass to the exclusion of trees. Just as key grazing resources become more important as stocking rates increase or drought conditions continue, so does the browse resource. Browse is widely recognised as an important drought period fodder source, as well as an important high quality nutritional supplement. Zimbabwean range research has focused on the elimination of 'bush' (13), arguing that greater weight gains are achieved through bush clearance (14). This is certainly true, as the tree layer has undoubted competitive effects on grass production (although there are compensatory effects). However, it is in terms of survival at high stocking rates, rather than weight gains for beef production, that browse must be viewed in the CA context. Under 'ideal' conditions cattle are grazers, but under stressed conditions they switch effectively to browse.

The other factor that conventional range research omits is that the communal areas are a multi-species system - goats, donkeys and humans all make use of the tree resource. The low canopy level, coppiced structure of the communal area woodland is ideal for browsing. Since the area is well thinned due to continuous offtake for wood fuel and other wood products the decrease in grass production is probably

not that great (see Chapter 2; 15) compared to complete clearance.

In a discussion of the government's previous attempts to initiate a bush clearance programme in Mazvihwa (16) some local farmers explained the reason why the local people did not cooperate and the plan was abandoned. They went on to articulate their own preferred management strategy for the local Acacia woodland:

> "In this region the cutting of trees will be no good. The livestock rely heavily on trees here. They are very important in the dry season and droughts. It is a good idea to cut tall muvunga (Acacia sp.), because the ground will be shaded and there will be no grass and the tree will be too tall for the goats to eat. We should cut some old ones and leave the young ones. It is also best to cut those trees that do not produce pods. These are sought first when we look for trees for fencing. Second we choose the old shade casting trees leaving the young pod bearing trees to last." (Interview, Mr Bwoni and Mr Hoto, Mototi, Mazvihwa)

8.13 Implications for livestock and grazing management

The importance of developing grazing and browsing management strategies that tie in with the understanding of local ecological processes and local perceptions of priorities should be clear. However it is not easy. In some ways, local grazing management strategies do already attempt to regulate and manage the use of 'key resource' areas (17). Certainly browse species promotion and vlei management is high on the local agenda (18).

Local grazing management systems

The discussion of the clay veld 1 herd management during 1987 highlighted a number of issues surrounding the tensions of local management attempts which centred on the reservation of arable area drainage grazing. Local people argue that this form of 'deferred grazing' with a seasonal rotation between arable and grazing land resources is

critical to sustaining stock and the vegetation resource. An elderly local of this area explained his rationale for the system:

> "We should ensure that cattle are kept within the grazing area for the ploughing season. People should not take cattle into the fields, including the drains, as this will deplete the grass seeds. In the dry season the cattle should be in the fields and drains where they eat the dry seeds and spread them throughout the grazing area. The alternative paddocking system is definitely no good as it involves alot of work." (Mr Bwoni Snr, Mototi, 21.1.87)

The local drainage line in this area is usually protected from wet season and outsider use and reserved for critical dry season grazing. However two pressures combined to make this 'ideal' fall apart during 1987. The first was the resource crisis felt during the wet season, in part because of the exhaustion of local river grazing by cattle from Chivi across the river and the inability of the local lineage cluster, and even the ward councillor who lives locally, to prevent this. This precipitated the early use of the drainage line by local cattle. Later in the season the invasion of other cattle from elsewhere in the ward meant that the area ended up providing very little end of dry season fodder.

A similar situation has resulted in severe tensions between different communities in an area a few kilometres away in the edge zone. Here, the ruling lineage group tries to control a stream/drainage line system within the grazing area for dry season grazing. However immigrant groups living close to Mototi township with a very constrained grazing resource have, in several consecutive seasons, attempted to use this area as soon as grazing has been depleted in their allocated grazing land. Members of the ruling lineage have been powerless to prevent this as the offending group includes influential members of the new political order (20). A leading member of the ruling lineage reflects on the situation in 1987:

> "The drains were the places reserved for dry season

> grazing. Those people who sent their cattle into these areas found themselves fined by the headman. These days, people graze their cattle in the drainage areas as a sign of disobedience." (Mr Magaya, Marozve, 27.8.87)

Despite a series of negotiations and the offer by the ruling lineage group to the others of joint management for the dry season and open use of the extensive sand veld grazing land, no solution was reached and the dispute was still simmering into 1989 (21).

Exclusivity of grazing land is particularly limited in times of drought. During 1982-4 the huge flood of cattle that migrated to the sand veld hills resulted in a good deal of discontent among those resident there as they perceived the presence of many cattle from the clay veld precipitating the decline of their own animals. However, as they point out, it was impossible to refuse. Many were linked through kinship with members of the clay veld lineages (who migrated away from the sand veld themselves, see Chapter 3), others were friends clearly in need of help. Discussions held in the sand veld area at the onset of the 1987 drought reflected upon this experience and a loose agreement was reached in one valley that a restriction on influx would be imposed. This persisted through the drought, but in other areas cattle from across the clay veld moved without restriction (22). A farmer from the sand veld explained his discontent in terms of the break down of reciprocity in resource sharing:

> "The reason why we in the makomo [sand veld zone] are no longer happy is that the cattle are sent to the makomo and are just left there for the time of the drought. When the drought ends all the cattle are taken and those who looked after them in the makomo are just left to farm on their own." (Mr Kembo, Group workshop, Mototi, April 1988).

The observations of recent years are reflected in historical recollections. People say that the Chivi people were discouraged from grazing across the river in the distant past, but there were no sanctions against them.

Within the Mazvihwa area there was a situation of almost complete open access. People comment that cattle could wander anywhere, because there was plenty of surplus grazing in the past.

In practice, grazing was generally restricted to relatively small areas around lineage cluster homesteads that became locally associated with a particular named grazing area (Scoones and Wilson, 1988). However there was always massive overlap, as the attempts at demarcation of grazing scheme boundaries have vividly shown (23). Despite some claims to the contrary (eg Holleman, 1969), there is no evidence of local 'wards' acting as resource management units (Scoones and Wilson, 1988).

The institutional requirements for successful common property management at the whole grazing area level appear to be absent in many of the communal areas of southern Zimbabwe. These would include - potentially exclusive resource endowments, stable institutions for management, the ability to apply sanctions and sufficient land resources for successful production (cf. Runge, 1986). Despite this, some communities have achieved successful grazing scheme establishment, although a basic precondition appears to be a local resource surplus - land remains the key issue in the grazing debate (Cousins, 1988).

'Key resource' grazing management

An option that has not been tried would be to focus on enhancing local management of the 'key resource' areas, rather than attempting to manage exclusively whole grazing areas. For it is these areas that are central to existing management systems and have been linked to local land use politics through spiritual-religious association (Mukamuri, 1988; 24).

Reflecting on past practice and potential future management, farmers commented in a series of interviews

about the potential for regulating use of vleis and other particular key resources. This usually involved the use of fences, which some in discussion objected to (25). In Chivi, people regulated the use of vleis for grazing during the period after the ban on agriculture was imposed and before the areas were completely fenced off (between late 1940s and early 1950s). The local councillor explained the system:

> "Cattle were kept off the vleis until the people had collected the grass and reeds for other purposes; only then were cattle allowed on for dry season grazing." (Interview, 26.8.87)

Elsewhere another farmer independently suggested that:

> "The vleis must be fenced off to some extent, so that cattle do not eat the grass in the rainy season. Cattle then can be allowed on in the dry season." (Chitaro, Chibvumba, 5.8.87)

In the past such a system occurred by default during the government's attempts to restrict vlei use of any sort. The DC of Chibi despairingly recounts the situation:

> "The fences.. were all broken down to give cattle access during the drought... once the fences were repaired the herd boys put the stock inside the fence to ease herding." (DC Chibi, 1964)

8.14 Are 'key resources' sustaining CA livestock populations?

The question 'how and why do the herds keep growing?' has been a recurrent theme in this thesis. The exploration of foraging behaviour pursued in this Chapter has offered a partial answer in terms of the opportunistic and adaptive response of populations to a spatially and temporally heterogeneous environment. 'Key resource' use and the other components of grazing and management strategies combine to ensure that livestock populations can be kept at high population densities (see Chapter 4). The 'carrying capacity' level is ultimately determined by the availability and production of 'key resources' in the dry

seasons of dry years. As long as local environmental heterogeneity ensures reserve forage and movement between zones or to particular forage patches is permitted, the calls for destocking (27) can be restrained. A similar situation applies to wildlife populations:

> "Culling is ecologically unnecessary where sufficient spatial heterogeneity exists to provide reserve forage. Some drought related mortality is natural and probably beneficial to both plant and animal populations." (Walker et al, 1987: 381).

The question now arises: can the CAs continue to sustain high populations of animals into the future? What are the limits? The argument that follows from the analysis of this Chapter is that a highly disaggregated approach to land units is needed to assess the potential environmental impacts of high stocking rates. Putman argues the case on the basis of a study of grazing ecology in the New Forest, England:

> "Grazing animals do not use all habitats equally and .. some sustain much higher impact than others. Further, different patches of the same community type suffer different grazing pressures dependent on their juxtaposition with other communities or geographical position.." (Putman, 1986: 189).

If key grazing resources are degraded through inappropriate or excessive use the continued effectiveness of existing management strategies in sustaining livestock populations may become threatened. The consequences of not managing 'key resources' thus may be significant in terms of the longer term sustainability of the system. A greater knowledge of the potential uses and risks of use of 'key resource' systems is needed before advances can be made. This issue will be considered in the next Chapter.

Footnotes

1. This study was carried out with the assistance of Johnson Madyakuseni and the cooperation of the herd owners at Magwidi, Saul Jim, Madyakuseni and Chikudo.

2. Intervals used in other studies of cattle foraging behaviour have varied between 1 min and 30 mins. Rollinson et al (1956) investigated the error increase between observation intervals of 1 min and 4 min and showed there was only marginally increased error. It is thought that the error included in this study will be larger, but the general pattern of behaviour portrayed.

3. The rambotemwa is a portion of protected woodland thought to be associated with the grave sites of earlier inhabitants of the area. There were restrictions on use and entry of rambotemwa in the past, although many of these practices have died out (Mukamuri, 1988). It escaped the widespread cutting of the early colonial period and only recently has been cut to any great extent. As a consequence the woodland is more mature than other parts of the topland grazing area.

4. Bare rock is estimated by Agritex in land-use planning exercises to be anywhere between 10 and 35% of total area in the granitic hill zones of the region.

5. Reduced watering frequencies in pastoral situations to one watering every 3-4 days have been found to have little effect on animal productivity (King, 1983).

6. Crop residues tend to be low in protein and phospherous and high in lignin and fibre. However there is considerable variation between individual plant parts, different plants, alternative varieties and species of crop. This offers the opportunity for selection by animals or management by owners (Van Soest, 1988).

7. Different studies referred to the quality of different plant parts. Ruterford (1979) refers to leaves and twigs, Barnes (1982) to leaf material only and the others to browseable plant parts, including presumably both leaves and twigs. Chemical analysis techniques are rarely identical in different laboratories, so this adds another source of error to any comparison between studies.

8. The goat following studies were undertaken by Tavengwa Chifamba Jnr and Vengesai Ndhlovu with the kind cooperation of the owners.

9. In terms of goat browse the sand veld trees are poor both in structure and composition. The higher growth form

restricts grazing and the lack of Acacia species is also a deterrent.

10. The general pattern of the Zimbabwean studies is reflected in the foraging strategies found elsewhere. The major difference is that in herded pastoral situations goats range over far wider areas (Malechek and Provenza, 1983).

11. The history of grazing management research in Zimbabwe dates back to the early experiments at the Matopos research station (Haylett, 1932), prompted by the enthusiasm for rotational paddocked grazing system in South Africa (Pole Evans, 1932). Long term experiments were established at a number of research stations in Zimbabwe (Kennan, 1969).

The most significant research into grazing management in the dryland areas occurred during the 60s and 70s at Matopos research station. Research on paddock configurations during the 1970s was a major feature (Denny, Barnes and Kennan, 1977; Denny and Steyn, 1977; Denny and Barnes, 1977), but the studies were not particularly conclusive.

A parallel debate has been the importance of short duration grazing (Savory, 1978; Savory, 1988) in multi-paddocked systems at high stocking rates. The Charter trials investigated the potential during a period of unusually high rainfall (Gammon, 1984). More recent research has shed doubt on the advisability of using the disturbance regime proposed by Savory (Salihi and Norton, 1987).

12. Denny and colleagues (eg. 1980/1) report in the Livestock and Pasture sections annual reports over a number of years on the progress of the Matopos continuous vs rotational grazing experiments. They conclude that there is no demonstrated advantage of rotational grazing in terms of animal production and that changes in grass species compostion can be attributed to rainfall rather than grazing management. These findings parallel the Australian research findings (Wilson, Harrington and Beale, 1984). This is reflected in the detailed grazing studies of Gammón (1976), where he shows that continuous grazing does not result in repeated grazing of grass tillers and that in terms of grass production and composition rotational and continuous systems have comparable effects. Despite these results, Gammon (1983) still argues for rotational grazing

system assuming that they have benefical effects on range condition in the long term.

13. This experience was recounted by James Gambiza during a visit to Makaholi field station in February 1987.

14. The beef export quota to the EEC allowed under the Lome Convention requires stringent health restrictions. As a consequence the Veterinary department has divided the country up into Foot and Mouth risk areas, buffer areas and free areas. Beef is only allowed to be exported from FMD free areas. Cattle are not allowed to move between these zones and fences have been erected to restrict such movement with EEC finance.

15. The theme of 'bush control' in Zimbabwean range research has been around since the 1940s (Weinman, 1948) and has persisted as a central component of the recommendations of grazing management to the present (West, 1958; Teague, 1973; Hill, 1984). Experimental work has shifted from clearing experiments (Plowes, 1956) to ringbarking (Ward and Cleghorn, 1964) to chemical control.

16. Gammon (1983) argues that "the increase in quantity and quality of herbage produces as a result of bush clearing far outweighs the benefit of browse for cattle." Dye and Spear (1983) show that throughout a range in rainfall from 185 to 750mm the yield of cleared veld is 2-3 times higher than uncleared veld. Barnes (1982: 628) provides comparable data from a number of sites in Zimbabwe.

17. Kelly, Schwim and Barnes (1978) show that selective clearing of shrubs and small trees (stem diameter less than 10cm at 20cm from the ground) in a clay veld area (Tuli) produces 56% of the increased yield of complete clearing, while maintaining the benefits of tree cover (for browse, termite control, shade etc.)

18. Bush control became central to the government policy agenda for grazing management during the 1950s. Vigorous policies were promoted in many areas, but the response was not good.

19. Mike Drinkwater (1988) provides a detailed case study of the local attempts at key resource control in Chirumhanzu.

20. The community discussions that led up to the start of the ENDA-Zimbabwe community management of indigenous woodland project continually emphasised the role of browse in the community planting and management plans. Similarly, workshops held during the establishement of the Zvishavane Water Resources Project focussed on the importance of management and utilisation of vleis for grazing and agriculture.

21. Immigrants in this area have been elected to the local Village Development Committee and Councillor posts. These are the new structures along with the linked party cell structure that officially holds administrative power following independence.

22. This is based on a discussion with Mathou Chakavanda in April 1989.

23. Cattle moved from Indava ward into Murowa and Mutambi wards during 1987. They tended not to migrate up into the hills, but moved to the lower sand veld areas.

24. Cousins (1988, in prep) has shown the prevalence of boundary disputes in new grazing schemes. The attempts at establishment of the Indava ward grazing scheme has resulted in long protracted wrangles between different protagonists. The fence line on one boundary was eventually fixed by complex negotation and the incorporation of a disenchanted group (from outside the ward) into the scheme. In areas where particularly valuable grazing is found (eg along the Gwenombe river) the implementing officials have not been able to resolve boundary conflicts and have so far avoided erecting the fence line (Interview with Mr Maraga, Agritex EW, April, 1989).

25. A consideration of the local spiritual-political significance of wetland patches is beyond the scope of this thesis, but has been documented in detail for the study area by Billy Mukamuri (1988). Vleis, springs, pans, river ponds, woodland patches and certain mountains are all known to be associated in particular circumstances with spiritual-political significance. As these areas are also key grazing resources in many instances, the implications for local management of local lineage based political control of such resources is important to consider.

26. Since it was the vleis with particular local spiritual-

political significance that were fenced off, older people objected to the introduction of a modern (European) fence into a sacred place. Such places are believed to be guarded by spirit guardians (mermaids, snakes etc) and so protected from damage without the aid of a fence (Group discussion, Masinire, Chivi, 18.9.87).

27. Destocking is seen as possibly necessary in the First Five Year Development Plan and the National Conservation Strategy.

9. DEGRADATION AND LIVESTOCK PRODUCTION

9.1 Introduction

High populations of livestock have been maintained in the communal areas, but what are the long term consequences of this? Is degradation occurring? This Chapter considers evidence of degradation of livestock systems in the CAs of southern Zimbabwe by looking at changes in primary and secondary production over time and by investigating erosion patterns in grazing lands.

What is degradation?

An appropriate definition of degradation is needed before an assessment can be made. As Chapter 2 emphasised, savanna systems are typically resilient; permanent shifts to lower levels of productivity due to shocks and stresses to the system are thought to be rare; indeed resilience may in fact increase with higher stocking rates (Walker, 1980b).

Following Abel and Blaikie (in press), range degradation can be defined as:

> "An effectively permanent decline in the rate at which the land yields livestock products under a given management system".

In the case of the agropastoral system of the CAs the whole range of livestock products and services, including draft power, transport, milk and meat, are of concern (see Chapter 5).

Permanent changes in the productivity of the vegetation will affect the yields of livestock products. However the detection of trends in primary production due to factors other than interannual or cyclical rainfall changes is difficult. Temporary shifts in primary productivity or species composition should not be taken as evidence for degradation. Evidence of degradation from vegetation

monitoring can thus only be expected from long term studies.

The same applies to investigating shifts in secondary production. Changes in livestock productivity parameters due to changed rainfall conditions does not constitute evidence for degradation. In the same way, changes in parameters due to changes in population density (eg. depressed birth rates at high stocking levels) does not represent evidence of degradation of potential production, as long as no permanent shift in the relationship occurs. For instance, if stocking rates are reduced and birth rates return to previous levels, then permanent changes in system productivity have not occurred as a result of a period of high stocking rates.

Spatial and temporal scales must also be considered. The spatial dynamics of degradation is relevant in relation to the role of 'key resources'. For instance, some topland areas may be subject to losses of productivity but erosion/deposition processes may result in increases in production elsewhere. By contrast, if 'key resource' areas suffer irreversible losses of productivity, this may be critical for overall system sustainability, even though the area is small.

Temporal scale is also significant in terms of understanding what 'irreversible' or 'permanent' means. The variability of production levels in the savanna agroecosystems of the study areas has been a recurrent theme of the previous discussions; such variations may also have a cyclical nature. The time scale over which measurements are made is therefore critical in detecting long term trends over noise produced by interannual variations (1).

Although 'degradation', defined in terms of say soil loss, may be occurring the impact on secondary production is likely to be obscure. There may be a long lead time before

any effects are felt. Even though ostensibly irreversible changes are occurring the impact, within reasonable planning time frames, may be insignificant and the cost of alleviating the 'degradation' may far exceed its impact.

Degradation is thus a complex concept, requiring precise definition in a way appropriate to the system under consideration. This Chapter will consider a range of evidence from the agropastoral system of the study areas. The following sections will review the debate about degradation and livestock in the CAs and then turn to examining some of the evidence from the study areas. First evidence of changes in primary production will be considered. This is then followed by an investigation of changing patterns of secondary production. Finally local perceptions of degradation processes are considered with an examination of the potential impact of erosion on livestock production.

9.2 The degradation debate

Claims of 'degradation' in the Communal Areas date back to the early colonial period (Watt, 1913; Haviland, 1928). At this time, concern about the impact of the new settler farms and ranches was also expressed (Beinart, 1984). As Chapter 3 has discussed, official alarm reached its height during the 1930s and 1940s when land-use and livestock policy increasingly included environmental protection as an explicit aim. The destocking policies were the culmination of this trend. Confident statements were made that irreversible damage was being caused and permanent productivity declines were imminent. Dr. O. West comments in his Pasture Officer's report after a visit to Belingwe reserve in 1948:

> "[The grazing areas] have by continuous heavy grazing every growing season year after year, been pushed to a point from which, if relief is not afforded very soon, deterioration will become increasingly rapid."

Since then, others have come to similar conclusions.

Cleghorn (1966) concluded that nearly half of the Communal Lands were bare or overgrazed (2), while Whitlow (1988) reports that over 80% of 'eroded' land in the country is within the Communal Lands (3). These views are reflected in current government policy, which puts tackling environmental degradation in the CAs at a high priority for policy action (eg. Government of Zimbabwe, 1986 (The first Five Year Development Plan); Government of Zimbabwe, 1987 (The National Conservation Strategy))

There is no question that significant erosion occurs within the communal areas of Zimbabwe, caused in part by livestock. This has been demonstrated in a number of studies (Stocking, 1972; Whitlow, 1988). In particular parts of the country, such as the Save valley, the problem is acute (Campbell et al, 1988). The question is not whether erosion or vegetation changes, occur since they undoubtedly do, both through 'natural' and human induced processes. The question is rather what are the implications for livestock production and so peoples' livelihoods?

Much of the confusion and dispute over 'degradation' centres on this question. As discussed in Chapters 2 to 4, conventional range assessment measures that are widely used to gauge whether 'degradation' is occurring are not necessarily applicable to the CA agropastoral system. They tend to assume a vegetation-herbivore equilibrium coincident with a conservative, beef ranching 'ideal', and deviations from this are taken to be evidence of 'degradation'. However as previous Chapters have shown, the nature of the agropastoral livestock economy is such that high stocking rates are required; this results in less vegetation biomass and (probably) more erosion (4). The question is can these levels be sustained?

9.3 Changes in primary production

Degradation will be detected by primary production studies when long term reductions in productivity are observed,

that are independent of rainfall variation and that have a negative effect of the output of the livestock sector.

Chapter 2 has shown how variations in primary production are primarily affected by rainfall, but mediated by soil type. Range experiments carried out over many years are equivocal about irreversible changes in potential productivity (O'Connor, 1985; (5)); although changes in species composition do occur. No long term primary production data exists for CAs, although there are many reports of areas, especially on clay veld savanna, where 'degraded patches' exist due to changes in physical soil properties (MacDonald, 1978), which can only be reversed by ripping and reseeding. Areas of high stock concentrations around kraals, dip tanks or watering points are obvious examples.

Kelly (1973) studied primary production ecology at a number of different sites of different land-uses in SE Zimbabwe (6). He claimed that the high stocking rates of the CAs had resulted in degradation. However no indication is given as to the effects of observed differences (between CAs and wildlife/ranch systems) in grass species (annuals rather than perennials in the CAs), litter cover (less in the CAs) and infiltration rates (lower in the CAs) on secondary production. The study is thus inconclusive with regard to the sustainability of livestock production in the communal areas (7).

Thirteen seasons later the same sites were relocated by De Jager (1988) and similar measures made. However no evidence of directional trends could be found; each site had undergone a range of quite unpredictable changes often due to the interaction of rare events (eg. fire, high levels of herbivory etc.). Current status in variable savanna systems is thus often the result of chance interaction of different factors that may act cumulatively, but do not predictably follow any trend.

9.4 Changes in secondary production

Degradation will be detected in studies of secondary production when long term changes in output (measured by birth rates, extraction rates, draft productivity etc.) that are independent of variations in rainfall and animal densities are found.

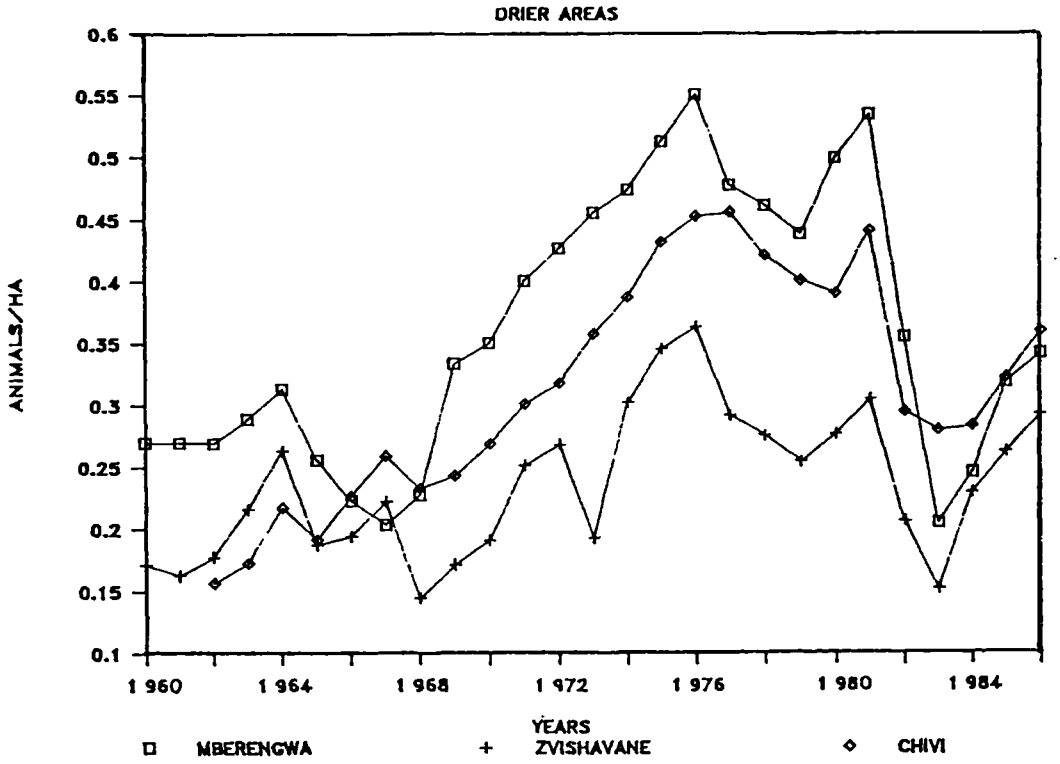
The time series data on livestock populations for the study areas can be investigated to see if permanent changes in secondary production can be detected. The period between 1960 and 1986 will be taken for detailed examination; a subset of the longer time series analysed in Chapters 3 and 4.

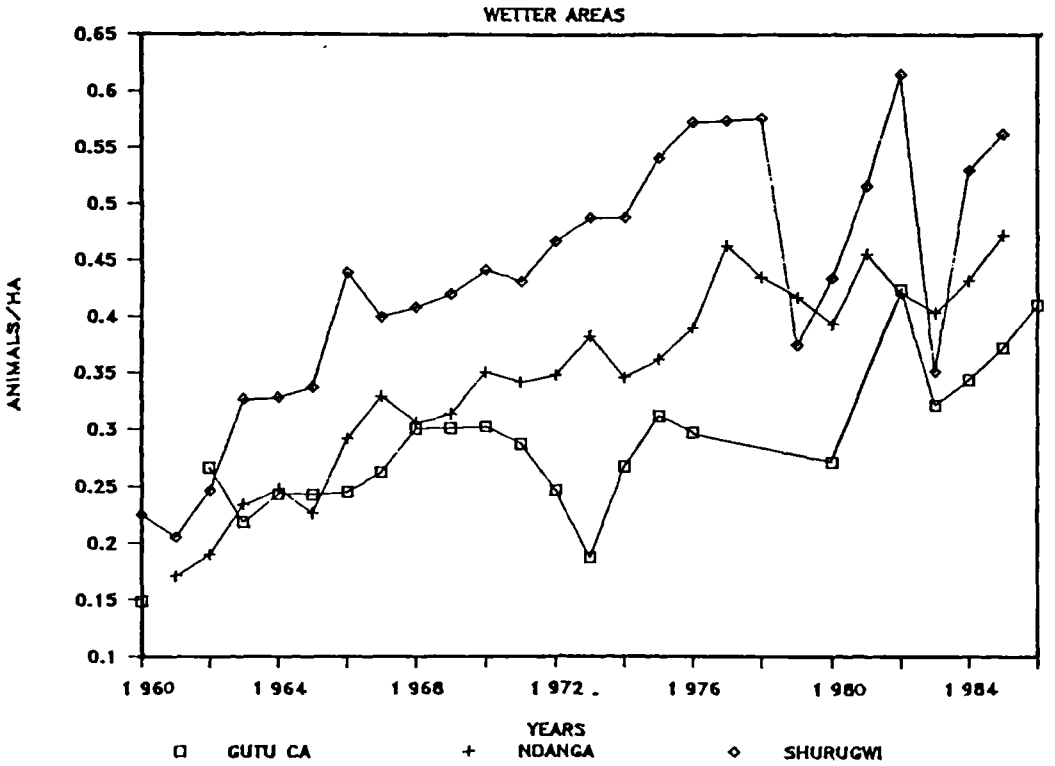
Changes in cattle population density

An examination of the trends in population density for each of the regional study areas was carried out for the period between 1965 and 1986. Figures 9.1 and 9.2 show the cattle population for each of the regional study areas between 1960 and 1986. Following the stress years of 1965 and 1968 (see Chapter 4), populations rose steadily through the 1970s to reach high population levels during this wet period (see Appendix 1). This was reduced during the late 1970s by the impact of disease with the breakdown of dipping services in the war. During the early 1980s, populations declined significantly due to drought, but have begun to recover since.

There was no trend in annual rainfall for the period overall (correlations of rainfall with time all insignificant), so any population density trend could possibly be attributed to changes in the potential carrying capacity of the land, rather than rainfall induced changes. Regression analyses showed slight (but insignificant) positive increases in population density over the period for all areas.

Figure 9.1: Changes in cattle population densities (1960-1986): a. Drier areas; b. Wetter areas.





It appears therefore that population levels (variable with rainfall) have been maintained over the past 25 years. No indication of changes in potential population levels are observed, suggesting that degradation processes are not having an impact on the ability of cattle populations to be maintained at high levels.

Although the numbers of animals are being maintained, the data gives no indication of quality (in terms of weight, ability to pull ploughs, milk production etc.); it is quite plausible that 'degradation' of the natural resource base will be felt in terms of these factors first, before any declines in numbers (8).

Changes in herd productivity parameters

For Swaziland, Fowler (1981) argues that increasing grazing pressure has resulted in decreased birth and extraction rates (9) from the Swazi Nation cattle herd and recommends control of stock numbers. Declining calving percentages and increased death rates since the drought years of the mid-1960s have resulted in a decreased extraction rate. From 1967 to 1980 the herd increased, but the rate of increased tailed off as death rates increased and birth rates decreased; some form of density dependent regulation is observed.

Although the population density at which maximum offtake is achieved was exceeded during this period for the aggregate national herd, this does not imply that permanent changes in potential system productivity had occurred. A reduction in stock density would increase the aggregate herd's technical efficiency in terms of beef production. However, economic output should not be measured soley in terms of beef sales and herd increment (extraction rates), as other outputs, such as draft power, may be increased at higher population densities. As argued in Chapter 4, a reduction in population to a conservative stocking level for maximising beef output would be inappropriate in the

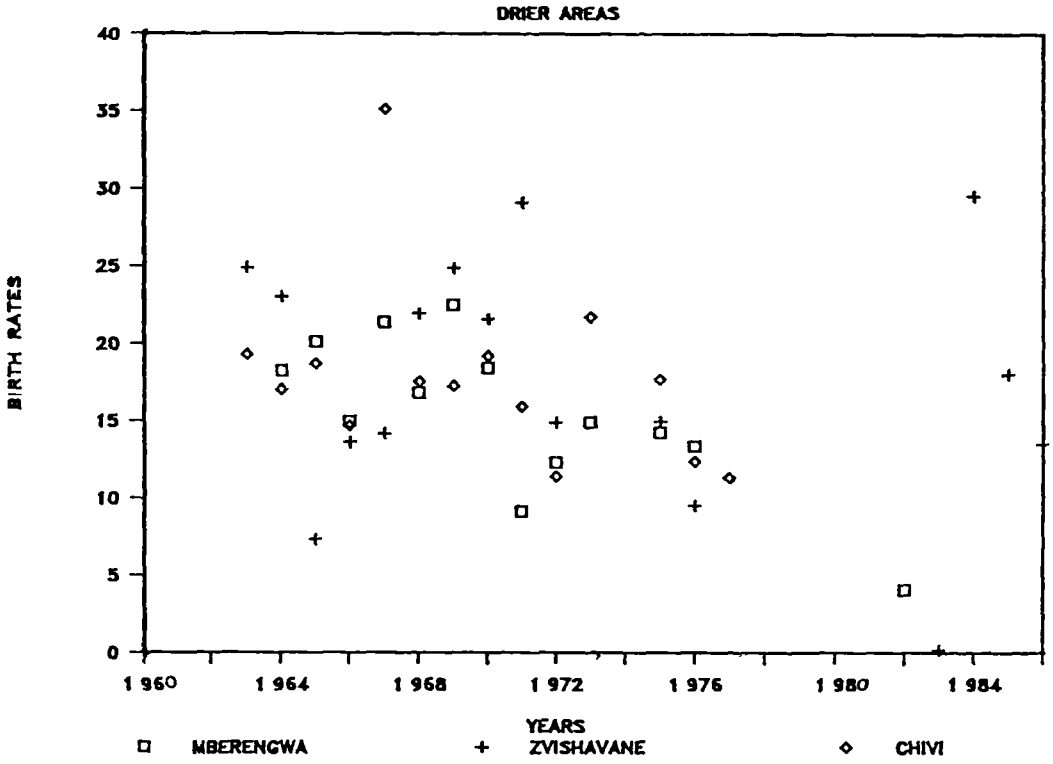
Zimbabwe CA context. It is high population levels that maximise economic returns for cattle (Chapter 5).

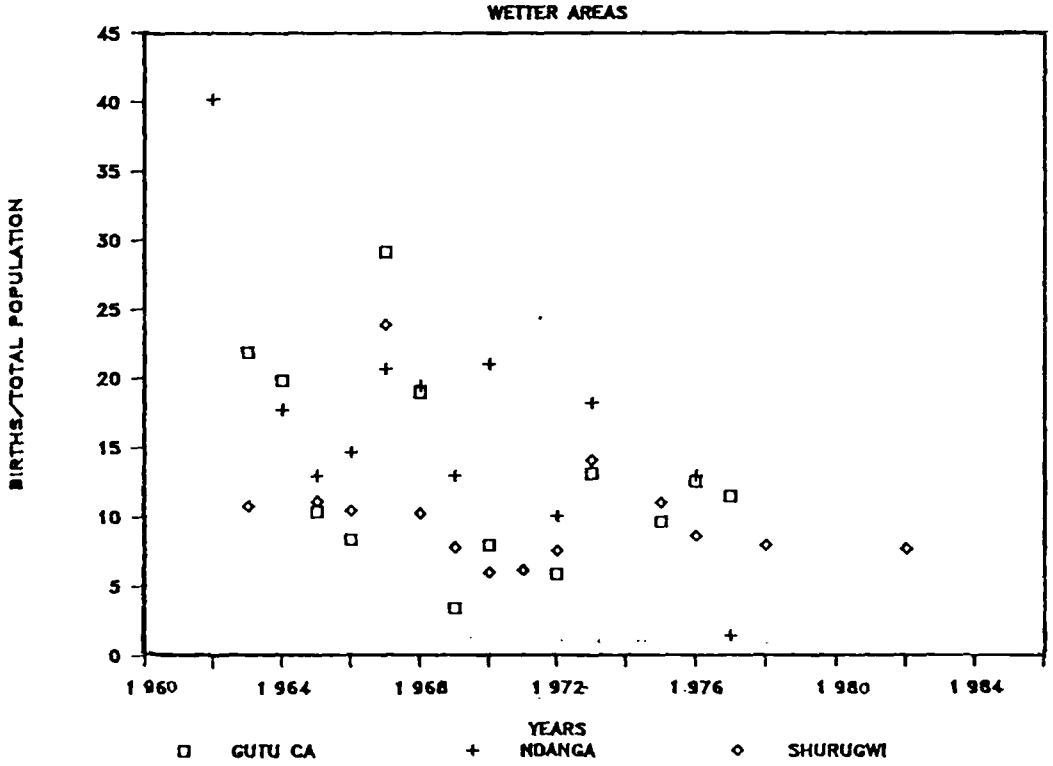
In the study areas similar parameters can be estimated. Birth and death rates of cattle populations in the wetter and drier regional study areas were examined for the period 1961-80; a subset of the data examined in Chapter 4. Figures 9.3 and 9.4 show the changes in birth and death rates over this period for all areas. Data on birth rates for Mazvihwa (Zvishavane District) are included from the dip data (see Chapter 7) for the period from 1983-1986. Birth rates, death rates and rainfall levels are correlated with time to investigate temporal trends in Table 9.1, between 1961 and 1980 (the period after destocking). As in previous sections, the drier CAs are contrasted with the wetter areas in the regional study area.

Table 9.1: Temporal trends in birth rates, death rates, stocking rates and rainfall levels (1961-80)

	N	Correln	Significance
Birth rates:			
Drier areas	43	-0.33	0.016
Wetter areas	57	-0.42	0.001
Death rates:			
Drier areas	60	+0.18	0.07
Wetter areas	49	+0.03	NS
Stocking rates (1/density):			
Drier areas	60	-0.37	0.000
Wetter areas	60	-0.70	0.000
Rainfall:			
Drier areas	60	+0.36	0.000
Wetter areas	60	+0.45	0.000

Figure 9.2: Birth rates of cattle population (Numbers of calves as percentage of total population at start of year): a. Drier areas; b. Wetter areas (1960-1980).



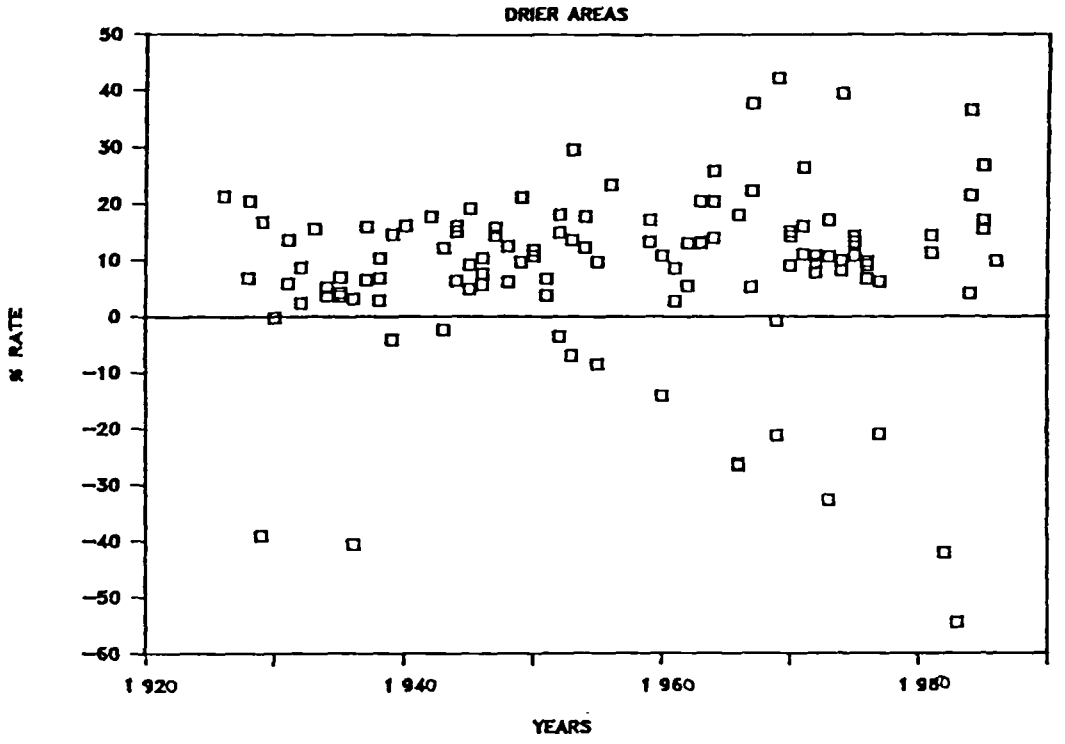


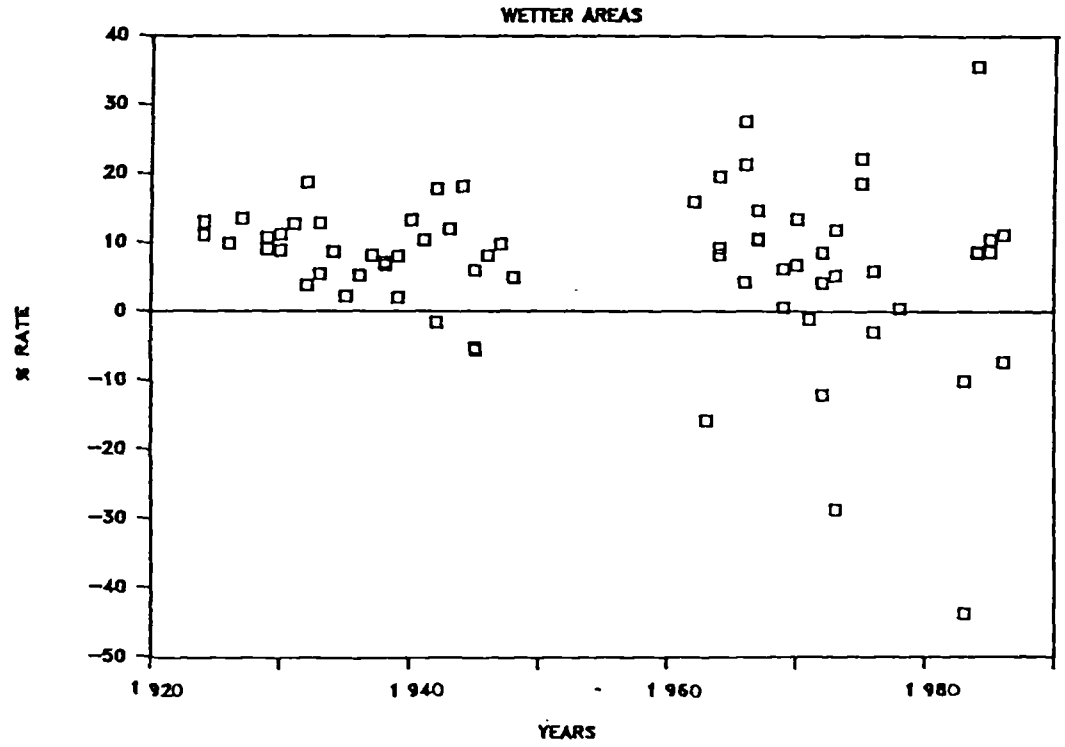
These results highlight some interesting patterns. This was a period of increasing rainfall, especially in the late 1970s (10) and increasing cattle population densities. Birth rates declined in both areas between 1961 an 1980. Birth rates declined while rainfall increased in both areas for this period, suggesting that it was probably the increases in cattle density that resulted in the lowered birth rates. This coincides with the conclusions of Chapter 4. Death rates do not show clear trends. The high death rates in the drought years of the mid-60s and early 1970s, particularly in the drier areas, give rise to the basic pattern observed. However, as noted in Chapter 4, density dependent processes do appear to operate in non-stress years.

It appears that the depression of birth raes during the 1960s and 1970s is a density dependent phenomenon. There is no evidence that there has been a permanent change in the form of the relationship between birth rates and animal density. Indeed a consideration of the period after 1980 demonstrates a pattern of recovery following the reduction of livestock populations through drought. As documented in Chapter 7, populations crashed during 1982-3 and again in 1987-8, as a result of drought impact. Lower densities in the 1980s have meant increased birth rates (11) and low non-stress year death rates, with populations rapidly recovering, at least in part through intrinsic growth. It seems that the depression of birth rates during the 1970s was therefore not a permanent phenomenon, resulting from the reduction of potential through degradation.

The level of extraction rate (sales plus herd increment rate) for the study area cattle populations between 1923 and 1986 is shown in Figures 9.5 and 9.6. The herd reductions due to drought in the 1930s, 1960s and 1980s are shown, as well as the depression of population growth during the 1970s due to disease factors.

Figure 9.3: Extraction rates of cattle population (Numbers sold plus herd increment as percentage of total population at start of year): a. Drier areas; b. Wetter areas (1923-1986)





For both drier and wetter areas, there is no significant trend in extraction rate over time. Correlations of extraction rate with time were insignificant for both areas and for both 1923-86 and 1961-80. According to Jarvis (1984), stable or increasing extraction rate, as shown for this data, provides evidence that there is no (economically defined) 'overgrazing' (12).

Increasing cattle densities resulted in lower birth rates, yet cattle populations continued to grow in absolute numbers and sales rates were maintained. Following the collapse in cattle populations during the 1980s, birth rates increased and death rates dropped. Cattle populations have been increasing rapidly. The existing data on production parameters from the study areas therefore cannot be used as evidence for degradation.

Cumulative overstocking and degradation?

An assessment using the study area data was carried out to test the cumulative degradation model developed by Child (1988). He found, for a commercial beef ranch in SE Zimbabwe (comparable to some parts of the drier study areas), that changes of reproductive performance (calves per cow) were largely independent of both rainfall and current stocking rate, but related to a measure of cumulative overstocking for the period 1960-86 (13). This was found to be an important variable in explaining reductions in reproductive performance (independent of management) from the 1960s. This is offered as evidence of degradation in the cattle section, not seen in the adjacent area where game ranching is practised (14).

Following Child, but using study area data, annual carrying capacities are calculated according to a version of Coe et al's (1976) rainfall-animal density equation (15). In each year the difference between actual and carrying capacity stocking levels is calculated. This difference relates to the annual level of under- or overstocking. These values

are summed cumulatively over the period 1961-1980 and related to birth rates for the period.

Figures 9.4 a and c show the pattern of annual under/overstocking in the study areas according to this model between 1960 and 1986. In the case of Zvishavane district, the population fluctuates between years of overstocking (droughts) and understocking (wetter years), highlighting the importance of an opportunistic strategy for management. The Mberengwa and Chivi populations increase to a higher level during the 1970s and fluctuate at levels assumed to be above the annual 'carrying capacity'. When a cumulative assessment of under/overstocking is made, this is emphasised as sequential years of apparent 'overstocking' have occured (Figure 9.4b.

The wetter study areas show a different pattern. Up to the mid-70s annual under/overstocking levels fluctuate approximately around the assumed annual 'carrying capacity' level, but the rainfall in the late 1970s meant that the areas were apparently understocked during this period. This pattern was reversed in the early 1980s when rainfall again declined (see Figure9.4c). The 'understocking' of the 1970s means that if a cumulative assessment is made, the Gutu and Shurugwi populations show no patterns of overstocking during the period; Ndanga only becomes 'overstocked' during the 1980s according to this model (see Figure9.4d).

Birth rates of the two areas can be related to the pattern of cumulative stocking rates. Table 9.2 shows the relationship between birth rate and stocking rate for the wetter and drier areas between 1961 and 1980 and for the wetter areas between 1961 and 1986.

Figure 9.4: Under and overstocking and cumulative stocking rates according to rainfall derived carrying capacity estimates (kg/ha) between 1960 and 1986: a. Under-overstocking in drier areas; b. Cumulative stocking rates (drier areas); c. Under-overstocking (wetter areas); d. Cumulative stocking (wetter areas).

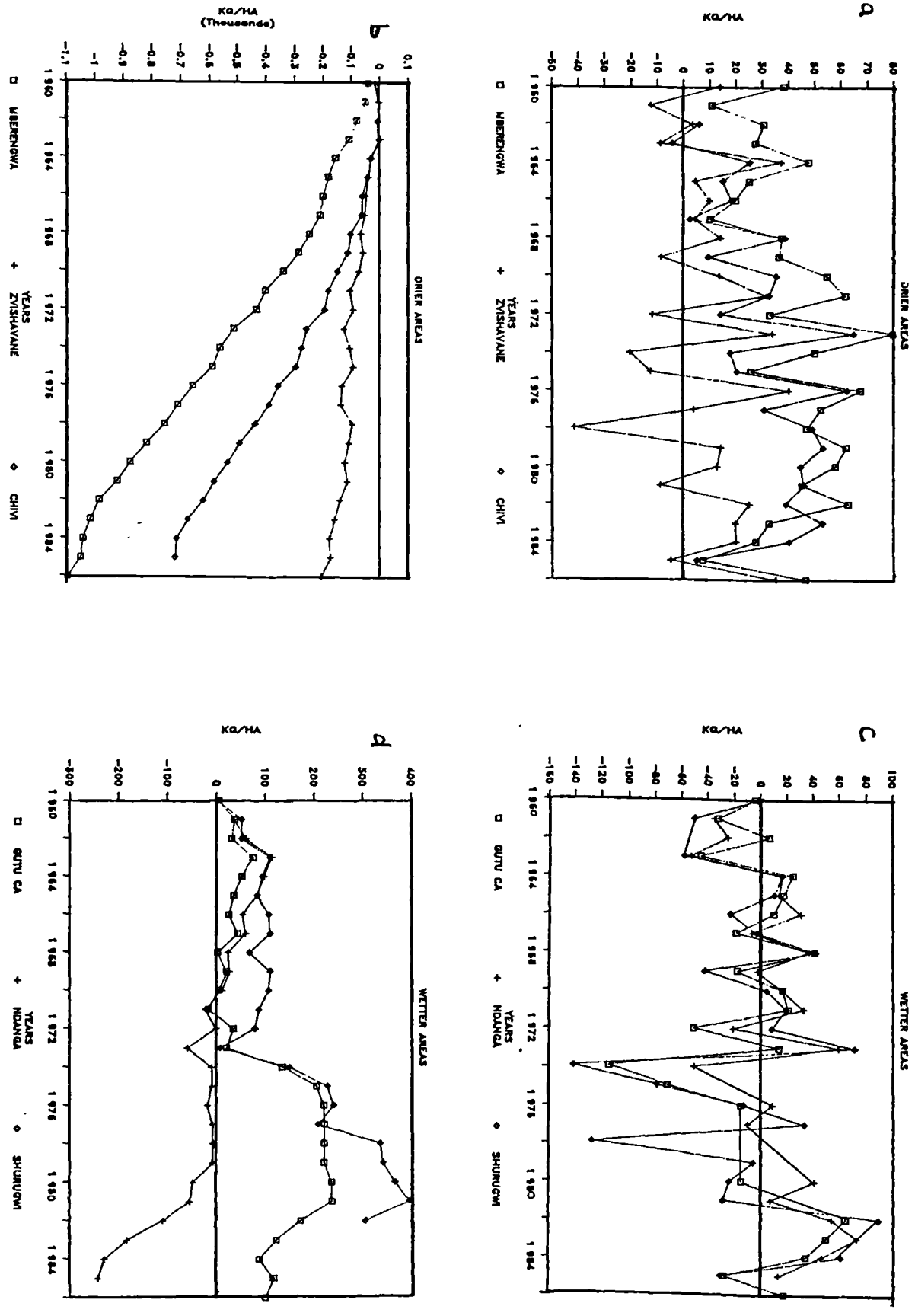


Table 9.2: Relationships between Birth rate and Cumulative stocking rate: 1960 - 1980

	N	Correl	Sig
Drier Areas	43	+0.41	0.003
Wetter Areas	49	-0.17	NS

In the drier areas the decline in birth rates between 1960 and 1980 is correlated with the observed cumulative overstocking level, as Child (1988: 433) found for the ranching system. However, if the birth rates in the period following the 1982-4 drought are considered, these show a significant recovery (11); a pattern not observed in the ranching system. This suggests that the resilience of the CA production system has been maintained and the lower densities following drought mortality allowed recovery. The patterns observed for the study areas between 1960 and 1980 are thus simple density dependent responses, with changes in birth rates best explained by density changes - a pattern apparently not shown for the ranching system.

The pattern in the wetter areas is again different. Despite apparent cumulative understocking, birth rates still declined during the period. Stock densities increased during the period and the increased primary production supposedly arising from the higher rainfall was not sufficient to compensate. It may be that the rainfall-carrying capacity relationship breaks down under these wetter conditions (16). Although no data is presented here, qualitative information suggests that calving rates increased dramatically following the 1982-4 drought (17); showing a similar density dependent pattern of recovery as that observed in the drier areas. Again birth rate changes can best be explained by changes in animal density.

Although elements of the pattern observed by Child for a

commercial cattle ranch and the CA situation are the same (notably for the drier areas), the conclusion that permanent degradation has occurred as a result of high stocking rates in the 1970s cannot be sustained for the CAs. This may be because the CA data set is too aggregated and its quality does not match the detailed farm records used by Child. However, the possibility should not be discarded that different processes are being observed in the two areas.

Following Walker's (1980b) argument (see Chapter 2), under high, unstable stocking rates over some time, the rangelands of the CAs may have become more resilient. Changes in grass species composition to swards with larger, ungrazeable reserves or to rapidly recovering annual components may have combined with changes in woodland structure to allow increased browse potential. The selection of hardier animals will have also added to the increased resilience of the CA system. The ranch lands by contrast may have become more suscpetible to shocks and stresses, and the apparent permanent decline in birth rates observed by Child during the 1960s-80s may be a symptom of this.

Instability of fodder resource availability is a feature of the CA system (especially in the drier areas). Coping with this instability is central to livestock owners' opportunistic strategies in these areas. Moving animals out of the area or to particular 'key resource' areas, combined with the mortalities observed in the CAs (see Chapter 7 and 8) will result in a lower impact on grazing resources in the critical drought years when stocking rates exceed annual 'carrying capacity'. Longer term cyclical changes in population parameters in relation to wetter or drier periods will also have an adjustment effect. The environmental costs of an opportunistic strategy are increased when the lag time for adjustment is large. This is particularly a problem in the clay veld savannas of the drier areas which appear to be more susceptible to the

impacts of high stocking rates (Chapter 2). These impacts may have been compounded in a ranching system in dry clay veld savanna, where movement is restricted (by paddocks) and high mortality levels averted by supplementary feeding.

9.5 Local perceptions of environmental change

Discussions with informants in the Mazvihwa sample focussed on local perceptions of primary production change and degradation. They emphasised the resilience of the grassland system. Variations in available production (standing crop) was seen to be highly dependent on rainfall, although affected by a range of other factors including the impact of herbivores (cattle and termites). 57 people were asked the open ended question: what are the reasons for the lack of grass? The reasons given and the percentage of all respondents mentioning them are given in Table 9.3.

Table 9.3: Reasons for lack of grass standing crop: local perceptions.

Reason for lack of grass	% of respondents
1. Lack of rainfall	96.5
2. Too many cattle	29.8
3. Termites	22.8
4= Fewer trees	8.8
4= Land exhaustion	8.8
6 Less grazing area	5.3
7= Settlement patterns	3.5
7= Hot sun	3.5
9= Thatching grass	1.7
9= Lack of paddocking	1.7

Fluctuations in rainfall dominate local peoples' understanding of savanna ecology; herbivores act to modify the system by removing biomass. People do not deny that

higher cattle populations result in the removal of more grass (in combination with harvester termites on the clay veld), but they do dispute that grazing results in major irreversible effects, except in particular instances. These perceptions reflect, in large part, the agroecological range management view (see Chapter 2).

Only two reasons were given that represented permanent changes in land productivity. Land exhaustion was given as a reason by some informants resident on the sand veld, where there is a sense that long term use (including previous cultivation) has resulted in fewer nutrients in the soil (7). The removal of trees was also mentioned as a factor resulting in permanent shifts towards reduced grass production. People recognise that some trees promote grass (see Appendix 3), but trees (particularly large trees) are also linked with rainfall (Mukamuri, 1988; (18)).

Following this discussion about the reasons for lack of grass, a follow-up question was asked: if rain returns, will grass return - where and where not? This was seen by many as a rather ridiculous question, as the unanimous verdict was that grass would return to previous levels following drought. To emphasise the point people recounted the rapid recovery of grasslands following the 1984-5 rains, saying that, even in the bare yards of their home compounds, grass sprouted in profusion. However a number of people added certain caveats to this conclusion. There are particular areas where grass will not return. These include areas where people are concentrated together (the 'lines'), sodic patches in the Mopane veld and paths where cattle walk to the river (19). These are the patches that people recognise as being permanently 'degraded'.

A number of discussions moved on to the issue of compositional change of grassland. Despite much debate everyone insisted that changes in grass species (notably the disappearance of Hyparrhenia sp.) was exclusively due to rainfall changes. No-one would accept the idea that

heavy, selective grazing would result in such changes.

Although local people say that grass production and so 'carrying capacity' is determined by rainfall and that, for the most part, high cattle populations do not result in permanent damage to the environment, there is a level of awareness (20) about the problems of soil erosion in the grazing land. This was expressed in a series of discussions with members of the sample households in Mazvihwa.

A simple discussion point started the debate - people were asked to describe the major reasons for erosion in the grazing land. This sometimes initiated a detailed explanation for the evolution of a particular gully with the various factors causing its growth described. Table 9.4 combines all the responses from 44 different discussions, indicating an overall prioritisation of causal effect.

Table 9.4: Reasons for erosion in the grazing area: local perceptions

Reasons for erosion in grazing area	% of respondents
Cattle paths	63.6
Heavy rain	27.3
Sledges	25.0
No grass due to no rain	22.7
Contour ridges	13.6
Lack of trees	9.1
Wind	9.1
Fields in drainage lines	4.5
Settlement lines	2.3
Underground water	2.3

According to local views, erosion is caused by a complex interaction of factors (21). Cattle paths to watering points are the most frequent causal factor mentioned, but the incidence of concentrated paths is related to

settlement patterns and the system for arable-grazing land allocation. Abiotic factors are also mentioned such as the incidence of heavy rain or strong winds, following a period of drought where grass cover is reduced. Illegal activities, such as the use of sledges (dragged by animals) or the cultivation of some drainage lines are also acknowledged.

The pattern of utilisation of the landscape is seen to be critical. In historical reflections of changes observed, people note that the concentration of settlements into lines, the movement of fields higher up the catena and the poor construction of contour ridges and drainage channels resulted in large increases in soil erosion. This was particularly so in the clay veld area of Mazvihwa, where centralisation was most thoroughly implemented (see Chapter 3). Concentrations of water, people and stock have been the major cause of soil erosion according to local impressions.

The processes of erosion and siltation resulting from changes in land use, notably the movement of arable land up the watershed into concentrated blocks and the establishment of contour ridges, are regularly mentioned in discussions:

> "Long back the water used to run anywhere over the land, but now after the contours, the water runs in large, concentrated amounts." (Mr Masoche, Gundekunde, Mazvihwa, 9.8.87)
>
> "The first time we noticed gullies was when the contours were introduced. The river has filled with sand since that time. The contours deposit water into streams near the fields, which go to the grazing areas and cause gullies there." (Mai Vafi, Mazvihwa, 27.5.87)
>
> "The country got torn when the place was cut with contours." (Mr Magaya, Marozve, 27.8.87)

The land question is clearly central to the whole issue of degradation in the communal areas. The allocation of 'reserve' land to the hilly, poor soil areas and the squeeze of population into small areas with the

establishment of European settlement in 'the farms' are common themes:

> "The reason why the Europeans don't cause soil erosion is that they don't farm the sloping areas. It is the Africans who have been told to farm these areas and are blamed for soil erosion." (Group Discussion, Mukwakwe, 26.8.87)

> "When the farms came the people saw the problem of overpopulation. When a farm gets into a place with people, that land will be dying". (Mr Masoche, Gundekunde, 9.8.87)

The interaction of rainfall, trees and land is complex in local perceptions of environmental process, and directly linked to the role of spirit guardianship in land protection (18):

> "If you maintain the forests the rain will continue to come, so renewing the area. When you see a place get no rain it will be getting old." (Mr Masoche, Gundekunde, 9.8.87)

An apparent contradiction exists between the observation of soil erosion, yet the maintenance of cattle populations at high levels, apparently without long term negative effects on potential productivity. The implication is that, although erosion exists, its impact is not seriously felt. A consideration of temporal and spatial scales of soil losses provides some help in resolving the issue.

9.6 Temporal and spatial dimensions to degradation

The temporal dimension of degradation has been investigated by Biot (1988) through the development of erosion-production models of economic soil lifespan. His models show that, on deep soils in Botswana rangelands, the existing net soil losses will only result in a serious loss of primary (and so secondary) production after 400-500 years. On some soil types in Zimbabwe similar patterns may be occurring. Reduction of stocking rates will reduce the net loss of soil, but the economic cost of such measures

will likely be far higher than the net gains in production realised only over a very long time frame. In other words, the impact on lowered secondary production is minimal over reasonable planning horizons.

Abel and Blaikie (1988) apply a simple model of stocking rate - vegetation cover - erosion rate to data from some Zimbabwean CAs. They show that stocking rate reductions would have to be very large to realise even small increases in herbaceous cover and marginal reductions in erosion cover. They conclude that such destocking exercises would not be acceptable (22).

A consideration of spatial scale focuses attention on where erosion is occurring. Gullies formed as a result of cattle paths across topland grazing areas, or sheet erosion derived from bare areas around settlements, may have limited impact on overall grazing potential. This contention is supported by the observations of cattle foraging behaviour reported in Chapter 8. It is 'key resource' grazing areas that provide the most significant contribution to cattle feeding and so ultimately determine the potential 'carrying capacity' of the land, as it is these areas that provide end of dry season or drought fodder. Reduced primary production of an area of topland will have a lesser impact than reduced primary production of an equivalent 'key resource' area. Erosion processes on the topland may actually increase the potential of bottomland key resource areas through deposition and accumulation (23; See Chapter 2).

The most direct link between the physical environment and impact on secondary production would appear to be through changes in the production potential of key resource areas. An important mechanism by which livestock populations have been maintained at high levels would appear to be the use of key grazing resources. The explanation of the apparent contradiction presented above could lie in the fact that sufficient key resource areas of high production potential

have been maintained within the study areas, so keeping population levels higher than conventional analyses would expect. The analysis presented in Chapter 8 would suggest that reduced production potential in such areas will have a significant impact. These arguments are difficult to test, but the logic suggests a concentration of attention on key resource degradation.

Erosion processes in vleis was discussed in Chapter 2. The advancement of headward gully erosion in vlei areas is a potential problem. Grazing vleis are particularly susceptible to erosion of this sort (Theisen and Marasha, 1976; (24)). Similarly gully erosion on river banks and along drainage lines caused by cattle paths and wet season use is also a potential threat to system resilience (25). The development of local management systems (26) that regulate wet season use of such areas, in relation to local stocking rates, seasonal primary production levels and availability of alternative topland grazing would seem a more viable option than the alternatives of either destocking or total restriction of use of key resources that have been employed in the past (see Chapter 3). Such a system would be in line with existing management practices of opportunistic use of grazing resources and allow the maintenance of high animal densities.

9.7 Economics and land degradation

Changes in vegetation and erosion of soils are part of the natural processes of savanna ecosystems. A pragmatic approach to the question of degradation is to investigate the impact of such processes on the resilience of the system and the ability to continue providing livestock products. Dixon et al (1989: 52-3) take an economic perspective to dryland degradation:

> "In some cases, it will not be worthwhile to invest in rehabilitation, even if the land subsequently does become irreversibly degraded. If the costs of

> protection outweigh the potential benefits, it may not pay to prevent further damage. Policies should not be based simply on reversing or arresting degradation itself, but rather on making the best economic use of resources available.... The choice of which lands to rehabilitate, which lands to protect from further degradation and which lands to allow to degrade is a key issue in the development and management of dryland areas".

The indications are that livestock densities have been maintained successfully in the study areas under high stocking rates with opportunistic management strategies. However it is not known how the costs of such a strategy will affect production (in terms of both numbers and quality) in the more distant future on the different savanna types of the study area. There is a need therefore to continue monitoring production levels through a period of recovery induced by higher rainfall levels (as is apparently occurring now) to see if there are any indications of reduced production potential. This needs to be linked to an investigation of production-erosion relations (eg. relating economic production to soil life models) to get an idea of the relative flows of costs and benefits of different management strategies over time (27). This needs to take a spatial dimension, differentiating between the 'option value' (Seckler, 1987) of different components of the environment (eg. topland vs. 'key resources') for sustaining livestock production.

Footnotes

1. The whole 'desertification' debate hinges on the issue of detection of trend from variation caused by 'normal' fluctuations in the environment (Warren and Agnew, 1988). Only with long term data on primary or secondary production can any conclusions be drawn. The few studies that have been carried out (eg. Alchrona, 1988; Hellden, 1984 for the Sudan) have not pointed to many changes that cannot be explained by annual rainfall variations.

2. Cleghorn's (1966) regularly quoted study was carried out on the basis of a questionnaire survey of District officials who were asked to classify the grazing condition

of the reserves into 'bare', 'very overgrazed', 'moderate' or 'good'. The utility of such a one off assessment should be seriously questioned.

3. Whitlow's (1988) study was carried out nationally on behalf of the Department of Natural Resources. A grid square analysis of aerial photographs were used to gauge whether the site fitted into one of several erosion classes. The photographs used were largely taken between 1980 and 1984, which included the period of serious drought. As the report acknowledges, the high levels of erosion observed in the Communal Lands is in part due to their geographical position (granitic, hilly country), as well as the impact of human induced factors. There is also the problem of comparison between areas, when detection levels vary due to tree cover, resulting in underestimates of erosion levels in forested commercial farms or National Parks.

4. The relationship between rainfall, vegetation cover, soil type, slope and erosion level has been modelled in the Soil Loss Estimation Model for Southern Africa (SLEMSA) (Elwell and Stocking, 1982), and tested on sand veld croplands. This model has been also extended for use in rangelands in Botswana (Abel and Stocking, 1987) and used for national erosion hazard mapping in Zimbabwe (Stocking and Elwell, 1973).

5. Long term herbivore impacts are also highly dependent on soil type (see Chapter 2). Barnes (1965) showed that 15 years of high stocking levels on sand veld did not result in significant changes, while on clay veld soils at Matopos, high stocking rates may result in long term lowering of production due to vegetation and soil changes (Carew, 1976).

6. The four land use types studied by Kelly (1973) were: no use in a tsetse corridor; light use by wild herbivores in a cattle/game ranch; moderate use by cattle in a cattle/game ranch and intensive use by cattle and goats in Matibi No. 2 CA. The Communal Area sites were estimated to have a stocking rate of 1LU/4-5 ha, however the choice of one site next to a fence, en route to water, probably meant that intensity of use was higher. Each site was chosen to have similar soil depths and woody vegetation and a range of soil and vegetation measures were taken over two seasons.

7. The long term nutrient depletion of sand veld communal area grazing lands is a subject that has not been investigated. The flow of nutrients from soil to vegetation to animal and then (at least in part) to kraal and field areas is one that could in the long term undermine the sustainability of the system (Swift et al, 1988). This may be ameliorated by the effect of trees (Gambiza, 1987).

8. Although ensuring sufficient numbers of cattle is central to local economic objectives, these animals must be able to provide productive services. This trade-off between stocking density and output has been explored for weight gain rates, but not in terms of draft efficiency, manure output and other factors. The availability of draft animals in good condition to respond to the onset of the first rains is often critical to agricultural success in these drier areas where a 'response farming' system operates.

9. Extraction rates refer to the number of slaughtered/sold animals plus the change in the herd inventory as a proportion of the total herd. It is regarded as a good measure of technical efficiency as it includes inventory changes. Jarvis (1984) uses this as an economic measure of evidence of 'overgrazing'.

10. Following the droughts of the mid-60s and early 70s the rest of the decade had high levels of rainfall (see Appendix 1).

11. Post drought recovery is shown for Zvishavane District, from data derived from Mazvihwa dip tanks (average of clay and sand veld areas). Following birth rates (No births/total population) of 0.4% in 1983/4, there were birth rates of 29% and 18% in the following two years. In terms of calves/cow (where cows = 28.7% of the total population (see Chapter 5)), this represents calving rates of 100% and 63%. The calving rate (calf/cow) for the ranch area studied by Child (1989) was between 26 and 32% for this period. Recovery levels in Runde, Chivi and Mberengwa were equivalent to this according to dip record data. However this data has not been completely analysed so is not presented here.

12. Jarvis and Erickson (1986) claim a rising extraction rate. For national figures they show that between 1950-59, the rate was 12.5% and between 1968-77 it was 15.0%.

13. The calculation of cumulative stocking rates makes certain assumptions. It assumes that a year of annual 'over/understocking' results in an additive increase/decrease of the level of cumulative impact. For instance 1 year of 10% overstocking followed by 1 year of 10% understocking will have no net effect. This may be too simplistic an assumption about the processes of herbivore-range interaction.

14. Taylor and Walker's (1978) study of vegetation indicators on the two section of the same ranch (Buffalo Range, near Chiredzi) showed that the cattle section had better 'range condition' than the game section in 1973. This they attribute to the regulated movement of cattle. A repeat survey during 1987 found that in the cattle section there had been a decrease in cover abundance, a decrease in litter cover, a decrease in grass height and an increase in soil capping since 1973. In the game section, these indicators had either improved or not changed significantly. Child (1988: 380) argues that a trend of degradation is being observed in the cattle section, but not in the game section.

15. The equation used by Child (1988) is used here. It is:

$$\text{Log } (H) = 1.685 \log (\text{rainfall}) - 1.095$$

Where: H = kg/km^2 and rainfall is annual precipitation in mm. Animal numbers are converted to kg weight by assuming that 1 animal is on average 200kg. This may be an underestimate in the drier areas, however this assumption does not affect the pattern observed.

16. Coe et al (1976) suggest that the carrying capacity-rainfall relationship they presented may not work in areas of higher rainfall (above about 800mm).

17. Recovery levels for the wetter areas cannot be assessed quantitatively as I do not have dip records for this area. However, discussions with farmers in Shurugwi suggested that birth rates were very high following the good rains of 1984-5 and GTZ (1987) reports that between 23% and 34% of the cattle population were 'young stock' indicating significant births in previous years.

18. Large trees (as well as mountains) are associated with rainfall provision. Spirit guardians, linked to local

lineage ancestors, are associated with such resources (Mukamuri, 1988).

19. Stocking (1977) has discussed the mechanisms through which run off from sodic patches can result in spectacular erosion. Stocking (1972) discusses the range of human induced erosion impacts, including the siting of dip tanks, watering points and settlement sites.

20. Discussing soil erosion is a sensitive matter in rural Zimbabwe. Environmental legislation has meant that people have been policed for years. Most are aware of the rules although they may vehemently disagree with them. The discussions held with sample households were mostly open and honest, with a free discussion of the impact of contour ridges, sledges and fields in drainage areas (all serious areas of contention).

21. Wilson (1988) has discussed in much more detail the perceptions of soil erosion and measures to combat it. This is based on a set of interviews of local people living in the clay veld area of Mazvihwa. Many of the same themes emerged during a series of discussions and interviews with people in different parts of Mazvihwa during the dry season of 1987. Many of these interviews were skilfully conducted by Billy Mukamuri.

22. Abel and Blaikie (1988) develop a series of simple models that relate soil loss to effective vegetation cover. A relation between vegetation cover and biomass is then used to assess the relationship between stocking rate (as related to available plant biomass) and soil loss. If a static relationship is assumed, the benefits in terms of soil loss reduction due to different levels of destocking can be investigated. Due to the negative exponential form of the relationships, destocking, when the vegetation cover is very poor, may result in some soil loss reduction. However, under most conditions the cost of a stocking rate reduction of 49% to acheive a 5% increase in herbaceous cover is a very heavy cost.

24. Such landscape level erosion processes may be critical in the evolution of 'key resource' areas in the first place. Such patches may not be fixed but change over time (see Chapter 2).

25. The heavily used Muchekwachekwa grazing vlei discussed

in Chapter 8 is an example of potential 'key resource' degradation. High use rates over many years resulted in a short grass sward, a certain amount of soil churning around a well and the initiation of a gully due to the movement of cattle from kraals in the edge zone coming to graze the vlei. Following the heavy rains of 1988, a large portion of this vlei was washed away and the gully moved headward by about 50m. The consequences for local cattle grazing is unknown, but the old well site now no longer exists.

26. The heavy use of the clay veld site (1) drainage line during the 1987 was documented in Chapter 8. This resulted in the creation of a series of paths through the area and the potential for high erosion levels. A visit during 1989, showed that most areas had regained dense grass cover, but some remained bare.

27. A discussion of local grazing management systems is beyond the scope of this thesis, but a discussion is included in Scoones and Wilson (1988). The key issue is whether existing territorial control of the grazing resource, in terms of neighbourhood grazing areas, could become a focus for 'key resource' management, building on the practice of lineage control of such areas (see Chapter 8 and Mukamuri, 1988). These may form an alternative to, or component of, grazing schemes currently proposed, which attempt to demarcate complete boundaries (Scoones, 1987).

28. An economic approach to assessing degradation would involve the calculations of benefit and cost flows. The benefits of livestock production (per unit area) have been discussed in Chapter 5. A critical additional issue is the trade-off between increased density and the flow of benefits over time. Environmental costs are more difficult to quantify, but a production-erosion model, such as developed by Biot (1988), would be useful. Following this, decisions about the discounting of cost/benefit flows must be made to ensure intergenerational equity. This discussion is beyond the scope of this thesis, but is examined at length in Barbier (1989), Pearce et al (1988) and Dixon et al (1989).

10. CONCLUSION: ISSUES FOR POLICY

This concluding Chapter summarises some of the central themes developed during the previous pages and addresses briefly the policy implications of these. This is not intended as an in-depth policy analysis, rather an attempt to pursue some of the general conclusions of the research towards a preliminary assessment of practical implications for CA livestock policies. A more complete treatment of some of the wider policy implications of this analysis has been attempted in Scoones and Wilson (1988).

This Chapter returns to an assessment of the trade-offs between the agroecosystem properties - productivity, stability, sustainability and equitability. This provides the basis for examining the central conclusions in relation to range management, livestock management and economic issues. Only with the complementary insight from economic and ecological analyses, combined with farmer perspectives and historical investigations, does the significance some of these issues come to light.

10.1. Agroecosystem properties

Productivity

The assessment of livestock productivity presented in Chapter 5 found that, if the full range of livestock functions was taken into account, the level of productivity on a per animal and per hectare basis is significantly higher than if measures solely geared to meat production are used. The ability to stock at high levels is essential to overall livestock productivity. Chapters 3 and 4 demonstrated that CA cattle owners are not primarily beef producers and that sale levels remain low for sound economic reasons. Measures of production appropriate to the agropastoral systems of the CAs are needed that recognise that cattle and donkeys provide primarily service functions, while goats are important for meat production

and sale.

Productivity varies significantly between savanna types, with primary production of crops and grassland being potentially highest in the clay veld area or in vlei patches in the sand veld. Higher quality fodder values of clay veld grass and browse complement this (Chapter 2). These ecological contrasts are reflected in the structure of the livestock communities in different zones, with goats thriving particularly in the clay veld (Chapter 8).

Stability

The variability of primary and secondary production also differ between savanna types. The instability of primary production in the clay veld means that cattle populations do not reach high potential densities due to the effect of droughts (Chapter 4). The more stable production in the sand veld, added to by the importance of 'key resource' grazing in vleis (Chapters 2 and 8), means that cattle survive better in this zone, especially in times of drought (Chapter 7).

The pattern of livestock production is reflected in comparisons of crop production variability across different savanna types. Unstable production in the clay veld means there is a greater need to seek alternative off-farm income sources and store grain than in the sand veld, where crop production is more stable. This in turn affects livestock investment and disposal patterns in different zones (Chapter 6).

Livestock management strategies in all zones are characterised by opportunistic responses to environmental variability. This includes the use of browse, stover and 'key resource' grazing (Chapter 8). In serious droughts the strategy of cattle movement is particularly important in the clay veld (Chapter 7).

Sustainability

Savanna grazing systems appear to be remarkably resilient, especially in sand veld zones. Stocking rates in the study areas have been maintained at high levels for some time with no evidence of long term, permanent impacts on secondary productivity. This is despite extensive evidence for soil erosion in these areas. The impacts of erosion processes on livestock production are unclear in terms of both economic costs and the time frame over which impacts are felt (Chapter 9).

Livestock populations are sustained by the availability of fodder resources at the end of the dry season or in drought years. A major reason why stock populations have been maintained at high levels that keep growing seems to be the continued availability of 'key resources' - vleis, river bank grazing etc (for cattle in particular) and browse (for goats in particular; Chapter 8). Changes in the availability of these resources is critical to understanding 'degradation' in CA livestock systems (Chapter 9).

Equitability

Factors of production - land, labour, equipment, cattle and income are distributed highly inequitably. Comparisons of different wealth groups in the Mazvihwa sample shows that agricultural output, food security status and income and expenditure patterns are all highly differentiated. This interacts with differences in production noted between ecological zones. Of particular importance is the role of remittance incomes to the rural economy and so the consequences of differentiation in the urban economy (Chapter 6).

These differences in household economy affect the patterns

of investment and disposal of livestock, and so provide some explanation of the variation around generalised bioeconomic models of livestock population change (Chapter 4).

Inequalities of ownership at the household level are counteracted by cooperative relationships of herding and sharing of stock within household clusters and loaning of animals between households. Equitability thus needs to be understood in the context of the lineage mode of production (Chapter 6).

10.2 Livestock populations and household economy

The linkage between livestock populations and household economy is thus different between different ecological zones and different wealth groups. Identifying these groups is helpful in understanding the range of interactions between ecology and economy and the implications for livelihood strategies. Different groups, identified within the Mazvihwa household sample (Chapter 6), can be identified in terms of contrasts in both their mean levels of income and its variance; that is in terms of both productivity and stability. Gupta (1985, 1989) provides a useful classification into which the analysis presented here fits. Figure 10.1 presents the contrast between ecological zone and wealth group in terms of mean and variance income levels.

Figure 10.1 Socio-ecological differentiation in income patterns (after Gupta, 1985).

	High mean income	Low mean income
High variance income	Clay veld Wealth 1-2	Clay veld Wealth 3-4
Low variance income	Sand veld Wealth 1-2	Sand veld Wealth 3-4

Figure 10.1 suggests that high mean incomes are received by the higher wealth groups and lowest variances in incomes are found in the sand veld. The edge zone is not considered in the simple matrix, but this would be expected to show an intermediate pattern (1). These generalised patterns are supported by the household economics analysis of Chapter 6.

Increases in mean income are associated with increased assets and access to factors of production; these are linked to wealth rank. Increases in income variance are associated with ecological factors. The unstable clay veld system results in highly variable crop outputs, drought susceptible cattle populations and a concentration on a mixed livestock system that can exploit the high quality vegetation and cope with the variability in production (see Chapter 2).

Differences between High mean/low variance (HMLV) groups and Low mean/High variance (LMHV) groups are associated with a range of factors. LMHV groups are likely to have higher food and cash income deficits and so respond with a variety of risk adjustment strategies. They are more likely to have a diversified income base, choose risk averse crops and livestock (millet vs maize, goats vs cattle) and rely

on a range of off-farm sources due to low and variable agricultural output. For the same reason, wild resources from common property resources are likely to be a more important component of livelihood strategies. HMLV groups are expected to show the opposite pattern - more concentration in income earning activities, greater reliance on agriculture and more risk prone investments. These general patterns have been supported with data from Chapter 6.

The distinctions between the groups outlined in Figure 10.1 becomes blurred when the sharing of resources is considered. This may occur between different ecological zones, with livestock movements or loaning between the high variance, drought susceptible clay veld to the more stable sand veld (Chapter 7). Similarly, stock sharing and loaning relationships and cooperative work arrangements act to support especially low mean income groups, with higher income groups sharing their assets (Chapter 6; Appendix 9).

What are the implications of these distinctions for the structure of the rural economy in the study area? Regular surplus production from agriculture, sufficient for reinvestment in the local production base, is only apparent in the HMLV groups (ie sand veld wealth groups 1-2). Only occasional good harvests are achieved by the HMHV groups in the clay veld, but because of land shortages, land extensive agricultural production is constrained for most people and limited reinvestment takes place.

For most HM income households, remittance incomes are an essential component in ensuring the reproduction of rural housheholds. For most LM income groups surplus accumulation is unlikely and a diverse range of strategies are employed to gain income; sometimes they have to be supported either by the state (food relief) or relatives.

These patterns of income generation affect the nature of

the local livestock economy. It is largely those HM income households (supported by agriculture or remittances) that have the opportunity to invest in large stock; investment in small stock is, by contrast, more widespread. However the degree to which income surpluses are invested in rural accumulation in livestock is again constrained by other demands, notably school fee expenditure. Investment in schooling is seen in terms of increasing the opportunities in the off-farm employment market - the source that contributes most to rural cash incomes. Other obligations also constrain the chances for rural accumulation. These include the high dependency ratios shown in all households, even in older ones where continuing obligations to relatives' children exist, and the shallow lineage level obligations of sharing of livestock assets that act against private accumulation for profit.

What does this imply for the future? For most households there appears to be limited prospects for increased agricultural production levels beyond those that exist to support households in food. The limited direct expenditure on agricultural production reflects this. Shortages of draft and land are critical factors in constraining options for agricultural expansion. This relates to the whole question of land policy in Zimbabwe which remains unsatisfactorily resolved (2). Options for income generation through livestock also look limited. Land is too scarce for beef production, as cattle populations are already high and above levels suitable for maximising beef outputs (Chapter 4). While goat production is potentially viable, marketing is the major constraint. It is certainly the perception of many households that the future lies in off-farm income in the formal sector, although the rural informal sector may offer some opportunities (3).

10.3. Policy issues

The interactions between ecology and economy summarised above have a range of implications for policy, research and

extension. Some key issues will be briefly sketched below.

Planning

The contrasting agroecology of different savanna types has been a central theme of this thesis. The demonstration of different ecological and economic characteristics of these zones has been important in providing a framework for explaining a wide range of data from the regional level to the local level. A focus on the contrasting functional properties of different savanna systems, with characterisation of the agroecosystem properties of different components at different spatial scales, has been the basis for the comparative analyses.

Much of this insight from savanna ecology is not used in agricultural planning. Instead, mapping is carried out according either to very general classifications of Natural Regions (Chapter 1) or in terms of compositional characteristics (eg. vegetation types identified from aerial photographs). The functional significance of different areas is often not recognised. For instance, the vlei 'key resource' grazing patches are not formally recognised as grazing land during the planning of grazing schemes.

A contrast between the properties of different savanna types and their interaction with income levels/asset ownership (see Figure 10.1) may also be an important attribute for defining planning and extension 'recommendation domains' (4). Currently the dominant characterisation of rural communities is in terms of cattle ownership. Although this is highly significant, the assessment of ownership is complex and recognition of local patterns of sharing and loaning must be taken into account before any classification is meaningful.

The discussion of section 10.2 has shown how the data presented in previous Chapters supports a set of

distinctions based on the interaction of economy and ecology that have far reaching implications. The focus of past (and to an extent current) extension procedures has been the Master Farmer Clubs; most of whose members are in the high mean income categories. This ignores the low mean income groups, whose options do not necessarily include 'improved' agricultural and large stock production; indeed off-farm sources may be better bets. Even within these groups, extension recommendations for clay veld vs sand veld vs 'key resource' agriculture/livestock management will be very different. This should reflect the dynamics of zones' and patches' contrasting ecology, rather than assuming uniformity (5).

Range management

The management of range resources has been dominated by an analysis of topland grazing in terms of indicators that assume a desired compositional structure of the grassland, often ignoring the role of bottomland 'key resources' and browse. The variability of grassland composition and production in semi-arid areas, particularly under high use levels, means that these may not be appropriate measures in the CA context (Chapter 2). Indeed they appear to underestimate 'carrying capacity' levels several fold, as they are designed for relatively conservative beef ranching contexts, rather than high use agropastoral situations (Chapter 4).

The exploitation of a spatially heterogeneous and temporally variable environment by cattle in the CAs means that an opportunistic strategy is adopted that makes particular use of 'key resource' grazing and browse, and may use fodder resources at a wider spatial scale at times of severe fodder scarcity through herd movement. Goats tend to use more localised fodder resources, especially browse. These elements of the multi-species livestock production system in the CAs need to be incorporated in range

assessment procedures, as well as the design of grazing management schemes (Chapter 7-8).

Livestock production

Livestock production assessments tend to focus on beef sales, with donkeys and goats largely ignored. This neglects the other roles of cattle, donkeys and goats. An economic assessment of different stock species for different functions in an agropastoral system (Chapter 5) demonstrates the comparative advantage of cattle and donkeys for draft and transport and goats for meat production.

Shortages of draft power mean that high stocking rates can be expected; but the limits to further growth in cattle populations appear to be close (Chapter 4) and further land for grazing resources will be needed to sustain the agropastoral system. The trade-off between high overall numbers and lower birth rates, higher death rates and reduced draft performance is complex and requires further investigation. What is clear is that components of farmers' existing management strategies - movement of animals, use of 'key resources', supplementary feeding of browse and stover etc - all contribute to reducing the potentially negative impacts of high animal densities. The development of these strategies need to be central to livestock management research and policy.

Goat production is potentially significant with high growth rates and a management objective geared towards sale and slaughter. However marketing (see below) and high kid mortalities, especially in the sand veld zone, limit high the production potentials being reached (Chapters 5-7).

The appropriateness of any extension recommendation will again vary by savanna type and wealth group according to Figure 10.1. For instance, pen fattening of cattle or fodder legumes may only be relevant to HM income groups,

while goat production support may be more widely applicable.

Environmental issues

Most analyses of CAs assume environmental degradation to be severe, nearing the catastrophic. Although the evidence of erosion is unquestionable, its impact on production is unclear. This study has found no evidence for long term degradation, but this is no reason for complacency.

In order to formulate recommendations for policy that are realistic (rather than using 'carrying capacity' estimates that underestimate potential), a clearer understanding of the links between erosion and production are needed. This requires an economic analysis with a spatial and temporal dimension; asking the questions: what are the critical resources that sustain production? Where is degradation most costly to overall production? What are the relative costs and benefits of protection versus continued production? Are the discounted benefits accrued from protection (eg through destocking) greater than the costs of production foregone? These questions are only just beginning to be asked (Chapter 9).

Economic issues

The importance of off-farm income sources for investment in livestock is critical, especially at times of initial herd or flock establishment and for restocking after drought. Understanding the link between the urban and rural economies is vital. For instance, unemployment in the non-Communal Area sector will have a major impact on the drier rural areas where investment through agriculture is uncertain (particularly in the clay/edge zones).

Alleviating the constraints felt by different income groups

(Figure 10.1) requires the understanding and support of equilibriating mechanisms between high/low mean and variance income groups. In relation to livestock production this includes loaning, sharing and cooperative labour relationships. These are currently not central to extension approaches.

The generation of direct, regular and expanding livestock income is most likely to be achieved through the marketing of goats, especially in the clay veld areas. Although some attempts have been made at introducing goat marketing, these have had limited impact in the study area (6).

(↑ p. 514a-c)

It has not been the intention of this Chapter or thesis to provide answers to policy questions - more to pursue questions arising from the interaction of household economy and livestock management and production. This interdisciplinary approach is useful in exploring new angles and allowing an articulation with local perceptions. While exposing some myths, and suggesting new approaches that focus on the interaction between economy and ecology, many more questions are posed. Some have been outlined in this Chapter. These questions may require further sociological/economic investigation or they may need a more technical examination. However, without an integrative analysis, as attempted in this thesis, these questions may never get asked, or, if asked, their full context not be understood.

Footnotes

1. The distinctions between groups suggested by the matrix are not as clear cut as implied as evidenced by the data presented in previous Chapters. For instance, the edge zone households do not show an intermediate pattern of agricultural income.

2. Land is a major constraint to both agricultural production, but perhaps more significantly, livestock

Extensive dryland grazing management (*insert)

An assumption of land degradation or desertification often underlies the design of range policies in many parts of dryland Africa. This is usually derived from the use of the conventional range management model that assumes deviations from a successional climax vegetation represents overuse and overstocking (Chapter 2).

A number of conclusions of the previous Chapters take issue with this analysis for the case of southern Zimbabwe. To summarise some of the key conclusions:

- Despite large variations in vegetation states between years, high populations of livestock have been maintained within the communal area grazing system in an apparently highly productive livestock system (Chapter 4 and 5).

- The adaptive use of heterogeneous resources at different spatial scales is forwarded as a major reason how stock populations survive (Chapters 7 and 8).

- As long as opportunistic management strategies persist and the production potential of 'key resources' is maintained there is no need to contemplate stock reductions.

- The focus for environmental protection should be the maintenance or recreation of 'key resources' (Chapter 9). Grazing management recommendations should be centred around the optimal use and management of such resources.

These conclusions do not support the conventional prognosis that the communal rangelands are grossly overstocked and that destocking policies may be necessary.

The conclusions of this thesis argue for an alternative approach. The management of environmental heterogeneity and the encouragement of locally adaptive opportunistic responses to variability would be central themes. Compared

within the local landscape or movement to more distant resources. Restrictions on movement imposed by veterinary or marketing legislation constrains such responses (Chapter 7).

- Effective management compatible with local tenure patterns and structures of resource control requires design of grazing management interventions to be carried out at the local level, integrating local perceptions with technical insight.

Table 10.1: Approaches to extensive grazing management

Key resource grazing	Conventional grazing scheme
Management of small key resources for seasonal use (dry season/drought).	Management of extensive topland grazing for wet season use.
Production aims: survival, supplementary feeding for key animals; high stocking rates.	Production aims: for increasing animal production (beef); low stocking rates
Fine-tuned management for forage quantity or quality, dependant on local constraints.	Broad-scale management requiring complex enforcement and strong/new institutions.
Small area fenced and locally controlled: easier to manage and exclude others.	Large area fenced; potentials for boundary disputes. Expensive.
Improvement: management of water and nutrient flows, recreation of key resources (silted dams, digging of pans etc). Maintain bush for browse on topland areas.	Reseeding pastures with legumes; bush clearance to increase grass production.
Environmental: management of most valuable resource through selective seasonal use.	Protection of lower value grazing through rotational systems.

production and so via this route the provision of draft for agriculture. Extension of CA land area has not been feasible under current resettlement models. It is possible that the constraints imposed by the Lancaster House constitution and restrictive models for resettlement planning will be relieved in the review of land tenure issues in the early 1990s.

3. Government and NGO support for off-farm income generation are evident in the CAs. The Government's rural based 'growth point' and 'business centre' policies are examples of central attempts at increasing rural employment opportunities. Smaller scale NGO projects include such initiatives as fence making cooperatives, sewing/weaving groups, vegetable/fruit marketing etc. The extent to which these various efforts are having an impact is not known; certainly in the study area there have been very few changes.

4. Recommendation domains attempt to identify groups of people to which different 'packages' or 'messages' are given through the T and V extension system (see Drinkwater, 1988 for a review of the Agritex extension approach).

5. Differences between zones in Mazvihwa are not reflected in terms of fertiliser recommendations, as one example. Standard amounts are recommended for all people in all areas. These have been shown to be uneconomic (Drinkwater, 1988) and inappropriate to different soil conditions. Interestingly, the Agricultural Finance Corporation is more discerning in extending its credit services to CA farmers. Credit is no longer offered to clay veld farmers in Mazvihwa because of very poor repayment rates, reflecting the highly variable pattern of production in this zone in recent years. However, in the adjacent sand veld zone credit is still offered (Ken Wilson, pers. comm.).

6. The CSC started goat marketing in the study area during 1987. However the markets were irregular, poorly advertised and provided prices under the going local rate. In an interview with CSC officials in Bulawayo during 1987 they indicated that this was only a trial run and would be followed with further extension of marketing networks, possibly linked to cattle sales. This has not happened.

APPENDIX 1: RAINFALL VARIATIONS IN STUDY AREAS

National patterns of rainfall are shown in Figures A1.1 and A1.2 where rainfall isoheyts and patterns of variability of rainfall across the whole country can be seen. The study areas are in the drier areas of the country with higher variability in annual rainfall levels. The pattern of annual rainfall (July to June) for six sites in the regional study area is given in Figures A1.3 to A1.8 for recordings between 1923 and 1986. The position of the rainfall stations is shown in Figure 1.3.

Figure A1.1: National rainfall averages

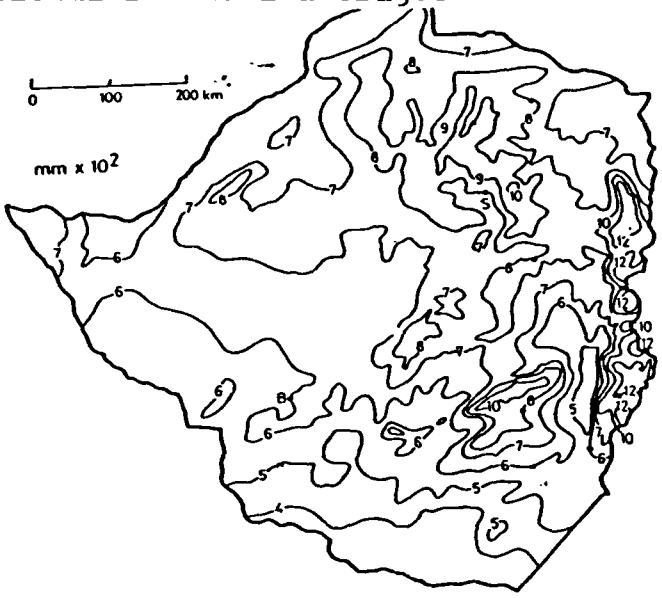
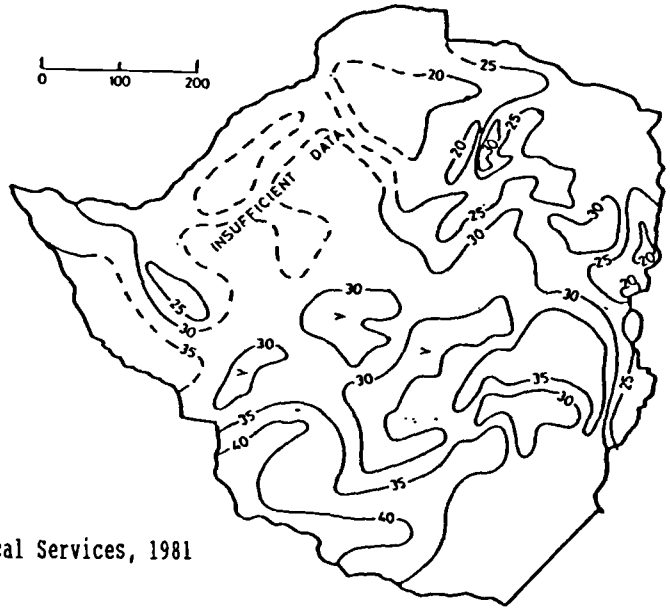
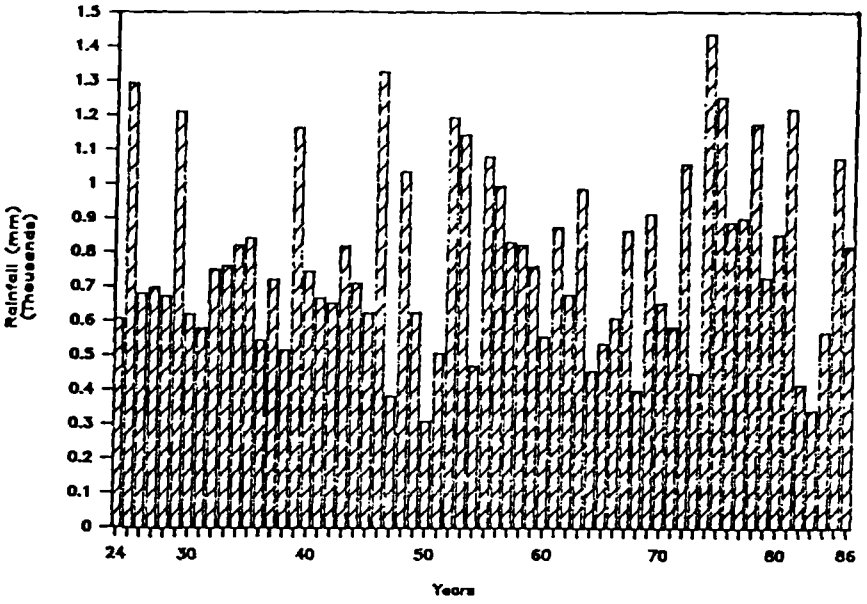


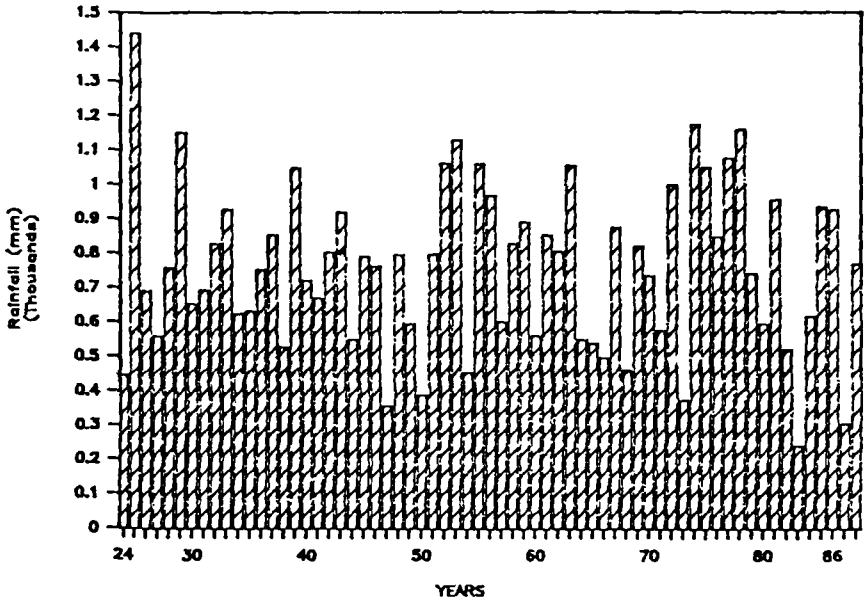
Figure A1.2 National rainfall variability

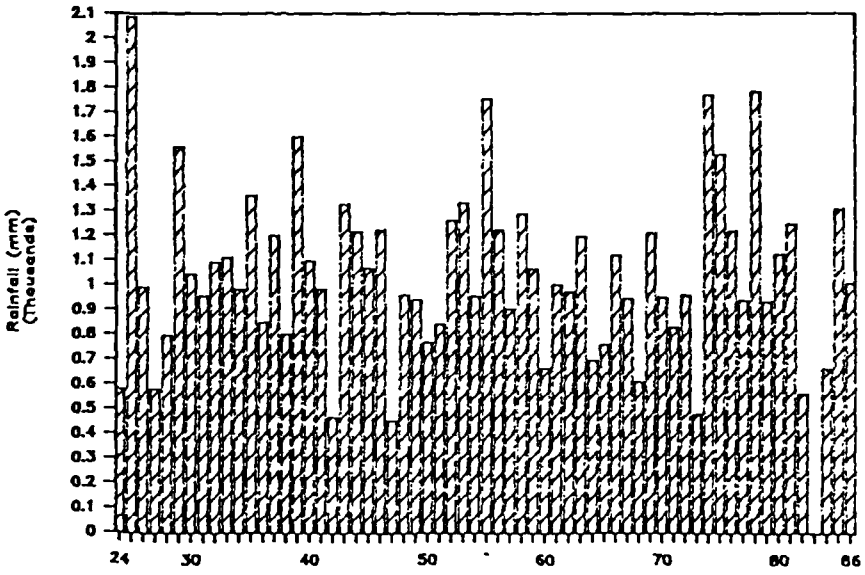


Source: Dept of Meteorological Services, 1981
(Zimbabwe Climate Handbook)

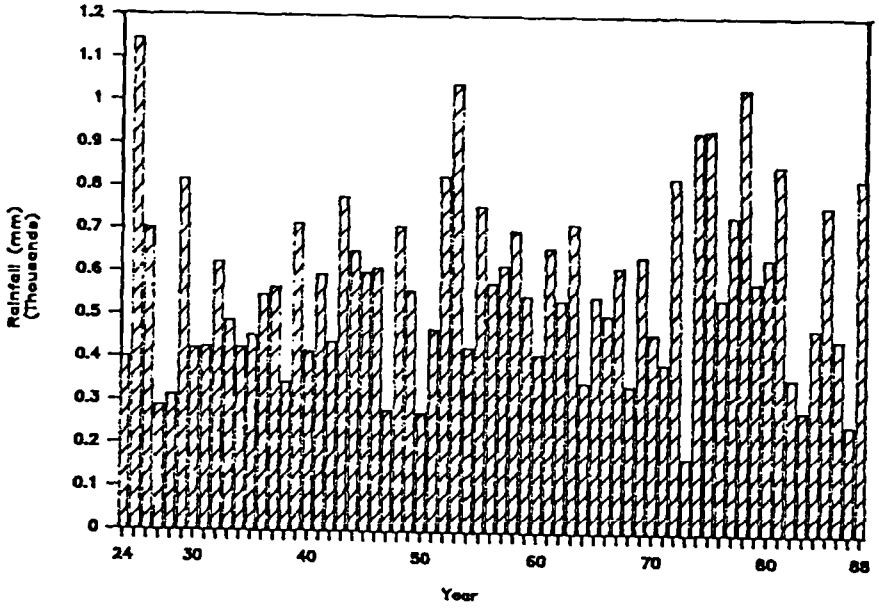
Figures A1.3-5: Rainfall patterns (wetter areas) between 1923 and 1986 (July to June). A1.3: Gutu (district centre); A1.4: Ndanga (Zaka); A1.5: Shuruqwi (in town/mine)

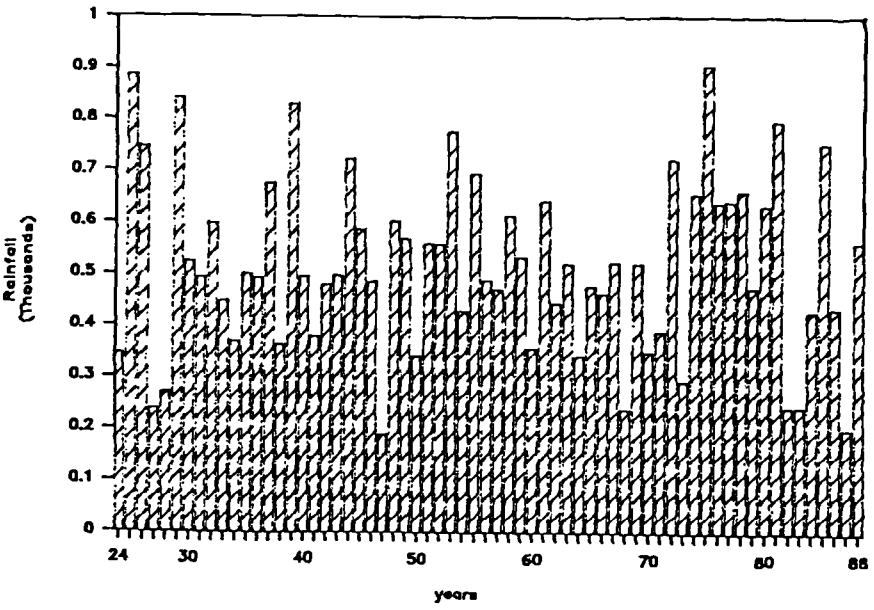


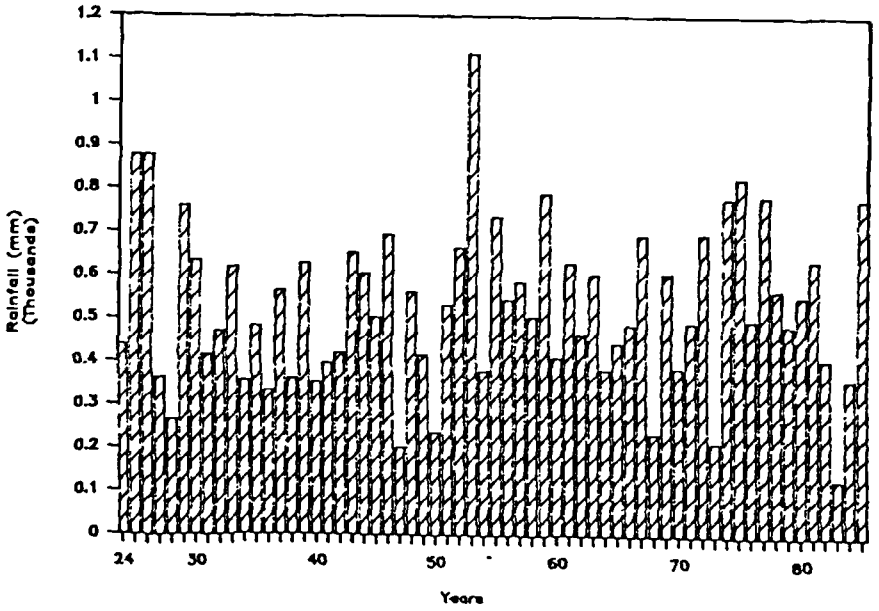




Figures A1.6-8: Rainfall patterns (drier areas), 1923-86. A1.6: Zvishavane (town); A1.7: Mberengwa (district centre); A1.8 Chivi (Chivi office)





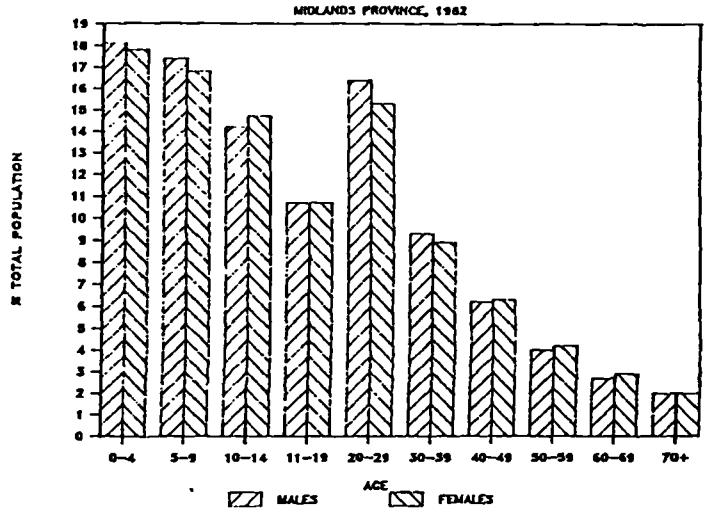


APPENDIX 2: SAMPLE REPRESENTATIVITY

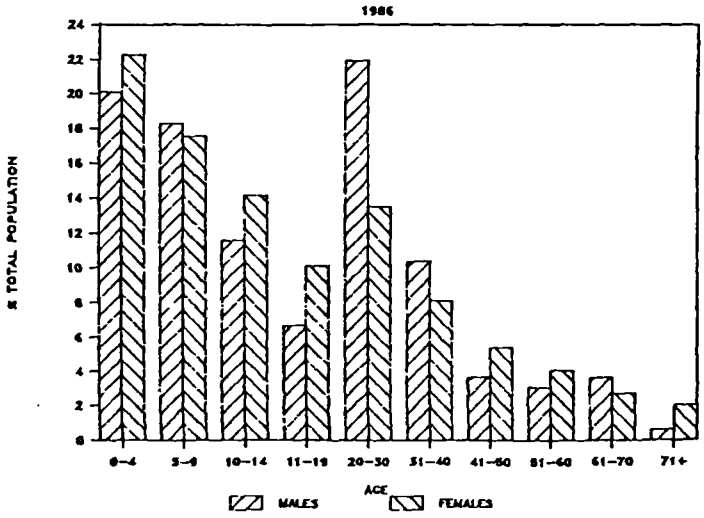
The representativity of the household sample in Mazvihwa is difficult to assess without comparable baseline data for the area. The surveys that have been carried out in the area have been limited. In this Appendix data on household demographic structure and cattle ownership are compared with two recent surveys. Data on these two aspects suggest that the sample households are broadly representative of the wider situation portrayed by other surveys with a larger sampling base.

Population age structure

The age structure of the sample population in 1986 is compared with that found for Midlands Province CAs in the 1982 census. The disparity in dates and classification of age categories makes the two data sets not exactly comparable. However Figures A2.1 and A2.2 show that the age structure of the sample population is broadly representative of that found at a provincial level.

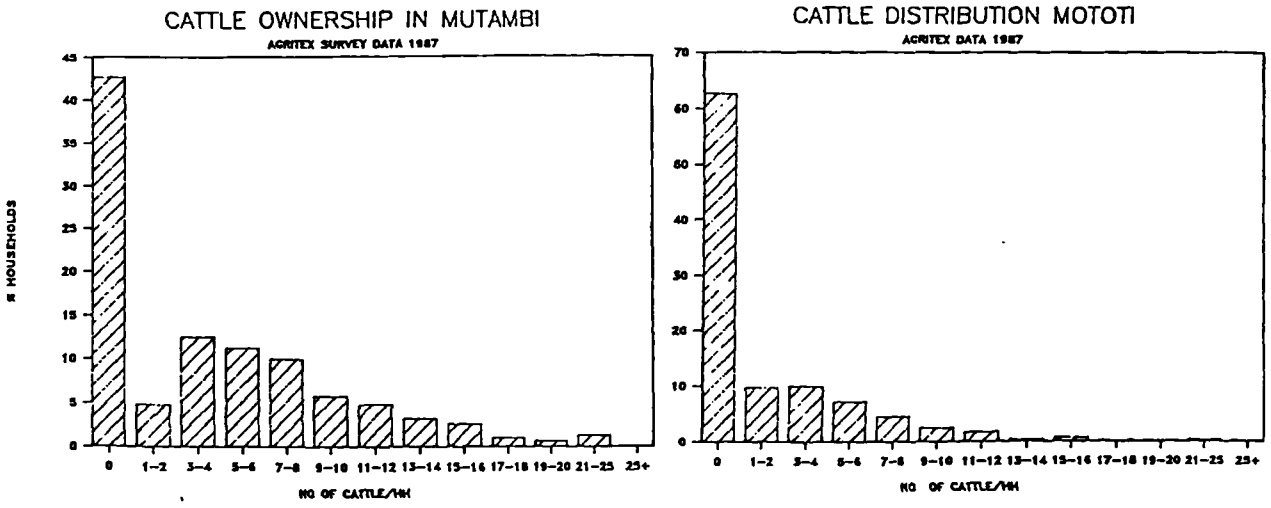


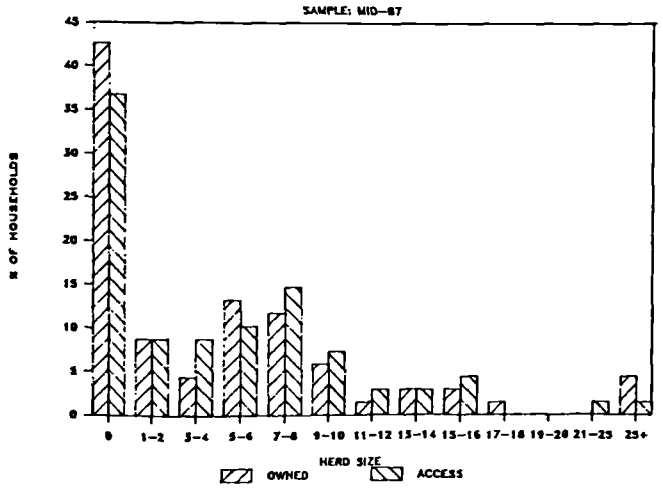
AGE STRUCTURE OF SAMPLE POPULATION



Livestock ownership

The pattern of cattle ownership assessed by Agritex during 1987 in different wards of Mazvihwa is compared with the sample assessment of the same year. The sample data contrasts 'ownership' (animals owned held in own kraal or loaned out) and 'access (animals held in own kraal; either owned or borrowed). The sample data (mostly Mototi ward) reflects the patterns discovered by Agritex in Mutambi more than the wider situation in Mototi. However the overall pattern, with a few large herd owners and many without cattle that is reported by other surveys (eg GFA, 1987) is shown.





APPENDIX 3: LOCAL PERCEPTIONS OF THE CONTRIBUTION OF TREES TO BROWSE AND THEIR EFFECTS ON GRASS PRODUCTION IN MAZVIHWA

The information presented in this Appendix is based on a series of interviews carried out in Mazvihwa CA with local informants. The aim was to gain insight into local perceptions of the value of trees for browse and the impact of tree cover on grass. The results presented here are an amalgamation of different interviews, many of which were carried out by Johnson Hove.

The list is given in alphabetical order by local name, and identifications are given alongside. The identifications are based on the work carried out by Ken Wilson and Bryn Higgs in the area, reported in the local tree dictionary compiled for ENDA-Zimbabwe (Wilson, 1987).

Key of symbols used:

C: Cattle
D: Donkeys
G: Goats

L: Leaves
H: Litter
B: Bark
F: Fruit

*** Highly favoured
** Eaten on occasions
* Only eaten in drought

TREE NAME	STOCK	TREE PART	RATING	EFFECT ON GRASS
Boscia angustifolia:				
MUBARIBARI	C	H L	*	PROMOTES
	G	H	*	
	G	F	***	
Combretum apiculatum:				
MUBHONDO	C	L F H	***	NO EFFECT
	D	L H B	***	
	G	L	*	
Grewia flavescens:				
MUBUBHUNU	C	L H	***	PROMOTES
	D	L H	**	
	G	F	*	

TREE NAME	STOCK	TREE PART	RATING	EFFECT ON GRASS
Rhus tenuinervis:				
MUBIKASADZA	C	L	**	HINDERS
	D	L B		
	G	L	*	
Pterocarpus angolensis:				
MUBVAMAKOVO	C	F L	**	HINDERS
	D	F	*	
	G			
Kirkia acuminata:				
MUBVUMIRA	C	L H	***	HINDERS
	D	L B	*	
	G	L	*	
Dalbergia melanoxylon:				
MUBWITI	C			
	D			
	G	L	**	HINDERS
CHABHOJANI	C	L	*	NO EFFECT
	D	B L	*	
	G	L	*	
Parinaria curatellifolia:				
MUCHAKATA	C	F L	***	PROMOTES
	D	L F B	***	
	G	L F	***	
Zizyphus mucronata:				
MUCHECHENI	C	L F	**	PROMOTES
	D	L	*	
	G	L F	***	
Mimusops zeyheri:				
MUCHECHETE	C	L F	***	NO EFFECT
	D	L F	***	
	G	L F	***	
Euclea undulata:				
MUCHEKESANI	C	L F	*	HINDERS
	D	L F	*	
	G	L	*	
MUCHENARAGOMO	C	F	**	NO EFFECT
	D	F	**	
	G	F	**	

TREE NAME	STOCK	TREE PART	RATING	EFFECT ON GRASS
Rhus lancea:				
MUCHOKOCHIYANA	C			PROMOTES
	D			
	G	L F	***	
Combretum erythrophyllum:				
MUDHUVU	C	L H	*	
	D	B L H	*	
	G	L	*	
Ficus soldanella:				
MUDOHONYA	C	F H	**	HINDERS
	D	F H	***	
	G	F H	***	
Ficus sp.:				
MUDOTI	C	F	**	NO EFFECT
	D	F	***	
	G	F	***	
Securinega virosa:				
MUDYAGAHUWE	C	L F	**	PROMOTES
	D	L	*	
	G	L F	***	
Strychnos potatorum:				
MUDYAHUDO	C	L	***	PROMOTES
	D	L	**	
	G	F	**	
Markamia acuminata:				
MUDYAMHARA	C	L	*	HINDERS
	D			
	G			
Euclea divinorum:				
MUDZIVARAHURO	C			HINDERS
	D			
	G			
Vangeuria spp.:				
MUDZVIRINOMBE	C	LHF	***	NO EFFECT
	D	LF	**	
	G	LF	***	
Bauhinia galpinii:				
MUFOMWE	C	LFH	*	NO EFFECT
	D	LFH	**	
	G	LFH	**	

TREE NAME	STOCK	TREE PART	RATING	EFFECT ON GRASS
MUFOMWEGWIZI	C	LF	**	HINDER
	D	LF	**	
	G	LF	**	
MUFUFU	C			PROMOTES
	D			
	G	P	**	
Tarenna neurophylla:				
MUFUPA	C	L	***	
	D	L	**	
	G	LF	***	
Lannea discolor:				
MUGANACHA	C	F	**	
	D			
	G			
Combretum microphyllum:				
GANGAMUSERO	C			
	D			
	G			
Boscia albitrunca:				
MUGARAGORA	C	LF	***	HINDERS
	D	FP	***	
	G	F	***	
Vitex mombassae:				
MUHUBVU	C	FL	**	
	D	F	***	
	G	F	**	
Bridelia mollis:				
MUHUMBAKUMBA	C	LHF	***	PROMOTES
	D	LH	**	
	G	LF	**	
Syzigium guineense:				
MUHUTE	C	LF	**	
	D	LF	*	
	G	LF	*	
MUJAKA	C			PROMOTES
	D			
	G			

TREE NAME	STOCK	TREE PART	RATING	EFFECT ON GRASS
Acacia nilotica:				
MUJERENGA	C	F	***	HINDERS
	D	F	***	
	G	FL	***	
Afzelia quanzensis:				
MUKAMBA	C	LH	***	PROMOTES
	D	PL	***	
	G	LH	***	
MUKANYAMBWA	C			
	D			
	G			
Burkea africana:				
MUKARATI	C	L	*	NO EFFECT
	D			
	G			
Tabernaemontana elegans:				
MUKASHU	C			
	D			
	G			
Acacia nigrescens:				
MUKAYA	C	F	*	?
	D	F	*	
	G	LF	**	
Crossopteryx februgia:				
MUKOMBEGWA	C			PROMOTES
	D			
	G			
Dichrostachys cinerea nyassana:				
MUKONASHANU	C			PROMOTES
	D			
	G			
Euphorbia spp.				
CHIKONDEKONDE	C		*	
	D			
	G	HP	*	NO EFFECT
Artabotrys brachypetalus:				
MUKOSVO	C	L	**	HINDERS
	D	F	**	
	G	L	**	

TREE NAME	STOCK	TREE PART	RATING	EFFECT ON GRASS
Commiphora mollis:				
MUKUHUNU	C	L	*	
	D	L	*	
	G	L	*	
Strychnos madagascarensis:				
MUKWAKWA	C	L	**	?
	D	L	**	
	G	LF	**	
CHIKWAKWASHU	C	L	*	
	D	L	*	
	G	L	*	
Lemon tree:				
MULEMONI	C	L	*	NO EFFECT
	D			
	G	L	**	
MUMBUTU	C			
	D			
	G	L	*	
Adansonia digitata:				
MUMBUYU	C	L	**	HINDERS
	D	L	**	
	G	L	**	
MUMBUYUPASI	C	L	**	PROMOTES
	D	L	*	
	G	F	*	
Brachystegia glaucescens:				
MUMBUZHE	C	L	**	PROMOTES
	D	L	*	
	G	L	**	
Acacia spp. (inc. A. tortilis, A. nilotica, A. sieberana, A. robusta, A. eribescens):				
MUMUHWA	C	F	**	HINDERS
	D	F	*	
	G	LF	***	
Kigelia africanum:				
MUMVEVA	C	LF	***	HINDERS
	D	FB	**	
	G	L	*	

TREE NAME	STOCK	TREE PART	RATING	EFFECT ON GRASS
Acacia nigrescens/polycantha:				
MUNANGA	C	L	***	HINDERS
	D	B	*	
	G	L	**	
Poulzozia hypoleuca:				
MUNANZVA	C	L	***	
	D			
	G	L	*	
Ficus sonderi:				
MUNHANDAVAVIRA	C	L	*	
	D	F	*	
	G	F	***	
MUNHORIDO	C			PROMOTES
	D			
	G			
Flacourtia indica:				
MUNHUNGURU	C	L	***	NO EFFECT
	D	L	***	
	G	L	***	
MUNHUNDUGWA	C	L	*	PROMOTES
	D	L	*	
	G	L	*	
MUNYADZA	C	L	*	HINDERS
	D			
	G	L	**	
MUNYAMARADZE	C	L	*	PROMOTES
	D			
	G			
MUNYAMBO	C	L	*	HINDERS
	D	L	*	
	G	L	***	
Friesodielsia obovata:				
MUNYANI	C	L	***	HINDERS
	D	L	*	
	G	LF	**	

TREE NAME	STOCK	TREE PART	RATING	EFFECT ON GRASS
Commiphora spp.:				
MUNYERA	C	LFH	*	HINDERS
	D	L	**	
	G	L	*	
Berchemia discolor/zeyheri:				
MUNYII	C	LH	**	PROMOTES
	D	F	*	
	G	LFH	***	
Ficus sur:				
MUONDE	C	LFH	***	PROMOTES
	D	LF	**	
	G	F	***	
Lonchocarpus capassa:				
MUPANDA	C	LH	**	HINDERS
	D	LB	**	
	G	L	**	
Colophospermum mopane:				
MUPANI	C	LH	***	HINDERS
	D	LB	*	
	G	L	***	
Dichrostachys cinerea:				
MUPANGARE	C	LF	***	HINDERS
	D	LF	***	
	G	LF	***	
Combretum molle:				
MUPEMBERE	C	L	***	PROMOTES
	D	L	**	
	G			
Commiphora marlothii/Albizia tanganyicensis:				
MUPEPE	C	L	*	HINDERS
	D	B	*	
	G	L	*	
Sclerocarya birrea:				
MUPFURA	C	LH	***	PROMOTES
	D	L	**	
	G	LF	***	
Brachystegia boehmii:				
MUPFUTI	C	L	**	PROMOTES
	D	L	**	
	G	L	**	

TREE NAME	STOCK	TREE PART	RATING	EFFECT ON GRASS
Acacia galpinii/Acacia albida:				
MUPUMBU	C	LH	***	HINDERS
	D	LH	**	
	G	LH	**	
Combretum collinum/Combretum fragrans:				
MUPWEZHA	C	L	*	PROMOTES
	D	L	***	
	G			
Vernonia amygdalina:				
MURIMEREN'OMBE	C	L	*	PROMOTES
	D			
	G			
Annona stenophylla:				
MURORO	C			
	D			
	G	L	***	NO EFFECT
Xeromphis obovata:				
CHIROVADUNGURU	C			
	D	LF	**	HINDERS
	G	L	***	
Carissa edulis:				
MURUNGURU	C	L	*	NO EFFECT
	D			
	L	L	***	
Acacia ataxacantha:				
RUKATO	C			HINDERS
	D			
	G	L	***	
Cassia abreviata:				
MURUMANYAMA	C	L	**	NO EFFECT
	D	L	**	
	G			
Ozora insignis:				
MURUNGU	C	L	***	NO EFFECT
	D	L	**	
	G			
RUVAZHE	C	L	**	HINDERS
	D			
	G	L	**	

TREE NAME	STOCK	TREE PART	RATING	EFFECT ON GRASS
Dalbergia melanoxylon:				
MURWITI	C	L	*	
	G			
	D			
Hexalobus monopetalus:				
MUSAKAME	C	LFH	**	
	D	L	*	
	G	L	*	
Brachystegia speciformis:				
MUSASA	C	LH	**	HINDERS
	D	L	*	
	G	F	***	
Piliostigma thonningii:				
MUSEKESA	C	LF	*	PROMOTES
	D	F	*	
	G	F	*	
Lannea edulis:				
MUSAMBASI	C	L	**	NO EFFECT
	D			
	G	LF	***	
Ficus spp.:				
MUSHAVI	C	LHF	*	PROMOTES
	D	F	*	
	G	F	***	
Pseudolachnostylis maprouneifolia:				
MUSHOZHOWA	C	F	*	PROMOTES
	D	F	*	
	G	LF	***	
Uapaca kirkiana:				
MUSHUKU	C	L	***	PROMOTES
	D	B	**	
	G	F	*	
Croton megalobotrys:				
MUSHUKU-GWIZI	C			
	D			
	G	F	*	
MUSOROSHINI	C	L	*	
	D			
	G	F	**	

TREE NAME	STOCK	TREE PART	RATING	EFFECT ON GRASS
Diospyros mespiliformis:				
MUSUMHA	C	FH	***	NO EFFECT
	D	F	*	
	G	F	***	
Diospyros lycoides:				
MUSUMADOMBO	C			HINDERS
Euphorbia tirucalli:				
RUSUNGWE	C	L	***	
Terminalia sericea:				
MUSUSU	C	LH	***	HINDERS
	D	LH	**	
	G	LH	**	
Lannea stuhlmannii:				
MUSVIMWA	C	LFH	***	PROMOTES
	D	LFH	**	
	G	LF	***	
Bolosanthus speciosus:				
MUSVINGAMHARA	C			PROMOTES
	D			
	G			
Ficus sycomorus:				
MUSVITA	C	LFH	***	PROMOTES
	D	F	***	
	G	F	***	
Dovyalis caffra/zeyheri:				
MUSVORITOTO	C	LFH	**	
	D			
	G	LH	**	
Ficus sp.:				
MUSVOTOGAVA	C	F	***	HINDERS
	D	F	**	
	G	F	**	
MUTAKURAKAMBA	C	LB	**	PROMOTES
	D	L	*	
	G	LF	***	
Strychnos spinosa:				
MUTAMBA	C	L	**	PROMOTES
	D	L	*	
	G	L	***	

TREE NAME	STOCK	TREE PART	RATING	EFFECT ON GRASS
Gardenia spatulifolia:				
MUTARARA	C	LFH	***	HINDERS
	D	LH	*	
	G	LH	***	
Cobretum hereroense:				
MUTECHANI	C	LH	***	PROMOTES
	D	LH	***	
	G	LH	***	
Grewia moniticolor/bicolor:				
MUTEHWA	C	LFH	***	PROMOTES
	D	LFH	***	
	G	LFH	***	
Ximenia caffra:				
MUTENGENI	C	L	*	PROMOTES
	D	L	*	
	G	L	*	
Julbernadia globiflora:				
MUTONDO	C	LH	**	HINDERS
	D	L	*	
	G	L	**	
Schotia brachypetala:				
MUTONDOCHURU	C	L	*	HINDERS
	D	F	*	
	G	F	*	
Azanza garkeana:				
MUTOHWE	C	LH	**	PROMOTES
	D	LH	***	
	G	L	*	
MUTSIKANEHMA	C	L	*	
	D			
	G			
Combretum imberbe:				
MUTSVIRI	C	LH	**	NO EFFECT
	D			
	G	L	**	
Acacia tortilis:				
MUUNGA	C			
	D			PROMOTES
	G	PL	***	

TREE NAME	STOCK	TREE PART	RATING	EFFECT ON GRASS
Canthium huillense:				
MUVENGAHONYE	C	L	**	
	D			
	G	L	*	
Ficus sp.				
MUVHUVHURA	C	L	*	PROMOTES
	D	L	*	
	G	L	*	
Albizia amara:				
MUVORA	C	L	**	
	D			
	G	L	**	
Cissus spp.:				
MUZAMBIRINGA	C	LFB	**	
	D	LFB	**	
	G	LFB	**	
Peltophorum africanum:				
MUZEZE	C	L	*	
	D			
	G			
Lippia javanica:				
MUZIMBANI	C	L	**	
	D	L	***	
	G	L	***	

APPENDIX 4: GRASS COMPOSITION AND QUALITY IN MAZVIHWA

This Appendix compiles data on grass species composition and quality in the different zones in the Mazvihwa study area. Sources are a study of local classifications of grass species, data on grass species occurrence from the vegetation transect study and a review of the literature on grass quality.

A collection of grasses was made during the rainy season of 1986-7. This was taken to different key informants and the prevalence, drought resistance, forage value etc. was discussed of each grass. There are not that many local names for grass and local classifications tend to lump large groups of species together. Detailed knowledge of grass properties was not found, but the comments made by different informants is recorded below. This was assisted by the background work carried out by Wilson (1985). Unfortunately the grass collection got destroyed, so the identification of local names according to scientific nomenclature is patchy.

Bangamhou: A grass that cuts the feet of cows like a knife; not an important fodder grass.

Bisaimba: Found on heavy clay soils often in old field sites; sometimes eaten by animals.

Bumurahororo (Dactylotenium aegyptium): Good palatable grazing, found along the contours or roadsides in the clay veld.

Bungwe (Typha latifolia): Grows in wet places, such as streams or river banks. Cattle do not like it very much, but will eat it during droughts.

Chidyatanya: Found mostly in clay veld. Favoured by livestock, but not important to overall nutrition.

Chimunyu (Chloris spp.): Found on sodic soil areas, but also on other clay soils. Eaten by livestock.

Chiraramhene (Hyparrhenia sp.): An important fodder grass found in undisturbed areas, especially on heavier soils. It is now found less than in the past.

Chitsetserere (Tragus berteronianus): Associated with sodic soils and degraded areas. It is very drought resistant and germinates rapidly following drought. Although it 'does not make cattle fat' it is nevertheless important as it can 'provide salt' and food following drought.

Dhimba (Schmidtia sp.): Found in the infertile sandy soils.

It does not provide substantial fodder, but can be eaten. Its advantages include its ability to remain standing following heavy rain. It can also be used for thatching.

Dhodlani (Pogonarthia squarrosa). Found in the sand veld. A reasonable fodder that is quite drought susceptible. Some people say it is disappearing.

Ghondya: Found in the vleis. A soft and wet grass that can be eaten by animals, especially in droughts. This is now only found in the wettest vlei areas.

Ha'achi (Urochloa mosambicensis/Brachiaria sp.): A valuable fodder grass that is found in the clay veld. The availabilty of this grass in the clay veld is given as the major reason for the differences in size/quality of animals there compared to the sand veld. It is also very heavily attacked by harvester termites. It is drought susceptible and reestablishes quite slowly after droughts (perenial).

Ha'achi yekumakomo (Eragrostis superba): A good fodder grass, a perennial and quite drought resistant, but not high quality fodder.

Jepfure: Found in rocky places in the hills; Eaten by livestock.

Mapfuri: Found growing on granite hills in cracks and crevices. A hardy grass that is only palatable following light rain and mist when the material becomes softer. It may be a last resort drought fodder for cattle resident in the hills.

Mugejo (Panicum sp.): Found in wetter areas. Reasonable green fodder.

Muromowegonde: Found in wet places such as vleis. Sheep and donkeys eat this especially.

Muzangari: Found in the hills growing among rocks. This is again used as a drought fodder.

Nhandira (Digitaria sp.): Found in a wide variety of habitats and soil types. The creeping habit of the grass means that is quite resilient to grazing. It provides bulk food but is of poor quality. Donkeys in particular make use of this plant. The grass can be used to make arm bangles (shambo).

Nhokwe: Sedges found on the river edges or in wetter vleis. Sometimes eaten by both cattle and donkeys.

Rurebvu (Microchloa kunthii): Found in sandy areas in small clumps. Very small and an insignificant feed source.

Shanga (Reeds): Sometimes grazed when young, however the availablity of reeds has decreased since the last drought.

Shanje (Cynodon dactylon): Grows well on sandy soils, on heavily grazed river bank areas and on termitaria. It colonises eroded areas well and through grazing remains green all year. It has a low growth habit and is particularly favoured by donkeys.

Shavahuru: A tall strong grass that grows on contour ridges and in some parts of grazing areas in sandy soil areas (probably Hyperrhenia sp). It is reasonable grazing, but is excellent thatching material. It has largely disappeared from Mazvihwa, but was present during the wetter 1970s.

Shawi (Eleusine indica): Very similar to finger millet; often grows together in the same field. When green it is a reasonable fodder.

Shengezhu: A tall grass that is found close to waterways (possibly Pennisetum purpureum). This grass is good for grazing and thatching. It has now disappeared from most sites in Mazvihwa.

Sine (Aristida spp., Heteropogon contortus and Hyperthelia sp.): The local term refers to all grasses with spiky seeds. The Aristida spp. are found largely in the sand veld, but also as colonisers elsewhere. They are poor grazing. H. contortus is found along contour ridges and relatively undisturbed places particularly in the sand veld. It is not regarded as particularly good grazing, but is used for thatching.

Singezane (Sporobulus pyramidalis): Found particularly in vleis. Although not good grazing, it does persist through drought and provides important reserve fodder in some areas.

Perotis patens: Poor grazing grass found on disturbed sand veld areas.

Panicum maximum: Found in particular micro-environments, such as under trees, in both savanna zones. It is a high quality fodder grass selected particularly by cattle.

Eragrostis curvula: Found in the sandy soils; poor fodder value.

Species occurrence in the vegetation transects

Species identified in each of the transect quadrats are ranked according to percentage occurrence in the quadrats. The sand veld transects were: Miombo woodland 1 and the contour ridge. The clay veld transects were the Mopane woodland, Acacia woodland and the drainage line transects (see Chapter 2). The study was carried out in the wet season of 1987-88. Identifications were done by Mr S. Kativu of the National Herbarium.

CLAY VELD SITES		SAND VELD SITES	
34.83	BRACHIARIA DEFLEXA	31.58	PEROTIS PATENS
30.34	TRAGUS BETERONIANUS	26.32	BULBOSTYLIS HISPIDULA
27.00	SETARIA PUMILA	25.00	HYPERTHELIA DISSOLUTA
21.67	CHLORIS VIRGATA	23.42	ARISTIDA CONGESTA
19.92	UROCHLOA TRICHOPUS	23.16	SETARIA PUMILA
18.37	ERAGROSTIS CILIANENSIS	20.00	DIGITARIA CILIARIS
16.41	ERAGROSTIS TRICHOPHORA	18.16	D. AEGYPTIUM
15.27	ARISTIDA CONGESTA	13.16	ZONIA SP.
12.14	UROCHLOA MOSAMBICENSIS	12.89	E. TRICHOPHORA
12.00	ARISTIDA ADESCENSONSIS	10.00	CYNODON DACTYLON
11.35	BRACHIARIA XANTHOLEUCA	5.26	CYPERUS AMABILIS
10.73	DACTYLOCTENIUM AEGYPTIUM	5.26	BRACHIARIA DEFLEXA
10.35	SETARIA HOMONYMA	5.26	E. SCABRIVALIS
7.84	ARISTIDA SCABRIVALVIS	5.26	A. ADESCENSONSIS
7.02	PEROTIS PATENS	5.00	T. MONACHNE
7.02	DIGITARIA CILIARIS	5.00	UROCHLOA TRICHOPUS
7.00	SPOROBULUS FESTIVUS	2.63	TRIRAPHIS SCHINZII
5.68	ERAGROSTIS VISACOSA	2.63	ERAGROSTIS RIGIDOR
5.26	BULBOSTYLIS HISPIDULA	2.63	P. SQUARROSSA
5.00	ARISTIDA RHINOCHLOA	2.63	TEPHROSIA SP.
3.51	ERAGROSTIS ASPERA	2.63	TRAGUS BETERONIANUS
1.75	ZONIA SP.	2.63	ERAGROSTIS BIFLORA
1.75	UROCHLOA PANICOIDES		

Crude protein content of grasses found in the study areas

No chemical assessments were carried out of grassland quality during the research. Reference to published sources gives an idea of the contrasting patterns of Crude Protein as a percentage of Digestible Matter. Highest levels are found during the growing season (around December) and this decreases through the dry season to the lowest level between July and September. Barnes (1982) quotes a typical range for the southern African grass layer in the semi-arid zones of between 12-15% in the wet season and 3-6% in the dry season. This varies both between species and savanna type. Plowes (1957) studied different savanna types at Matopos in southern Zimbabwe during the 1949-50 season. He found that the average range for the thornveld (heavy soils) was highest (22.35 - 3.1% CP of DM), next the black clays (19.6 - 2.62%) and lowest was the sand veld (15.86 - 2.04%). Species specific variations shown for this, and other studies in the region, are shown below. The actual figures should not be taken too seriously, but the implications for comparative grassland quality of the different savanna types in the study area is of interest. A

consideration of the species composition of the grassland transects, indicates that the expected pattern of higher quality grassland in the clay veld is shown. However there are many common species to both veld types, and it is probably edaphic factors, rather than species specific differences, that have the dominant influence on grass quality.

Grass species	Max	Min	Ref
Hyperrhenia filipendula	13.5	2.6	1
Heteropogon contortus (clay)	23.1	2.3	1
Heteropogon contortus (sand)	19.6	2.4	1
Themeda triandra	12.4	1.8	1
Cynodon dactylon	8.9	4.5	1
Dactyleotenium aegytium	14.2	8.3	2
Urochloa mosambicensis	15	4	2
Panicum coloratum	19	9	2
Digitaria pentzii	13.0	2.9	1
Pogonarthia squarrosa	8.8	1.9	1
Aristida graciliflora	12.7	2.4	1
Rhyncheletrum repens	10.4	1.9	1
Eragrostis rigidor	7.0	2.9	1
Eragrostis curvula	13	6	2
Aristida adscensionis	10	2	2
Eleusine indica	12	3	2
Sporobulus pyramidalis	14.3	4.3	2
Sorghum	4	3	2
Maize	7	6	2
Millet (bullrush)	6	4	2

Sources: 1: Plowes (1957); 2: FAO (1981)

APPENDIX 5: SYMBOLIC AND CEREMONIAL USES OF LIVESTOCK

The use of livestock in local ceremonies was an issue that recurred during discussions and interviews. This Appendix provides a summary of the various occasions when stock are used, exchanged, dedicated or slaughtered. The information is derived from interviews carried out in Mazvihwa, Runde, Chivi and Mwenezi CAs by different members of the research team. The fact that a particular practice is recorded as existing does not of course mean that it universally occurs. The prevalence of different practices will depend on many factors, but particlularly religion. With the growth of Christianity through the influence of the missions in the colonial period, the importance of particular 'Karanga customs' has diminished, although there was a certain revival during the liberation struggle. Some practices have been imported from other areas of Zimbabwe, as connections through marriage and work have increased, others have been adapted to fit in with Christian religious ceremonial requirements. The actual way a particular ceremony is carried out also varies between different people. There is often a fairly uniform consensus on what should be done, but in practice a ceremony can take a variety of forms.

The role of cattle in exchange and dedication is important in the context of understanding intra-household ownership and resource control patterns. The exchange of an animal through, for instance, a gift of bridewealth may be an important route to acquistion of animals. Similarly, dedication may obscure individual ownership, as a particular person may be holding an animal on behalf of the spirit of a deceased member of the family and it is the spirit who formally 'owns' the animal. Inheritance and disposal regulations of such animals are complex, but may be important for gaining access to livestock or their products.

Mudzimu bulls: Spirit bulls make up c. 33% of the sample bull population. Many household clusters have a dedicated bull 'belonging' to a spirit ancestor. A bull is dedicated if there are certain problems in the family thought to be caused by an ancestral spirit. Alternatively a bull may be dedicated as a mark of respect to an important member of a family some time after death. A black bull is chosen from the kraal of the local 'Karanga' breed and a ceremony called. The beast is dedicated with snuff and ceremonial

beer (brewed by women of post-reproductive age) and the animal then formally 'belongs' to the ancestor. Indeed the animals is, in some senses, the worldly representation of the spirit. The bull is therefore treated with great respect. The spirit bull is held by a senior member of the family, but if the holder wants to sell the animal consultations must be made through the spirit medium (name holder of the spirit) and it is possible to transfer the spirit name to another, younger bull.

Lobola cattle (bridewealth exchanges):

Mavhuma: If a girl is made pregnant before the formal approach to the girl's parents with a request for marriage, a fine must be paid. The request is usually for a cow or heifer.

Mombe youmai: This cow comes with the overall lobola payment, but is paid to the mother who keeps it for her sons. This is a relative recent import to the area from elsewhere in Zimbabwe, but is being increasingly practised.

Pwanyazhowa: A single animal is given as part of the early lobola negotiations to the future in-laws. This must be paid as an animal.

Rugaba: Cattle or cash equivalents are transferred to the in-laws.

Danga: The final payment of cattle or cash equivalents. The total is expected to be in the region of 5 - 10 cattle. These are rated locally at $150 per animal and in the local courts at $100. This cash equivalent valuation is so far below the actual market value of animals ($300-400) that cattle are invariably sold and these payments paid in cash.

Fines: Traditional courts run by the chief or muchinda (sub-chief) used to have the right to fine people in livestock. The range of fines were quite flexible and without a formal code. The different people interviewed who used to have powers to fine indicated that those convicted of murder or adultery were charged a number of head of cattle, while petty theft could result in the fine of a goat or several chickens.

Nhaka: The distribution ceremony of a dead man's possessions, notably cattle and wives. Cattle are distributed amongst the sons and brothers. The eldest son takes the bull and the father's ceremonial weapons.

Mbwazukuru: If a woman's family is being troubled by misfortune or illness, a n'anga (traditional healer) will be called. If s/he finds that it is the spirit of the woman's grandmother that is annoyed a goat must be dedicated. A female goat is transferred from the woman's husband's kraal to her parents. A ceremony is held, where the goat is dedicated to the grandmother in order to appease her angry spirit. The name holder of the spirit will then look after the goat. The spirit name holder has the right of slaughter or sale over the goat and its progeny. However because it is formally 'owned' by the grandmother's spirit, the products tend to be widely shared. One informant commented that if you are the grandson of the spirit and are in particular trouble, it is possible to approach the spirit holder and request a gift of a goat from the original goat's progeny.

Masungiro: On the occasion of the first pregnancy of a woman, the husband's family should present a female goat to her mother and a male goat for subsequent slaughter to her father.

Kugadzira ceremony: This ceremony involves the welcoming back of the spirit of a dead person to the home some months after death. The grandson of a dead man will be expected to clean the ceremonial weapons of the dead grandfather. Following this he will be given a goat. The wives of the dead man are also expected to jump across the weapons on the thresholds of their kitchens. If they jump without stumbling they have been shown to have been faithful. If not, their families are expected to pay a fine in livestock.

Kurashira: This involves the transfer of a bad spirit, that is causing misfortune in the home, to an animal. A n'anga will conduct the ceremony for a family and choose the type of stock necessary. Spirits are generally transferred to black goats or chickens. The animal is then taken far from the home and released. These animals are not supposed to be touched, otherwise the bad luck or disease will be transferred back to you. For this reason there a quite a number of wild black goats in Mazvihwa.

Mitoro: The rain ceremony held to combine the forces of the local ancestral spirits and the influence of the regional territorial rain cult to influence the onset and success of the rains (Mukamuri, 1988). A ceremonial goat (black) is slaughtered at the grave site of important ancestors as a mark of respect.

Other ceremonial goat slaughters: Goats are slaughtered at every major ceremony including marriages and funerals.

Kuidza ropa: The 'testing of the blood' of someone for expertise in livestock husbandry. It is believed that different people have different 'blood' for keeping different types of animals. Parents will usually test out their children for goats and chickens. If the reproductive or survival performance of the animal is not good then the child is deemed to have 'bad blood' and the animals may be transferred to another brother or sister. This is a widespread practice for chickens and goats, but not common for cattle. The goat or chicken will then become nominally the child's and the child will have certain rights over it. It may be one route to acquisition of goats, particularly for boys who retain the flock when they establish a home. Girls who 'own' goats through this route continue to do so after marriage, but the goats remain at the parental home.

APPENDIX 6: LOCAL KNOWLEDGE ABOUT LIVESTOCK DISEASES

This Appendix collects together information from various informants on the subject of livestock diseases. Most interviews were conducted in Mazvihwa, but additional information came from work in Chivi, Runde and Mwenezi communal areas. People recognise livestock diseases to be important and often consult with Vetinerary department workers on dipping days. However the local knowledge of diseases and their cures is not extensive. This probably reflects peoples' largely agricultural, rather than pastoral past.

Cattle diseases and problems

Nyongo - This combines most stomach ailments and is associated with a swollen gall bladder and lack of appetite. Nyongo is most prevalent during the rains when the grass is very green and wet. The local treatment is salt and soot from the kitchen roof mixed in water.

Mukonho - Black leg - The local cure can be either a hot knife placed over the affected part or the application of a hot water compress with the addition of herbs to the water.

Makangazha - Foot rot - Muddy conditions in kraals increase the likelihood of this problem. The movement of the kraal to drier conditions is thought likely to decrease the incidence.

Chigwere chemuro - Disease of the neck

Chigwere chemudumbu - Disease of the stomach thought to be caused by too much green grass or excess milk in calves.

Tick diseases - With the collapse of dipping services during the war the incidence of tick borne diseases increased dramatically. Locally people recognise three types of tick - zvitsvuku (red/brown), ziguru zijeri (large and white/grey) and zvitsvuku hunenge pfumbu (red and grey). These relate to the extant tick species: blue tick, bent legged tick, brown ear tick and bont tick (most common). Heartwater disease is perhaps the most common tick borne disease. Mastitis caused by tick damage to udders is still quite common.

Wounds - The muvengahonye herb is used crushed and put in

water.

Eye disease - Either small snail shells are crushed and smeared around the eye or the latex of chisvosve is applied above the eyes.

Parturition problems - Either nhanzwa or soso is smeared around the vagina to increase lubrication and ease birth.

Miscarriages - The skin of a rock rabbit is attached to the ear of the cow or is boiled in water and the water is fed to the cow to reduce the incidence of miscarriage.

Other cattle diseases noted by the Vetinerary Department:

Anthrax - uncommon outbreaks

Contagious abortion - rare

Brucellosis - rare

Worm infections - common

Foot and Mouth Disease - the study area is a buffer zone between FMD prevalent areas and the EEC demarcated FMD-free zone. Outbreaks are rare in the communal areas. In the past quarantine conditions were regularly applied (especially during the 1930s - see Chapter 3) to attempt to control the spread of the disease between districts and to commercial stock. The local breeds were however fairly resistant and not badly affected.

Goat diseases

Nyongo - A range of stomach ailments that is treated usually by a mix of salt water and soot or occasionally by the sap from the mutondo tree.

Chindee - Perhaps the most common goat disease (entero-toxemia) which results in the goat spinning around and dropping dead. No local cure is known.

Makangazha - Foot rot and sores caused by excess water in the kraal.

Chikwekwe - Sores around the mouth. This is very contagious and usually results in death. It is generally thought that it is best to slaughter the goat to avoid the spread of the disease.

APPENDIX 7: WEALTH RANKING

The wealth ranking exercise was carried out with three groups: men from the sample (13 participants), women from the sample (10) and the research team (8). The exercise has several phases (see Grandin, 1988 for a detailed discussion of methodology):

- A general discussion on the local understanding of 'wealth', exploring historical contrasts and differences between zones. This concluded with a specific discussion on criteria for classification. This part of the workshop lasted between 2 and 3 hours and involved the full group of participants

- The ranking of households in the sample into different groups. Four wealth groups were chosen on each occasion. Cards with the names of each household were called out and allocated to one of four piles. Those that were found to be difficult to classify were left to one side; these were allocated to different groups at a later stage.

- Discussions of the criteria used to rank different households were noted down by the workshop facilitators.

- The wealth groupings were reviewed and revisions made. A final consensus ranking by the workshop group was agreed to. This divided the households into four groups from Wealth 1 (wealthiest) to Wealth 4 (least wealthy). The actual ranking was carried out by between four and six members of the workshop in a private session lasting c. 1 hour.

- The sum of the ranks given for each household by the three workshops was calculated. This ranged from 3 (all workshops allocated the household to rank 1) to 12 (all workshops allocated the household to rank 4).

- The overall ranking was calculated, dividing the sample into four wealth groups. The final ranking was calculated on the basis of the sum of the three workshops' rankings: wealth rank 1 (sum 3-4), wealth rank 2 (sum 5-7), wealth rank 3 (sum 8-10), wealth rank 4 (sum 11-12).

The difference between the different workshops' ranking was not significant. The womens' group tended to rank households in higher categories, while the research group

ranked them in lower categories. For a few households there was large disagreement between workshop rankings, but the reasons for these was not pursued in detail.

The division of the 71 households ranked between ranks and ecological zones is shown below:

Wealth rank	N	Clay	Edge	Sand
Rank 1	17	7	6	4
Rank 2	17	13	2	2
Rank 3	20	11	9	0
Rank 4	17	11	5	1

The relationship between wealth rank, asset holdings and income levels is explored in full in Chapter 6.

The wealth ranking was carried out as a verification exercise to establish a system of stratification for the existing sample. It was carried out in April 1988 after much of the field research was completed. This had a number of advantages. The confidence in the research team was high as we had been working with these households for nearly two years; this allowed for open and honest group based discussion of sensitive issues. This would not have been possible at the outset of the research. The in-depth knowledge of different households and the pattern of household economy in the area made the directing of the general discussions easier and the interpretation of comments possible.

The wealth ranking was carried out at Mathou Chakavanda's home with the help of Billy Mukamuri, Simbisai Makumbirofa and Abraham Mawere. The use of a wealth ranking technique to stratify the sample was on the suggestion of Sam Jackson.

APPENDIX 8: EMPLOYMENT HISTORY CASE STUDIES

This selection of interview transcript summaries comes from a single cluster of households in the clay veld zone. It gives an idea of the range of employment opportunities that have been available for people in the sample over the past 50 years and the way migrant labour employment has assisted stock investment. The interviews were carried out with all sample households during June 1986; these interviews are only a selection of the full range. The interviews were mainly conducted by Abraham Mawere. The interviews here remain anonymous but the age at the time of the interview is given. This gives an indication of the pattern of domestic demographic development of households in relation to stock acquisition, as well as changes over time.

1. Age 70+

I started work in 1935 at Sabi river, just cooking tea for my European boss. On the third month I was changed to herding stock, but one day the donkeys disappeared. The boss was furious and told me I would have to work for the rest of my life for no pay. I therefore deserted the job. I went back to work after a year at home, picking up asbestos at Shabani mine. I only worked from January to July each year, since I had to return home to farm. I was caring for my brothers and sisters, since my father had died some time before. In 1940 I took up an underground job at the mine, but after 6 months I became ill and had to return home. I returned to the mine in 1942, but again was ill during 1944. I married in 1947 and had by then returned to work at the mine. After two years at home I again returned to work, first at the mine and then on railway construction. Occasional work continued until 1954 when I moved the home to its current place. The whole year was spent erecting the new home and clearing the fields. From then I spent a further year working in the mine (1957-8), a year in Chegutu (1960) and some time in Harare (1964-6). From 1967 I have not had any work and I returned to farm the fields and earn money through moulding bricks. I originally had cattle from a young age from a herding payment. I bought cattle in 1947 when working in the mine, in 1962 from money from brick moulding and in 1966 from the job in Harare. I also received cattle as a lobola payment on the marriage of my daughter. Since that time the cattle have decreased because of destocking, the war and drought.

2. Age 70 +

I started employment in 1933 being employed by a European who was cutting wood in the farms and the area here. In 1935 I was employed by another European also cutting wood to supply Shabani mine. In 1938 I went to Shabani mine underground, but after 8 months I ran away and got a job at Belingwe. In 1940 we were sent to Gweru under forced labour (chibaro), preparing the air field in case Hitler came. I was very frustrated when Hitler failed to come, as I was paid so little for a very hard and tiresome job. From 1941-6 I was at home, before going to Mwenezi to repair bicycles. I worked at that job up until 1973, when I returned home to help my wife in farming. I only purchased one heifer whilst in employment and this added to the ones I had inherited.

3. Age 60 - 70.

I started work long, long back and was employed to look after the chickens of a European. I moved on to a factory in Masvingo and was employed sewing buttons on clothes. This lasted for two years before I got a job at Mashaba mine, then Shurugwi mine and then Chakari mine in Kadoma. I worked in the mines for 26 years but had to retire when I got 'TB'. During this time I only bought beer and clothes for myself since I have not married.

4. Age 50 - 60

I started work in 1940 at Sabi mine, but later transferred to Shabani and worked there up to 1946. During 1947 I was made to do forced labour (chibaro) for some months. After that I spent time at home. Between 1949 and 1952 I returned to mine jobs both at Shangani mine and Shabani. In 1953 I migrated to South Africa - I went on a bike and got jobs working on the farms. I returned the following year, but went back in 1958 and spent 12 years there. From 1970 till now I have been at home farming and moulding bricks. I bought cattle when I was working in Zvishavane. They multiplied and some were sold to pay a lobola fee. Later on I bought more heifers on my return from South Africa. There are none left now because of drought.

5. Age 40 - 50

I started work in 1962 as a dip superintendent and this

continued for four years. I was then employed in a gum tree planting scheme just locally (in 1970). From that time I have been getting money from local piece work, such as thatching or moulding bricks. During my employment I only managed to buy clothes for the family as the pay was so little. The cattle I own were purchased through farming.

6. Age 30 - 35

I started working in 1974 when I got a job in Harare, but from 1978 I transferred to work near Zvishavane. I quite recently got married and established a home. I have not been working all the time, but for most of it. During the time I have bought some goats and recently a donkey, but never any cattle. We rely on relatives for ploughing.

7. Age 30

I started work in 1972 at Empress mine in Kadoma and that year bought a sheep. I returned home and the next year got a job in Bulawayo until 1975. From 1976 to 1979 I was in South Africa and I bought two heifers following my return. From that time I have been at home and am now a builder.

8. Age 28

I started working in 1979 at the mill at the Shabani mine. I worked there for five years until the mill's closure. I now work underground. I have bought a number of cattle. The first was in 1979, but this died, and then again in 1986. I also bought a sheep in 1980. However much of my salary must be spent on supporting my wife, as well as my father's home with groceries and food. Also I have been helping to pay for my young brothers' school fees.

9. Age 28

I started work in 1982 when I got a job in Harare. I later moved to Gweru, then to Gwanda and now I work near Bulawayo. I married in 1987 and have not used the money from work to buy cattle, but have bought some goats. The money is sent to my mother and wife at home. My father no longer stays there.

APPENDIX 9: CATTLE AND DONKEY SHARING RELATIONSHIPS: CASE STUDIES

The cattle and donkey sharing relations pertaining in early 1987 (Figures A9.1 to A9.4a) and late 87 (Figure A9.4b) for a selection of household clusters is shown diagramatically.

Each cluster shows different examples of sharing relationships. The following discussion outlines these relationships between stock, their products and associated equipment, highlighting how the situation changed through 1987 and into 1988.

Figure A9.1: Cattle and donkey sharing relationships, Magaya cluster

L = Loaned animal(s); ↗ = Sharing relationship (cattle); ↗ = Sharing relationship (donkeys); G = Own cattle used; G = Own donkey used; ⌐⌐ = Herding group; A/B = individual outside sample

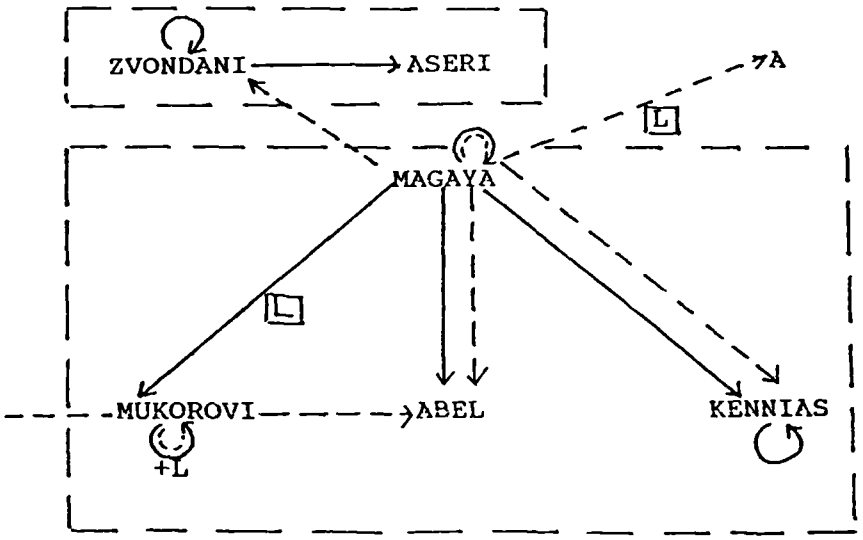


Figure A9.2 Cattle and donkey sharing: Magwidi cluster

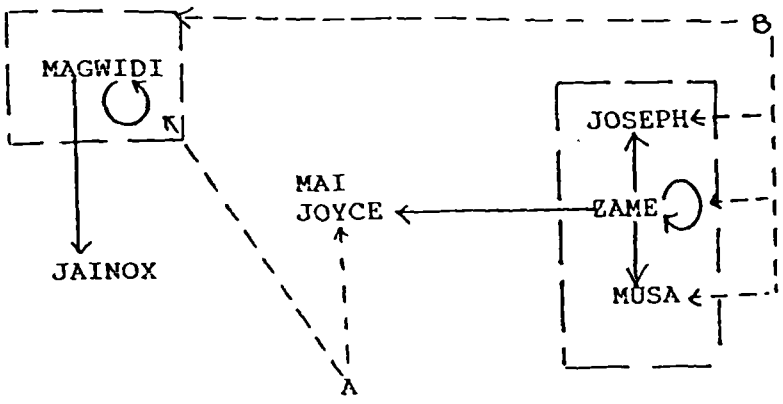


Figure A9.3 Cattle sharing: Ndumo cluster

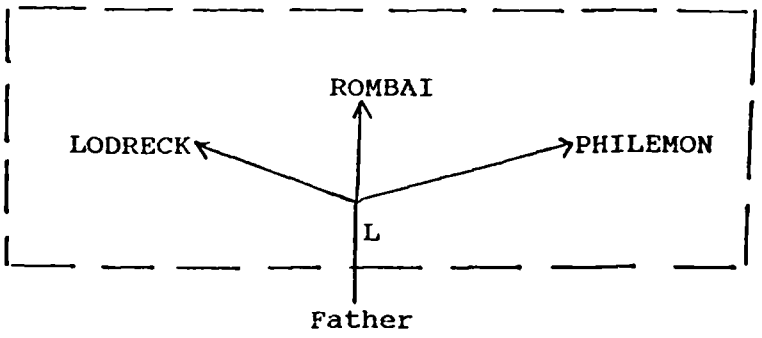
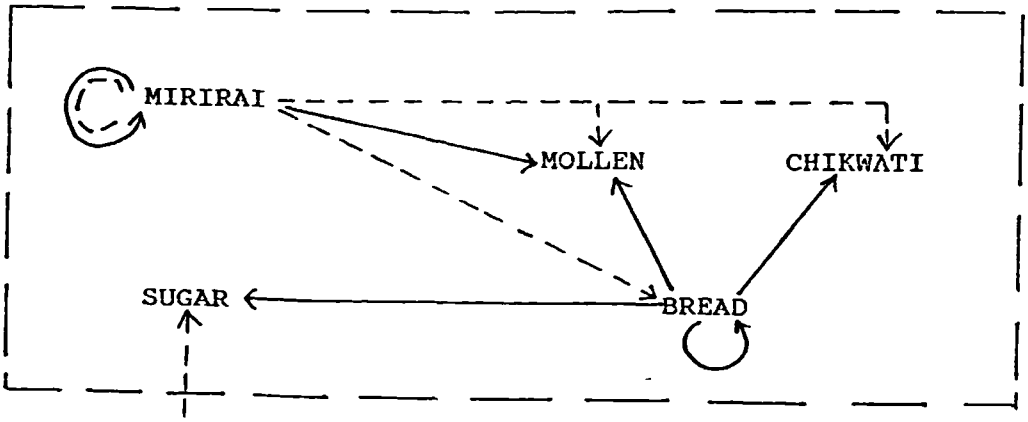
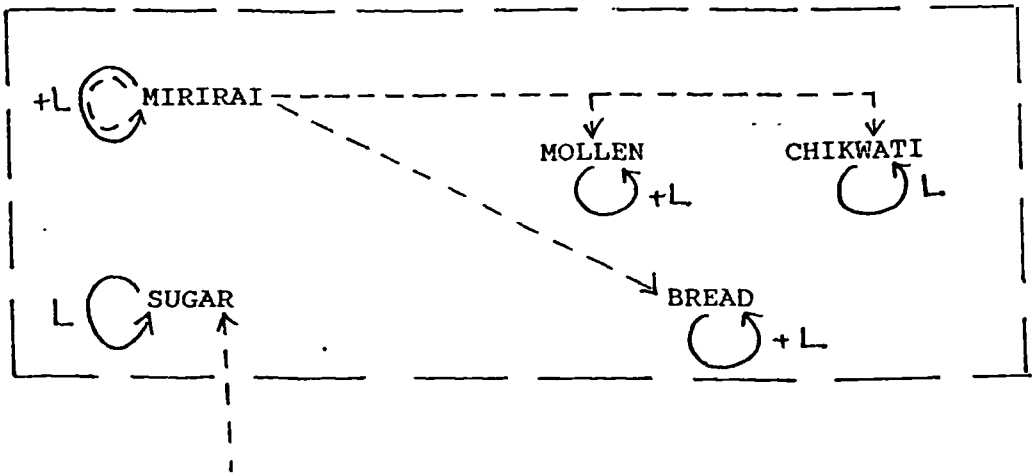


Figure A9.4: a. Cattle and donkey sharing: Sugar-Bread cluster (early 1987). b. Late 1987





L = Loaned animal(s); ↗ = Sharing relationship (cattle); ↗ = Sharing relationship (donkeys); G = Own cattle used; G = Own donkey used; ⌐¯ = Herding group; A/B = individual outside sample

The situation in Figure A9.1 is typical of the 'big man' patriarchal lineage cluster, where the head owns a large herd and loans the cattle out to relatives or shares his spans with them. Donkeys, being held by even fewer households in the cluster, are shared more widely. The pattern of sharing is reflected in the herding arrangement, which shows two herding groups, and the sharing of equipment where a cart and cultivator owned by Magaya is shared by all members of the cluster (although some may pay for the cart on occasions). Milk products are not widely shared in this cluster; Abel's household receives some from Magaya, but otherwise owned or held cattle are the only source. Manure is not shared at all.

By 1988 the situation had changed. With more cattle of their own Kennias and Mukorovi became less reliant on Magaya, but his patronage remained very important in terms of other resources. Aseri moved from the area completely, taking his father-in-laws' home and land when he resettled himself in northern Gokwe. He acquired the use of his remaining cattle and so was released from dependence on others' support during the ploughing season.

Figure A9.2 illustrates a situation where two sub-clusters exist with differing interactions between them depending on the resource. The overall cluster is based on lineage based sharing of cattle. Donkeys on the other hand are all borrowed from other people in the locality. Milk is shared by Magwidi with Mai Joyce and Jainox, while Zame shares milk with Joseph and Musa. Magwidi's cart is shared by everyone, while his harrow is shared by Jainox. Mai Joyce supplies a harrow to Joseph, Musa and Zame. Herding is done by a hired herd boy at Magwidi's kraal; the others take turns, but the bulk of the work was being done by Joseph when he was well.

By 1988 the pattern was very similar. Musa had acquired a cow, so increasing the availability of draft power for that cluster and the wives of Musa and Zame had to increasingly take over the herding and other stock management responsibilities as Joseph's health declined. Jainox, the person most on the periphery of cluster relations was not supported as much during the 86-7 season as he had been before; this distancing from the cluster continued (due to various disputes) during the following year.

Figure A9.3 illustrates a situation where three sons are

reliant on cattle lent to them by their father. This is an informal loan where the cattle can regularly be removed; they themselves do not classify it as a ronzera arrangement. These cattle are managed and used by the three brothers together; sharing products, services and labour inputs. This set-up remained stable through 1987 and 1988 and the cattle looked increasingly to be a permanent loan from the old father.

Figure A9.4 shows the same cluster at two different points in time (86-7 and late 87). Prior to March 1987 the cluster had few cattle, owned by two homes. Combined with donkeys, these made up two spans that ploughed the various fields. During 1987 a large influx of cattle arrived on loan from relatives in drought stricken Indava ward (about 50 cattle arrived, loaned to each of the homes). This meant that each home now had access to sufficient cattle for all purposes and the sharing of cattle products and services ceased. The pattern of sharing of donkeys remained, as did the old herding system where the whole cluster had a cooperative arrangement. Equipment sharing also remained the same; carts were borrowed from outside the cluster and everyone had free access to Sugar's cultivator. During 1988 some of the cattle were withdrawn by their owners so the large surplus disappeared, but some were retained on a longer term ronzera basis.

In general, there is a much tighter relationship between groups of households with cattle than with donkeys. Cattle are central to the structure of the lineage cluster, whereas arrangements around the use of donkeys is quite flexible. As stock numbers increased (or additional loans were received), the degree of sharing of cattle between households has declined. This does not mean to say that lineage cluster relations have been abandoned; they remain strong in relation to other factors, such as equipment sharing, cooperative herding or the attending of cooperative work parties. These case studies thus illustrate that the relations of production are flexible and responsive to changing circumstances.

The nature of lineage cluster organisation does not differ hugely between ecological zones. However the edge zone appears to exhibit the tightest and most stable relationships. This is almost certainly because this zone is the home of the key families from the ruling lineage where kin obligations are particularly strong. Most of the

individual farmers, producing without close links with others, are found in the plains zone and all come from immigrant lineage groups.

A simple household perspective is therefore insufficient to explain the role of livestock in the household economy or the impact of differentiation of ownership of assets. A more thorough insight into the dynamics of production relationships and the sharing or loaning of assets is needed than that revealed by simple 'ownership' distribution surveys (Scoones and Wilson, 1988).

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