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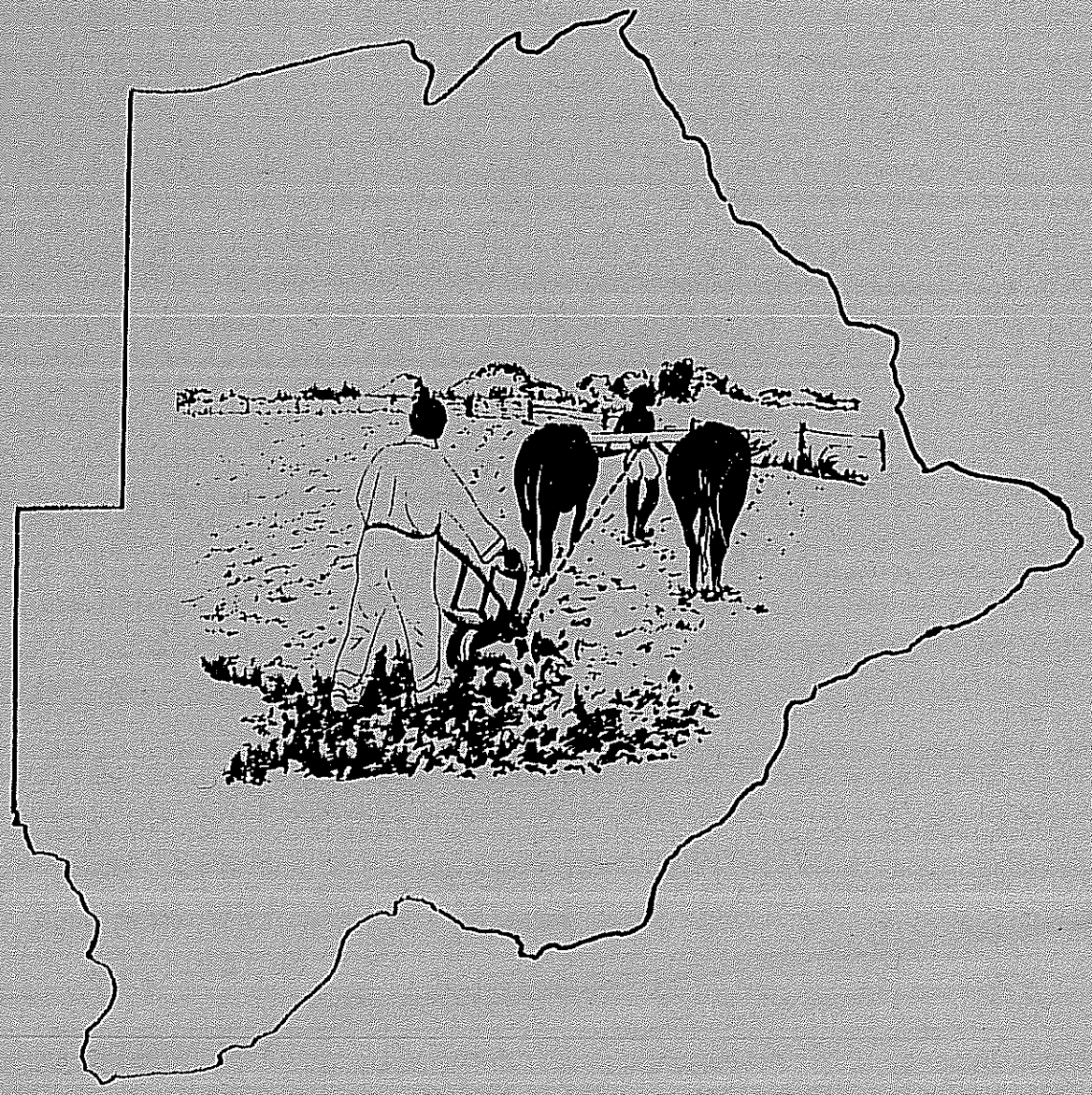
A PROFILE OF ENVIRONMENT AND DEVELOPMENT IN BOTSWANA



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A PROFILE OF ENVIRONMENT AND DEVELOPMENT IN BOTSWANA

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October 1986

PREFACE

Like many other developing countries, Botswana faces mounting pressure on its environmental resources, particularly renewable ones. Efficient and sustainable use of these resources has become a requirement but not yet a fact. As a result, presently achieved rapid economic development may be threatened in the future. It has, therefore, become a necessity (not a luxury!) to conserve th environment so as to sustain economic achievements.

Most people as well as governments are aware of the need to conserve the environment while using it, but solutions are not always available or they are difficult to implement. This is due to the complexity of the issues, involving economic, technological, social, cultural and ecological facets. This report attempts to highlight the importance of the various relationships between these facets for the description, analysis and possible solutions of environmental problems. Past solutions have often focussed on one aspect and therefore proved difficult to implement. Instead, solutions may be found through a number of measures which need to be supported by government and the people alike. It is not the intention of this report to provide such solutions. Such decisions need to be included within the National Conservation Strategy (NCS). This report provides the data for the National Conservation Strategy. The National Conservation Strategy and this project both form part of the Clearing House Arrangement, agreed upon by the Government of Botswana and UNEP.

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ACKNOWLEDGEMENTS

This report results from close cooperation between the authors and various ministries as well as non-governmental organisations. The authors would like to express their gratitude to all people who contributed to the project. They are too many to list in person. They cover the Ministry of Agriculture, the Ministry of Local Government and Lands, the Ministry of Mineral Resources and Water Affairs, the Ministry of Commerce and Industry, the University of Botswana, the Kalahari Conservation Society and the Forestry Association of Botswana. All members of the National Conservation Strategy Coordinating Group, Department of Town and Regional Planning deserve special mentioning for their continuous support and close cooperation. District Officers assisted in the collection of information from their regions. The project has also greatly benefitted from the contributions of its reference group. We are grateful to UNEP and the Government of Botswana for initiating the Clearing House Arrangement, which included this research project. The Dutch Government provided funds for the project.

The project has been executed by the National Institute for Development Research and Documentation, University of Botswana and the Institute for Environmental Studies, Free University, The Netherlands. We thank their Directors (Mr. N.T. Morapedi (Acting) and Dr. J.B. Opschoor, initiator of the project idea) and staff for the supervision provided as well as academic and secretarial support. We thank Mr. V.B. Moremi for preparing the front cover, and Mr. G. Koorutwe for his assistance with some of the maps. The lay-out of the report was done by Mrs. R. John and Mr. E.M. Veenendaal. Mr. D.L. Kgathi, NIR and Mrs. I. Mogotsi, the Department of Economics, have collected and summarised socio-economic data on wood use and wildlife and vegetation respectively. Corresponding chapters in this report made extensive use of their findings. Finally, we are grateful to Prof. W.F. Mnthali for editing the final report.

Errors in the report, however, remain the responsibility of the authors.

JAAP ARNTZEN and ELMAR VEENENDAAL

Gaborone, October 1986.

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LIST OF ABBREVIATIONS

ALDEP	Arable Land Development Programme
APRU	Animal Production Research Unit
ARAP	Accelerated Rainfed Arable Programme
BAMB	Botswana Agricultural Marketing Board
BCL	Bamangwato Concessions Limited
BDC	Botswana Development Corporation
BMC	Botswana Meat Commission
BPC	Botswana Power Corporation
CARG	Communal Areas Research Group
CITES	Convention on Internaional Trade on Endangered Species
EEC	European Economic Community
EDL	Environment Development Linkages Project
FAB	Forestry Association of Botswana
FMD	Foot and Mouth Disease
GDP	Gross Domestic Product
GOB	Government of Botswana
IES	Institute for Environmental Studies,Free University,The Netherlands
ILCA	International Livestock Centre for Africa
KCS	Kalahari Conservation Society
LDP	Livestock Development Projects
LSU	Livestock Unit
NIR	National Institute of Development Research and Documentation
SACCAR	Southern African Coordination Conference of Agricultural Research
SADCC	Southern African Development Coordination Conference
SARCUSS	Southern African Regional Commission for the Conservation and Utilisation of Soils
SLOCA	Support Livestock Owners in Communal Areas
TGLP	Tribal Grazing Land Policy
TSP	Total Suspended Particulates
UNEP	United Nations Environmental Programme
WHO	World Health Organisation
WMA	Wildlife Management Area
WUC	Water Utilities Corporation

NOTE TO READERS

The report covers a wide range of inter-related environmental and developmental issues. The authors have attempted to keep the report as brief as possible while providing both baseline information on and an analysis of environment and development in Botswana. In order to accomodate different needs and constraints of readers (e.g. available time and required level of detail), the report includes:

- an executive summary with the main findings
- appendices with figures, tables and maps, which are too detailed for the main report but are thought to be relevant for development planning and implementation purposes. All references in the report to appendices start with an A. For example, Table A.6.4. refers to the fourth table in Appendix 6.
- chapters structured so as to facilitate easy access.

In addition, a large number of references is included in the main text comprising the most relevant reports and books. A comprehensive bibliography is due to be published late 1986.

EXECUTIVE SUMMARY

Mounting pressure on the country's environmental resources has raised people's general awareness of environmental problems, such as land degradation, and has made action to counteract a deterioration of the environment, a matter of urgency. The Clearing House Arrangement between the Government of Botswana and UNEP is only one piece of evidence of government's concern on this matter. The research which forms the basis of this report, and the preparation of the National Conservation Strategy are two important and complementary components of this Arrangement.

The central theme of this report is that environment and development are closely linked. Environmental problems and remedies are therefore considered within this development context. The report deals with a full spectrum of environmental issues and, as a result, it shows and emphasises the linkages between various issues as well as activities.

This report attempts to bring together and analyse the major research findings on environment and development in Botswana. In doing so, we hope that research results become more accessible to development planners and consequently, environmental considerations are incorporated in all stages of development planning. To be more specific, the report gives:

- an overview of the state of the environment in relation to economic development.
- a review of major present and anticipated environmental problems and of presently known options to remedy them.
- a survey of relevant legislations, institutions and development programmes.

In addition, we hope that the report also provides a useful general methodology for analysis of environmental issues (chapter 1). The report opted to use the sectoral-oriented approach (instead of the problem-oriented approach) because most data and institutions are organised along sectoral lines. However, this choice requires a strong emphasis on the linkages between various sectors and on subsequent integration. An example of the latter is given in Chapter 8 for two of the most serious environmental problems, i.e. pressure on land and water resources. This integrated analysis uses the distinction between causes, effects of and responses to environmental problems. Responses to problems by people or government may form again cause(s) of other environmental problems (chain-reaction). Government has the option to respond directly or to induce required popular responses through the provision of incentives and disincentives.

The links between development and the environment are strong in Botswana and until now primarily based on resource utilisation (agriculture, wildlife, wood, plants and minerals). Mineral exploitation and livestock are the dominant economic activities and other productive activities such as industries are relatively small. As a result, pollution is limited and not widespread. Emphasis on economic diversification may alter this situation in future. Over-utilisation has generally a negative influence on development as the productive capacity of land decreases and rehabilitation measures may be difficult (reversible or not) and cost money. Preventive measures may prove cheaper in the long run but the economics of conservation is hardly examined in Botswana. Non-renewable resources such as minerals are finite and therefore

their exploitation cannot form a sustainable source of development. For Botswana, the implication is that development must be sustained by reducing dependence on mineral exploitation.

Linkages betweeen economic activities exist through:

- competition for environmental resources (land, water, vegetation, etc.)
- competition for economic resources such as labour and capital.
- structural links. For example, cattle can be used as draftpower.

The report pays special attention to the following aspects:

1. trends: environmental problems usually become manifest gradually and sometimes only after a number of years. The report covers as much as possible the period 1966-2000.

2. spatial differences: Botswana is large in size and includes significant environmental variations. For example, rainfall and soil vary regionally and habitats vary from the unique Okavango swamps in the north to arid ecosystems in the south west.

3. distinguished socio-economic groups: Environmental problems affect poor people usually more seriously than people who have sufficient means to adapt. In Botswana, numbers of cattle owned is a reasonable proxy for wealth. So-called vulnerable groups can be identified as belonging to the poorest part of the population (e.g. female-headed households, herdmen, farm labourers, remote area dwellers).

4. international aspects: Exports and imports are relatively high in Botswana. By importing processed goods, the country avoids domestic resource use and pollution associated with the production of such goods. Import substitution will increase the demands on local environmental resources. In addition, Botswana shares most large surface water sources with neighbouring countries (Chobe, Limpopo, Okavango). For example the catchment area of the Okavango lies mostly outside Botswana. Finally, the country has signed a number of international agreements such as CITES and participates in international bodies such as SADCC, UNEP, etc.

Environmental constraints influence human activities heavily in Botswana. Rainfall is very erratic with recurrent droughts as a 'normal' part of the pattern. However, seasonal rainfall fluctuations are even higher than the annual ones. Three largely unrelated periods can be distinguished in seasonal rainfall distribution. For example, the amount of rain in January and February explains 80% of the variation in annual crop productivity. Areas with lower average rainfall face also a less reliable rainfall pattern. Soils are generally fairly poor and mostly suited for extensive land use.

Botswana is in general well endowed with a number of environmental resources. Large deposits of diamonds, coal and copper/nickel have been identified and exploration for a number of other minerals such as gold and oil continues. Wildlife is abundant in numbers and species. The latter is due to the variety of ecosystems and the vastness of the country which has until now left adequate space for wildlife. Savannas dominate the vegetation although forests exist in the northern part of the country. Water resources appear to be the most limiting resource although the potential of groundwater, particularly in western Botswana, has not yet been fully assessed. The country has two large natural water sources (Okavango and Chobe) but these are far away from the demand in eastern Botswana. In addition, they are shared with neighbouring countries.

Livestock has long been the dominant economic sector and it still is the major, economically most attractive, rural activity. Livestock are multi-purpose and provide, apart from meat, also milk and draftpower. Livestock numbers have continuously increased after Independence. Cattle numbers doubled (as did the human population) to around 3 million in 1981. During the recent drought, the number of goats increased dramatically from 621,000 in 1981 to 889,000 in 1984 (compared with a decrease in cattle numbers to 2.7 mln) and goats regained some of their position of the early 1970s. Goats are performing better during droughts but the increase is possibly also the result of increased BMC prices. However, the exact cause(s) can only be established after the drought. A combination of factors is probably responsible for the continuous increase in cattle numbers: favourable price developments until 1979, government subsidies, government veterinary services and spraying campaigns, plus the urge to have at least 20 head so as to become less susceptible to droughts and acquire own draftpower. Livestock numbers exceed the carrying capacity in most parts of the country, particularly in small districts such as South East and North East. Overgrazing is not a new phenomenon but it is more intense and widespread than ever before. Moreso it affects cattle productivity through higher mortality rates and lower birth rates. The move "to go west" has hardly alleviated the situation in eastern Botswana. This move is only feasible for large cattle owners and threatens to some extent the activities of remote area dwellers. A clear indication of overgrazing is that livestock holders consider grazing rather than water the main constraint. Water can usually be acquired by moving cattle or purchasing water from boreholes (farmers use a so-called fallback strategy). However, grazing is difficult to find and fodder is expensive. Pressure on grazing and and water has encouraged privatisation of e.g. boreholes. Around 60-70% of the rural population holds cattle and this percentage has not yet decreased. However, smallholders are 'forced' to keep livestock increasingly in already overcrowded mixed farming areas. In future fewer people may be involved in livestock holding and this will negatively influence the availability of animal draftpower in the arable sector. Improved animal husbandry practices are not likely to solve the problem of land degradation unless stocking rates decrease, institutional arrangement with respect to land management are made and alternative income sources are made more attractive.

The arable sector has developed slowly. Risks of (partial) crop failures are high because of the erratic rains and the comparatively low returns to labour have led to the widespread adoption of a low input, risk aversive strategy on the part of the majority of poor arable farmers. The total arable land claim is small: including short term fallow, arable land covered 800,000 ha in the mid 70's but less than 300,000 ha is annually cultivated. Crop production is most feasible in eastern Botswana and around the Okavango. Molapo farming is practised on a small scale around the Okavango. Irrigated crop production covers around 1,000 hectares but equals the water use of the entire livestock sector (35% of total use). Possible irrigation in future will lead to huge water requirements and hence competition will arise with other activities. Because initial investments are low, more people are involved in crop production than in livestock. Productivity and returns are low but the sector remains important for those without better alternatives. Farmers face to various degrees constraints such as labour, draftpower and capital. Arable revenues are generally positively related to herd size. Apart from the low input oriented strategy, increased use of tractors contribute probably to lower productivity per hectare as large areas can be ploughed but not adequately weeded, thinned, etc. Deforestation through clearing of land and particularly soil erosion (water and wind) appear to be the most important environmental problems related to crop production. Few data exist on the extent of erosion in arable land but these indicate that it is an underrated problem. In practice, no measures are taken to limit the process (e.g. windbreaks and grass

strips like in Swaziland and Zimbabwe). Arable land is not used continuously and a dynamic process of field abandonment and opening of new ones exists. Arable expansion has probably contributed only marginally to overgrazing with possible exception of Barolong. There is as yet no indication that new arable land is less suitable than existing fields. Government has launched several policies to boost agricultural production (ALDEP, ARAP and FAP) but environmental considerations have received too little attention. In view of the general land pressure, it seems necessary to emphasise higher productivity per hectare and encourage better soil and water management.

Wildlife and veldproducts have played traditionally an important role as source of food etc., particularly in the sparsely populated western and northern parts of Botswana. Wildlife is abundant in number and composition due to the variety of ecosystems and the availability of land.Historical data on wildlife numbers are virtually absent but numbers appear to have fluctuated considerably, mainly related to droughts. Wildebeest and Hartebeest are most migratory and generally migration patterns become more distinct during droughts. It is too early to say what the effects of the present drought in combination with encroachment of other human activities will be. Recovery of wildlife will be more difficult but the recognition of wildlife as a major resource for development and corresponding reservation of National Parks and Reserves (17% of the country) and plans to establish wildlife management areas (20%) suggest that wildlife has a future. Wildlife has proven to be essential for tourism in the northern, varied and more accessible, National Parks and Game Reserves in particular Chobe National Park. Environmental effects of tourism are not properly documented but the uncontrolled mushrooming of tourist camps in the Okavango and the spread of salvinia through tourist boats appear the main problems. Hunting occurs throughout the country in so-called controlled hunting areas. Subsistence hunting is most important particularly for the poor households in western Botswana, and is responsible for some 90% of the kills (1978). However, recreational hunters hunt more frequently rare species for trophies. Government introduced a quota system for hunting and the number of quota issued has been decreased during the drought. In Ngamiland, only 32% of the animals in quota are killed. However, records are incomplete as 70% of the licences are never returned. The extent of poaching, mostly of predators, is hardly known but was (under-) estimated to be 13% in Western Kgalagadi in 1976. Most threats to wildlife appear however, to originate from other human activities. The recently adopted Wildlife Conservation Policy provides adequate opportunities to integrate wildlife utilisation and other land use forms to boost development in wildlife management areas. The Okavango and South West Central Kgalagadi ("Schwelle") should be carefully considered as pressure on these areas has rapidly increased. In addition, resource management in National Parks and Reserves has become increasingly important.

Botswana's fish resources in the north are far from the consumers markets in the east. Its full potential is not yet exploited 1,000 tonnes annual catch compared with a sustainable potential of 2500 tonnes. In the past, over-exploitation occurred in Lake Liambezi.

Veldproducts are increasingly used for subsistence and commercial purposes. The former increase results from the overall population growth; the latter from urbanisation, emerging shortages and processing opportunities. Veldproducts can be an important source of food and income. Presently, Mopane worm, Mokola palm, Grapple plant and thatching grass are most important. Depletion of these resources has occurred locally and threatens income opportunities for rural people. Legislation allows to control harvesting of such resources through a permit system but the basic question - how much can be harvested on a

sustainable bases needs still further investivation. For example overgrazing is likely to contribute to depletion of thatching grass but the extent is not known.

Wood Utilisation is comparable with the use of veldproducts. Wood is used for a variety of purposes and energy may only be half of the demand. Fencing for agricultural purposes also consumes considerable amounts (50%). Standing crop of wood varies based on the type of vegetation, the extent of arable production, and the extent of bush encroachment. Average standing crop varies from ±10.6 tonnes/ha in Central district to 22.6 in South East. Approximately, 60% of the biomass of trees can be used for energy purposes. Woodlots are mostly small and the majority have not performed satisfactorily until now. Wood shortages have emerged around larger settlements and generally in South Eastern Botswana. Deforestation is not yet widespread but woodcutting in combination with clearing of vegetation for cultivation and settlements has caused erosion locally, particularly in hilly areas and around villages (e.g. Mmankgodi). Deforestation may in future occur around larger settlements in the sandveld. Adaptations to wood shortages may accelerate land degradation processes (e.g. burning down of trees) and the required extra socio-economic inputs (e.g. spend more time on wood collection or purchase wood) affect other activities. Solutions to wood shortages lie again in the integration of wood use in overall development and land use planning. Possibilities exist with regard to wood trade from surplus to shortage areas, management of the natural vegetation (e.g. establishment of Forest Management Areas) and the use of affordable substitutes (e.g. wire fence). Locally, woodlots may contribute to alleviate shortages. Tree planting exercises probably have a limited direct effect but they may raise people's awareness to conserve trees.

The mining sector has become the backbone of the country's economy. The annual production had an estimated value of P961,000,000 in 1984 compared with only P20,000 in 1966. Diamonds, copper, nickel and coal are most important. Large coal deposits remain untouched at the moment because of low world market prices. Environmental resource requirements and environmental impacts depend on the nature of the mining process and its location. The latter is by necessity in the proximity of the deposits and cannot easily be changed. The operational mines present are mainly located in previously mixed farming and grazing areas and direct land claims are very small (456 km^2). The copper/nickel mine in Selebi-Phikwe required the largest infrastructural facilities (e.g. Shashe project). This mine is the largest water consumer in the country (6.1 mln m^3) and consumes 80-90% of the power generated by the power station in Selebi-Phikwe. Requirements of diamond mines in Jwaneng, Orapa and Letlhakeng are smaller but also demanded establishment of a wellfield and a dam. Open pits exist at the diamond mines and in Selebi-Phikwe. Clearly, mining related infrastructure and settlements change the local environment. The copper and nickel mine causes pollution of the air and water. Monitoring of the air quality in the town indicates that air quality objectives set for residential areas only, are regularly exceeded, to a large extent due to the location of the town in the dominant wind direction. Air pollution is a source of complaint by people and may influence their health; no effects have been found on the vegetation. Monitoring of the water in the Motloutse river indicate above normal concentration of heavy metals. Abatements of air and water pollution have been implemented to curb the pollution.

Apart from actual exploitation, exploration activities are going on in large parts of the country. These may extend the lifetime of existing mines such as Selebi-Phikwe, where proven deposits almost doubled, or may lead to entirely new mining activities. In the latter case, environmental effects depend largely on the location and type of mining. Exploration activities as such have limited environmental effects. Generally, exploration improves the

accessibility of areas and, apart from positive developmental effects, this may facilitate poaching. The future of the mineral sector depends to a large extent on the discovery of additional deposits. Solutions to the relatively limited environmental problems could lie in strengthening of environmental considerations in all phases of planning, e.g. through an environmental impact assessment, extended use of the Town and Country Planning Act and the establishment of more systematic quality standards and standards for emissions and effluent.

Similar measures would also be needed to restrict negative environmental activities emanating from industrial activities etc. Although such activities are presently small, they are expected to grow rapidly. Moreover, even small productive activities may cause locally serious environmental problems (e.g. garages and tanneries). Presently, meat-based industries, beverages and textiles are the most important industries. Trade and government are significantly larger sectors but these have generally smaller environmental effects, be it through resource use or pollution. If efforts to diversify the economy are successful, environmental effects of industrialisation may become more important. Land claims are likely to be small and concentrated, but demand for water and energy may increase substantially as well as pollution hazards.

As a result of the achieved economic growth, household consumption has increased in size and probably changed in composition. Improved living standards have boosted domestic energy and use. Consumption contributes to pollution through littering and, in large villages, nitrate groundwater pollution through sceptic tanks mainly. Since present problems are still limited, emphasis can be given to the limitation of future environmental problems. The preparation of environmental impact assessments would provide insight into anticipated problems and options to limit these. Control over emissions, disposal of effluent and solid waste in combination with pollution standards could assist government and enterprises in reducing negative environmental effects. Protection of water resources and people are main concerns for both. Finally, environmental education of workers and consumers could reduce pollution (e.g. flushing of chemicals).

Pressure on land has increased substantially and led to:

1. livestock encroachment into western Botswana
2. conflicts between livestock and arable production in eastern Botswana
3. land shortage around large settlements.

In addition, it has led to widespread and intense land degradation which in turn causes extra land requirements and decreases the productivity (loss of topsoil and increased run-off). Responses to land degradation have been minimal and have been mostly geared to exercise or acquire exclusive de facto or de jure land rights (e.g. through boreholes and ranches). Improved resource management and rehabilitation have not been adopted by people because of genuine limitations of options for action rather than because of ignorance. A key concern for government therefore is to ensure adequate mechanisms of resource management. Apart from institutional arrangements, this requires the provision of incentives and dis-incentives aimed at better use of land.

Simultaneous with increased land pressure, pressure on water has increased. Human activities compete to a different extent for water resources based on the size of use and the spatial distribution. Water constraints have occurred in south-eastern Botswana and more generally in eastern Botswana for the allocation of new boreholes (8 km distance). Crucial issues related to water are:

1. supply cannot easily be expanded where demand is growing most rapidly. The large surface water sources are in remote, sparsely populated areas. Best opportunities to establish new dams are in north eastern Botswana, where present supply is adequate.

2. the groundwater potential, particularly in western Botswana, is not fully known. In addition, information on recharge is inadequate and therefore it is not now possible to set a maximum sustainable water use for the country. Recharge is known to fluctuate with rainfall conditions and is relatively low in presently known aquifers.

So far, emphasis has been put on the expansion of waterworks. However, suggestions have been made to re-address regional imbalances by re-direction of those activities using large amounts of water to the north eastern water surplus area and to link the major watersources and demand points through a water circle or grid. Development of groundwater resources could compensate for drying up of dams during droughts. In addition, the efficiency of water use could be increased.

What is the future perspective? The country is clearly in a transition period, where efficient and sustainable use of environmental resources has become a requirement but not yet a fact. Many environmental problems including future ones can be limited or even avoided by integrated development planning and implementation where environmental considerations are incorporated along with others. Clearly efforts to raise environmental awareness through education, extension, etc., among development planners and people alike could assist. Systematic research efforts, e.g. at Ministries and the University of Botswana, could be strengthened to provide necessary support. The report identifies a number of gaps in knowledge such as, the economics of degradation and conservation and groundwater potential and recharge, as well as areas such as agriculture where statistical data are available but not analysed in detail. Regular monitoring and evaluation exercises appear essential to achieve sustainable resource utilisation. Land degradation may require separate attention as its causes are complex and the effects serious and widespread. No easy solutions exist and it appears urgent to at least attempt to implement possible solutions. Hopefully, such issues will be addressed during the on-going preparation of the National Conservation Strategy.

INTRODUCTION

Terms of Reference

This report is one of the outcomes of the Environment-Development Linkages Project (EDL). An environmental bibliography is in preparation. The project is part of the Clearing House Arrangement agreed upon by the Government of Botswana and the United Nations Environmental Programme (UNEP). The EDL Project is funded by the Dutch government. It is carried out jointly by the National Institute for Development Research and Documentation (NIR), University of Botswana and the Institute for Environmental Studies, (IES), Free University, The Netherlands.

The overall objectives of the project are fivefold:

1. to compile an overview of the state of the environment, in relation to economic developments.

2. review backgrounds of major present and anticipated problems and of presently known options for the alleviation of these problems.

3. survey of present environmental legislation, administrative arrangements and institutions, and of environmentally relevant development programmes.

4. establishment of a comprehensive collection of environment-development related documents to ensure present and future access.

5. annual publication of an environmental information index including brief annotations of new environmental documents to improve general awareness of environmental information among development planners.

The fourth and fifth objectives are met by the preparation of an environmental bibliography and the acquisition of environmental documents by the NIR. This report focuses on the first three objectives. It attempts to bring together and analyse the main research findings on environment and development issues. Past research results are scattered over numerous, often bulky reports and particularly older research was often lost out or of sight. Consequently, research results did not play an optimal role in development planning. The EDL project in general and this report in particular aims at improving access to relevant environmental data by development planners, identifying gaps in knowledge and consequently suggesting future research areas, and finally suggesting systematic data collection to describe the state of the environment.

The report is meant to facilitate the incorporation of environmental considerations in stages of development planning. Obviously, environmental planning helps if it is based on a knowledge concerning e.g.:

1. causes and size of environmental problems, including trends
2. effects of and response to such problems by people
3. government options to support adequate responses

The timing of the project seems opportune. As pressures on environmental resources mount, environmental problems become more manifest and government seems increasingly concerned with environmental conservation. For example, the EDL project is undertaken while the National Conservation Strategy is under preparation. In addition, the Livestock Development Project has been

broadened to explicitly include range issues in communal areas a comprehensive land use planning exercises. The results of EDL are also mea to contribute to the successful completion of these projects as well as fo the other projects of the Clearing House Arrangement.

The target group of this report are development planners at central government and district level. It may also be relevant for non-government organisations and individuals with interests in environmental issues.

Scope and Limitations of the Report

Environment and development as defined in chapter 1 are broad concepts and their analysis could cover an almost inexhaustible number of topics. The project lasted one year and therefore, a selection of major topics has been made in consultation with the reference group. Selection criteria have been:

- the nature and extent of effects on the country's environment (through pollution and exploitation)
- the contribution to the national economy as well as specific poverty groups
- the future importance with respect to environment and development.

The major topics addressed by the project are summarised in Table 1. Activities with local environmental effects have been generally excluded unless these effects are serious in nature. Generally, emphasis has been put on the more widespread problems.

Table 1

Major Selected Environment Development Topics

Problem	Examples	Economic sectors mostly involved
- Land degradation processes	- overgrazing, bush encroachment, soil erosion, desertification deforestation	- Livestock/arable production, Wildlife Vegetation and Wood use
- Competition for land	- encroachment of arable land into grazing areas, fragmentation of wildlife, opportunities for rural people	- livestock/arable production, Wildlife and vegetation use
- Competition for water	- depletion of ground water, disturbance Okavango ecosystem	- livestock/arable production, wildlife and vegetation use, mining, manufacturing
- Pollution	- air pollution, water pollution	- mining, manufaturing energy, consumption

Because of the limited time available, the report has the following limitations:

1. the relationship between environment and health is only marginally covered. This could be the subject for a specific study later.

2. limited use has been made of international literature, which could be relevant to Botswana's situation. Readers interested in specific topics in this report may wish to add such information through the services of documentation centres such as SACCAR in Sebele, local libraries, Infoterra services from UNEP and ILCA.

CHAPTER ONE:

BOTSWANA'S ENVIRONMENT AND DEVELOPMENT

1.1. A Conceptual Framework

Development aims at improving the living standards of all people and can be considered as a prime objective of society. Development is not just a matter of economic growth. It implies aspects such as the distribution of acquired benefits and their sustainability. The Government of Botswana has formulated four overall development goals: 1) rapid economic growth 2) social justice 3) sustained development and 4) economic independence. In the short run, these goals may appear to conflict. However, they have to be pursued simultaneously and with equal endeavours to achieve long-term development which can be sustained by the environment and society.

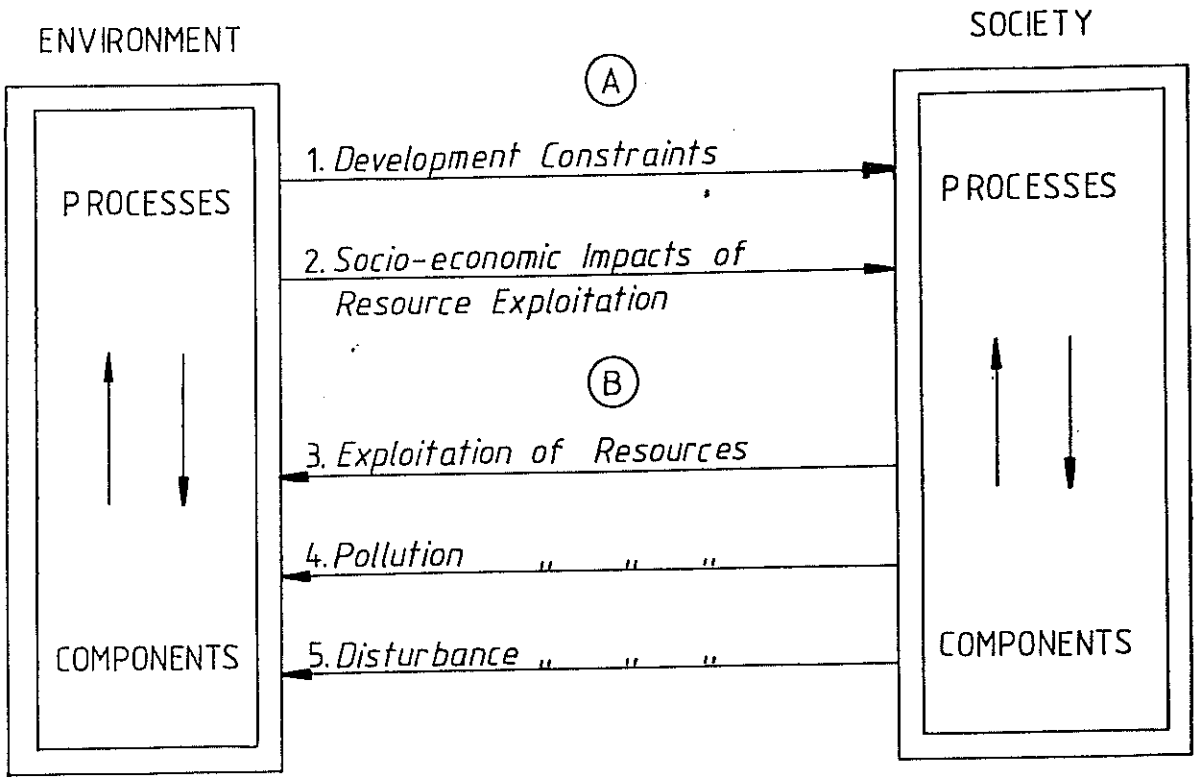
Human activities are the agents of development through the input of human, financial and environmental resources. Development is always, be it directly or indirectly, based on the environment through: 1) the utilisation of resources such as water, energy and minerals, 2) the provision of living conditions (e.g. air, sun, land) for people.

Environment is here understood as the total of biotic and abiotic resources surrounding people. Excluded are artificial and human environment. Societies are considered as groups of people with specific characteristics and rules such as values, skills and institutions influencing the type and size of human activities. Societies can be defined on a national and sub-national level. The former refers to inhabitants of a country: the latter for example to local communities. Most societies maintain external links which need to be considered too.

It is important to note that relationships between environment and society work in two directions, i.e. from the society on the environment and vice versa. In other words, the state of the environment has repercussions on the society and its development. The main relationships are summarised in figure 1.1. This figure is meant to highlight systematically, interactions between concepts such as environment and development. In this study, the figure has assisted in the selection of the relevant issues within the context of Botswana and therefore, formed the starting point of data collection and analysis.

Figure: 1.1.

A Schematic Presentation of Environment-Development Linkages



Source: Adapted from Opschoor, 1981.

The environment sets constraints to developments (arrow 1) by the availability of renewable and non renewable resources and by events such as droughts resulting mainly from internal environmental processes. The use of environmental resources also has impacts on the society, for example on human health and economic differentiation (arrow 2). Pollution may occur as a side effect of human activities (arrow 3). Finally, environmental impacts may arise from presence and movement of people. For example, people may trample vegetation and disturb wildlife. External factors may influence the environment and society (e.g. shared border rivers and export). Apart from the development constraints set by the environment, all environment development linkages emerge from human activities. The most relevant activities in this context are economic ones, be they productive or consumptive. Environmental effects of other human activities operate mainly through producers' and consumers' activities. Given Botswana's economic structure and resource use, seven groups of activities have been distinguished:

1. livestock production
2. crop production
3. mining activities
4. wildlife and veld products utilisation
5. wood utilisation
6. other productive activities
7. consumptive activities by people.

The sectors include both productive and consumptive activities but do not follow standard economic classifications. For example, wildlife, veld products and wood utilisation are considered as separate activities here in view of their importance to households. During this study, the sectoral approach was used as opposed to the problem-oriented approach. The latter takes problems such as soil erosion as the starting point of analysis whereas the former starts from sectoral perspective. The sectoral approach is used because many data and organisations including government are structured along sectoral lines. However, one should take care to include interactions between sectors and their contribution to specific environmental problems. This has been attempted in this report in the various sectoral chapters and by the integrated discussion of the main environmental problems in chapter 8. For the integration, a chain analysis of "causes - impacts - responses" has been used as summarised in Figure 1.2. This analysis is dynamic as usually not all responses are fully effective and some can create new environmental problems.

Figure 1.2

A Framework for the Analysis of Environmental Problems

	Causes	Impacts	Responses by the	
			People	Government
Environment				
Society				

Source: United Nations, 1984 (adapted).

As a result of interactions and internal processes, society and environment change continuously. Table 1.1 summarises the elements and processes within each. These are discussed in section 1.2 in the country's context and feature throughout the report.

Table 1.1

Relevant Components and Processes in the Environment, and Society

	Components	Processes
Environment	abiotic: land, water, soil, air, minerals temperature, light biotic: vegetation, animal life cycles, population dynamics vegetation and animal life	soil formation, exhausting and erosion, bush enchroachment, desertification, groundwater processes, rain fall patterns, temperature
Society	human population, socio-economic groups, economic activities, technology, culture, legislation, institutions, organisations, education, human settlements	population growth, seasonal migration urbanisation, economic differentiation, innovations cultural, organisational and institutional changes etc.

To do justice to the outlined conceptual framework, the following factors require specific attention:

1. the temporal dimension. Past and future trends need to be determined. Independence (1966) has been chosen as starting point for past analysis whereas future developments may extend to the year 2000.

2. the spatial dimension. Districts have been chosen as the level of regional analysis. Whenever necessary, local references may be made as well as other sub-divisions such as rural versus urban.

3. interactions between the distinguished sectors. Such interactions exist through

   - competition for socio-economic and environmental resources (e.g. land and labour)
   - structural relationships such as animal draftpower.

   The main interactions relevant for EDL are summarised in Table 1.2.

4. different socio-economic groups. Development and environmental problems tend to benefit and affect groups of people differently. Although recent data on income distribution do not exist, one can easily distinguish so-called vulnerable groups.

5. government policies and legislation. These can be directed towards specific sectors and problems or be general and generally aim at assisting people in coping with (environmental) problems.

Table 1.2.

Main Linkages between Human Activities*

	Livestock Production	Crop Production	Wildlife/ Vegetation Use	Wood Use	Mineral Production	Other Productive Act./ Consumption by Households
Livestock		Draftpower Manure	Competition for grazing	Bush encroachment		Inputs, Processing Industry, Food
Crop Production	fodder crop residues			vegetation clearing fencing		Food
Wildlife Veld Prod. Utilisation	Diseases Competition	Weeds Pests, Crop		Damage to trees (e.g. elephants)		Inputs processing industries food
Wood Use	Wood for kraals and fences (corrosion/ drift)	Wood for fencing				Wood for construction, energy
Mineral Production		Pollution		Clearing of Vegetation		Consumption energy and water, pollution
Other Productive Activities and Household Consumption		Pollution				

*All activities compete, to varying extent, for water and land.

6. external factors. Today's societies have usually all external links. They may also share environmental resources.

In the following sections, the conceptual framework will be discussed in the specific context of Botswana. Components and processes indicated in Table 1.1 are reviewed. Trends since Independence and some future trends will be covered.

1.2. Botswana's Society

1. Population Settlement Patterns

> Rapid population growth - low population density - rapid urbanisation - 80% of people live in rural areas - most people live in the east

Botswana's population is small but rapidly growing. The de-facto population increased from over 500 000 just before Independence to nearly one million in 1981 (Figure 1.3 and table A.1.1). Past developments have revealed three trends. Firstly, population growth is high and even seems to have increased from 2.3% per annum in the intercensoral period 1964-1971 to 3.3% p.a. in 1971-1981. Growth rates for rural population have been similar in all districts (Figure 1.4 and Table A.1.2.). Secondly, the population density remains low but varies from district to district. For example, population density in Ghanzi is less than 1 compared with 61 in South East District (Table A.1.1). In general, small districts have higher population density* than larger ones. Thirdly, the country faces rapid urbanisation.

The urban population has increased by 10.7% per annum between 1971-1981 but over 80% of the population still lives in rural areas. New towns such as Gaborone and Selebi-Phikwe grow much faster than older ones such as Lobatse and Francistown. Urbanisation has caused a notable relative increase in total population in South East District (from 6% in 1964 to 12% in 1981). In 1981, four rural villages had over 20,000 inhabitants and 13.4% of the total population stayed in villages of more 10,000 inhabitants. In 1971, this percentage was 6.7% only (NDP6,12). A considerable but decreasing part of the population still stays at the lands and cattleposts (1971:44.1%; 1981: 35.7%). The trend towards sedentisation manifests itself also in the increasing number of small villages with less than 500 inhabitants (45 in 1971; 206 in 1981). Such villages include settlements at the lands.

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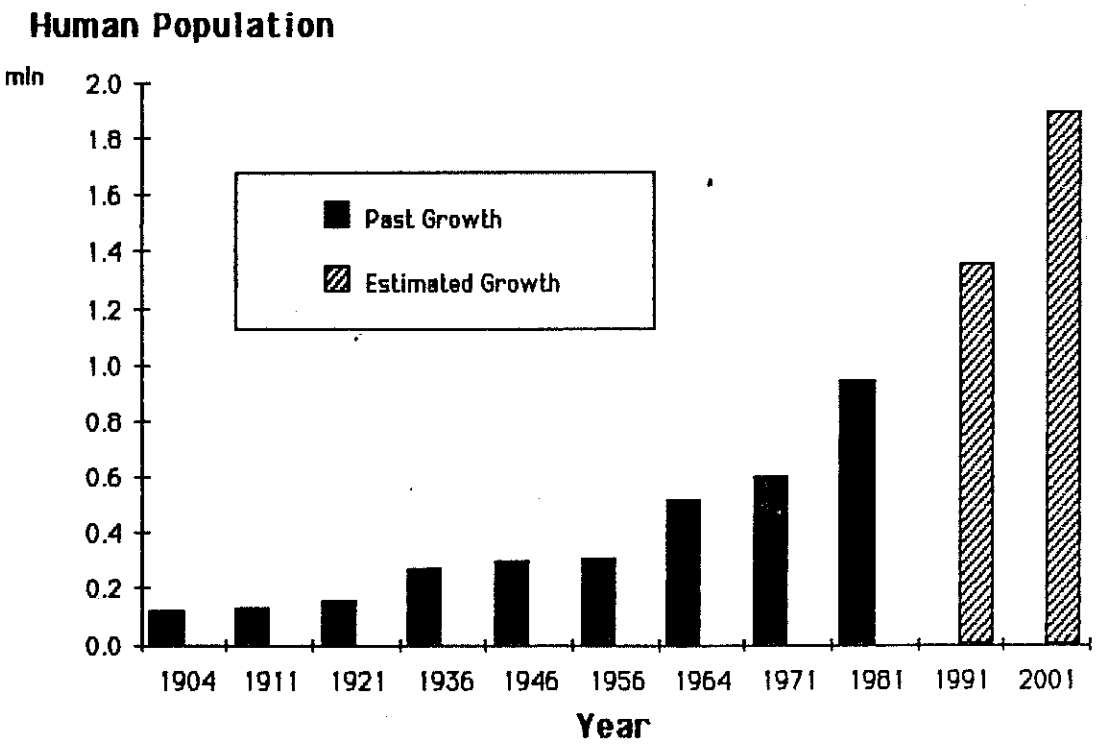
* the concept of urban areas is used in different ways in Botswana. Usually, Gaborone, Francistown, Lobatse, Selebi-Phikwe, Orapa and Jwaneng are considered as towns. If the criterion is that towns have at least 75% of the labour force in non-agricultural sectors, Palapye and Tlokweng also qualify.

Figure 1.3

Past and Future Development of Human Population

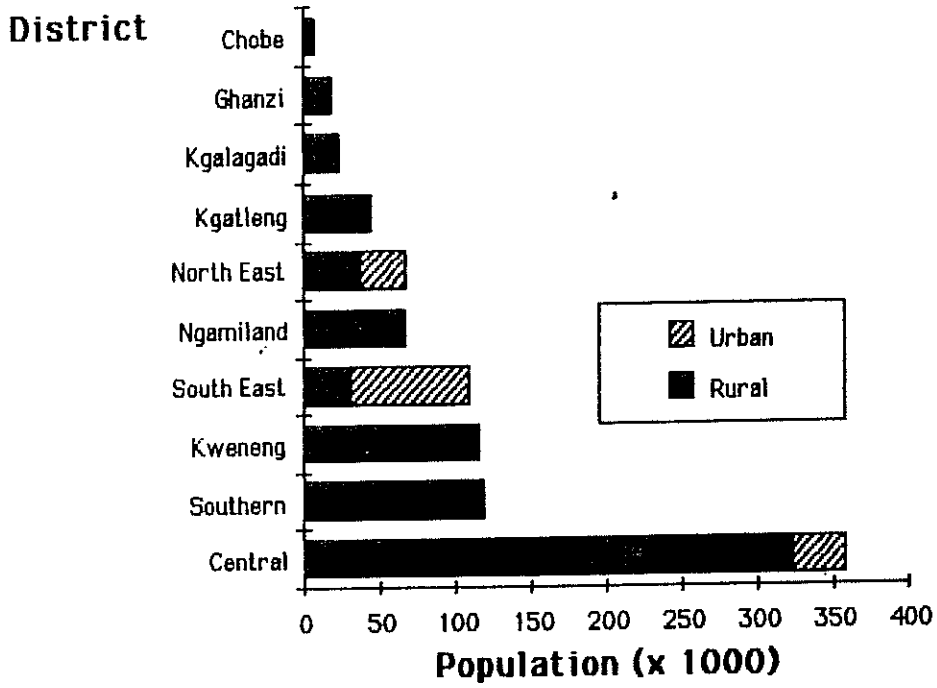


Source: Population Census, (past.) Growth scenario's from NDP6.

Rapid future population growth will put an additional burden on the development tasks of the country. Even a growth rate of 3.0% will almost double the population by 2001. As population trends cannot easily be reverted on the short run, the country has to achieve a correspondingly high level of economic growth to at least stabilise the average standard of living. At a regional level, rapid population growth may increase pressure on small districts to levels where space is short, to provide the majority of the population with opportunities in agriculture.

Figure 1.4.

Human Population by District



Sources: CSO, 1976; CSO, 1982.

2. Education

Improved education of young people

Educational facilities have expanded rapidly since Independence (Government of Botswana/UNICEF, 1986). Consequently, an increasing part of the population is or has been at school. This percentage is highest in urban areas and lowest in remote rural districts (Kann, 1984). In 1981, 43.4% of the population above 4 years had never been to school; 24.6% attended and 32.0% had left school. Most people had left school during or at the end of primary school (61.2% and 27% resp). Younger people have more frequent and longer school experience. Out of the age-group 5-19 years, 35% never attended school and 42.3% of the people with school experience had post-primary experience. Corresponding figures for the age-group 20 and older are 4% and 62%. Government policies and increased urbanisation will result in a generally more and better educated population in the future. This creates opportunities for informing people better on environmental matters and more efficiently assist through extension work etc. In this respect, it is important that environmental knowledge, abundantly present among particularly older rural people, is not lost.

3. Institutions and Legislation

Emerging new institutions - new legislation - resource management gap

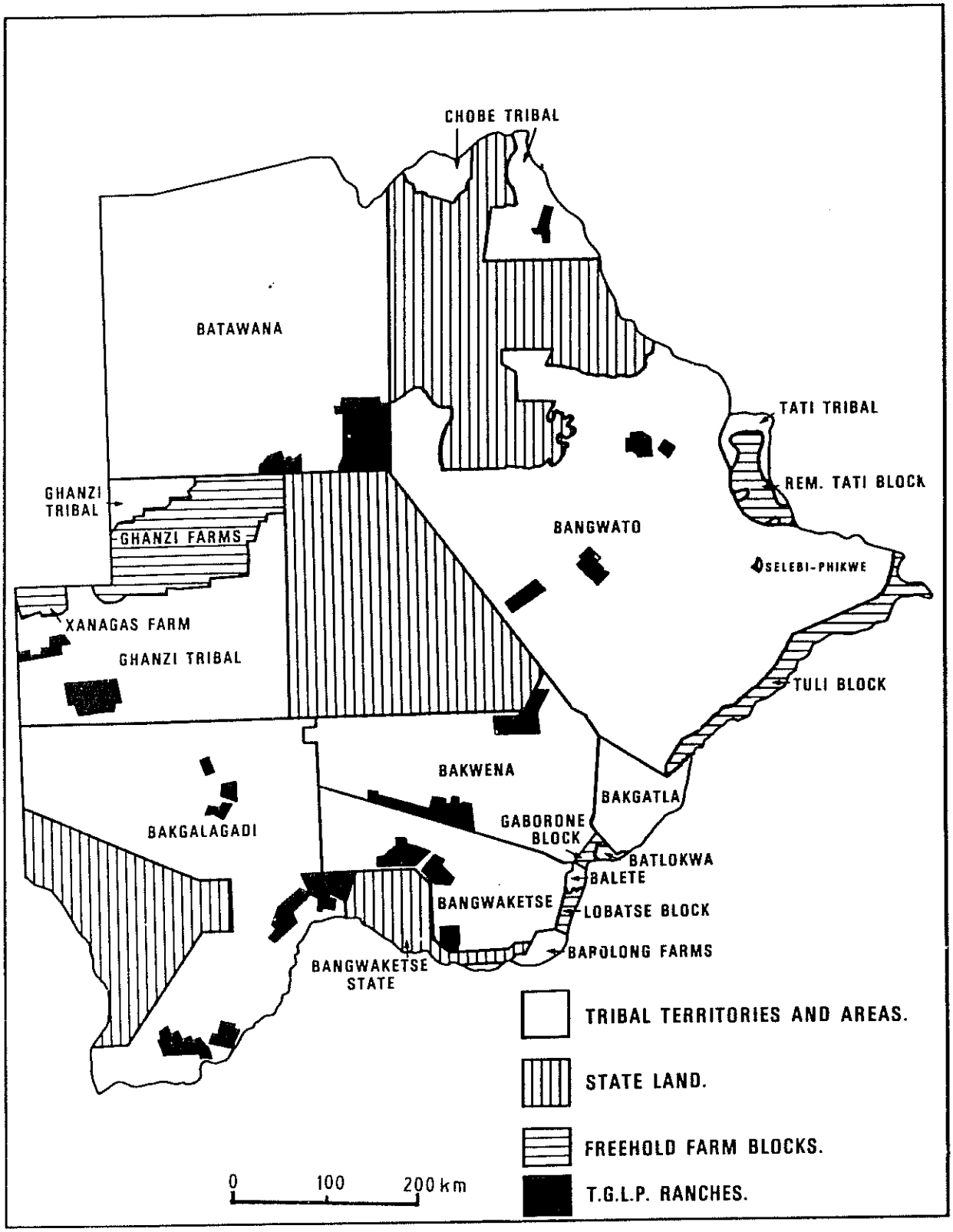
Most land in the country is Tribal Land compared with 23% State Land and 6% freehold land (map 1.1).

The role of the traditional structure in allocating and managing environmental resources and the subsequent transfer of most power to new institutions such as Land Boards have been the subject of various studies (Machacha, 1982; Mathuba, 1983). The traditional structure's involvement was mainly based on three factors 1) it extended down to grassroot level, 2) it was tied to an adjudication system and 3) it operated while land resources were still abundant (Brown, 1983). The latter made it relatively easy to implement management practices such as requests by overseers to people to move cattle to other areas. Already prior to Independence, the traditional structure lost influence, manifested, among others, in self allocation of fields in grazing areas (Werbner, 1983; Arntzen, 1984). The gradual erosion of traditional power is probably due to two factors. Firstly, increasing pressure on resources rendered traditional adaptations ineffective. Secondly, rural populations became increasingly heterogenous following investments in large herds and in non-agricultural ventures by some. The resulting increased socio-economic differentiation led to increased different interests (Lawry, 1983). Government gradually introduced new institutions to fill the emerging gaps. Land Boards were planned in 1970; the Agricultural Resources Board in 1974. Other newly created relevant institutions are the Water Apportionment Board (1968) and the Town and Country Planning Board (1977). Although Land Boards and the Agricultural Resources Board are increasingly authoritative, they have as yet hardly managed to fill the management gap of environmental resources (CARG, 1984). Present legislation provides various management instruments but emphasis has been given to education and persuasion of people, so far with generally limited success. Some existing tools may be difficult to implement and enforce, among others because of logistical constraints (e.g. insufficient manpower and transport). It appears necessary to involve people themselves extensively in management issues so as to reduce the tasks of planning and enforcement by government officials. In view of different interests of people, it is as yet unclear to what extent communities are able to manage resources. (Devitt, 1981; Lawry, 1983; Arntzen, 1985). The role of the traditional system has not been phased out completely. Chiefs and their delegates continue to play a role in allocation of land and in some regions overseers are still active with respect to grazing land (Brown, 1983; Gulbrandson, 1984).

Resource allocation and management continues to be dealt with district by district. Although non-tribesmen can be allocated land and boreholes in a district, it is in practice so far difficult and opportunities are limited. Therefore, movement out of small districts is not an easy solution towards relieving pressure.

Map 1.1.

Land Tenure in Botswana



Source: NDP6

Environment related laws are post-Independence with the exception of the Fauna Conservation Act (1966). Immediately after Independence, tribal mining rights were transferred to the Republic. The emphasis of present legislation lies on the regulation of resource use. Pollution issues are only addressed in the Water Act (1968) and Atmospheric Pollution Prevention Act (1971). Laws deal in three ways with environmental resources:

1. by restricting land use in specified areas (e.g. Forest Reserves, National Parks, and Mine Lease Areas).

2. by regulating general land use in specified areas (e.g Tribal Land Act and Town and Country Planning Act).

3. by imposing conditions on land use and creating possibilities for active resource management (e.g. Agricultural Resources Conservation Act and Herbage Preservation Act).

Relevant laws will be discussed in more detail in the sectoral chapters. Suffice here to note that the opportunities offered by laws are in some instances hardly used (e.g. Agricultural Resources Conservation Act). In other cases such as the Water Act, the power to grant or refuse water rights has been used to block some developments.

The Botswana Society has been for a long time the major non government organisation concerned with the environment. Many articles in the annual Botswana Notes and Records deal with environmental issues and the Society furthermore organised symposia dealing with the Kalahari (1971), drought (1978), and the State of the Environment (1983). Recently, more non-governmental organisations have emerged probably as a result of increasing resources pressure and conflicts and present institutional management problems. The Kalahari Conservation Society (KCS) addresses itself mainly to issues related to wildlife whereas the Forestry Association Botswana (FAB) is active on issues of wood use and supply. Both institutions are new and it is difficult to assess their role in detail. It appears however, that the FAB particularly already contributes to raising awareness of environmental problems. Future contributions will heavily depend on the establishment of support at grassroot level (e.g use 4b-clubs, schools village development committees etc).

Botswana is involved in various forms of international cooperation on the environment and development. In Southern Africa, the Southern African Development Coordination Conference (SADCC) attempts to increase regional cooperation between Southern African states and reduce independence on South Africa. Some focal points are directly related to the environment such as erosion, energy and forestry. Botswana furthermore participates in the Southern African Regional Commission for the Conservation and Utilisation of Soils (SARCUSS), which through its various sub-committees such as Conservation and Land Use Planning, discusses common environmental problems and approaches towards solutions (e.g. locusts).

Finally, the country participates actively in UNEP activities and has signed the CITES international convention to regulate trade in endangered wildlife species.

4. Technology and Culture

More boreholes - tractors - attitudes towards cattle

The use of new technologies has allowed changes in productive activities, mostly in agriculture. Already before Independece, boreholes allowed expansion of livestock into previously inaccessible areas. They also caused more permanent use of the range around boreholes. During the late 1970's use of mechanised draftpower substantially increased. The tractor allows ploughing of larger areas and probably increases the land-extensive nature of crop production.

Attitudes of people heavily influence their activity pattern and resource use. For the majority of Batswana, livestock is not a mere economic activity to generate income or savings (Werbner, 1983). Livestock also represents wealth, and status etc., which can be used for socio-cultural purposes within society (e.g mafisa-system; provision of draftpower etc). Some local communities are however, hardly involved in livestock and instead engage mainly in crop production (e.g. Bayeyi) or hunting and gathering (e.g. Basarwa).

5. Economic Activities

Rapid but unbalanced economic growth, led by mining and beef production - little diversification of the economy - unemployment main problem - reduced economic growth forecasted.

The livestock and related meat processing industry were the traditional pillars of the economy. However, since the 1970's mining has been mainly responsible for exceptional economic growth. During the period 1979-1984, the economy is likely to have grown on average by 11.2% per annum (constant prices) but only by 4.6% if one excludes mining.

The above has led to a considerable change in composition of Gross Domestic Product (GDP) per sector but the economy remains heavily based on direct use of environmental resources. (Table 1.3). Mining now accounts for 29% of the GDP. The agricultural sector's influence has decreased substantially from 39.4% in 1966 to 7.4% in 1982/1983; recently as a result of drought. Trading has been an important sector in the country, reflecting large imports particularly from South Africa. Productive sectors other than mining and agriculture are relatively small.

Table 1.3

Gross Domestic Product 1966-1983

	1966 Pmln	%	1971/72 P mln	%	1975/76 P mln	%	1982/83 P mln	%
Agriculture	14,5	39,4	33,1	32,3	65,7	31,5	73,5	7,4
Mining	-	-	11,2	10,9	33,6	16,1	286,3	28,7
Manufacturing	2,9	7,9	5,1	5,0	20,9	10,0	81,7	8,2
Water/Electricity	0,3	0,8	1,3	1,3	11,1	5,3	29,5	3,0
Construction	2,1	5,7	10,0	9,7	18,8	9,0	43,2	4,3
Trade & Hotels	6,8	18,5	17,5	17,0	42,5	20,4	223,5	22,4
Transport	3,0	8,1	3,8	3,7	12,5	6,0	29,8	3,0
Services	2,4	6,5	8,8	8,6	28,6	13,7	82,2	8,2
Government	4,9	13,3	11,8	11,5	36,1	17,3	147,4	14,8
Total GDP	36,8	100,0	102,6	100,0	269,8	100,0	997,1	100,0
(current mkt prices)								
Total GDP	129,0		287,0		446,0		968,9	
(at 1979/80 values)								

Source: National Development Plan 6

Diversification of the economy has so far been limited. The government sector is relatively large and provides many jobs (36% of formal employment). This has been made possible by rapidly increasing government revenues, used to expand and improve public services in rural and urban areas as well as to provide incentives for development of other economic sectors.

Unemployment is high at a national level of 25.3%* (Ministry of Finance and Development Planning, 1986). In addition, 6.7% of the labour force is visibly underemployed. Unemployment is highest in urban areas, i.e. 31% compared with 24% in rural areas, and among females, i.e. 31% compared with 19% among men. The informal sector, excluding agriculture, provides relatively few jobs (16%). The formal sector is the main source of urban employment (72.8%) whereas agriculture is in rural areas (65% of employment). The growth of formal employment has slowed down during the early 1980s and in the near future annual projected increase in employment will fall short of the expected increase in labour force: 11,500 versus 21,000 (NDP 6).

Economic growth is likely to slow down in the near future. NDP6 envisages an average annual growth rate of GDP by 4.8%. This estimate is based on a slow development of mining (3.5%) which is expected to be compensated by diversification of the economy (e.g.

* An unemployed person is a person of over 12 years who was not working during the survey period but wanted to work. Underemployment refers to a person who wishes work more than he did during the survey (of less than 35 hours per week).

manufacturing growth rate 8.3% p.a). Consequently, exports will grow less, resulting in a small deficit on the balance of trade (P-123.3 mln over NDP6 period). Formal employment is expected to grow slightly faster than GDP as the non mining sectors are more labour intensive. In 1991, approximately 208,000 jobs, will be available in the formal sector including almost 49,000 self-employed persons. Government revenues from mining are expected to decrease. As a result, overall government revenues will remain almost stable in real terms (0.2% growth per year). More will be spent on recurrent expenditure, leaving no real growth for the development programme. The assumptions for the above calculations are conservative. Nevertheless, as Botswana's environment and economy are difficult to predict and control, one should be aware that continuation of drought and particularly less favourable external mineral conditions may extra affect economic growth and government revenues.

6. Socio-Economic Differentiation.

> Socio-economic differentiation determines the type and magnitude of environmental resources utilisation as well as the options to adapt to shortages of such resources.

As a result of the unbalanced economic growth, income opportunities are limited. Formal employment is mostly appreciated by people because of its comparatively high and stable rewards but remains small. The leading mining sector is capital intensive and provides only a limited number of direct jobs (Government of Botswana/UNICEF, 1986). The other major economic sector, cattle, is not feasible for the poor and is characterised by a skewed distribution of revenues. As a result, income distribution is and has been skewed for long and has led to a socio-economic differentiation of the population. No recent nationwide data are available on economic differentiation. Old income distribution data indicate highly skewed distribution in both rural and urban areas.* Poverty was found to be more widespread in smaller settlements. Socio-economic groups depend differently on various income opportunities. (Table 1.4).

Poor households depend mainly on gathering wages and remittances whereas rich households derive most from livestock and wage employment. Given the country's economic development, it is unlikely that differences have become less. In the absence of recent data on income distribution, attempts have been made to identify so-called vulnerable group, i.e. households or individuals likely to be poor:

1. households without or less than 10 cattle (approx. half of the farm holdings),
2. herds men (+21,000) and freehold farm workers (+ 5,000)
3. remote area dwellers (+ 44,000),
4. female headed households (approx. half of the rural households)
5. Chronic destitutes.

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* Central Statistics Office presently conducts a new income distribution survey.

Table 1.4

Income Profiles for the Rural Population (1974/75)

Percentile Income groupings[2]	Crops	Animals	Wages	Manufacturing	Trading	Services	Hunting	Gathering	Housing	Transfers	Other	Total
Poorest 10%	9	14	9	10	–	2	9	22	11	19	-5	100
10%–30%	10	13	17	6	1	3	1	16	10	19	4	100
30%–50%	10	19	21	5	2	2	1	12	9	14	5	100
50%–70%	11	31	17	6	1	2	1	7	6	11	7	100
70%–90%	8	39	20	4	1	1	3	5	5	8	6	100
Richest 10%	5	40	38	1	1	2	4	3	2	5	-1	100
Total	9	27	20	5	1	2	3	10	7	13	4	

Source: Colclough and McCarthy, 1980.

Although most households derive income from a mixture of activities such as wages, crops and livestock, livestock ownership per se can be considered as a good criterion for income and wealth. Households without and with less than 10 cattle can be considered poor, medium households have between 10 and 40 cattle and (relatively) rich households have over 40.

1.3. Botswana's Environment

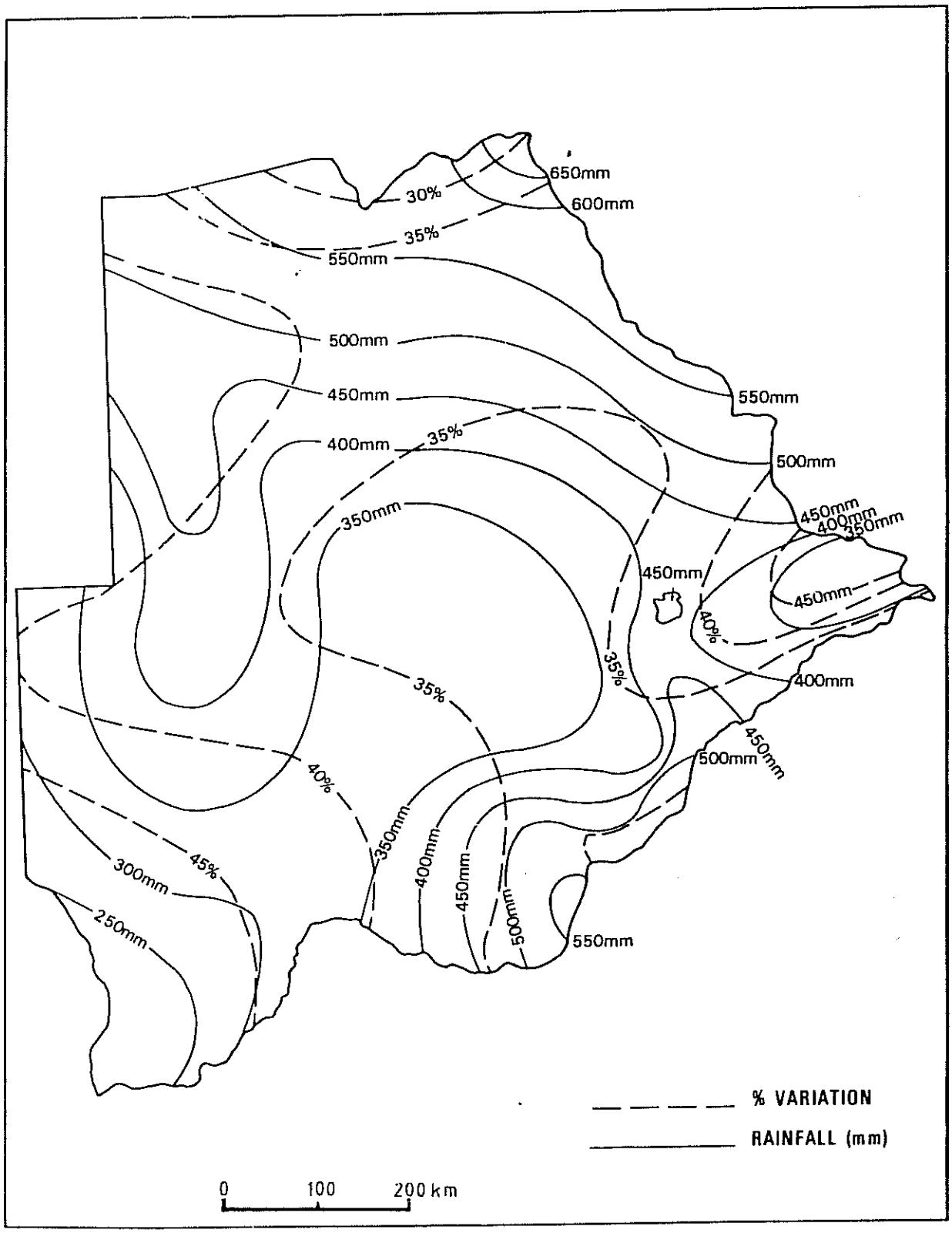
1. Climate

> Erratic rainfall - recurrent droughts but difficult to predict - large seasonal and regional variations - extreme temperatures.

Botswana is a land-locked country located on theTropic of Capricorn. Rainfall varies annually regionally and seasonally. Map 1.2 shows annual average rainfall in Botswana. Lower average rainfall coincides with more erratic rainfall. The rainy season is divided by dry spells in up to 3 periods (Vossen et al 1986). Generally, the following periods can be distinguished: 1) an early season rainfall period (Oct-Dec), 2) a mid-rainfall period (Jan-Feb) and 3) in some regions a) late rainfall period (March-April). The pattern is most pronounced in south-east Botswana. (See Fig. 1.5).

Map 1.2.

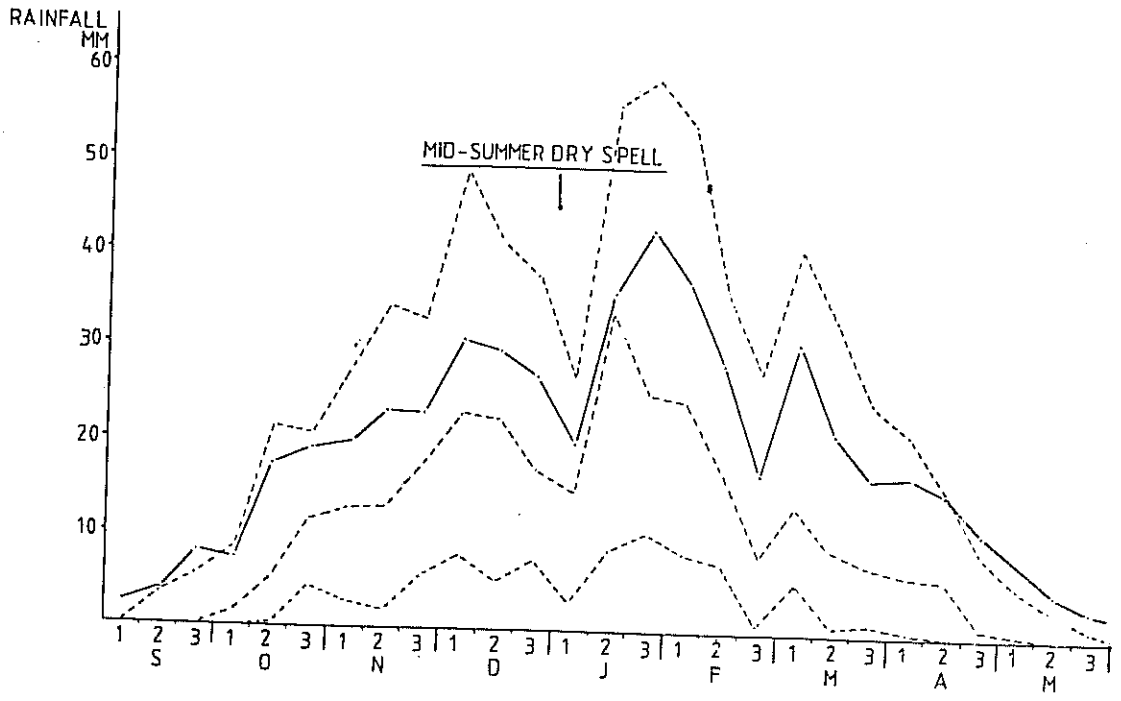
Annual Average Rainfall in Botswana and % Variation in Rainfall



Source: NDP6, Bhalotra 1985A

Figure 1.5.

Seasonal Rainfall Distribution of Gaborone (1925-1984): Mean 10-day Rainfall and 25% and 75% Probabilities



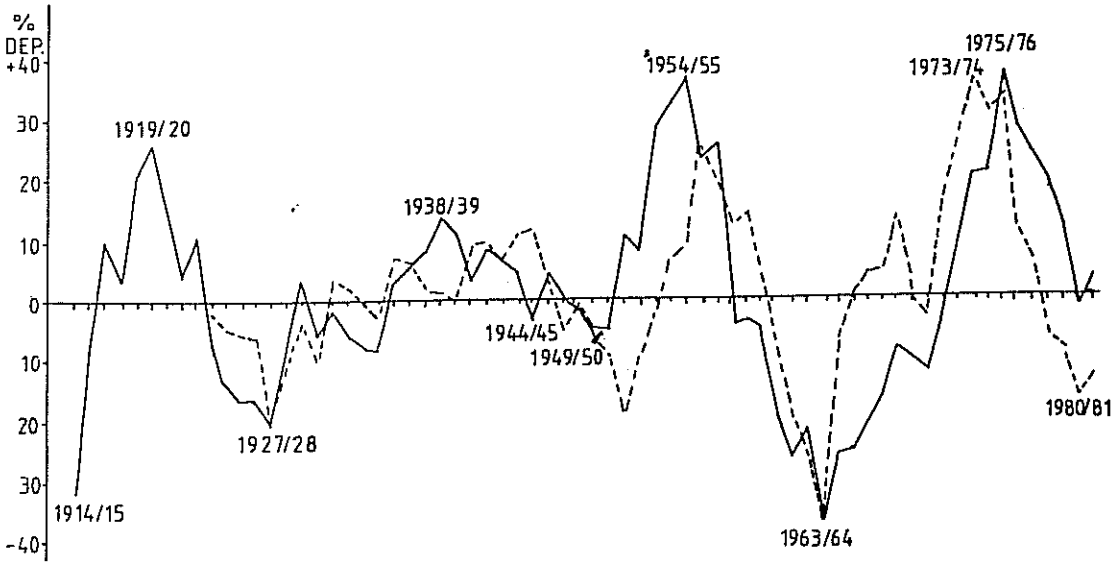
Source: Vossen, et al. 1986.

The variability of rainfall within a season is found to be higher than between seasons. The seasonal coefficient of variation is 28% while the monthly variation ranges from 60-114% for the Gaborone station. (Bhalotra, 1985 B). This shows the high chances of dry periods within the rainfall season. Inter-seasonal variation follows roughly a cyclical pattern (Tyson 1976). Figure 1.6 shows this pattern for Gaborone and Mahalapye. A sigmoid pattern emerges with a length of 15-20 years in six out of every ten years the seasonal rainfall is found to be lower than the mean. Table A.1.4. shows annual rainfall for a number of rainfall stations, and indicates annual and regional variability since the beginning of this century. It appears difficult to predict onsets of droughts as well as their intensity.

Temperatures in summer can reach over 40°C leading to high potential evapotranspiration (upto 2,000mm per annum) and to soil temperatures of up to 70°C. During winter, temperatures are mild with chances of night frost in most parts of the country.

Figure 1.6.

5 year Running Mean of Departures Percentage from Normal of Seasonal (October April) Rainfall
—— Mahalapye Rainfall ---- Lobatse Rainfall



Source: Bhalotra, 1985 B

2. Water

Limited surface and groundwater - international aspects

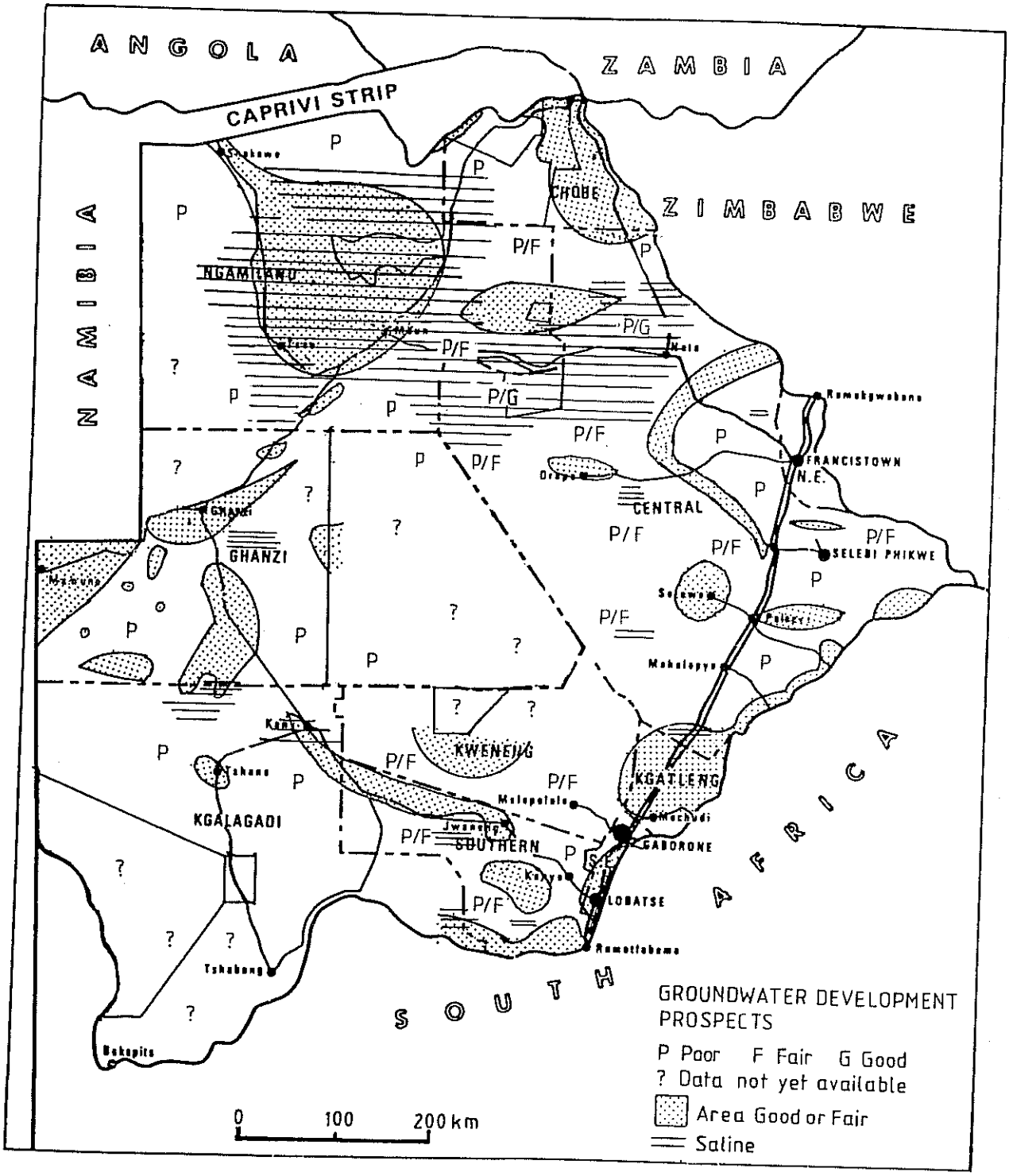
In semi-arid countries like Botswana, water is a major constraint for development. Available water sources can be sub-divided into surface water and groundwater sources. The former depends mostly on rainfall in the catchment areas; the latter may be possible or partly rely on recharge by infiltration of rainfall.

Most rivers are located in the east and north and can be sub-divided into:

- rivers originating outside the country: Okavango, Kwando and Nata river
- rivers mainly originating in Botswana: Notwane, Tati, Shashe, Motloutse
- border rivers: Molopo, Limpopo, Chobe/Zambezi
- internal rivers: Boteti

Map 1.3

Groundwater Development Prospects in Botswana



Source: Sketch based on detailed hydrogeological Maps, Department of Geological Survey

The Okavango and Chobe are by far the largest surface water sources with mean annual run-off of approximately 11,000 mln m^3 and 44,000 mln m^3 respectively. The other rivers are not perennial although water is usually close to the surface. A few large dams exist, notably Gaborone dam (capacity 144 mln m^3), Mopipi dam (90 mln m^3) and Shashe dam (85 mln m^3). According to the National Development Plan 6, only 17% of the run-off in rivers in Eastern Botswana is stored in dams. Excluding the Okavango, an estimated mean net 501 mln m^3 of water runs out of the country every year (Wilson, 1978). An agreement between Botswana and South Africa allocates each country 3.6m^3/second of Limpopo water at the confluence of the Shashe. Other surface water sources are smallscale, seasonal and mostly used by livestock and wildlife.

An estimated 5000 operating boreholes are scattered over most of the country. They are mainly used for domestic use in villages and for livestock. A few concentrations of boreholes, i.e. wellfields, exist in Ramotswa, Jwaneng, Mopipi and Paje. VIAK (1985) identified aquifers at Serowe, Mmamabula, Kanye, Molepolole. However their yields and recharge needs further investigation.

Generally, data on groundwater and its recharge are still lacking especially in Western Botswana, Map 1.3. gives a general idea of groundwater development prospects in Botswana.

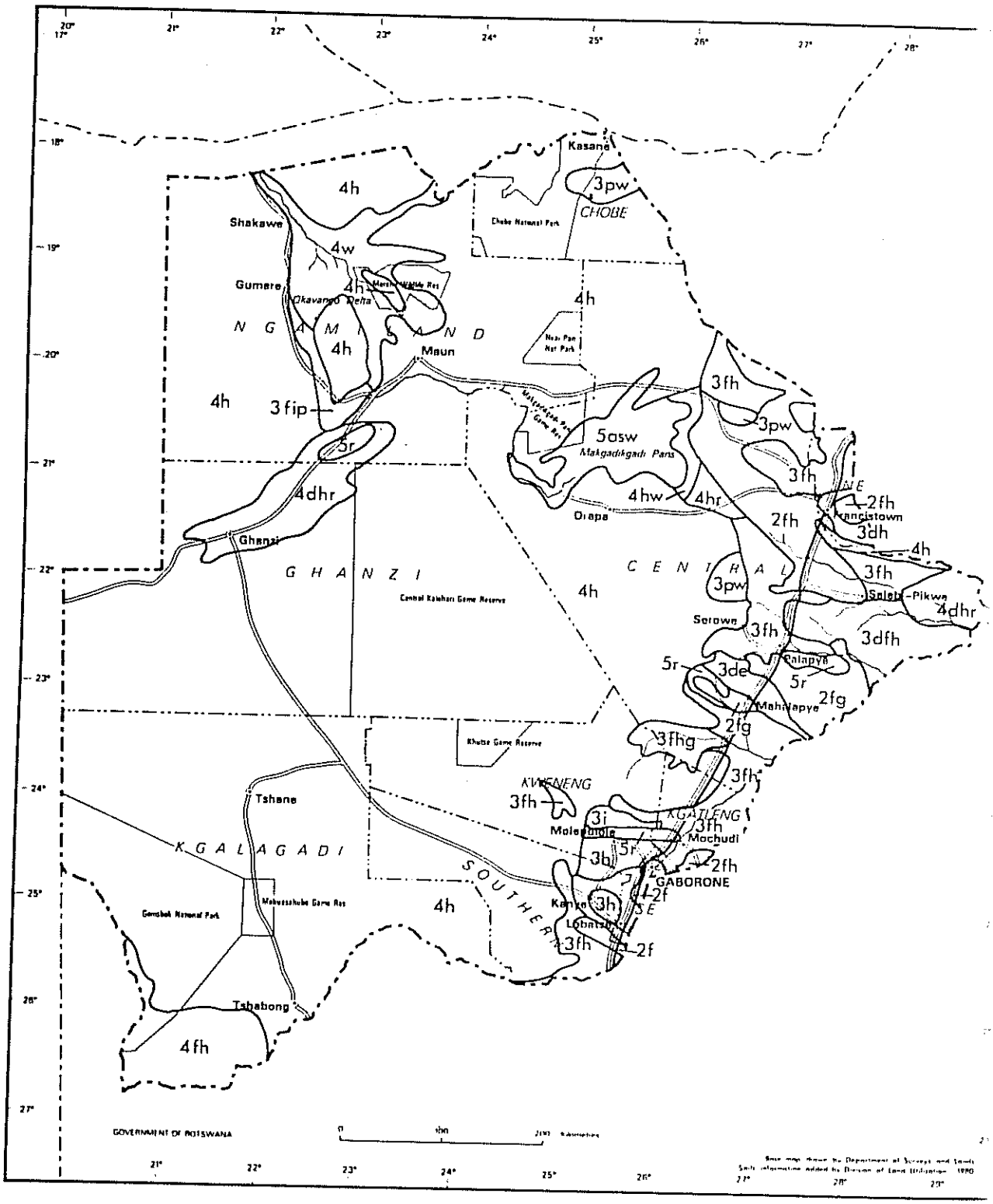
3. Soils

Mostly marginal soils - sandveld - hardveld

Between sixty and seventy percent of Botswana is covered by Kalahari sand. The sands vary in depth from less than three to occasionally over a hundred metres deep (sandveld) and are sometimes underlain by calcrete of varying thickness. Within the sandveld, various units have been distinguished on the basis of land form, texture, chemical composition and colour or geological origin (DHV 1980). In the eastern hardveld, the soil is characterised by sandy loams and loamy sands. Around hills the soil may be stony and shallow. Soils in eastern Botswana are hard, clod forming and have a naturally high bulk density and a tendency to surface capping. Natural fertility is low (Sims, 1981). Map 1.4. shows a generalised soil map of Botswana. For eastern Botswana more detailed soil suitability maps are being prepared by the Ministry of Agriculture. Prevailing soil and climate conditions make most of the country suited for extensive agriculture only.

Map. 1.4.

Soils of Botswana



Source: Sims, 1981

CLASS	CHARACTERISTICS
2l	Sandy clay loams, loams or clay loams with moderate soil fertility
2fg	As above with slight surface crusting
2fh	Sandy loams with moderate soil fertility
3de	Shallow soil with moderate erosion
3dfh	Shallow sandy soils with low fertility
3dh	Shallow sandy soils
3fh	Sandy (loamy sand) with low fertility

Legenda Map 1.4

SOILS OF BOTSWANA

CLASS	CHARACTERISTICS
3fhg	As above with surface crusting
3fip	Clayey soils hard or very hard when dry. with low fertility.
3h	Sandy (loamy sand or coarse sandy loams)
3i	Loamy or clayey soils with hard or very hard consistence when dry
3pw	Clayey soils, somewhat poorly drained
4dhr	Very shallow sandy soils with common surface stones or rock outcrops

CLASS	CHARACTERISTICS
4fh	Sand with very low fertility
4h	Sand
4hw	Sand with poor drainage
4w	Soils with poor drainage
5asw	Alkaline and saline soils with very poor drainage
5r	Rocky and/or very stony

4. Minerals

Large mineral deposits

Botswana is rich in mineral occurances. Major minerals, currently being mined are precious stones and metals, base metals and industrial minerals (see chapter 6).

5. Land

Land pressure in eastern Botswana - land use conflicts increase.

Land is a finite resource. Despite the low population density, land pressure exists particularly in the smaller districts such as South-East and North-East. In eastern Botswana, hardly any unused land can be found. Land pressure has not eased because no more land-intensive practices have been adopted and agriculture remains the main rural activity and form of land use.

Table 1.5.

Tribal Land Use by District* (1983)

	Communal	Commercial	Wildlife man. areas	Parks/ Reserves	Unzoned
Southern	18,800	5,400	2,500	0	0
South-East	1,150	0	0	0	0
Kweneng	19,900	8,100	6,300	2,500	0
Kgatleng	7,500	0	0	150	0
Central	55,950	14,800	5,000	3,900	60,050
North-East	2,150				
Ngamiland	31,800	7,650	26,700	6,000	37,650
Chobe	3,900	3,000	0	13,850	0
Ghanzi	22,950	350	18,350	52,800	0
Kgalagadi	28,000	15,000	25,000	25,550	11,900
Total	192,100	54,300	83,850	104,750	109,600
	35.3%	10.0	15.4	19.2	20.1

*Figures are at best rough estimates. Zoning is subject to frequent changes and no accurate district data could be obtained.

Sources: Sandford, 1980; Ministry of Local Government and Lands

Table 1.5 gives an impression of land tenure and land use in the districts. State land amounts to a quarter of the country and covers mainly national parks and urban areas. Less than 5% is freehold land, almost exclusively used for agriculture. Around 70% of the country is so-called Tribal Land mostly used for agriculture. In the western and northern parts of the country, large areas of tribal land are designated as wildlife management areas whereas some land is not yet zoned.

6. Vegetation

Most of Botswana's natural vegetation can be classified as savanna, i.e. grasslands with a more or less developed tree layer. A number of vegetation decsriptions exist for the entire country (De Beers 1962, Van Rensburg 1971 and Weare and Yalala 1971) and for parts (Rains & Yalala, 1968; Blair Rains and Yalala 1972; Timberlake 1980; DHV 1980b). Many authors describe local vegetation. Map 1.5 shows the country's vegetation based on a structure classification (Weare and Yalala 1971).

The following classes are distinguished:

1. shrub savanna
2. tree savanna
3. close tree svanna on rocky hills
4. semi arid schrub savanna
5. grass savanna
6. aquatic grassland
7. dry deciduous forest
8. riparian forest
9. woodland

Forests and woodlands occur mainly in the Chobe and Okavango regions. Taxonomic vegetation classifications are also available (reviews Werger 1978; Skarpe 1986, SMEC 1986).

In undisturbed savannas a balance between grass and tree layers exists which is determined by (Huntley and Walker, 1982).

a. **Rainfall**

Grasses benefit most from superficial but trees also from deeper soil water (Walter 1964). Hence more rainfall stimulates tree growth because excess rainfall infiltrates deeper into the soil. (see also Knoop and Walker 1985).

b. **Soil Nutrients**

relatively little is known about their role.* Phosphate can be seen as a limiting factor.

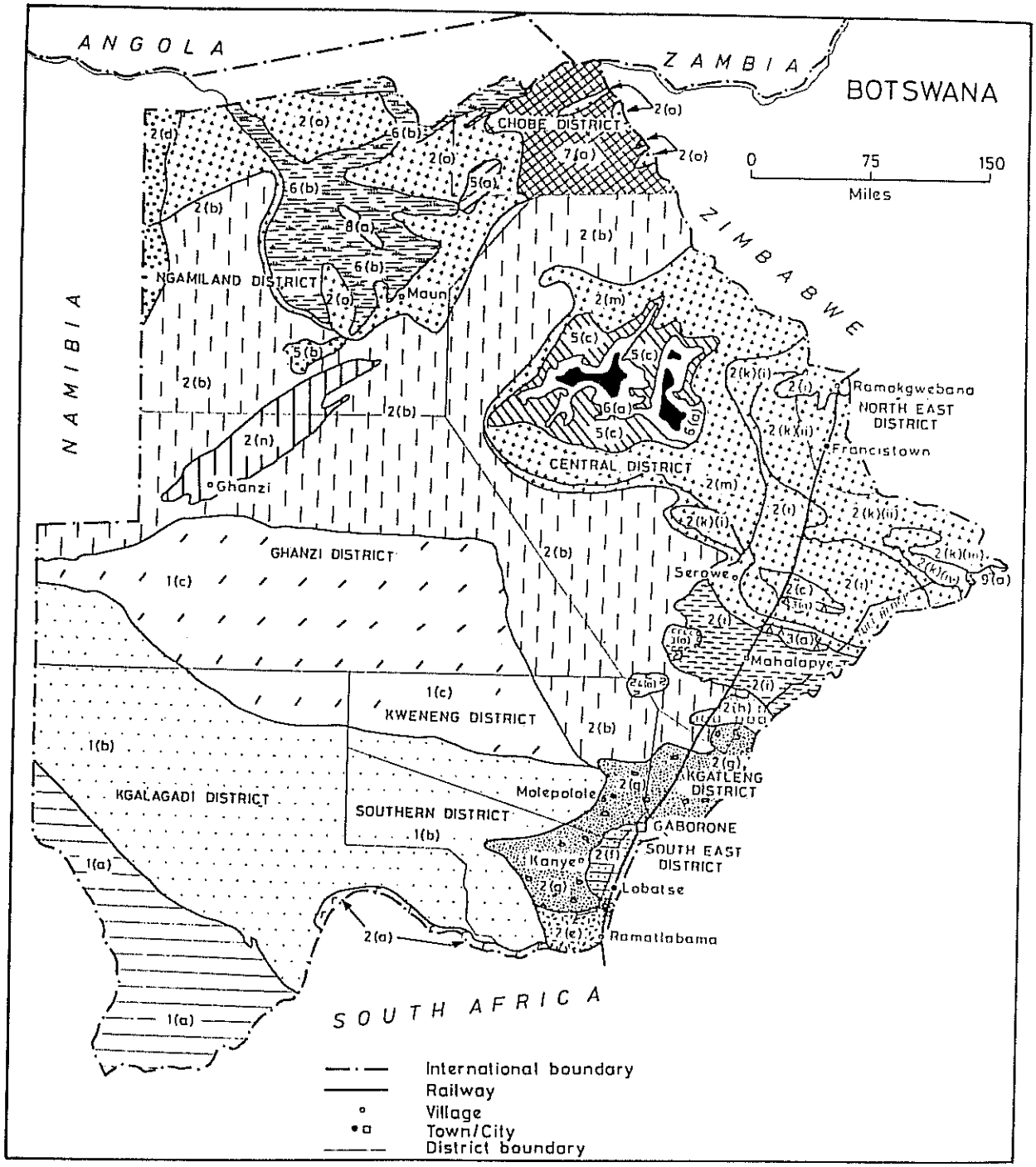
c. **Veldfires**

Until recently, a considerable part of Botswana's range was burned annually (10% in 1975, Field 1978). This percentage has decreased in recent years, as campaigns against veldfires proved successful. In savannas with a higher (600 mm) rainfall, grass production is normally higher and hence veldfires are hotter and cause a higher die off rate among trees. In savanna's with a low average rainfall fuel load may become so low, that trees sprout and revive quicker than the grass. In such cases, tree growth may actually be enhanced. It thus seems, that feld fires in northern Botswana may cause a reduction of the tree layer, while in the southern Kalahari this effect, is much less pronounced.

* Tolsma et al 1986 published some results on Botswana.

Map 1.5.

Vegetation of Botswana



Source: Weare and Yalala, 1971

Legenda Map 1.5
VEGETATION OF BOTSWANA

1 SHRUB SAVANNA
- a. Arid Shrub Savanna
- b. Southern Kalahari Bush Savanna
- c. Central Kalahari Bush Savanna

2. TREE SAVANNA
- a. Molopo Thornveld
- b. Northern Kalahari Tree and Bush Savanna
- c. Tree and Bush Savanna with Mopane
- d. North-West Tree Savanna
- e. A.Erioloba Tree Savanna
- f. Semi-Sweet Mixed Bushveld
- g. Arid Sweet Bushveld
- h. C.Imberbe Bushveld
- i. A.Nigrescens/C.apiculatum Tree Savanna
- j. Mopane Bushveld
- k. Mixed Mopane Bushveld
  - i. Close tree, mopane dominant
  - ii. Mixed Mopane/Acacia trees
  - iii. Mixed Mopane/Acacia low tree Savanna
  - iv. thicket woodland/mopane dominant
- l. Mopane Sour Bushveld
- m. Mixed Mopane tree and bush Savanna
- n. Ghanzi Bush Savanna
- o. Ngamiland Tree Savanna

3. CLOSE TREE SAVANNA ON ROCKY HILLS
- a. Croton/Combretum association

4. SEMI ARID SHRUB SAVANNA
- a. Acacia Shrub Savanna

5. GRASS SAVANNA
- a. Mababe Grassland
- b. Lake Ngami Savanna Grassland
- c. Delta Grassland
- d. Fringing Pan Grassland

6. AQUATIC GRASSLAND
- a. Vlei Grassland
- b. Swamp Grassland

7. DRY DECIDUOUS FOREST
- a. Chobe Forest

8. RIPARIAN FOREST
- a. Okavango Fringe Forest

9. WOODLAND
- a. Riparian Woodland

xx Tree Savanna with Mopane

Intensive grazing by wildlife and cattle may reduce the grasscover and cause bush encroachment. This process is discussed in detail in chapter 2.

The Okavango Delta has a distinct vegetation based on the seasonal inflow of water into the area. Plant communities range from aquatic grassland, woodland and savanna to forests. The flood plains which may be inundated, depending on the level of the annual floods are central features. These flood plains provide an important food resource for wildlife in the delta. Table A.1.5 gives a plant communities classification as used by SMEC (1986).

7. Animals

Large variety of wildlife

Botswana, has a large diversity of wildlife. Firstly because of the great differences in habitats that can be found: from aquatic habitats in the Okavango Delta to very dry semi-desert habitats in the south west of the country. Secondly because areas with wildlife still cover a large part of the country (up to 40%). Especially the large grazing and browsing animals are of great importance as a resource, as they form within the savanna exosystem the link* between the plant biomas production and the large predators. Bird life is also extremely rich in Botswana. It e.g. possesses large amounts of various raptor species, that have become rare elsewhere in Africa. The breeding colony of cape vultures at Otse deserves special mentioning. One of the last refugia for this species in Africa.

Cattle and to a lesser extent goats are the main domesticated animals. The ability to adapt to the dry savanna makes these the basis for a large livestock sector.

* See Appendix A.4.

CHAPTER 2

LIVESTOCK PRODUCTION

2.1 The Livestock Sector and the Environment

1. Livestock Numbers and Spatial Distribution*

> Cattle numbers increase similar to population growth - western parts hold more smallstock - cattle encroachment into Western Botswana

Since early this century, livestock numbers have continuously increased except during droughts and periods of disease. The average growth rate of the national herd between 1971-1981 was 3.6% per annum and slightly exceeded population growth. Presently a Motswana owns an average of 2.7 cattle and 1 smallstock. The past development of smallstock numbers appears to have been more erratic but recently numbers are increasing rapidly (Figure 2.1).

Livestock was historically kept in the eastern part of the country. This is still the case but livestock is spreading into the western and northern sandveld (Cooke, 1985). Regional data from the Agricultural Statistics are too aggregate to reveal the magnitude of this development. The expansionist movements have been more or less compulsory as grazing areas in the eastern part are overutilised and no new grazing can be found there. Fig. 2.2-2.5 describe the spatial distribution of livestock (see also Table A.2.2.)

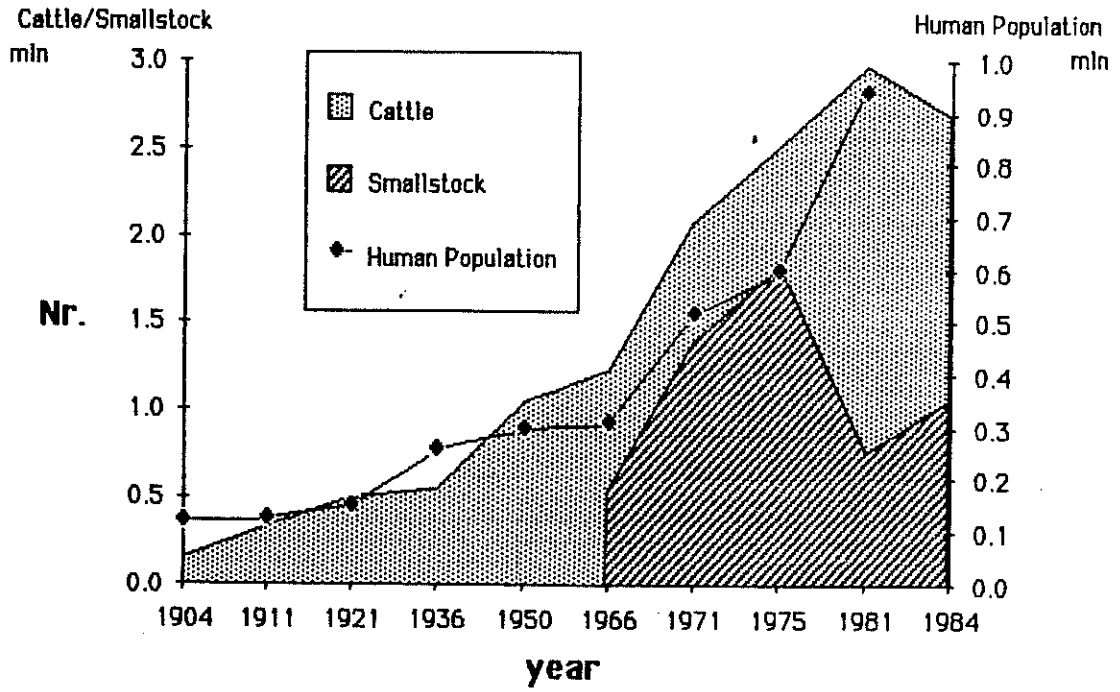
The distribution of livestock over districts has been fairly constant since 1979. The western and northern part of the country are comparatively less frequently involved in cattle holding. These areas are mainly used by large cattle owners who can afford the costs associated with borehole drilling, hiring of labour etc. People in South East are also less frequent cattleholders but in this case it is due to land pressure and better alternatives outside agriculture. Goats and sheep are most important in the western part of the country. An option in small overgrazed districts such as South East, would be to supplement cattle by additional goats. No data support that this already happens.

The above spatial distribution refers to Tribal Land only. It excludes livestock kept at freeholds farms and furthermore does not distinguish between cattle kept in communal areas and at leasehold ranches established as part of the Tribal Grazing Land Policy. The few data available for freehold areas show that they contribute 15-20% of the national herd and their increase has been similar to that of the national herd. Ghanzi, Molopo and Tuli Block are the major freehold cattle areas (Table A.2.3). The last two also play a major role in cattle trade, involving the purchase of cattle from

* Livestock refers to cattle and smallstock, mainly goats and sheep.

Figure 2.1.

Cattle and Smallstock Numbers in Botswana (x1000)



Sources: Hubbard, 1983; Mhlanga, n.d.; Population Census 1904-1936.

surrounding communal areas with the intention to fatten them and ultimately sell to BMC (McDonald, 1980). Freehold areas keep relatively few smallstock: approximately 5% of the national herd.

Figure 2.2.

Cattle Distribution (1984)
By District

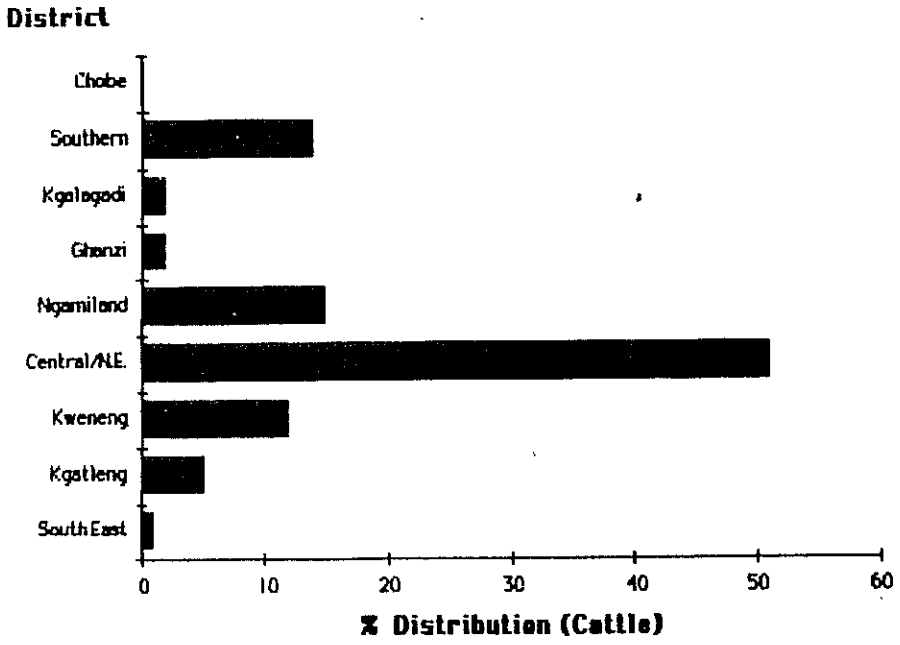
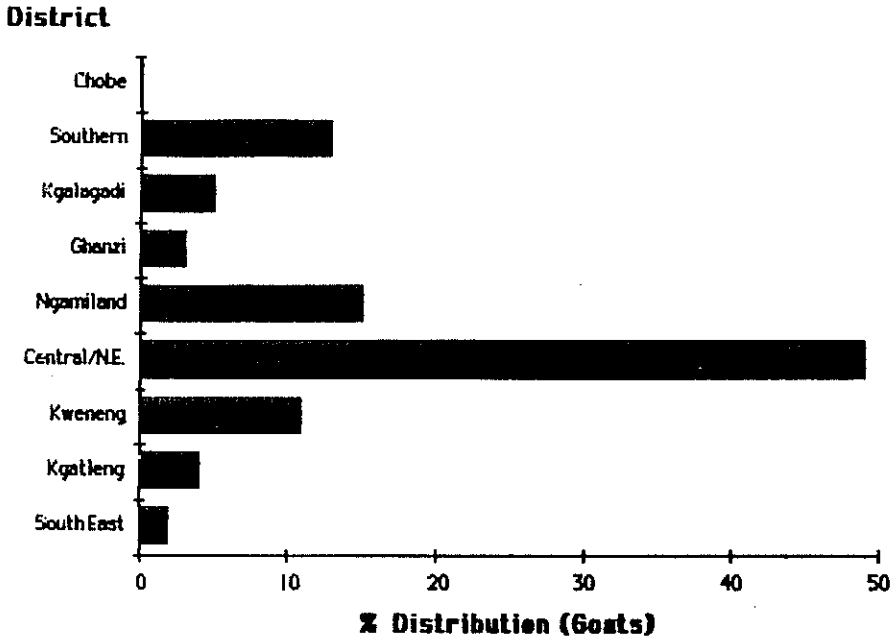


Figure 2.3.

Goat Distribution (1984)
By District



Source: CSO Agricultural Statistics

Figure 2.4.

Cattle Numbers per Person (Rural)
By District (1981)

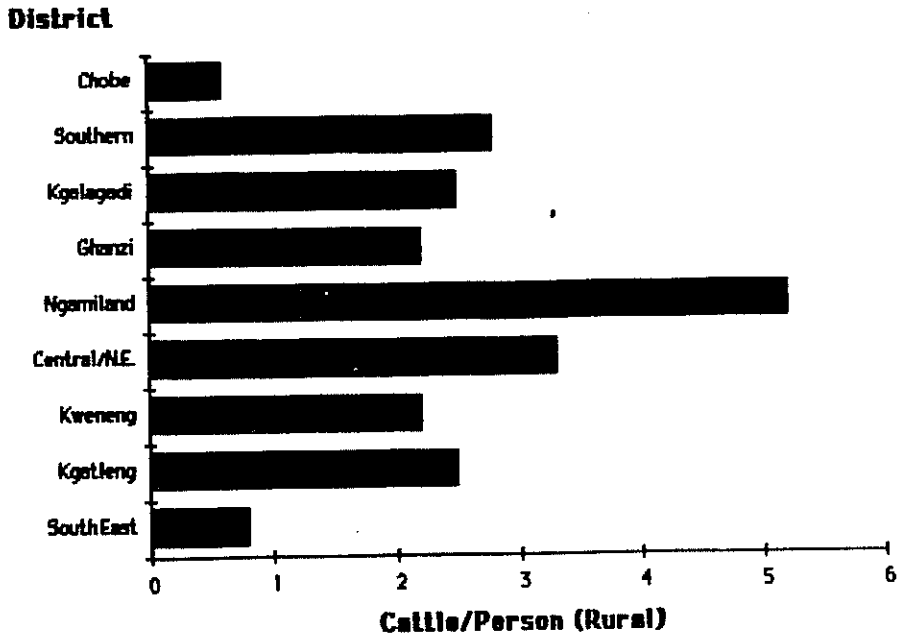
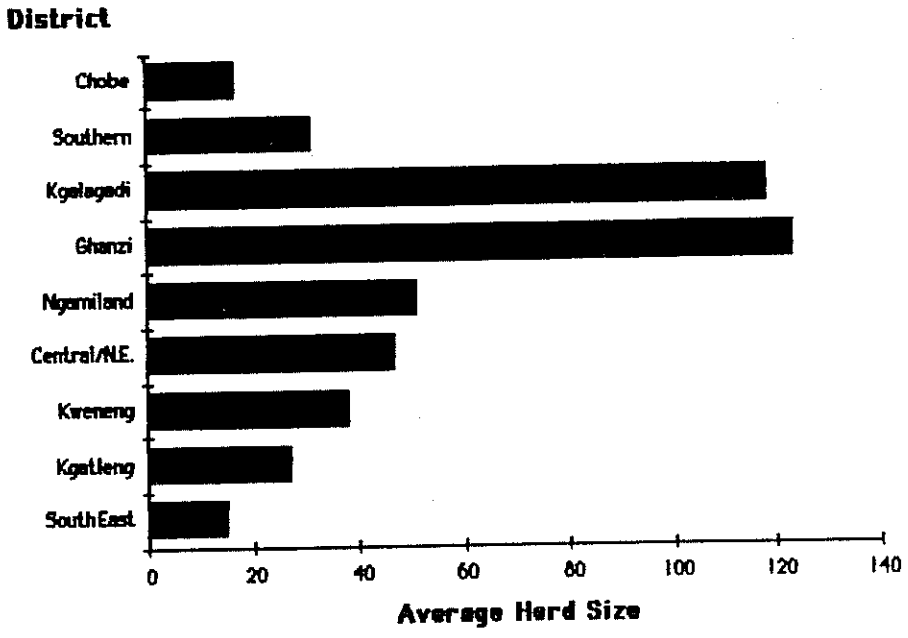


Figure 2.5.

Average Herdsize Cattle
By District (1981)



Source: CSO Agricultural Statistics

2. The Carrying Capacity of Rangelands

> Range suitable for extensive grazing - western part has lower carrying capacity - drought lowers carrying capacity

Botswana's rangeland resources can be classified in different types of savanna (see chapter 1). The following are relevant for rangeland (Weare and Yalala 1971):

Shrub savanna :	South western Kalahari sandveld
Tree savanna:	Northern and eastern Kalahari sandveld, southern hardveld, Mopane veld.
Grass savanna :	Makgadikgadi pans
	Aquatic grassland: Okavango.

The cattle sector was in the past confined to the productive parts of the tree savanna zone but has penetrated increasingly into the shrub savanna, into grass savanna north and west of the Makgadikgadi pans and into the grasslands of the Okavango.

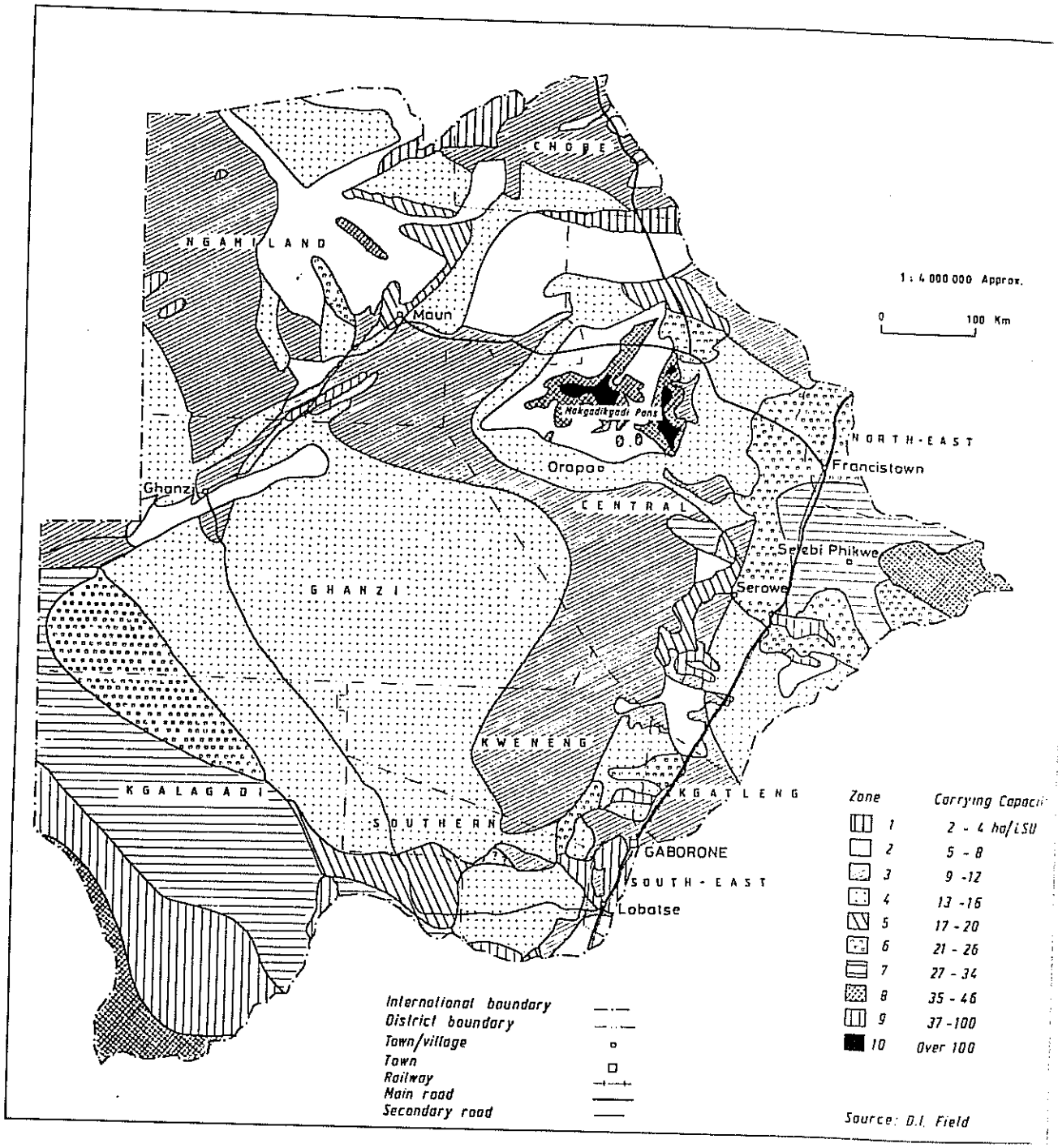
Any range can only sustain a limited number of livestock. This figure is called the carrying capacity of the range, at which a balance between grass and woody layer is maintained. The forage quality is good and the grass production is adequate. Grazing pressure in excess of the carrying capacity depletes the grass resources, changes the species composition and generally leads to an increase of the woody layer. These processes cause a decrease of the actual carrying capacity, which can also result from drought and fires. In such circumstances, the actual carrying capacity differs from the potential carrying capacity. The potential carrying capacity is generally calculated under the assumptions of average rainfall conclusions.

Table 2.1 shows two potential carrying capacity estimates for districts. The first one by Field (1978) is mainly based on rainfall and the second one (Field, 1977) based on a theoretical approach considering rainfall evaporation, soil topography and vegetation type. Map 2.1. shows the potential carrying capacity map based on the theoretical approach.

Other authors use direct field measurements (grass clippings) to obtain actual carrying capacity figures (Hendzel, 1981). Other carrying capacity assessments are based on long term grazing trials (Mckay, 1968). These trials indicated a carrying capacity of 6-8 hectare/livestock unit LSU on rangeland in good condition and 12 Ha/LSU on degraded rangeland in this area.

Map 2.1.

Potential Carrying Capacity of Botswana's Rangelands



Source: Field, 1977

Table 2.1

Potential Carrying Capacity Estimates
by District(ha/LSU)*

District	Estimate based on rainfall	Theoretical approach
Southeast	12	5 - 12
Kgatleng	12 - 16	9 - 20
Central	8 - 21	5 - 46
North East	16 - 21	21 - 34
Chobe	8 - 12	2 - 16
Ngamiland	12 - 21	2 - 26
Ghanzi	16 - 21	5 - 34
Kgalagadi	21 - 27	13 - 46
Southern	12 - 21	5 - 100
Kweneng	12 - 21	9 - 26

Source: Field, 1977 and 1978
Notes: for specific areas also data available by Skarpe (1981), Blair, et al (1976), McKay (1968); Blair, et al (1972), Jetten (1985), A.P.R.U. Biannual Reports, D.H.V. (1980) and for a number of districts from the Range Ecology Section, MoA.

Although Field's estimates are of limited value because of his theoretical approach, his estimates indicate a significant spatial variation in carrying capacity. On average, the South-Western parts of Botswana has a lower carrying capacity while areas with a higher carrying capacity can be found in eastern central and northern Botswana. Higher average rainfall leads to better average carrying capacity.

Carrying capacity varies with vegetation type and rainfall. D.H.V. (1980) has calculated the range of variation in the Hukuntsi sandveld (Table 2.2.)

Grazing capacity varies considerably with grazing classes and amounts of rainfall. The grazing capacity is considerably reduced during periods of low rainfall.

Browse shrubs and trees are erroneously not taken into account in carrying capacity calculations. The assumption has been that browse plays only a limited role in the diet of cattle. However, browse is documented as important in sandveld areas and in the northern mopane tree savanna (Skarpe, 1981, Van Voorthuizen, 1976). Particularly in overgrazed areas and during droughts, browse is important. Exact data on its contribution to cattle diet are not known. Browse is

uses LSU = 450 kg live weight. Sometimes authors use slightly different from the data of theoretical approach only the main carrying capacity classes for each district have been taken into this table.

known to be a major source of food for goats. Grazing trials showed that during winter it forms 58% of the diet decreasing to 34% in spring (APRU, 1983/84).

Table 2.2

Calculated Grazing Capacity Classes (ha/LSU) under Different Rainfall amounts (Hukuntsi Sandveld)

Relatively grazing capacity class	GRAZING CAPACITY (Ha/LSU)		
	drought year rainfall appr. 100 mm	average year rainfall appr. 300 mm	good year rainfall appr. 500 mm
very low	50	20	15
low	25 - 50	11 - 20	7 - 15
medium	17 - 25	7 - 11	4 - 7
high	13 - 17	5 - 7	3 - 4
very high	13	5	3

Source: DHV (1980b).

3. Stocking rates and carrying capacity

Table 2.3 shows the stocking rates in 1980 and 1984 in districts. Overstocking occurs throughout the country. During the recent drought, stocking rates dropped by almost 10% but simultaneously the actual carrying capacity dropped probably much more. Since carrying capacity and stocking rates may vary significantly within districts the problem of actual overstocking may differ locally from the district average.

Stocking rates appear to be especially high in small regions such as Barolong (4.2 ha/LSU in 1980), South East (4.1 ha/LSU in 1980) and North East District (approximately 4.2 ha/LSU), and probably Kweneng North.

High stocking rates are not a new phenomenon for the small districts. South East district has been overstocked since the 1930s (Schapera, 1943) and North-East since the 1940s (Fortmann et al, 1983).

The level of control of herd owners over the range influences stocking rates. Carl Bro. Int. (1982) and subsequent Livestock Management Surveys found lower stocking rates in areas with limited access to waterpoints with the exception of freehold areas (Table 2.4).

Table 2.3.

Stocking Rates and Potential Carrying Capacity by District

District or Block	Stocking Rates (HA/LSU) 1980	(HA/LSU) 1984	Potential Carrying Capacity HA/LSU) (Field, 1978)
Southern			
Barolong	4,2	6,6**	12
Ngwaketse S.	8,9	15,8*	16-21
Ngwaketse N	12,9	10,0**	16-21
Gaborone			
Bamalete	4,1	4,0**	12
Kweneng S.	12,9	21,6	16-21
Kweneng N.	4,1	1,2**	12.16
Kgatleng	8,3	9,0*	12-16
Central			
Mahalapye	10,8	11,1*	12-16
Palapye	5,5	6,0**	16-21
Serowe	-	-	12-21
Mmadinare	6,9	7,9**	21
Francistown			
Tutume	-	-	12-16
Tati (non-freehold)	4,2	5,1**	21
Maun			
Ngamiland W.	-	-	12-16
Ngamiland E.	-	-	12-16
Chobe	-	-	8
Western			
Ghanzi	-	-	16-27
Kgalagadi	7,0	13,5*	21-27
Freehold Blocks			
Molopo/Lobatse	4,7**		12-21
Tuli	10,8*		12-21
Tati	7,1**		16-21
Ghanzi	9,6		16-21

* Denotes overstocking in at least part of the region
** Denotes severe overstocking in at least part of the region.

Including all livestock: cattle = 0.7 LSU: goats/sheep = 0.1 LSU; Donkeys/mules = 0.4 LSU and horses = 0.6 LSU
Sources: Carl Bro Int., 1982: Agricultural Statistics.

known to be a major source of food for goats. Grazing trials showed that during winter it forms 58% of the diet decreasing to 34% in spring (APRU, 1983/84).

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Stocking rates appear to be especially high in small regions such as Barolong (4.2 ha/LSU in 1980), South East (4.1 ha/LSU in 1980) and North East District (approximately 4.2 ha/LSU), and probably Kweneng North.

High stocking rates are not a new phenomenon for the small districts. South East district has been overstocked since the 1930s (Schapera, 1943) and North-East since the 1940s (Fortmann et al, 1983).

The level of control of herd owners over the range influences stocking rates. Carl Bro. Int. (1982) and subsequent Livestock Management Surveys found lower stocking rates in areas with limited access to waterpoints with the exception of freehold areas (Table 2.4).

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Ngwaketse N	12,9	10,0**	16-21
Gaborone			
Bamalete	4,1	4,0**	12
Kweneng S.	12,9	21,6	16-21
Kweneng N.	4,1	1,2**	12.16
Kgatleng	8,3	9,0*	12-16
Central			
Mahalapye	10,8	11,1*	12-16
Palapye	5,5	6,0**	16-21
Serowe	-	-	12-21
Mmadinare	6,9	7,9**	21
Francistown			
Tutume	-	-	12-16
Tati (non-freehold)	4,2	5,1**	21
Maun			
Ngamiland W.	-	-	12-16
Ngamiland E.	-	-	12-16
Chobe	-	-	8
Western			
Ghanzi	-	-	16-27
Kgalagadi	7,0	13,5*	21-27
Freehold Blocks			
Molopo/Lobatse	4,7**		12-21
Tuli	10,8*		12-21
Tati	7,1**		16-21
Ghanzi	9,6		16-21

* Denotes overstocking in at least part of the region
** Denotes severe overstocking in at least part of the region.

Including all livestock: cattle = 0.7 LSU: goats/sheep = 0.1 LSU; Donkeys/mules = 0.4 LSU and horses = 0.6 LSU
Sources: Carl Bro Int., 1982: Agricultural Statistics.

Table 2.4

Stocking Rates According to Access to Range in Tribal areas

	1980	1982	1983
Communal range use	7	5.7	7.5
Preferencial range use	27	13.5	13.9
First Development Area	16.0	17.0	14.2

Source: Carl Bro. Int. 1982: Livestock Management Survey 1982/83

4. Participation in the Livestock Sector

30-45% of rural households without cattle - no major change in cattle holding rates hence more range users - skewed distribution of livestock.

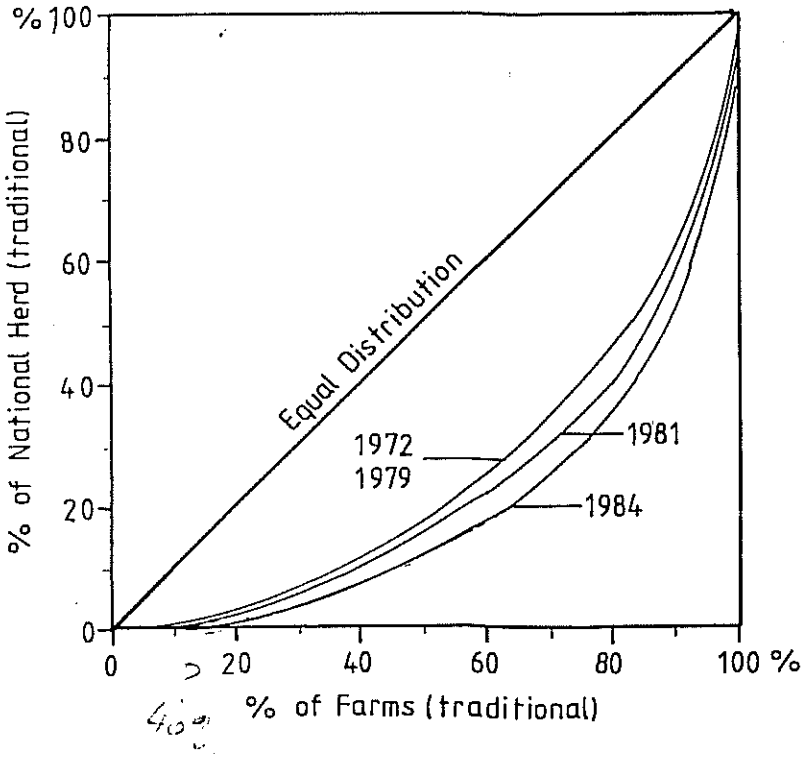
Keeping cattle requires relatively high investments (e.g. purchase) and additional inputs such as water and labour, which many households cannot afford. It is therefore not surprising that only slightly more than half of the rural housholds hold cattle. Due to difficulties in comparing various statistics, it is not possible to assess how participation rates have developed since 1966. The Rural Income Distribution Survey shows that in 1974 55% held cattle (Ministry of Finance and Development Planning, 1976). Agricultural Statistics estimate the percentage of cattleholders since Independence to fluctuate between 63-75% but these statistics only look at agricultural farms, not at all households.* Assuming a constant ratio between agricultural farms and total number of rural households in 1974 and 1981, 62% of the rural households held cattle in 1981. If one assumes that the balance between the total number of rural housholds in 1981 and agricultural farms fully consists of non-agricultural households, then only 53% of the rural households held cattle. However, assumptions are not completely realistic. Available evidence suggests no significant change in participation rates in the past. Goats and sheep are less frequently held. The Agricultural Statistics estimate that between 1978 and 1984 56-62% of the agricultural farms held goats and only 14-18% sheep. In absolute terms, the number of cattle holders has increased in 1972/3 44,660 and after a top of 60,000 in 1978/9, dropped to 57,300 in 1983/4 (Agricultural Statistics). Therefore, the number of users of the range has increased by 28% in 11 years.

* A household qualifies as agricultural farms if it has at least 100 points, indicating a minimum level of agricultural involvement. Households without livestock, which do not plough in a specific year drop out unless they have at least 4 hectares fallow land.

Cattle distribution is very skewed (see e.g. CSO, 1976; Agricultural Statistics). Figure 2.6 shows the cattle distribution in the country (see also Table A.2.4.) The present distribution is more skewed than in 1972. Almost 30% of the cattle holders hold 4% of the cattle whereas the 8% of farmers with herds in excess of 100 head held 45%.

Figure 2.6.

Cattle Distribution



Source: Agric. Statistics

Herdsize distribution data for goats are only available for the recent period. The distribution is similar to cattle but has become less skewed during the drought.

5. Livestock Management Practices and Productivity

Management practices and, biological productivity appear to depend on herd size rather than on land tenure (Carl Bro Int. 1982; Hubbard, 1982). Large cattleposts reach in practice similar productivity levels as freehold or leasehold farms. Ranching does not automatically lead to the adoption of improved management (Bekure, 1981).

Table 2.5.

Practices and Productivity for Ranch and Cattle Post Herds of Different Sizes

	Normal Cattle post	Large cattle post	Ghanzi Ranches
MANAGEMENT (% of herds)			
Bonemeal routine	7	89	100
Botulism vaccination	2	66	60
Anthelmintics	2	33	80
Tick Control	27	33	100
Kraaling	64	100	
Active Weaning	0.2	22	100
CALVING			
Calving %	40	52	52
Calving interval (months)	20	19	16
% cows over 6 years never calved	8	3	0
Calf mortality under 1 year as %	12	2	3

Source: Carl Bro, 1982: p.3.04

Socio-cultural factors and absenteism of the owner play an important role in the actual realisation of the potential benefits to be gained from ranching. Small herds often face management constraints (labour, cash) and are therefore often biological less productive. The observed "scale-advantage" results from different financial means available and from the different claims on livestock. If multiple productivity in communal areas (e.g. milk, draftpower) is taken into consideration, fenced off ranches do not necessarily* have a higher land productivity than communal areas (Table A 2.5). In other words, improved management may not lead to more intensive land use, unless fodder can be used on a large-scale.

Calving rates (calves/total cattle) are slightly higher in small herds. Mortality declines with increased herd size. Sales rates are high among small herds as a result of urgent cash needs, lower for the medium size herds and increase for larger herds again (Table A.2.6). A comparison of freehold ranches and cattle in Tribal Land reveals similar calving rates, higher mortality rates at the cattle post and lower sales rates. The second observation is explained by the "herdsize effect"; the third results partly from trade by freehold farmers. The gross sales ratios are 38.8 and 7.3 respectively whereas the net ratios (sales minus purchases/total cattle are 20.8 and 5.9 (Ministry of Agriculture, 1984). Sales rates in freehold farms, however, appear considerably higher. During

* For example, in communal areas in Zimbabwe ploughing and manure was estimated to be 49% of total cattle productivity; milk and domestic meat consumption made up 33% whereas only 17% was contributed through sale of cattle (Blackie, 1982).

the recent drought, freehold farmers seem to respond faster by increasing sales. Other effects of drought on herd performance include a decrease in calving rates, less visible in freehold areas, particularly after one year of drought, and an increase in mortality rates, particularly among small herds. Mortality rates for cattle in tribal lands have increased from 13.6% in 1981 to 19.3 in 1984 (Tribal Land cattle) with excessively high figures for herds of less than 10 head: 30.1% and 65.0% respectively.

The Livestock Management Surveys and Farm Management Surveys reveal large regional variations in herd perfprmance. These differences are related to variations in

- herd size
- rainfall conditions
- regional grazing pressure.

No systematic research has examined the relationship between range quality and cattle productivity.

Drought affects productivity of cattle. A study by APRU (APRU 1983) in the Metsemotlhaba communal areas revealed an overall mortality of 48% in 1983. Cows reached a mortality of 63% and calves 91%. The initial stocking rate in the area was about 2.5 ha/LSU. Recent stocking trials by APRU at Masiatilodi indicate that individual animals perform better under lower stocking rates (6-12 ha/LSU) as compared to higher stocking rates (2-4 ha/LSU). From this, the conclusion seems justified, there is a negative relationship between range quality and cattle productivity especially during droughts. However, the exact nature of the relationship is not known.

The Herd Management Survey shows that on the level of individual herd performance, various socio-cultural and educational factors contribute to explaining different performances (e.g. family affairs, quality of management, possible absenteism of herd owner). Such factors are usually also emphasized in local or regional studies.

Herdsize, management and viability of herds are linked. Carl Bro Int. (1982) has identified three main turning points:

20 head : herd has better chance to survive drought; draftpower can be used without straining cattle too much
40 head : establishment of an own cattlepost in grazing areas
100 head : acquisition of own/group owned borehole.

These turning points correspond with differences in resource utilisation (grazing and water) and suggest that cattle holders aim at having at least 20 head. Presently, almost half has less than that.

6. Utilisation of Grass and Water

> Livestock largest water consumer - grazing most serious constraint - restricted access to boreholes

Cattle drink on average 45 litres per day and consume 12kg dry weight of forage (per LSU). Therefore, the livestock sector is the largest consumer of water in the country (Figure 8.1.)

The Waterpoint Survey showed that farmers use a flexible strategy towards watering their cattle. Based on farmers' options and their economic means, they select waterpoints which are reliable (=hold water), convenient (= close to land, village or cattlepost) and cheap (Fortmann and Roe, 1981). During the wet season, cattle is moved to surface waterpoints (free of charge); during the dry season, farmers gradually resort to boreholes and wells with the village boreholes as ultimate fallback if one fails to get access elsewhere. The pattern of water use is related to socio-economic means. Borehole owners usually own large herds. For example, the average herdsize of members of borehole groups in Kgatleng is 88 compared with 27 for the district average (Peters, 1983). In Kgatleng, 26% of the cattleholders have direct access to boreholes whereas 25-45% rely on the purchase of borehole water (Opschoor, 1981). Although farmers face water problems, they are usually able to solve these, albeit sometimes at high costs. It is, however, virtually impossible to find adequate grazing for cattle. The traditional response of moving cattle does no longer work. Therefore, farmer consider lack of grass by now as(the most serious problem (Fortmann et al, 1983). Particularly small farmers face shortage of grass. They do not have security of a borehole and surrounding grazing areas. They often keep their cattle at the lands where grazing pressure can be higher (e.g. in Kgatleng; Arntzen, 1985).

7. Marketing and Prices

> No structural increase off-take ratio - well developed, export-oriented marketing structure - BMC's emphasis on high producers prices.

Government has long established an extensive marketing system for beef. Cattle are sold for local consumption to butchers and small abattoirs, or to B.M.C. for export purposes (Figure A.2.1). Little is known about the local consumption and its relation to BMC sales. No structural increase in off-take ratio (local consumption plus sales for export/total herd) seem to have taken place since Independence. The ratio fluctuates around 10% (Table A 2.8). The bulk of cattle is sold to BMC abattoir in Lobatse (annual cap: 200,000) and Maun (started to operate in 1983; cap. 15,000 cattle). Farmers can sell directly to BMC or through cooperatives or agents (McDonald, 1980; Hubbard, 1983; Bailey, 1982). Farmers remote from BMC-abattoirs receive lower net cattle prices because they incur higher transport costs and losses in weight. Spatial rotation of selling to BMC and its quota system require planning on the part of

the seller. Such planning does not match with sudden cash needs of small cattleholders, who therefore sell mainly via agents, often freehold farmers or cooperatives. In 1976, 42% of the sales by freehold farmers originated from herds in Tribal Land. Cooperatives have become more important over time and are now responsible for approximately 20% of the purchases by BMC as compared with 15% for direct sales and 65% for agents. BMC operates as a producers cooperative and has passed on operational surpluses to the sellers. The company focussed more on higher producers prices than on expansion of capacity and markets (Fidzani, 1985). Only recently, it was agreed to establish a new abattoir in Francistown as the capacity of the existing abattoirs have become inadequate. BMC's prices differ based on: 1) quality of the meat 2) access to EEC market and 3) seasonality. The last criterion is meant to spread cattle sales more evenly over the year and offers higher prices for farmers who sell cattle after the dry season. Responses of farmers to pricing issues are hardly known. One would expect a mixed response, where small farmers may sell less cattle because their cash needs are easier met and they aim at building up herds but larger farmers probably respond positively by selling more.

Beef exports have increased ever since Independence except during outbreaks of foot and mouth disease leading to closure of the EEC market for Botswana beef (Table A.2.9). In 1984, 55% of the beef was sold to the EEC, 33% to South Africa and 12% to other countries. The EEC and to a lesser extent South Africa have prices above world market level which have benefitted the sellers to BMC by up to 32% (EEC) and 1.5% (South Africa) (Hubbard, 1983). During the outbreak of Foot and Mouth Disease in 1979, the BMC managed to fill the gap partly by selling more to other countries.

Unlike cattle, smallstock is mainly sold for local consumption. Smallstock slaughtering by BMC has followed an erratic pattern since Independence with sales of up to 40,000 in 1971 and below 1,000 in 1980. Recent price increases have led to a revival of BMC smallstock slaughtering (16,000 in 1984). It is not known whether this represents a higher total offtake of merely represents a shift from local consumption to sales to BMC.

8. Atrractivity of Livestock - Income

Relatively high income from livestock - sales buffer for crop losses during droughts

Livestock production is presently the most attractive rural income proposition. Its attractivity results from environmental conditions, more adversely affecting crop production, the favourable livestock price development until 1979 and the absence of significant other income generating activities. The early Farm Management Surveys suggest that farmers increasingly rely on livestock income in the period 1970-1986. Later Farm Management Surveys[4] show that livestock income amounts to 75-100% of total agricultural income and during drought it is even used to compensate for crop production losses (Table A 2.10).

Income from livestock increases for larger herds. During droughts, livestock income for smallstock was found negative (Farm Management Survey 1983). The Rural Income Distribution Survey found that in 1974 richer households derive a large proportion of their income out of livestock (Table 1.4).

9. Government Policies and Legislation towards Livestock Development and Resource Utilisation

> Extensive government assistance - re-orientation towards communal areas in 1980s

The main thrust of government efforts lies on 1) the implementation of three Livestock Development Programmes (LDP), 2) veterinary services and cordon fences, 3) waterpoints spacing policies and 4) the provision of necessary legislation.

LDP1 and 2 have been reviewed extensively (Odell, 1980a; Sandford, 1980; Bekure and Dyson; Hudson, 1982). A basic component of both programmes formed the establishment of leasehold ranches for cattle (and under LDP1) sheep to raise productivity and, under the Tribal Grazing Land Policy (TGLP), to relieve overstocked communal areas. Other elements were the establishment of trekroutes to abattoirs, the provision of fattening ranches and the establishment of communal grazing cells (LDP 2). TGLP, closely linked to LDP 2, aimed at increasing biological productivity of livestock, range improved in communal areas and the reduction of rural income inequalities. Some central elements of the original White Paper such as stock limitations and the requirements for ranch development have never been implemented. Consequently, some ranches have not been developed and others are heavily overgrazed (e.g. Nojane ranches). Apart from practical implementation difficulties, the TGLP faced difficulties because of:

1. wrong assumptions: e.g. empty land is available for ranches; (28% of the planned ranches had to be dezoned), higher productivity is realised by fencing off
2. farmers often encounter problems and huge costs finding water as no groundwater surveys not undertaken prior to zoning.
3. communal areas are not relieved as:
   - leasehold farmers continue to move cattle between their ranch and communal areas.
   - 36% of the ranches already had boreholes owned by the lessee. In such cases, no movement has taken place.
   - people got evicted from the new leasehold areas and added pressure to the communal areas.

The White Paper already recognised that in small districts no space could be found for ranches. Emphasis has now shifted towards communal areas, where most cattle are kept (NDP 6, 195). SLOCA and AE10 finance livestock development of smallholders and groups in communal areas. Experiments with communal area grazing cells as a form of group resource management have been negative (Dyson - Hudson and Bekure, 1981 and NDP 6). Recently the third Livestock

Development and Range Management Project has started with further emphasis on communal areas through the preparation of comprehensive land use plans, renewed trials with community based resource management and a planned review of incentives provided to communities to manage grazing and water on a sustained basis.

Government has several vaccination campaigns and has built a vaccine producing institute as well as a veterinary laboratory. In addition, cordon fences have been constructed in most parts of the country to restrict cattle movement and contain diseases (Map.A.2.1). The combined effect has ,been that no major epidemics have taken place and the 1979 - outbreak of Foot and Mouth Disease could be restricted.

Various forms of government assistance has led to a significant net annual subsidisation of the livestock sector (15.7 mln in 1981; Presidential Commission on Economic Opportunities, 1983).

Government has been actively involved in the control over the number and location of boreholes. The traditional rule of a minimum of 8-km distance between boreholes, has been adopted too by Land Boards (Roe and Fortmann, 1980). This distance should be kept to avoid overgrazing but in practice more cattle than assumed (500 LSU) use boreholes (e.g. Motsomi, 1982). As spots for new boreholes are difficult to find, pressure to reduce spacing exists. Under certain circumstances, the distance is now allowed to be less. Spacing of boreholes cannot be separated from cattle numbers. During the preparation phase of TGLP, government declared a borehole freeze to avoid farmers drilling boreholes in designated commercial zones. This measure, however, has been ineffective and many boreholes were later found in commercial areas. Despite the key role of boreholes in livestock production, the exact number of boreholes, their ownership and access are not known countrywide nor in most districts (exceptions for example Ngamiland and Southern District). The National Development Plan estimates the country to have 10,000 boreholes for various purposes, half of which are operating. The Tribal Land Act (1970) transferred most resource management powers from the chiefs to Land Boards. Land Boards allocate boreholes and are empowered to declare boundaries between grazing areas and mixed farming areas (to restrict arable encroachment into grazing areas). The Agricultural Resources Conservation Act allows the Agricultural Resources Board to impose stock orders if the grazing conditions justify such action. Such orders could limit livestock numbers. Modern institutions have established themselves well but they have not really filled the resource management gap left by the traditional structure (CARG, 1984). Management tools such as stock orders and boundary identification of grazing areas have so far not been used, among others because of practical constraints (e.g. lack of manpower). Traditional institutions such as overseers have retained locally some influence (Brown, 1983; Gulbrandsen, 1984) but it seems not feasible to attempt to revive the traditional system.

2.2 Trends in Livestock Development

1. Livestock numbers have continuously increased during this century except in periods of drought or disease. This increase has not been accompanied by a structural increase in offtake rates, which fluctuate around 10%. This has led to widespread overstocking. However, particularly small districts have been overstocked since

the 1940s/1950s and it is therefore to be expected that livestock numbers will continue to increase in future, unless control measures are considered and/or alternatives for livestock holding are found. If the same growth rate as in 1971-1981 is assumed, the national herd will reach 3.3 mln in 1990, 4 mln in 1995 and 4.7 mln in 2000. Even if the growth rate would be much lower (e.g. 2% per year), the national herd would still be 3.9 mln in 2000. In smaller districts, livestock numbers grow already slower than the human population or even decrease. This will become more pronounced in future. Pressure to expand west and northwards may increase. However, such expansion will become more difficult because of conflicts with other forms of land use and is only feasible for farmers who can afford boreholes.

2. The proportion of the population keeping cattle has probably been fairly constant in the past. In absolute terms, the number of cattle holders has increase until it stabilised after 1978. Difficulties with access to grazing and water and higher production costs may push smallholders out of cattle production in future and this will have implications for other sectors (e.g. through draft power on the arable sector). Droughts will accelerate this process. The distribution of cattle would, as a result, become more skewed. Scarce data for the past suggest that the distribution has already become slightly more skewed.

3. Increasing numbers of livestock are kept in mixed farming areas (e.g. in Kgatleng now approx. 30%). Livestock kept there belong mostly to small holders who economise on labour by keeping cattle at their fields and who cannot afford borehole costs and fees in grazing areas. Mixed farming areas can be more crowded than grazing areas (e.g. Kgatleng) as users in grazing areas are fewer and accces can be regulated through boreholes. In mixed farming areas, smallholders utimately fall back on village boreholes. The difference between both zones is likely to augment in future through increasing exclusivity of boreholes in grazing areas and in general through a possible more skewed cattle distribution.

4. Improved management practices do not lead to more intensive land use. Therefore, lower stocking rates are crucial to any form of sustained range utilisation. Offtake rates have not shown a structural increase but are higher during droughts. Offtake is generally higher for freehold farms, rates are generally smallholders and larger herds. The policy of BMC has been to maximise producers' prices and not to increase off-take numbers. Establishment of the new abattoir in Francistown may increase off-take rates as slaughtering capacity has probably been a constraint in the past.

5. Smallstock developments are less well known, particularly related to local consumption. Numbers and off-take to BMC were high early 1970's and are recently increasing again. Goats appear to perform relatively well during droughts. Livestock other than cattle contribute 15-20% of stocking rates nationwide.

6. Government has continuously expanded veterinary services and cordon fences (Map A.2.1.) so that diseases like FMD decrease in frequency and spatial distributions (Map A.2.1). Experiences with the livestock development programmes have led to a shift of emphasis from ranching to communal areas which to a large extent still need

to be specified (e.g. land use plans, community resource management). In the past, the livestock sector was subsidised. Government now holds the view to move away from net subsidies to livestock and diversify the economy (NDP 6, 1986).

2.3 Range Degradation Related to Livestock

Overstocking occurs now throughout most of the country and it has increased in intensity. Overstocking is the driving force behind a number of sequential processes of environmental degradation: 1) bush encroachment, 2) soil erosion and 3) desertification. These processes are enhanced and sometimes ameliorated by other sectors. For example, clearing of fields and woodcutting contribute to soil erosion but wood cutting may counteract bush encroachment (Van Vegten, 1981).

Table 2.6

Tree Species Indicative for Bush Encroachment

Setswana Name	Scientific Name
	Acacia hebeclada
Mosu	Acacia tortilis
Moloto	Acacia erubescens
Mogotlho	Acacia erioloba
Mongana	Acacia mellifera
Mopane	Colopnospermum mopane
Moselesele	Dichrostachys cinerea
Mogonono	Terminalia sericea
Moretlwa	Grewia species

Source: Tolsma, et al, 1986. Van Vegten, 1981.

1. Bush encroachment is the process, where the grass layer in the savanna rangeland decreases and the woody layer increases. The open savanna land scape turns into a woodland with sometimes dense bush thickets. Although regional differences in rainfall and soil structure influence the precise nature, a general sequence of changes in vegetation can be distinguished:

   i. The most nutritious palatable and perienial grasses gradually dissappear due to selective grazing and are replaced by less palatable, often annual, species. The forage quality for livestock decreases.

   ii. The total cover of the soil by grasses decreases. Bare patches occur. The amount of unpalatable herbs increases.

   iii. Grasses dissappear completely and the open space can be taken over by unpalatable herbs, bulbuous plants (liliaceae).

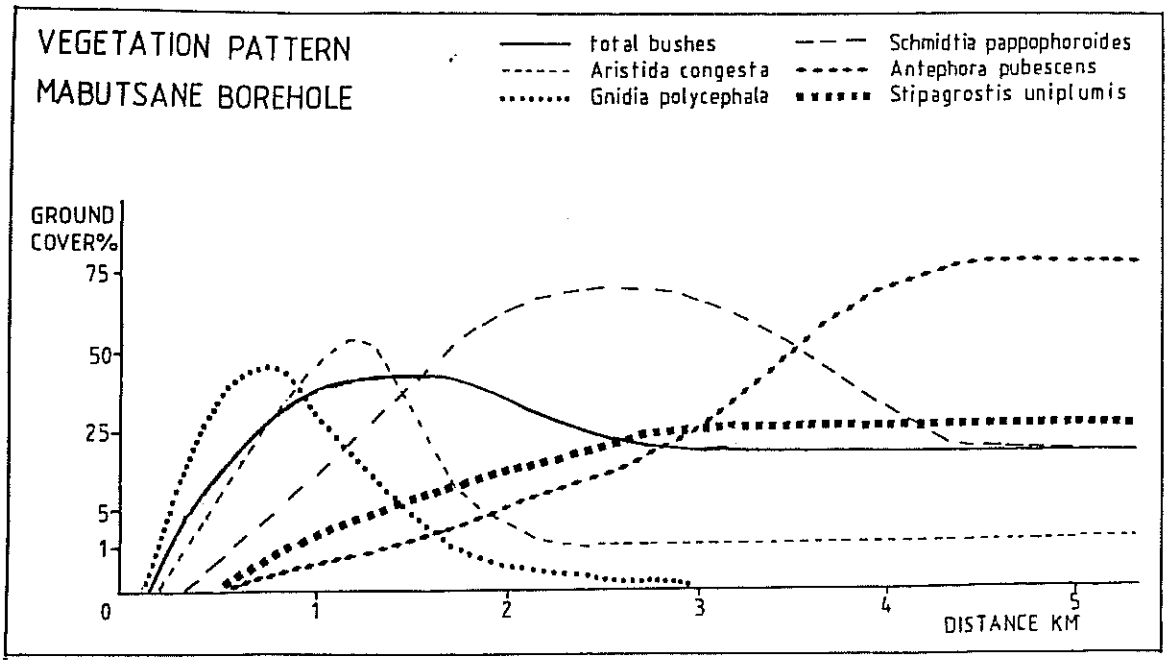
   During steps 1-3 the amount of trees and bushes increases.

   Descriptions of vegetational aspects of this process can be found in Van Vegten (1981; 1982), Pole Evans (1948), Walter 1954, Donaldson and Kelk (1970), and Tolsma et. al (in print). Table 2.6 shows the

main encroaching tree species in Botswana except for Acacia herbeclada and the Grewia species these are suitable species for fuelwood use. Bush encroachment starts from centres of cattle concentration such as villages and cattle posts (Field 1978). Figure 2.7 shows an example of bush encroachment around a borehole in the Southern district sandveld. The various stages of bush encroachment can be recognised here up to 4 km from the borehole.

Figure 2.7

Vegetation pattern at a borehole in the sandveld
(Mabutsane; drilled in 1959)*



*Note % ground cover is a vegetation analysis estimate. Figures should not be taken absolute and cannot be added.
Source: Glatzle (1975).

2. Soil Erosion

The grass layer protects the soil against the wind and rain and removal of this cover enhances soil erosion. SARCUSS (1981) and Gelmroth 1981 classify soil erosion in Botswana into:

a. Wind erosion:
The wind blows especially smaller soil particles away. Sandy soils are very succeptible.

b. Sheet or surface erosion:
More or less uniformal removal of soil from an area by detachment of soil particles through raindrop action and transport through runoff water.

c. Rill erosion:
Removal of soil by concentration of runoff water in small rivulets.

d. Gully erosion:
Removal of soil by excessive concentration of runoff water causing the formation of dongas or gullies, mainly in drainage ways and lower slope positions.

Hardly any quantitative information exists about soil erosion in grazing areas. However, soil erosion is a serious problem in Botswana. Table 2.7 summarises effects of range degradation on sheet erosion by indicating the increase in soil loss caused by the reduction of the vegetation cover. Indications of severe soil erosion are moving sand dunes (Kgalagadi district), gully formation (especially eastern Botswana) and dust storms throughout Botswana, (Field, 1978).

Table 2.7

Rough Estimate of the Vegetation (Crop) Cover Soil Loss Ratio*

Vegetation	Percentage of rainfall energy intercepted	Vegetation cover soil loss ratio
Dense pasture	90	0,01
Medium pasture	80	0,01
Sparse pasture	70	0,02
Slightly overgrazed pasture	60	0,03
Overgrazed pasture	40	0,10
Heavily overgrazed pasture	20	0,31
Bare soil	0	1,00

*The vegetation (crop) cover soil loss ratio relates on empirical formula established for Zimbabwe rainfall 60 soil losses.
Source: Van der Poel (1980).

3. Desertification

Large scale disappearance of vegetation ultimately leads to desertification. Desertification causes, through changes in the local climate, increased runoff, severe soil erosion and further reduction of the total vegetation cover. At this stage rehabilitation of the range becomes very difficult.

4. The Extent of Environmental Degradation

The proportion of bare soil as an indicator for the extent of land degradation, can be measured by landsat imagery. Map 2.2. summarises preliminary research results by Ringrose (Dept of Environmental Science, University of Botswana). Devegetated areas occur throughout Botswana. In some areas the stage of desertification seems to have been reached (Bokspits, Matsheng

villages, Mopipi and Rakops). Land degradation has become widespread in the western part of Botswana and around the Okavango. Particularly in Kgalagadi and Ghanzi, including the Central Kalahari game reserve, wildlife and cattle are increasingly competing for the same grazing resources. In this area, devegetation may have been stimulated by harvester termite action (Ngwamotsoko, 1985).

Map 2.2 shows the situation of Botswana's range during a drought period and hence effects of overgrazing and drought have not been separated. The map does not include bush encroached areas with a dense cover of shrubs nor a significant part of central district, for which area no adequate data is available. Due to this lack of data and the large scale of the map, the poor condition of the range in the eastern part of the country and in the small districts is not documented. Map 2.2 is based on data from one year only and trends cannot only be ascertained until the exercise has been repeated for several years. Few data on trends in range degradation processes exist. Table 2.8 shows the development in the tree layer around Olifantsdrift in Kgatleng. Experience with the Nojane TGLP ranches (Bekure and Kgosidintsi, 1979; Skarpe 1981) show that the range in a sandveld can be damaged in a few years only.

Figure 2.8 shows the increase in soil erosion in the Metsemotlhaba communal area during the recent drought. This area had in 1983 a stocking rate of 2.5 Ha/LSU and a cattle mortality rate of 48% (APRU, 1983) and is hence an example of the effect of severe overstocking on land degradation and on cattle productivity in the small eastern districts.

Table 2.8

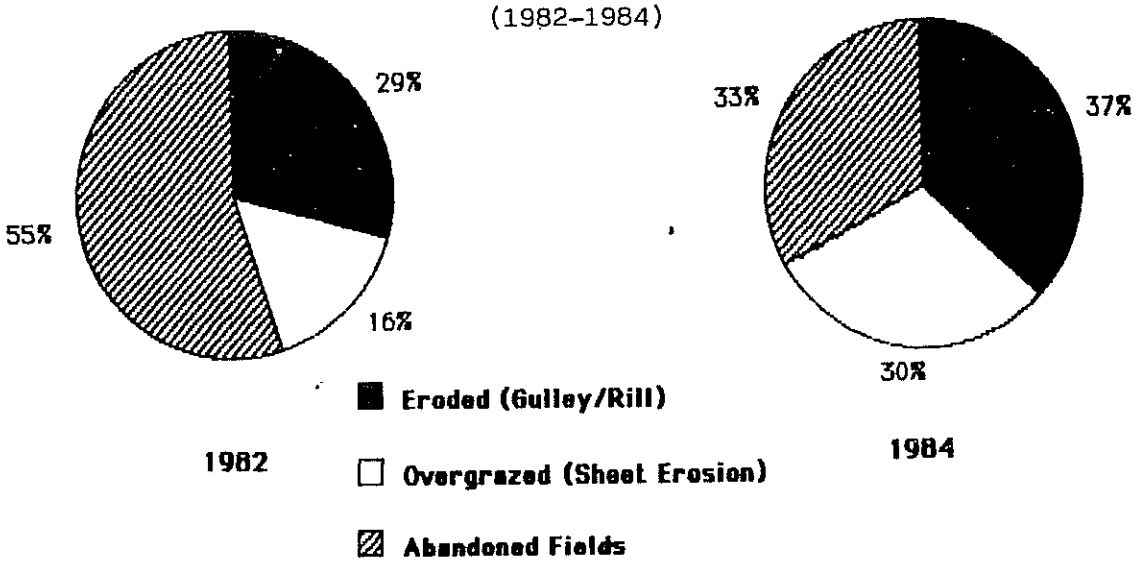
The Relation Canopy Cover Class-Woody Biomass and the Surface Areas Covered by each Canopy Cover Class in Proportion to the Total Study Area (1950-1975)

Canopy cover class (%)	Above ground woody biomass (fresh mass) in kg.ha^{-1}		Surface area covered by canopy (cover class given as % of total area)		
	Average	Range	1950	1963	1975
0	0		7.6	6.1	5.7
0-1	59	32- 98	41.4	23.8	3.0
1-5	2050	521- 3038	38.1	40.2	29.6
5-10	2860	440- 4170	7.1	10.1	28.2
10-30	3740	1280- 6820	3.6	12.0	13.6
30-50	5820	2610- 9160	1.3	6.0	7.2
50-75	9860	3290-22400	0.5	0.6	11.6
75-100	21210	6420-37840	0.4	1.2	1.1

Source: Van Vegten, 1983.

Figure 2.8

Area* with Exposed Soil
in the Metsemotlhaba Communal Area
(1982-1984)



Source: Ringrose, 1986.
(Total Area: 1982: 1059 6.6 Ha; 1984 = 11383.9 Ha)

.4 Strategies to Alleviate Range Degradation and Sustain the Livestock Sector

Difficulties to strike suitable groundwater at reasonable costs and increased competition and conflicts with other forms of land use set limits to expansion of grazing areas. Moreover, the present degraded state of existing grazing ares affects development prospects of the entire livestock sector. It is therefore in the interest of the sector to shift emphasis from expansion towards quality improvement in terms of sustainable productivity. The latter includes curbing overgrazing and restoration of the productivity of degraded grazing areas.

Any strategy should at least bear the following in mind:

a. Livestock production is an integral part of and still a dominant activity in the rural economy. Therefore developments outside the sector itself have repercussions on it and mere sectoral solutions do not work.

b. Livestock in communal areas serve various purposes, not just beef production. Draftpower, milk and manure are often underrated contributions.

c. Lower stocking rates are most important in achieving range improvement.

d. Grass is the most pressing and universal environmental constraint in present grazing areas. Water can usually be found although sometimes at high costs, only feasible for large cattle owners.

e. Present institutional arrangements are inadequate to cope with management of grass and water resources. Past attempts to arrest land degradation have had little success (see e.g. Fortmann et al,

1983). Local communities nor government have been able to resolve the problem. The former are generally aware of the problem but this awareness coincides with apathy to improve the situation.

f. Single, technical solutions do often achieve little as they do not recognise the broad context of the problem. Therefore, a package of various measures addressing the above issues is needed rather than a number of isolated efforts.

Strategies should focus on two broad main areas:

i. the adjustment of cattle numbers to the carrying capacity of existing grazing areas.

ii. the development of a smallstock sector in accordance with environmental opportunities.

Lower stocking rates are imperative for two reasons:

A. to adjust stocking rates to the decreasing actual carrying capacity of grazing areas

B. to attempt to reverse the process of degradation by allowing vegetation recover.

Prevailing circumstances still encourage growth of individual herds and subsequently total cattle numbers. This tendency will be particularly strong after the end of the present drought. Stabilisation of cattle numbers could be achieved by a structural increase in off-take rates and diversion of expansion oriented investments away from the livestock sector. A strong and viable sector could remain based on qualitative improvements. Past research has failed to look at options to increase offtake structurally. For example, farmers' responses to prices are largely unknown. Nevertheless, prices and improved marketing could be instrumental in increasing offtake. BMC could include environmental considerations in determining their prices and quota, instead of largely economic as used presently. This would probably lead to a more differentiated pricing system. For example, quota could be related to the extent of overgrazing in regions and prices could be negatively linked to rainfall. Marketing improvements should also look at the role of local consumption. During droughts, the total slaughtering capacity and marketing channels should be able to cope with the extra offtake, necessary to offset the natural decrease in carrying capacity. This extra offtake replaces movement of cattle as an adaptation strategy.

No experience as yet has been acquired with the imposition of stock limitations. Therefore, it is not known how effective these could be and what implementation problems would be faced. However, the experience shows the limitations to what intervention government is able and willing to undertake. In reality, it will be difficult to increase offtake if people do not experience finity of their grazing resource. In cases where this feeling is absent, land use planning could resolve this issue by delineating grazing areas in consultation with people.

Curbing of expansion investments would, for reasons of social justice refer to the very large herds mainly. This will be easier if indeed, the economy diversifies further. Government's intention to remove net subsidies to the livestock sector may provide a qualified dis-incentive for re-investment in livestock.

Lower or even zero stocking rates are also imperative for the improvement of rangeland. A combination of resting and bush control by fire and goats appears presently the only possible way to improve range productivity again. Unfortunately, these methods have not yet been tested in communal areas.

1. Improvement of the carrying capacity of rangeland

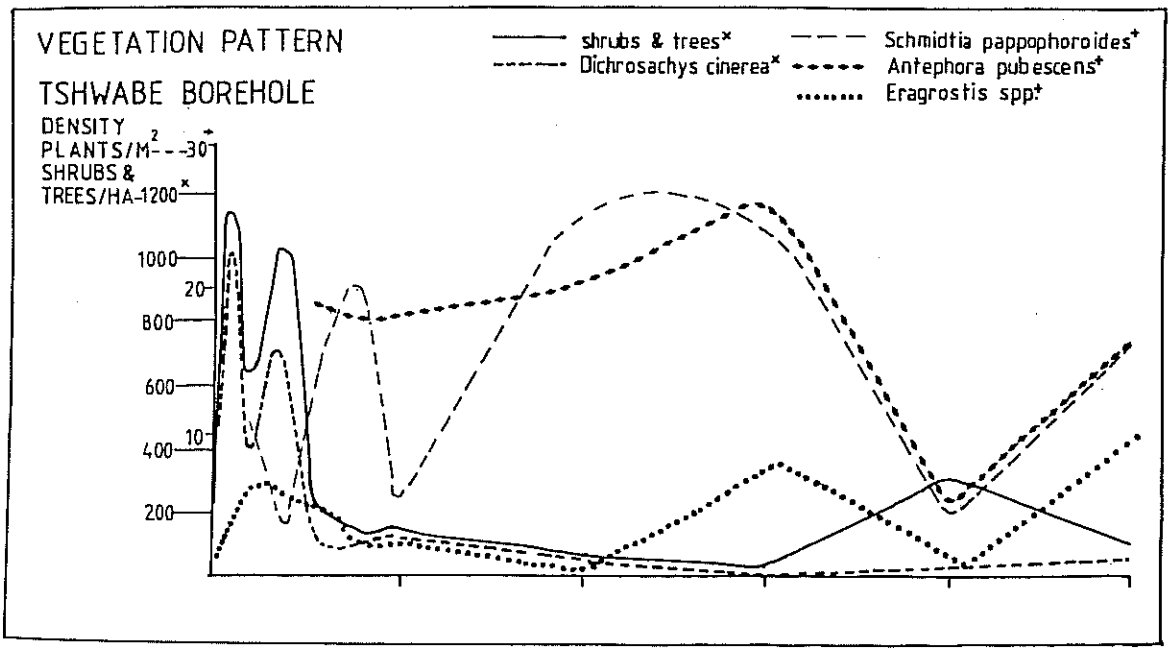
In the past, attempts have been made to improve the carrying capacity of grazing areas through passive and active management of the vegetation. The former includes, resting of degraded grazing areas by the removal or reduction of the grazing pressure and the introduction of so-called improved grazing systems. The latter refers to direct interference in the vegetation and use of fertilisers.

1. Resting

Few data are available on the regrowth of vegetation around abandoned boreholes. In the sandveld of Western Kweneng, grasses invaded relatively quickly (Seitshiro, 1978). Figure 2.9 shows that good grasses reappear close to the borehole only two years after its abandonment. Nevertheless, signs of bush encroachment remain clearly visible.

Figure 2.9

Density of Trees and Shrubs and some good grasses at Tshwabe Borehole after closure (2 years)



Source: Seitshiro, 1978.

Integrated enclosures in communal sandveld, reveal a similar quick restoration of vegetation since 1982 (APRU Annual Report, 1983-1984).

For the hardveld less data are available. Soil processes like crusting and compaction make the soil hard to penetrate for plant roots, and may inhibit recolonisation. Furthermore, as overgrazing is an older phenomenon in the hardveld, less grass seeds may be left for recolonisation. Range monitoring data (1985) from North-East district however suggest that a combination of less cattle and good rainfall can provide a relatively quick restoration of the grass layer.

Resting does not arrest the increase in bushes and trees caused by bush encroachment and needs therefore to be supplemented by other methods. Natural reduction of the woody layer takes decades (Walter, 1964) or may not happen at all. Parris and Child (1975) found effects of overgrazing on the tree layer 20 years and more, after cattleposts (at Mabuasehube and Makgadigadi pans) had been deserted.

2. Improved Grazing Systems

Since 1975, APRU has been investigating three grazing systems in Botswana

- continuous grazing
- 3 paddock per herd (moderate multi-camp)
- multi-camp systems

The trials showed that cattle performance was slightly better under continuous grazing, while the range quality was slightly more negatively affected. However, differences were hardly significant. These results are confirmed by McKay (1968) and Carl Bro 1982. Therefore it is concluded that:

- multi-camp systems do not significantly raise the carrying capacity of a range.
- any grazing system should be based on a continuous judgement of range quality. A farmer should farm his grass rather than his cattle.
- paddocks can have useful management functions: weaning and separation of individual animals. Sub-dividing herds; making them more manageable.

3. Bush Clearing

Removal of trees and bushes may increase the grass production by 20% (APRU,1979) to 300% (Barnes, 1982). Therefore restoration methods focussed on four removal methods (APRU, 1980).

1. Mechanical methods (chaining, buldozer blades)
2. Chemical methods* (cutstump treatment foliar application, basal areas application).
3. Use of fire
4. Use of goats and fire

* Environmental and health hazards of defoliating chemicals are high.

The first two methods were considered economically unfeasible and have not been pursued (APRU, 1980).

Trials at Morale reveal that tall trees can be suppressed by fires (APRU 1980 and Table A.2.11). However the degree of success depends on the direction of the fire (with or against the wind) and the fuel load in terms of dry grass. For example, in low rainfall areas and in overgrazed areas, the effect of fire may be limited, because of an inadequate fuel load. Since fires do not arrest the fast regrowth of small bushes, goat trials have been conducted to control bush regrowth (Sweet and Mphinyane, 1985 and Figure A.2.2).' Goats reduce regrowth of lower bushes (2m) while taller bushes remain unaffected. Browsing by goats was particularly effective in this study during the drought season 1984-85. A grazing pressure of 3 goats/ha caused signs of overgrazing in the grass layer. Other trials with goats (APRU, 1983/84) show their preference for specific species. As a result not all encroaching tree species are evenly controlled by goats.

4. **Fertiliser and Fodder**

Range improvement with fertiliser turned out to be economically unfeasible (APRU, 1980). Trials with exotic fodder species show problems during the establishment phase of the species. Exotic fodder species are probably unfeasible in view of the economic inputs needed. Indigenous fodder species have not yet been considered for range improvement. Presently, research has been started to investigate the feasibility of fodder crops but no conclusions can be drawn as yet.

The only expansion option in the livestock sector appears to be the development of smallstock, particularly goats. Goats are affordable for poor households, browse mostly and are fairly drought resistant (IFPP, 1985). They compete only in a limited way with cattle. However, more research is needed to assess the potential and the effects of increased goat development. Increase in the grazing pressure of smallstock without a concurrent reduction of grazing pressure of cattle would undoubtedly lead to increased range degradation.

CHAPTER 3

THE ARABLE PRODUCTION SECTOR

3.1 Arable Production and the Environment

Botswana's arable sector includes different, forms of crop production under different forms of land tenure. Although dryland farming is dominant, flood regime crop production (molapo) and irrigation are practised locally: molapo farming around the Okavango river and Boteti; some irrigation mainly in the Tuli Block and Chobe.

1. The Agroclimate

> Low and erratic rainfall - high chances of crop failure
> timing of arable activities is crucial

Low, variable and usually erratic rainfall is the major environmental constraint for dryland farming. Seasonal variations even exceed the annual fluctuations. In many parts of Botswana half the time crop water requirements are never sufficiently met. This has serious implications for production. The main crops in Botswana are sorghum, maize and millet and these require a minimum growing period of 90-130 days.* The critical growth period falls mostly in January/February and over 80% of the variability of the yield/hectare can be explained by the variability of rainfall in this period (Vossen, 1985). Map 3.1 shows the likelihood of a sufficient first and second rainfall period. Map A.3.1. shows the likelihood of a dry spell between the first and second season. The difficult climatological conditions are particularly important for planting dates and choice of crops.

Planting Data

The best planting date falls for most of the country between the end of November and mid-December** but farmers should be prepared to plant at any time between October and January or even February. Early planting has the risk of crops suffering from the midsummer dry spell during critical growing stages and farmers seldom plant before mid-November. The traditional way of planting part of the field after each shower over a period of several months appears to be the best approach of minimising the risk of total crop failure.

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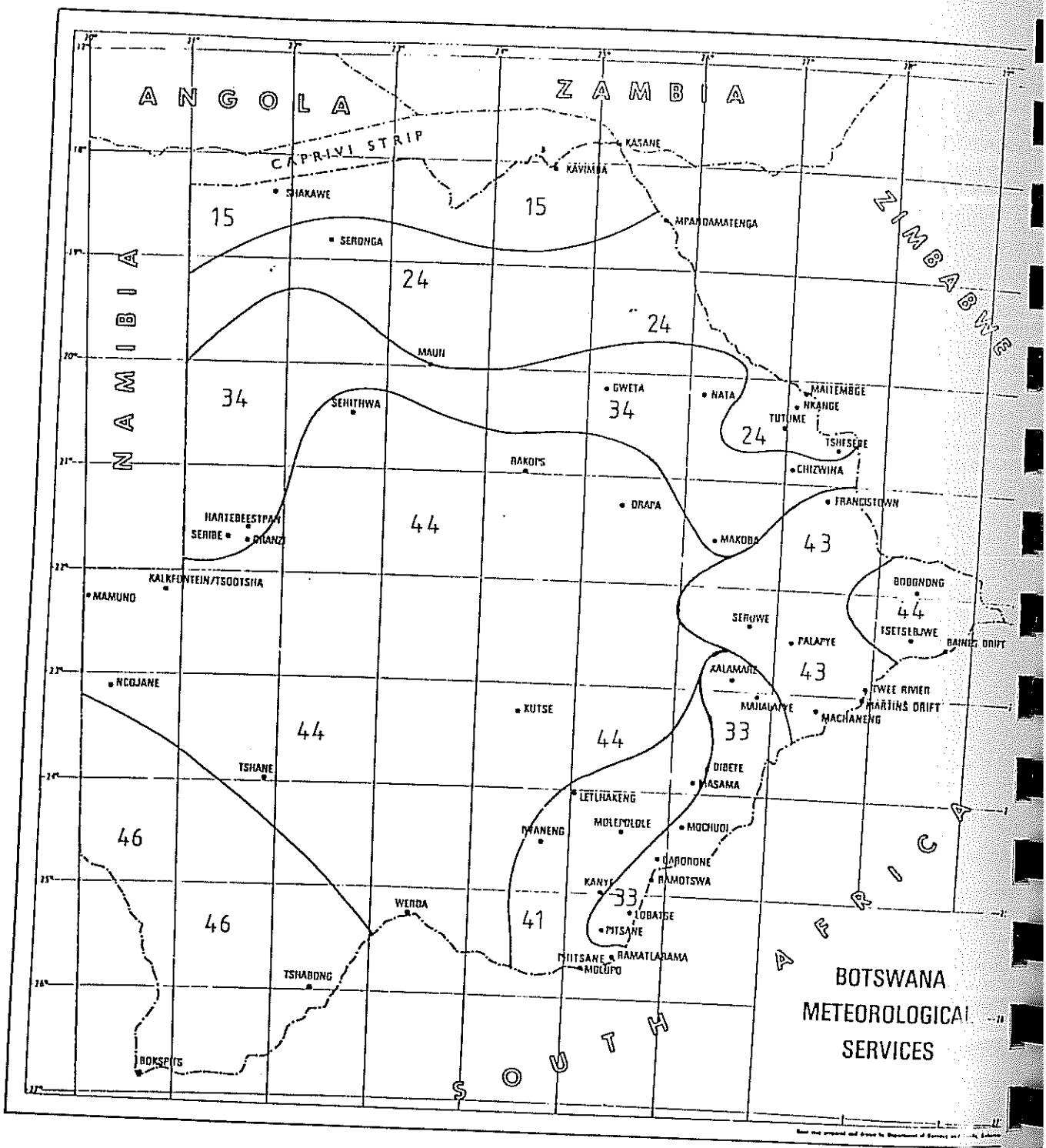
* This period includes length growth, flowering and the first steps of grain filling.

** Vossen et al, 1985; Venema and Rhebergen, 1985

Map 3.1.

The Length and Frequency of the First and Second Rainfall Period in Botswana



Source: Dambe, 1985

Choice of Crops

Crops differ in their resistance to drought. Sorghum, millet and beans are more drought resistant than maize. During the recent drought there were only minor shifts towards the more drought resistant crops (Table A.3.1). This may be related to labour constraints as (Dryland Farming Research Scheme (3) 1985):

- maize is much less susceptible to bird damage and hence needs less bird scaring
- the economic returns from maize are better
- the harvesting of beans is very labour-intensive

Many farmers, who broadcast, in fact use a mixture of one or two cereals with beans and melons. Possible benefits of this practice are:

- spreading of risks by planting more than one crops
- one crop may help protect the other from birds and noxious weed
- a more even use of soil nutrients

Local longer season varieties of sorghum (especially segaolane, marupantse) are performing better than newly tested shorter season varieties (Department of Agricultural Research, 1985; Mazhani, 1984 and 1985). Around Francistown the long red variety Town, Thaone ±135 days) is very popular. The ability to survive water stress rather than rapid growth is the biological selection criterion for crop varieties.

Legenda Map 3.1

THE LENGTH AND FREQUENCY OF THE FIRST AND SECOND RAINFALL PERIOD IN BOTSWANA

FIRST GROWING SEASON	SECOND GROWING SEASON
1. Frequency 80-100%, 100 days	1. Frequency 50%, 40-60 days
2. Frequnecy 80-100%, 60-100 days	2. Frequency 50%, 20-40 days
3. Frequency 80-100%, 40-60 days	3. Frequency 20-50%, 40-60 days
4. Frequency 80-100%, 20-40 days	4. Frequency 20-50% 20-60 days
5.	5. Frequency 20%, 60 days
6.	6. Frequency 20%, 40-60 days
7.	7. Frequency 20%, 20-40 days

Example: 15 represents a first growing season of 100 days with a frequency occurrence of 80-100% (1) and a second growing season of 60 days with a frequency occurrence of 20% (5)

Legenda Map 3.2

AGRICULTURAL ZONES IN BOTSWANA

Zone 1

Temperature:	summer 18° - 33°C (9° - 42.3°C) winter 12° - 30°C (-0.6° - 32.0°C)
Moisture:	rainfall 600 - 700 mm,
Texture:	sandy loam to silty clay (Kasane/Kachikau) loam to heavy clay (Pandamatenga/Kukulwane)[8].

Zone 2

Temperature:	summer 24° - 27°C (6° to 43.4°C) winter 16° - 25°C (-4.5° - 32.5°C)
Moisture:	500 - 600 mm November to April.
Texture:	medium sands, fine sands, some silty clay in the south.

Zone 3

Temperature:	summer average 23°- 37°C (6° - 43.4°C) winter average 17° - 25°C (-4.4° - 33°C)
Moisture:	450 - 550 mm,
Texture:	fine sands, sandy loams, silt and clay loams, sandy clay, clay.

Zone 4

Temperature:	summer average: 24° - 27°C (5° - 42°C) winter average: 15° - 22°C (-4° - 36°C)
Moisture:	450 - 550 mm.
Texture:	heavy clays, some silts and fine sands.

Zone 5

Temperature:	summer average 24° - 27°C (6° - 43°C) winter average 14° - 23°C (-4.5° - 33°C)
Moisture:	350 - 500 mm,
Texture:	medium and fine sands. Very small (relatively) areas of sandy loams and clay loams in depressions.

Zone 6

Temperature:	summer average 20°- 27°C (15° - 42°C) winter average 8°- 16°C (-5.0° - 30°C)
Moisture:	400 - 500 mm
Texture:	ranging from stoney through sandy loam, loam, to clay in drainage lines, valleys, and depressions. On the basis of area, the majority are sandy loams or loamy sands.

Zone 7

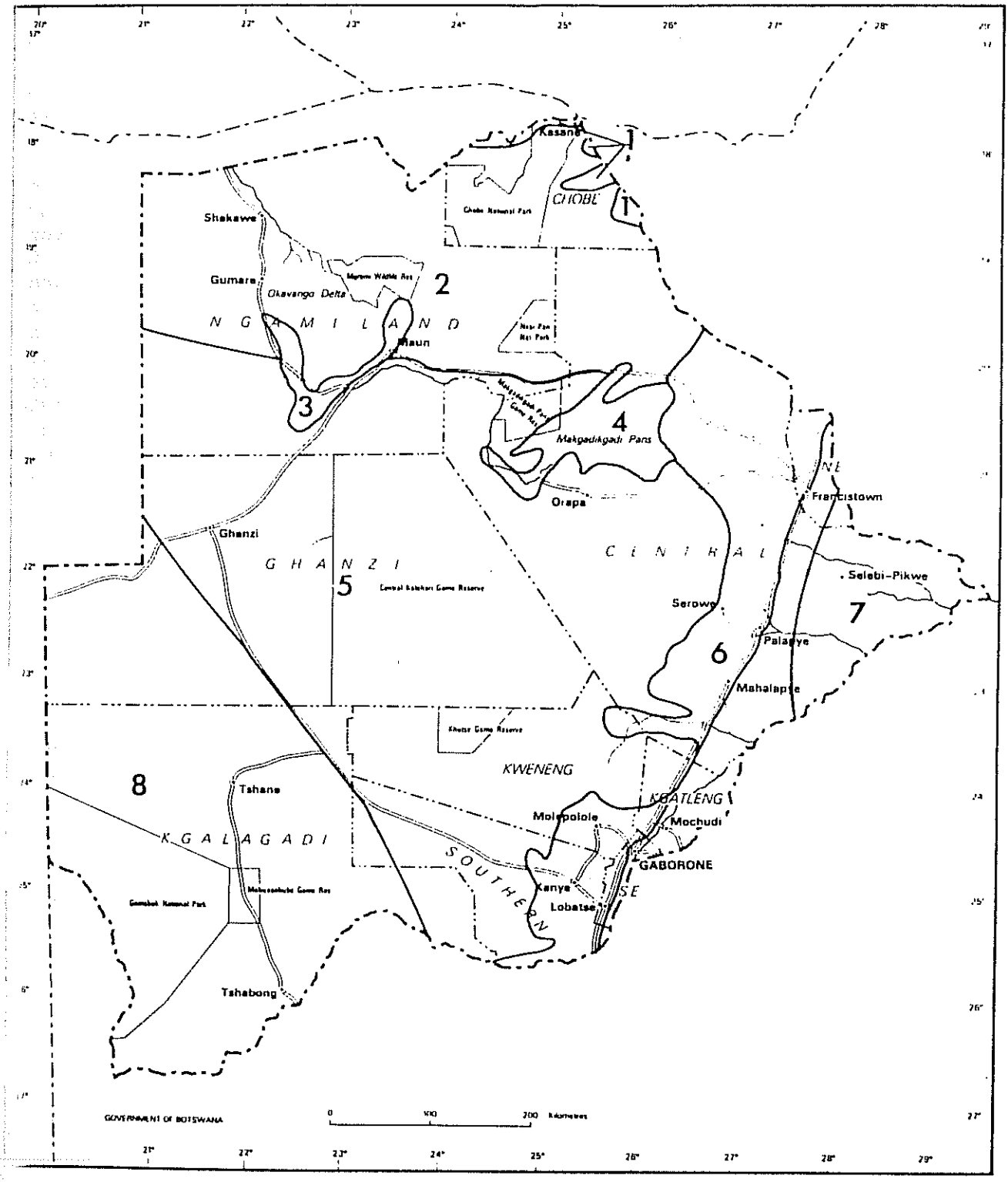
Temperature:	summer average 15.6° - 33°C (10° - 43°C) winter average 1.9° - 30.2°C (-5.0° - 35°C)
Moisture:	350 - 450 mm ±50%.
Texture:	sandy loam, loam, silty clay, clay

Zone 8

Temperature:	summer average 23° - 27°C (17° - 34°) winter average 12° - 24°C (-2° - 32°C)
Moisture:	200 - 400 mm,
Texture:	medium and fine sands. Very small areas of heavier soils in depressions.

Map 3.2.

Agricultural Zones in Botswana



Source: Sims, 1981

Agricultural Zones

Agricultural zones can be defined and are used for agricultural planning (land use, advice) and are usually based on soil and climatic characteristics (see e.g. Map 3.2.). Crop production is extremely difficult in the western parts of the country with low rainfall and very sandy soils. As a result, cultivation is concentrated in the eastern part. An improved agricultural zonation is currently being prepared by the Department of Meteorological Services.

Botswana's loamy hardveld soils crust and compact and are hard to penetrate for plant roots. Hence tillage practices are absolutely necessary (Dryland Farming Research Scheme (4) 1985). Deep ploughing (20 cm) gives better results than shallow ploughing (10 cm). Deep ploughing shows residual effects in a year or two. Even in the sandveld ploughing increases productivity, with deep ploughing superior to shallow ploughing in wetter years. Only in very dry years, the faster growing roots of crops in ploughed soils deplete the available moisture earlier. Under such circumstances the likelihood of crop failure is less in unploughed soils but harvests are marginal in both instances. Weeding is beneficial to crops, since it reduces competition for water and also the negative effects of parasitic weeds such as witchweed, striga asiatica and Alectra vogelli. Crop rotation may help to fight various weeds. Row planting is advocated.

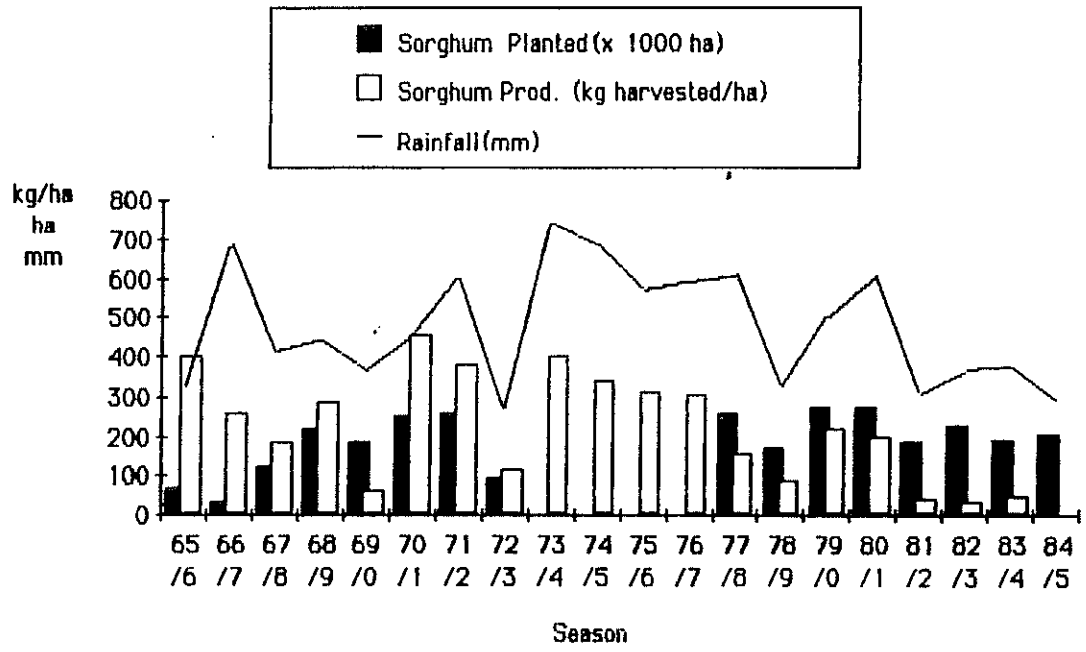
3. Development of the Arable Sector

> Crop Production lags behind population growth - most food grown in eastern Botswana

In general, the arable sector has developed very slowly. The productivity per hectare is still similar to the 1930s and limited area expansion has taken place (Figure 3.1. and Table A.3.1). The cultivated area per person has halved from 0.6 ha in 1940 to 0.3 ha in 1981. The arable sector expanded slower than the population and as a result the self-sufficiency ratio has dropped. Figure 3.1 shows considerable fluctuations in area planted and yields, mainly related to rainfall levels and distribution (Hay, et al 1985). Production levels of the mid-1970s have not been repeated since and increasing imports are required to meet domestic demand of approximately 200,000 tonnes per annum (Rural Development Unit, 1985). Arable land claims on a nationwide basis are small: up to 260,000 ha or less than 1% of the country are cultivated per annum. Overall arable land, including short-term fallow, was estimated to be 815,600 hectare in the mid-1970s or 1.4% of the country and around 1 ha per person (DHV, 1980 and Table A.3.2). Over 90% of the cultivated area is located in tribal land. The average ploughed area per ploughing household has been fairly stable at approximately 4.5ha, with much lower averages during droughts.

Figure 3.1.

Some Indicators of Arable Development



Source: Opschoor 1983; Agricultural Statistics 1981-1984; Meteorological Services

Molapo farming covers up to 4,800 ha per annum; only a few percent of the total cultivated area but productivity can be substantially higher than dryland farming (Rural Development Unit, 1985). Aerial photographs show that around 6,000ha have been under regular molapo cultivation. Erratic floods and structural changes in flood regimes cause considerable annual fluctuations in the area cultivated and in production. They have also led to the partial abandonment of some areas (e.g. the western side of the Okavango). Most freehold areas focus on livestock rather than arable production. Although between 40-50% of the freehold farms also engage in arable production, ploughing a total of 10-15,000 ha per year. Despite their small number, they contribute significantly to the country's total production because of the large areas involved and because of their higher productivity. Approximately 1,100 ha in the Tuli Block are irrigated (Table A 3.3).

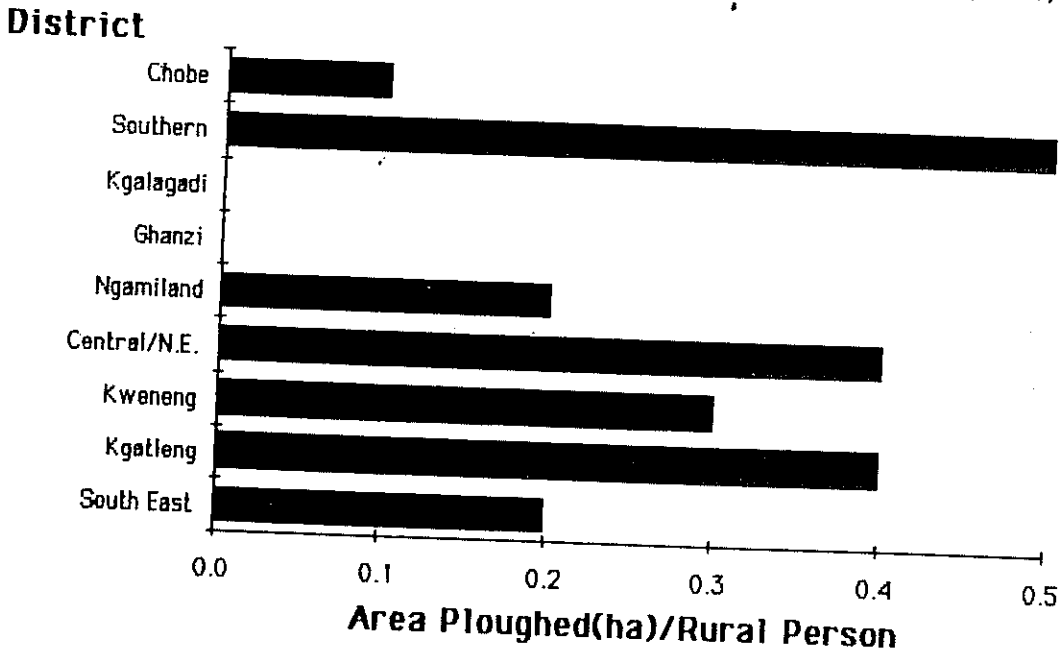
Crop production is concentrated in the eastern hardveld. Arable activities in Ghanzi and Kgalagadi are very limited (Figures 3.2 and 3.3)*. Southern District has comparatively few households involved in crop production but holds a more than proportional share in area cultivated and production. This picture results from the presence of a limited group of large scale farmers in Barolong. Ngamiland reflects the mixture of small scale molapo farming and sandveld crop production with more than proportional number of households involved in crop production but with relatively small areas ploughed and (surprisingly) low production. South East shows a similar pattern

* See also Table A.3.4.

which, however, probably emerges from land shortage and the existence of alternatives for crop production (Odell, 1980; Arntzen, 1985). Such a pattern is not yet visible in North East district and Kgatleng. Arable land pressure exists in small districts where over 10% of the land is used for cultivation and in the Barolong farms. In North-east and South-east district, pressure is compounded by the fact that large portions of the districts are under freehold tenure.

Figure 3.2

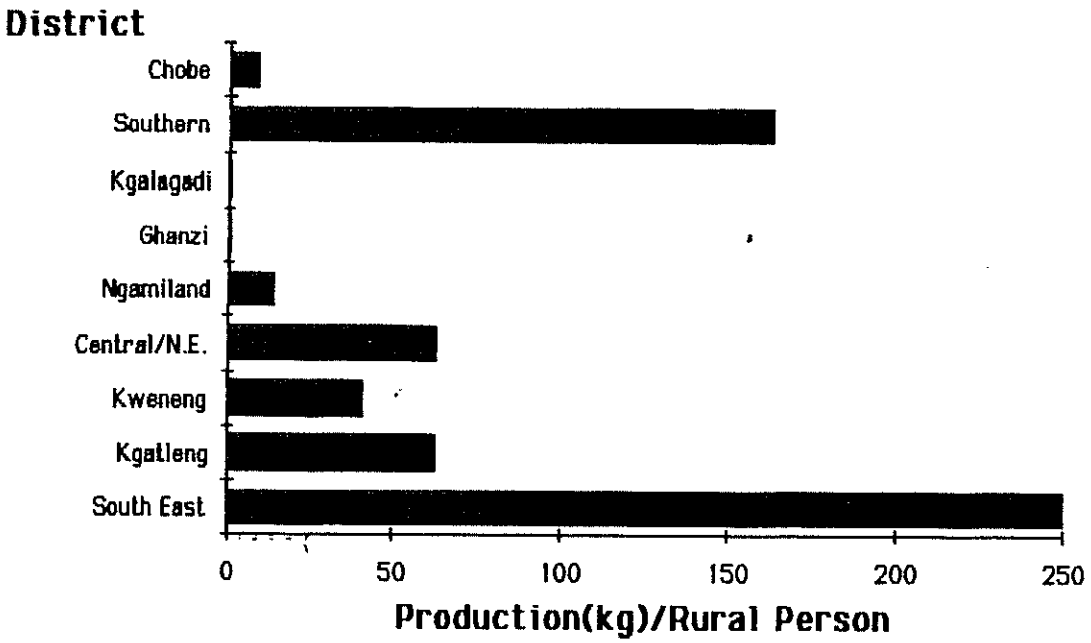
Area Ploughed in Botswana per Rural Person (1981)



Source: Agricultural Statistics

Figure 3.3

Production of Main Cereals per Rural Person (1981)



Source: Agricultural Statistics

4. Irrigation - Water Use

Small area under irrigation - very high water demands

Food crops and vegetables are grown on a limited scale under irrigated conditions. Despite an apparent increase in horticultural activities, research has paid little attention to these. In 1984, around 300 hectares of horticultural land were developed and 180 ha was actually in production. When satisfactory yields are achieved, this land suffices to fulfil the country's vegetable requirements at the moment. The Tuli Block constitutes almost half of the producers' areas (Department of Agricultural Research, 1986). Future demands estimates are not known but the use of vegetables is known to increase with higher incomes and urbanisation. Horticultural projects depend on irrigation. They are therefore located at suitable irrigation spots, to minimise the watering costs or close to the markets in large settlements to minimise transport costs. Despite the limited area under irrigation at the moment (± 1000 ha), its water demands are very high and amount to approximately 35% of the total water use in Botswana. Present water use for irrigation is close to 100,000 m^3/day.

Currently, the feasibility of water use in the Southern Okavango Delta is being studied. Areas considered for irrigation include fringes of Lake Ngami, the old alluvial flood lain north of Lake Ngami, pockets of land along the Nhabe, Boteti and Thamalakame rivers (SMEC, 1986)). Results of the study are not yet available.

5. Household Participation in Crop Production

No evidence of households as yet dropping out of crop production distribution of land and yields skewed

Despite adverse climatic conditions, more households participate in crop than in livestock production because arable land is still freely available and involvement requires less investments. Participation in arable activities can be measured by the proportion of households holding arable land or by the proportion of ploughing households. Agricultural statistics suggest that 80 to 90% of the agricultural holdings have cleared land but the actual percentage of ploughing holdings is lower. The actual percentages for households will be different as the Agricultural Statistics exclude households with a minimal agricultural involvement. In eastern Botswana 87% of the households held land in 1970/71.* It is difficult to discover a trend in household participation because data are incomplete and sources are not easily comparable. Agricultural Statistics suggest a decrease in agricultural holdings with land since Independence from around 99% in 1969/70 to 84% in 1981 (absolute increase from 51,500 to 70,800). However, Agricultural Statistics are here of limited value because of differences in sampling methods (early statistics have a small sample size) and the fact that nothing can be said about households (Table A.3.5).

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* Local and regional studies suggest land holders percentages of 80-100% (e.g. Opschoor, 1981; Marquardt, n.d.).

Households desiring land can generally still acquire it. Landless households are either too poor to clear and cultivate land or are well-off and have better alternatives. If the participation in crop production has dropped, impoverishment of households is likely to be the main cause.

The distribution of cultivated areas and production is highly skewed but stable over the years. This distribution reflects differences in means available to households (Tables A.3.6 - 8). In 1970/71 the bottom 53% of cultivating holdings cultivated 22% of the land; in 1980/81, the bottom 55% holdings accounted for 23% of the cultivated land and in 1983/84 52% cultivated 22% of the land. Farmers cultivating over 10 ha. are in general more productive. For example, in 1981, 5% of the farmers cultivated more than 10 ha, accounting for 28% of the total cultivated area and 42% of the total production. Below 10 ha, less difference in productivity exists. The degree of arable involvement and success depends on means available to farmers as can be seen in Table 3.2. Farmers with more than 40 heads of cattle cultivate larger areas and are more productive. Households without or with few cattle cultivate small areas and are less productive.

Table 3.1.

Cultivated Area and Yields according to Herd Size (%)

Herdsize	1980/81			1983/84		
(1)	(2)	(3)	(1)	(2)	(3)	
0	31.6	19.8	14.0	28.7	16.7	14.3
1-10	15.9	12.6	8.5	21.2	15.5	9.5
11-20	17.3	17.5	13.5	14.9	17.1	10.6
21-40	18.1	19.8	19.9	17.0	24.5	17.3
41+	17.1	30.3	44.1	18.2	26.2	48.3

(1) % holders (2) % cultivated area (3) % production.
Source: Agricultural Statistics.

6. Arable Practices and Constraints

> Risk minimisation and low inputs - draftpower and labour key constraints

Prevailing environmental conditions favour arable farmers who can take risks at low costs. This is not the case for the majority of farmers of arable land who have few or no cattle. Therefore, such farmers usually avoid risks and direct only limited inputs such as labour to the arable sector as better opportunities exist in other sectors. They aim at reasonable production over a period of time instead of maximum production in single years. Alverson (1984) shows that improved practices can raise productivity per hectare but the returns to the extra inputs are low and risks are high. For this reason, farming practices reflect first of all the low input

Table 3.2

Arable Practices in Botswana

1971/72	1977/78	1980/81	1982/83	1983/84	
broadcasting	91%	82%	96.1	85%	91%
weeding	n.a.	72%	88%	n.a.	71%
crop rotation	n.a.	31%	n.a	n.a	n.a
thinning	n.a.	56%	n.a.	n.a	n.a
row planting	9%	21%*	3.7%	+15%	5.4%
manure use	6	3	3.2%	3.3%	6.3%
fertiliser use	1	5*	0.5		1.7%
winter plouging	6	40	n.a	n.a	n.a
treatment seeds	6	n.a	n.a	n.a	n.a
contour ploughing	n.a	8%	n.a	n.a	n.a
fencing	n.a	40%	46.4%	n.a	n.a

* heavily influenced by Barolong and Pelotshetlha.
Sources: 1971/72, 1980/81, 1983/84, Agricultural Statistics.
1977/78 Odell, 1980
1982/83 Farm Management Surveys

strategy by farmers. They have hardly changed in the past with the exception of the use of mechanised draftpower (Table 3.2). Lightfoot (1981) shows that improvement of existing practices can significantly raise productivity and hence there is less need on the short run to introduce new practices for dryland farming.

Hardly any practices aim at restoring soil fertility and at preparing land for cultivation. Regional differences, however, exist, most notably in Barolong. In this region, row planting and the use of fertilisers are more common. In 1981, 38% practised row planting and 10% used fertilisers or manure. Odell (1980b) found that as many as 25% of the farmers of arable land had used manure or fertiliser in 1978. Most of these farmers are commercially oriented and can afford the required extra inputs. In 1978, the average field size was 8.4 hectare, of which 67% was cleared and 52% destumped (Odell 1980b). In other words, vegetation was completely removed on roughly half of the arable land although a significant portion of arable land was not used.

Farmers usually sow a mixture of seeds, consisting of sorghum, maize or millet and groundcovers such as beans and water melons. Approximately 70% of sorghum and millet is sowed as a mixture. This practice reduces risks and increases chances for a stable production (Roe, 1982).

It was previously mentioned that the extent of cultivation as well as the productivity of arable land are largely determined by socio-economic constraints. Three main constraints can be distinguished.

Their actual importance for individual farmers varies in relation to their socio-economic position. They are less restrictive for better off farmers.

1. **Inadequate Access to Draftpower**

Given erratic rainfall patterns, timely ploughing appears crucial for good results. Inadequate access to draftpower is associated with smaller cultivated areas and lower yields. Ownership of draftpower guarantees timely access but only slightly less than half of the cultivating households own draftpower. Rich households are more likely to own draftpower. They may even hire a tractor but are then able to choose the right time in contrast to poor households, which have to wait till they have secured enough funds. The percentage of draftpower ownership has remained constant since the early 70's (Table A.3.9). An increasing percentage depends on hiring draftpower, now approximately 27% which indicates commercialisation of draftpower. The role of the tractor has significantly expanded since the 70's. The tractor is most frequently used in Barolong, South East and Kgatleng. The rapid increase in the use of tractor use is due to its fast way of ploughing which reduces the need for other inputs such as labour and ploughs. During 1985, ARAP policy boosted tractor ploughing. This form of ploughing may cause extensification of crop production when households lack the means for follow-up stages such as weeding. During the recent drought, donkeys were also increasingly used. It is as yet not clear if this practice is a result of ALDEP or temporary because of drought (i.e. because cattle have died or need protection). Cattle have clearly lost influence though they remain the dominant type of draftpower.

2. **Lack of Labour**

Lack of labour is an apparent contradiction with the prevailing high unemployment. It is caused by:

1. the low level of productive labour allocated to the arable sector because of low returns
2. the seasonality of arable labour needs and the importance of its timely availability. Conflicts may occur with the livestock sector (e.g. during the calving period)

The result is seasonal labour shortage, particularly affecting poor households without means to hire labour (e.g. female headed households; Government of Botswana; 1974).

3. **Lack of Implements and Seeds**

Most households own at least a hoe and a plough: in 1970/71 93% of the cultivators owned a plough compared with 79% in 1983 (Government of Botswana, 1974; Agricultural Statistics).

Relatively few households own more implements (Table A.3.10). Implements are often in a poor condition and this affects the quality of arable farming. Lack of good implements is not a big constraint at present. Ploughs come along with the hiring of draftpower. It is a constraint in the improvement of crop production. Particularly during and after drought lack of seeds may limit the cultivated area. The majority of farmers now purchase seeds and use them in addition to their own seeds.

Table 3.3

Expenditures and Revenues by Farmers' Category*

	1981 variable costs/ha	gross margin/ha	1983 variable costs/ha	gross margin/ha
top 1/3 crop farmer	P7.3	P84.6	8.4	35.2
medium 1/3 crop farmer	P7.2	P49.2	1.6	- 1.3
bottom 1/3 crop farmer	P9.6	P13.1	28.3	- 24.8

* calculated as weighted average of various crops. The FMS farmers' stratification does not necessarily correspond with herdsize. Exact relationship between crop farmers' stratification and herd size is not known.

Source: Farmer Management Surveys.

Since poor households often have to hire inputs such as draftpower, (Litschauer and Kelly, 1981), their expenditures per hectare are higher than those of medium and rich farmers while their yields and gross revenues are lower. (Table 3.3).

Table 3.3 shows large variation in expenditures and revenues from crop production. No data are available on arable practices, constraints and yields in freehold areas.

7. Land Use Dynamics

Towards mixed farming - field abandonment and opening of new fields

Existing dryland farming practices lead to changes in arable land use. This area has received comparatively little attention. Most fields are only partly cleared (approximately 60% is cleared: Odell, 1980b; Arntzen, 1985) and even smaller portions are ploughed. Considerable amounts of arable land are not continuously used. Nevertheless arable land is abandoned after some time. In Kgatleng, arable land is cultivated between 10-50 years before it is abandoned (Arntzen, 1985a). In Ngamiland sandveld, cultivation periods are shorter (Sutherland, 1983). Infestation with weeds and soil

exhaustion are major reasons given by farmers for abandonment.* Additional reasons mentioned are loss of soil structure and acidification (loss of Ca and Mg). Weeds are undoubtedly a major problem. Creeping grass (Cynodon dactylon or motlho) can spread through fields and hamper ploughing. Witchweeds (mollwana) can infest sorghum and maize fields. Rotation to millet can provide a solution here. The role of soil fertility in field abandonment is more difficult to assess Scant data do not give a clear picture (Axelsen 1978, Tietema et al 1986). One of the nutrients most likely to be depleted is phosphorous. During a spell of good years the exhaustion of phosphorous from the soil may occur (estimated production 2-3 ton, dry matter/ha. potential P.loss up to 4 kg/ha). Nutrient stress sometimes occurs in years of good rainfall. Further data collection is necessary. In Kgatleng, poor households remain longer on old arable lands because they can less easily afford to move. Long-term fallow periods can be over 30-35 years. Abandoned fields are usually still claimed by old users and such claims may cause local land-shortage, particularly around villages. New fields are selected on the basis of soil suitability and proximity to other household activities. Mixed farming areas show a cyclical pattern of arable establishment - increase - abandonment and later re-establishment. These phases correspond with differences in arable densities (up to 30%). Land pressure may cause differences in arable density and long term fallows periods. It has not yet led to the occupation of poorer quality soils but this may happen in the near future starting in the small districts. No absolute land shortage exists as yet with the possible exception of South-East. Land pressure however forces people to open fields far away from their villages and involves them in extra costs which are least affordable by poorer households. Land pressure and mixed farming have led to frequent problems of crop damage.

Traditional farmers prefer their field(s) on different soil types (clay/loams/sand). They have a thorough knowledge of the local environment and use various trees and grasses as indicators for soil suitability (Arntzen, 1985 b). Table 3.4 summarises preferences for different types of soil as stated by farmers in Kgatleng.

* See Axelsen, 1978, Arntzen, 1985a, Tietema et al, 1986 and Steward Jones, pers. comm.

Table 3.4

Farmers' Views in Kgatleng on Characteristics of Soil Types (Modipane and Dikgonnye)

SAND	advantages:	yields even with little rain easy to plough good for millet, legumes and melons
	disadvantages:	loses fertility rapidly poor waterholding capacity vulnerable to erosion
LOAM	advantages:	more erosion resistant keeps fertility does not require lots of rain good for maize and sorghum
CLAY	advantages:	fertile erosion resistant good waterholding capacity
	disadvantages:	difficult to plough needs lots of rain

Source: Arntzen 1985b

8. Links with Other Sectors

Crop residues and fodder - crop damage by livestock
wood removal

Crop residues can be used as fodder. Mosienyane (1983) measured sorghum residues and calculated that even with a "modest" drymatter yield of 2.6 tonnes/hectare a field could feed a herd of 50 cattle for over 2 months. During drought periods, drymatter production in dryland farming may not exceed 500 kg/ha. Crop rests may also be used for mulching, which increases soil fertility and protects it against soil erosion. Fodder crops as intersown or second crop is becoming more popular (Division of Agricultural Research N.D., Edwards, 1985). It is too early to draw conclusions on possibilities for fodder crops in Botswana. Trials are ongoing.

Little is known about the magnitude of crop damage by livestock. In Kgatleng around 80% of crop producers actually experience crop damage but its size is unknown. The high percentage of farmers facing crop damage reflects the poor conditions or absence of fences around fields (Arntzen and Opschoor, 1982) Only 50% of the fields have fences and possibly half of these do not keep cattle out. (Agricultural statistics 1981 and Arntzen 1984). For this reason, fencing under ALDEP is a popular scheme. Most fences do not keep goats out. Therefore, the increase in numbers of goats poses additional problems for crop farmers.

Arable encroachment into grazing areas is often mentioned as a contributing factor to overgrazing. In Kgatleng, such encroachment has usurped during the period 1963-1982 less than three percent of the grazing areas. Elsewhere, the encroachment process may be more significant. No data have been collected to substantiate this. Most eastern parts of the country are fully utilised and therefore arable expansion affects other forms of land use.

Finally, arable development has an impact on the wood supply through clearing of land and through the need for fences around fields. The exact amount of annually cleared land is unknown. However, assuming an average standing crop of 20 tonnes of wood per hectare and an annual firewood demand in the range of 557,000 tonnes per annum, firewood consumption equals clearing of almost 28,000 hectares per annum or around 10% of the annually cultivated land. Assuming the fallow period is at least 20 years an average of at most 5% or around 10-15,000 hectares would need to be substituted annually. Particularly clearance of fields near settlements is likely to interfere with the local wood supply. On the other hand, abandonment of fields allows regrowth of woody vegetation and this process is mostly concentrated around long established, often larger settlements.

In 1981, 22,400 farmers or a third of the crop farmers had bush fences around their fields average field size 4.8 hectare. Wood use for a bush fence is in the range of 35 kg fresh wood per meter of fence (Tietema, 1986). Annual renovation of the bush fence is needed to keep these effective.

9. Farmers' Income - Attractivity Crop Production

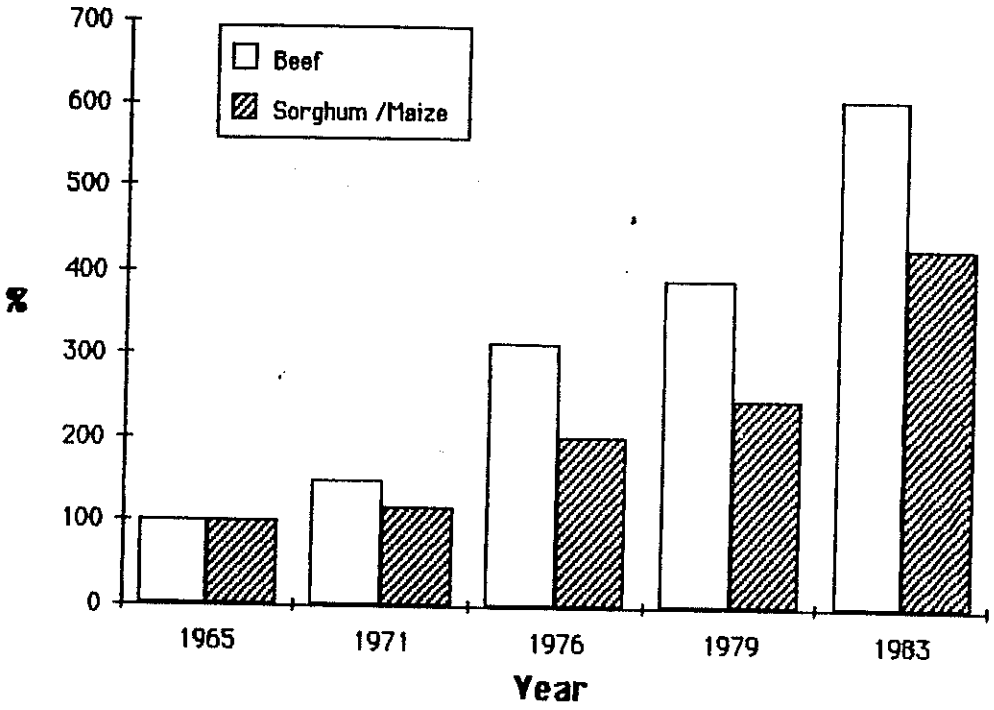
Low and erratic arable incomes - low sectoral returns to labour - favourable crop price developments after 1979

Farmer Management Surveys show that during the period 1978-1983, arable activities contribute only up to 25% of the agricultural income (Ministry of Agriculture, 1984). During good rainfall years such as 1980 and 1981, the sector's contribution was 25% and 15% respectively. During drought years, its contribution is much lower or even negative like in 1983. Income from livestock is used to supplement the arable income. Households without livestock have to look for other supplementary sources of income, notably non-agricultural activities.

The comparative attraction of arable agriculture can be indicated by price developments of the output and by returns to household inputs such as labour. Price developments favoured the livestock sector until 1979 (Opschoor, 1983 and Figure 3.4). After 1979, crop prices increased more rapidly as a result of changes in the crop pricing system and a slower increase of beef prices.

Figure 3.4.

Development of Beef* and Crop Prices (1965 = 100)



*Cold dressed weight
Sources: Botswana Meat Commission Annual Reports, EFSAIP, Hubbard, 1983

The Farm Management Survey shows an average crop price increase by 101% during 1978-1983 compared with an increase by 58% for beef.

The arable sector has however, become increasingly unattractive in terms of returns for labour. Opschoor (1983) suggests that the returns for labour were four times higher in the livestock sector in 1980, compared with 2.7 times in 1966. The Farm Management Survey shows similar discrepancies in normal rainfall years but even higher differences during droughts (Table A.3.12). As drought almost coincided with the price increase of crops, it is not yet possible to assess the structural effect of recent crop price increases on the returns of the sector.

10. The Economic Effects of Droughts

> Drought decreases arable activities and yields - each drought year has a different impact - poorest are most susceptible to drought

Drought, be it a single year or a period, has an immediate effect on the performance of the arable sector. Drought has primary and secondary effects on the arable sector which affect in particular poor households with few resources (Kgathi and Opschoor, 1981). Primary effects are generally (Table A.3.13).

1. smaller areas are cultivated. Hay et.al. (1985) estimated aggregated losses in terms of cultivated area in 1982-1984 to be 68,000 hectares or less than 1% in 1982/83 (good early rains) to 15% in 1981/82. Reductions in cultivated areas locally amount upto 40% (Vierich and Sheppard, 1980; Kgathi and Opschoor, 1981).

2. lower productivity per cultivated area. This results from lower harvesting rates as well as lower productivity of the harvested areas.

The significance of these effects in any particular year depends on the rainfall distribution Overall production losses during 1981/1984 are estimated at 99,000 tonnes or 72% of the expected production (Hay, et.al. 1985). So far, Agricultural Statistics reveal during the present drought a very modest shift towards sorghum (up to 58% from cultivated area) and millet away from maize (now down to 24%). Purcell (1976) only found a shift to beans during the 1972/73 drought year. Drought also affects animal draftpower availability. Assuming herds in excess of 20 head having own cattle draftpower, 7% less households could use own cattle in 1984 compared with 1981.

Secondary effects of droughts are (Kgathi and Opschoor, 1981):

1. lack of seeds for the next ploughing season

2. poor condition of animal draftpower

3. reduced opportunities to earn indirectly from the arable sector through hiring out of labour and hiring out of tractors. The former affect mostly poor households; the latter rich households.

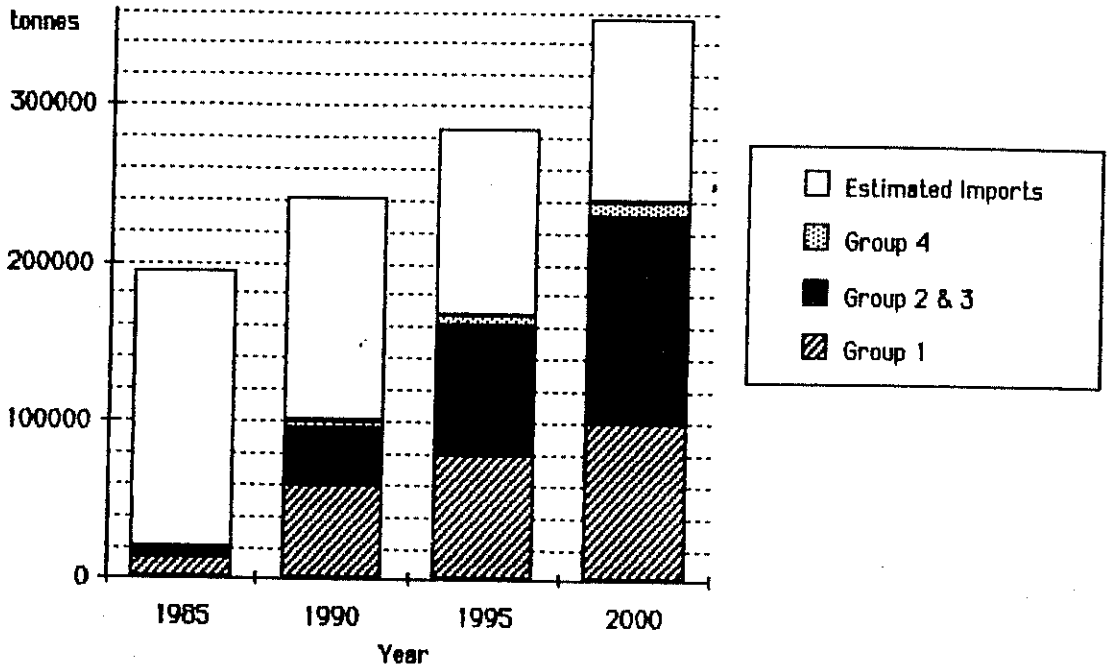
11. Governments Policies, Institutions and Legislation

Emphasis on production increase and diversification of Arable sector - Environmental factors are underplayed

Governments efforts are mostly directed at increasing food production and at reducing food imports. Environmental considerations do not play an explicit role. Additional topics of special interest are the combat against drought effects (e.g. food aid and strategic food supply), the increased production of seeds and improved storage capacity. Recently, a comprehensive National Food Strategy was adopted which identified 4 groups of farmers as target groups: 1) smallscale dryland farming, 2) commercial dryland farmers (e.g. Barolong), 3) irrigating farmers and 4) molapo farming. Figure 3.5. shows the production targets and estimated input requirements (Rural Development Unit, 1985).

Figure 3.5.

Food Production Targets and Import Needs



Source: Rural Development Unit, 1985

If these targets are achieved, self sufficiency in maize and sorghum would increase from 12% in 1985 to 78% in 2000. Commercial farming, including irrigation, are expected to contribute mostly to higher production (57%). After recovery of the drought, small scale farming is expected to show a moderate growth to 100,000 tonnes (approximately 40,000 in 1981).

Estimates of irrigation potential are high (e.g. 10,000 - 20,000 ha during 1990 - 2000) and seem optimistic as soil suitability assessments still have to be made in most cases (P19.2 mln allocated for 1985-1991). The Arable Land Development Programme (ALDEP) is specifically designed for the first and fourth category (less than 40 cattle and ploughing less than 10 ha; total target group 11,000 farmers) and offers various subsidy packages to alleviate the most pressing constraints, identified as draftpower, fencing, farm implements and watertanks. Additional improvements are made in the marketing structure (through BAMB), storage capacity etc. ALDEPs implementation has been hampered by drought. However, it has become clear that fencing is extremely popular (Table A.3.14.), indicative of widespread crop damage and inadequate fencing up to date. Furthermore, ALDEP appears to reach mainly medium scale farmers, not those without cattle and who are the poorest (Opschoor, 1983). Finally, ALDEP's original targets will be difficult to realise in small districts because of land shortage which can only be avoided by a dramatic shift towards mechanised draftpower (Maribe and Opschoor, 1980). The Financial Assistance Policy (1982) provides subsidy opportunities for the second and third group as long as investments exceed P10,000 and sales of crops are at least half of the annual production (e.g. FAP also assist horticulture projects).

This policy provides subsidies on investments in productive activities and temporary assistance for running costs (e.g. labour, training). In 1985, the Accelerated Rainfall Arable Programme (ARAP) was launched to provide additional incentives for dryland farming and, apparently, to assist farmers during drought and post-drought periods. Grants for ploughing, clearing, destumping etc. are provided to all dryland farmers with land (group 1 and 2). More extensive arable land use may be the result of ARAP as farmers may receive subsidies to plough larger areas than they are able to weed etc. Although ARAP is too recent to evaluate, it appears to have suffered from lack of preparation and consultation at district level.

District Land Boards and Sub Land Boards allocate arable land within their respective districts and have the opportunity to reallocate such land, if for example it has not been used for at least 5 consecutive years, or the land is needed to ensure a fair distribution of land among the people. Land Boards have to identify boundaries between grazing areas and mixed farming areas. These land use planning instruments however, have not so far been used. The Agricultural Resources Board has the right to order occupiers of land to undertake measures to conserve agricultural resources or regulate agricultural land use practices in specific areas or as a Board to undertake conservation measures. With respect to arable land, curbing of erosion is most prominent. Soil conservation activities are generally smallscale and only limited funds are available (e.g. Government provides P300,000 in the period 1985-1991) Government provides various extension services to farmers through the Agricultural Demonstrators. Efforts in the arable sector focus on improved practices, and pay little attention to environmental considerations.

3.2. Trends in Arable Development

1. The self-sufficiency rate of food production has dropped significantly in the past as a result of very slow progress in the arable sector with regards to cultivated area, arable practices and land productivity. Reduced self-sufficiency has increased the need for food imports, particularly during droughts when the country's production drops to about 10,000 tonnes.

2. Irrigation and molapo farming had very limited contributions to total production, hence the dryland farming was and is dominant. Freehold area involvement in the arable sector is limited but its contribution to the overall performance is relatively large. The Barolong region in Tribal Land is of similar importance because of the presence of large-scale, market-oriented farmers. To increase self sufficiency in future, programmes and policies have been formulated to diversify the arable sector by development of irrigation and molapo farming and to intensify support to both small and large scale dryland farmers (e.g. Pandamatenga area). In addition, interest in growing fodder for livestock increases. The above factors may lead to a significant increase of land use for arable purposes, presently only high in small districts or parts of other districts. Irrigation is now restricted to a few suitable spots. If plans for the future materialise, local conflicts may arise with other land use forms.

3. Dryland farming practices have hardly changed, with the exception of rapidly increased use of mechanised draftpower. Continued soil erosion and future use of more marginal soils are likely to lead to even lower future productivity levels. Soil conservation and improvement methods are not common.

4. Data are inadequate to assess trends in participation in the arable sector. Since the early 70's no major changes occurred in households with access to arable land (approximately 80-90%). Possibly, participation has decreased because of impoverishment of households or and some wealthier households do no longer engage in crop production.

5. The arable sector has become comparatively less attractive. Until 1979, crop price developments lagged behind livestock. Since 1979, increases in crop price exceed those for livestock but, because of the drought, it is not yet possible to assess its impact on sectoral returns per input such as labour. The livestock sector has had three or four times higher returns per workday in average crop years.

6. Crop production focuses so far on staple food. Cash crops are of secondary importance only and mainly grown by freehold farmers. Maize is increasingly grown as staple food despite unfavourable environmental conditions.

3.3. Environmental Effects of Crop Production

The most important environmental problem in arable agriculture is soil erosion. In addition, land shortage is emerging and conflicts with other sectors are increasing. DHV (1980b) reports severe, widespread gully and sheet erosion in Kweneng and Southern districts hampering future arable productivity in respectively 7% and 12% of the arable fields. Table 3.5 indicates the extent of erosion in arable land under different crops. For example, ground covering crops and mixtures give extra protection while good and medium stands of cereals give a better protection than poor stands.

Table 3.5.

Estimates of the Crop Cover Soil Loss Ratio*

Crop/vegetation	Percentage of rainfall energy intercepted	Crop cover soil loss ratio
Bare soil	0	1.00
Sorghum, maize, millet - good stand	60	0.06
" - medium stand	45	0.07
" - poor stand	30	0.17
Groundnuts, beans - good stand	70	0.05
" - medium stand	55	0.06
" - poor stand	40	0.10
Mixtures (e.g. sorghum/beans)		
" - good stand	75	0.05
- medium stand	60	0.06
" - poor stand	45	0.07
Sunflower - good stand	60	0.06
" - medium stand	40	0.10
" - poor stand	25	0.23
Dense weed fallow	90	0.01
Medium "	70	0.02
Poor "	50	0.05

*Relates via an empirical formula established for Zimbabwe rainfall to soil losses. Bare soil is used as the reference point. Late ploughing, planting in December and weeding of crop has been assumed.

Source: Van der Poel, 1980.

Van der Poel also calculated the magnitude of sheet erosion for a 1.5 m deep loamy sand soil near Mahalapye under traditional management (Table 3.6). The limit of acceptable soil losses is usually put at 4 tons/ha/year (van der Poel, 1980) Therefore even the little data available indicate that soil erosion in arable lands is a serious problem. Consequences of soil erosion are soil losses, reduction in soil fertility and changes in soil physical properties, making further arable production less productive.

Table 3.6

Calculated Soil Erosion from a Field near Mahalapye*

Crop	Bare fallow	Maize medium stand
Field type:		
three graded banks ploughed along the contour	11	0.77
ploughed up and down the slope	31	4.34
	103	14.42

*Field size 9 ha; slope 3% and average rainfall.
Source: van der Poel, 1980.

Little is known about long term effects of arable activities on the vegetation and soil. Once lands are abandoned, a secondary vegetation recolonises the bare land. However the ground cover does often not fully restore since abandoned land in mixed farming areas suffers from a high grazing pressure. Such lands may continue to be prone to soil erosion. Data on the revegetation process are largely lacking.

Little is known about the environmental aspects of irrigation in Botswana. Salination of the soil can occur if the water used for irrigation is too saline or if the drainage of the soil is insufficient Around the Okagango for instance, the saline groundwater appears close to the soil surface (SMEC, 1986). Irrigation may then raise the groundwater level and increase the salination risk. Tropical diseases such as bilharzia, malaria, sleeping sickness, trachoma and other waterborne diseases as dysentry and hepatitis may be enhanced by irrigation schemes. Risks for soil salination and the spread of diseases can however be reduced through technical design of irrigation schemes based on existing Southern African experience.

3.4 Strategies for Increasing Production and Alleviating Environmental Problems

Low food production, incipient land shortage and soil erosion emerge as the key problems of the arable sector. Continued soil erosion and future use of more marginal soils are likely to lead to even lower future productivity levels. Furthermore, the extreme susceptibility to drought and the high risks involved in crop production became apparent. Finally, the majority of present crop products seem to engage in the the activity because of lack of alternative income sources. Otherwise they are reluctant to put resources into it.

Any strategy aimed at increasing production on a sustainable basis should recogonise the adverse climatic and socio-economic context of the arable sector but may also aim at fully exploiting areas with a higher natural potential (e.g. molapo areas). Strategies for increasing food production can follow three lines:

a. expansion of the cultivated area of dryland farming
b. increased land productivity of dryland farming
c. emphasis on irrigation and molapo farming.

In view of the facts that crop production is the major source of rural employment and that from a distributional point of view it is most efficient to have food consumers as producers too, the main emphasis should remain on dryland farming. The emerging land shortage in eastern Botswana suggests furthermore that emphasis be put on better use of the presently underutilised arable areas rather than expansion. An improvement of the sectoral returns would assist in this matter but few studies have made suggestions regarding the implementation. The present drought made it impossible to observe positive effects of the price increase since 1979. Little is known too about the effect on soil fertility and productivity of more frequent cultivation. Soil depletion is more likely to occur when productivity levels are significantly higher than the present ones necessitating fertiliser application. Better utilisation of present arable land can also be encouraged by reduction of crop damage through fencing and adequate land use planning. The latter refers to the construction of drift fences as well as the reallocation of old fields. Land use planning could also identify suitable areas for arable purposes so as to avoid the opening up of less suitable areas. The second component could comprise increased land productivity. The present trend towards mechanised draftpower points in the opposite direction of more extensive use of the land and increases farmers' risks. The average productivity figures are admittedly extremely low but large variations in productivity occur in communal areas. Lightfoot (1981) indicated already that productivity could be doubled by a mere improvement in existing practices. Labour is the most serious constraint in the required weeding, thinning, birdscaring, etc. Therefore, policies or subsidies would have to be directed mainly towards this constraint. They could also be made specific to the target groups of farmers as constraints may be different for each group. Increased productivity would also imply extra attention to the higher yielding Molapo areas around the Okavango, Chobe and Boteti. For example, government attempts at controlling flood regimes and restore the flow in the western side of the Okavango. More intensive arable land use, however may enhance soil erosion. Regarding the effect of some generally recommended improved practices, the following are found:

i. contour ploughing
is meant to decrease run-off and increase the infiltration of rain into the soil. however, when ridges are not carefully aligned, run-off may actually increase. Farmers in Barolong plough across the prevailing wind direction to limit wind erosion (Horsepool, 1980). The effect on the production is not known.

ii. winter ploughing
is advocated to have a better infiltration of the first rains. However, winter ploughing removes crop resides for cattle and enhances wind erosion (Division of Agricultural Research, 1985). Presently, double spring ploughing is preferred.

iii. bare fallowing
accumulates soil moisture and provides a more secure harvest in the following year (DLFRS 4 1985: Whiteman, 1975). However, it enhances soil erosion (Table 3.5).

iv. crop rotation
may reduce parts and improve soil quality but it has hardly been adopted because cowpeas require too much labour. Intercropping does not offer an alternative as it reduces the reliability of the cereal component. It may, however, contribute to soil improvements.

v. kraal manure can be successful in wet years (Herbert, 1983). Its use may remain limited because of labour and financial constraints as well as limited land. About 25ha grazing are needed to produce the 12 tons manure necessary for one hectare of arable land (Herbert, 1983). Fertiliser trials on sorghum and maize showed the importance of phosphate fertiliser which has residual effects in the next season. However, the economic feasibility for the small traditional dryland farmer is questionable (Jones, 1984).

Unlike in countries such as Zimbabwe and Swaziland, attempts to reduce erosion through grass strips and windbreaks are hardly made nor is their impact investigated. Such measure may prove beneficial, particularly in slopy areas where some of the worst erosion occurs and for large fields.

The above illustrates that there is no single straightforward recipe for increased production from present farmers in communal areas. Extension work as a grassroot link between farmers and government assistance is therefore crucial, to ensure relevant policies which recognise regional variations in environment and farmers.

The third component refers to irrigation. The country's potential for irrigation is still to be assessed in detail. Furthermore, it is unclear whether irrigation is feasible for staple foods such as maize and sorghum instead of more profitable crops for export purposes. Consequently, the contribution from irrigation to food production can at best be questimated. Experiences from other countries show that irrigation may cause new environmental problems such as salination of the soil and spreading of waterborne diseases such as bilharzia and malaria. To counteract such potential problems and conflicts with other local land use forms, careful planning is required. However, irrigation is only feasible at spots with suitable soils and drainage and therefore, cannot easily be moved within land use plans.

CHAPTER 4

WILDLIFE AND VELD PRODUCTS UTILISATION*

4.1. Wildlife Utilisation and the Environment

1. Wildlife Utilisation and the Environment,

> Large areas for wildlife - different habitats - fluctuating numbers of wildlife

Botswana has large wildlife resources both in numbers and in area. The existing game reserves and national parks cover over 1,000,000 km^2 or 17% of the country's surface. In addition, the total area currently identified as suitable for the establishment of wildlife management areas covers another 20% of surface area. (Government of Botswana, 1986). Map 4.1. shows the existing national parks and game reserves and currently planned wildlife management areas. Apart from these large areas small sanctuaries or educational reserves exist at Mogobane dam, Bathoeng dam, Maun, Gaborone and Otse.

The country has a large variety of habitats and hence different species of wildlife can be found some of which are (inter)nationally conserved (Tables 4.1. and A.4.1.) Basically four main regions with specific features can be distinguished:

1. The Southern and Central Kalahari: A semi-arid savanna ecosystem with hardly any perennial surface water.

2. The Makgadigadi Pans: A semi-arid savanna/pan complex ecosystem with some perennial water.

3. Northern Botswana: sub-divided into the Okavango, a large savanna/woodland marsh ecosystem, and the Chobe, a savanna woodland with perennial water resources.

4. The Northern Tuli Block: a small remnant of the Botswana hardveld/savanna/woodland ecosystem.

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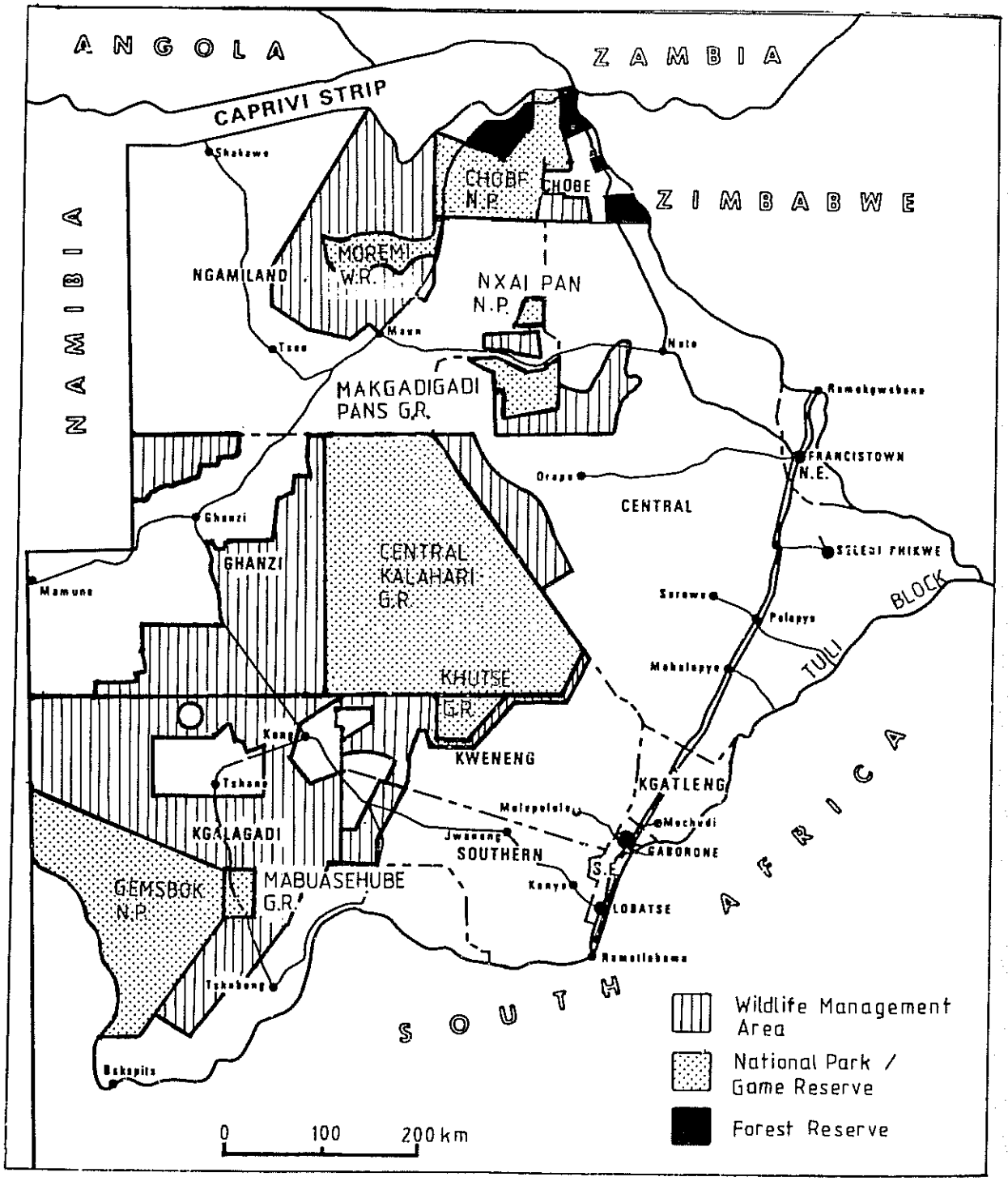
* Most socio-economic data in this chapter are drawn from an EDL background note by Mrs. I. Mogotsi.

Map 4.1.

National Parks, Game Reserves, Forest Reserves
and (Planned) Wildlife Management Areas



Source: Department of Wildlife and National Parks

Table 4.1

Conserved Animals in Botswana

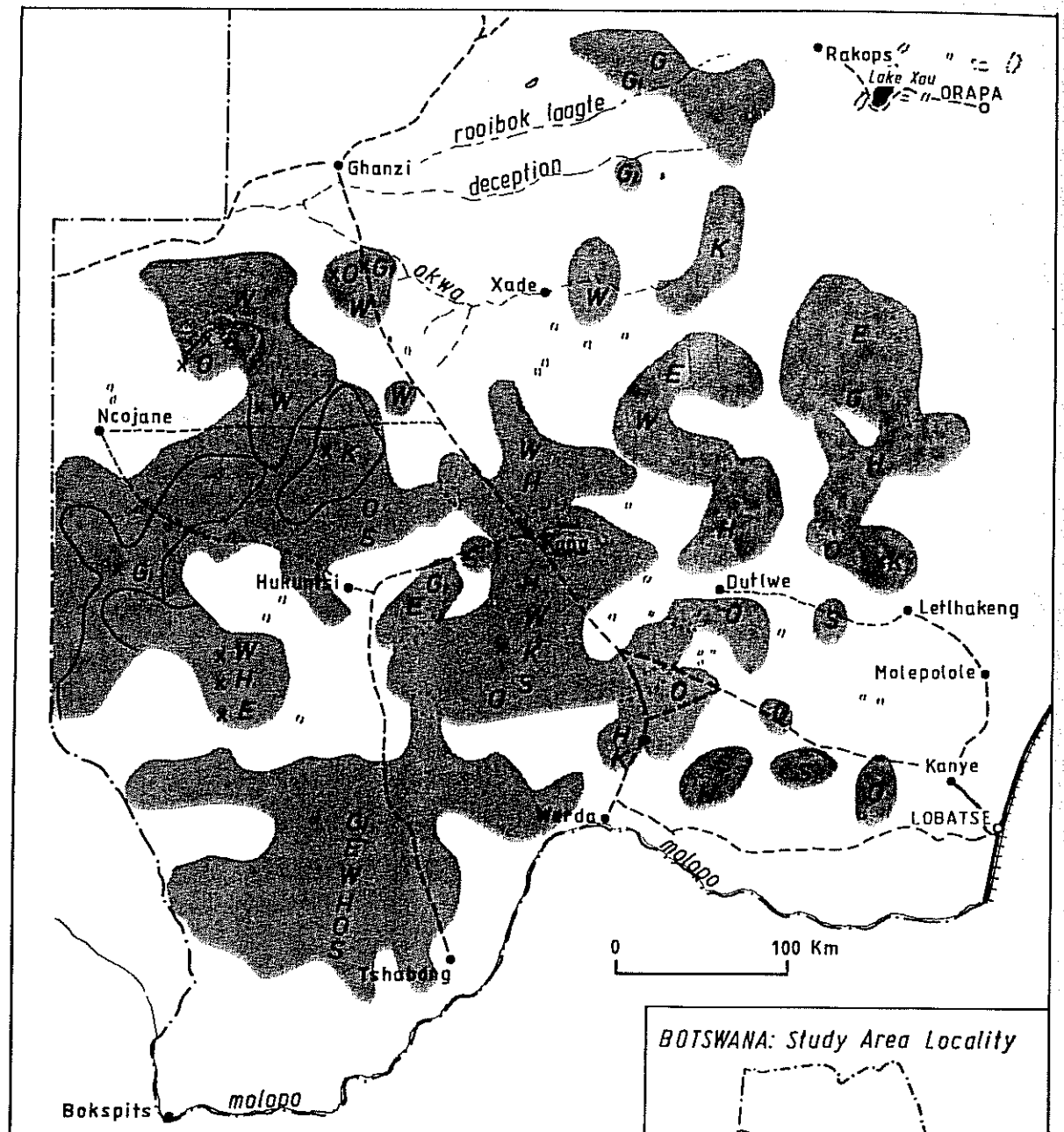
Mammals	Birds
Aardwolf - Thukhwi	Kgori Bustard - Kgori
Antbear - Thakalo	Stanley Bustard - KgoriKgoritmamaga
Blackfooted cat -Sebalabolokwane	All Buzzards - Segodi/Phakwe
Brown Hyaena - Phiritswana	All Cranes - Megolori
Cheetah - Lengau	All Eagles - Bontsu
Civet - Tshipalore	All Egrets - Bomoleane
Giraffe - Thutlwa	All(Falcons-Segetswane
Hippopotamus - Kubu	All Flamingoes - Makukara
Honey Badger - Matshwane	Fish Owl -
Klipspringer - Mokabayane	All Goshawks -Segodtsane/ Phakalane
Mountain Reedbuck - Mhele	Hammerkop - Mamasiloanoka
	All Harriers - Mmankgodi/Phakwe
Night-ape - Mogwele	All Herons - Kokoloauto
Oribi -	All Ibises - "
Otter - Lenyibi	All Jacanas - Mogatsakwena
Pangolin - Kgaga	All Kites - Mmankgodi/Phakalane
	Narina Trogon
	All Pelicans - Maya
Puku - Puku	All Sparrowhawks - Segootsane/ Phakalane
Roan Antelope-Kwalata/Tshetlha	All Storks - Makollwane
Rock Dassie -	Secretary Bird - Tlhangwe
Black Rhinoceros - Tshukudu	Spoonbill - Mmadiswana
Square-lippedRhinoceros-Tshukudu	All Vultures - Manong
Serval - Taoi	Reptiles
Sharpe's Steenbok - Phudumudu	Python-Tlhware
Vaal Rhebuck -	
Waterbuck - Letimoga	
Yellow spotted Dassie - Pela	

Source: Government of Botswana, 1982. Wildlife Conservation Education Unit, D.W.N.P.

Quantitative data on the wildlife populations in these regions are limited and largely based on aerial surveys which make them imprecise. Data collection is generally concentrated on the larger migratory mammals. In the central and southern Kgalagadi data have been collected by DHV (1980a) estimating e.g. Hartebeest at 293,000 and Wildebeest over 262,000 animals (Table A.4.2.). Map 4.2. shows areas with a high density of wildlife populations. The recent drought has affected these numbers to an unknown extent. Losses of up to 50,000 Wildebeest in 1983 at Lake Xau have been reported and in 1986 relatively large numbers of Hartebeest, Wildebeest and Eland seem either to have died along Botswana's south-western border or emigrated but the number involved is not known. Ngwamotsoko (1985) found in 1984 still relatively large numbers of Hartebeest, Wildebeest and Eland in the Northwestern part of Kgalagadi district

Map 4.2.

Areas in South Western Botswana with
a High Density of Wildlife



Source: DHV (1980)

(Table A.4.3.). In the Makgadigadi Pans, Zebra and Wildebeest are most numerous and estimated to be 100,000 and 50,000 respectively. (Table A.4.2.). In northern Botswana, Buffaloe, Lechwe, Elephant, Impalas and Zebra occur in large numbers (FAO/UNDP 1977; Kalahari Conservation Society, 1985). A comparison of those two data sources suggest that wildlife numbers have been fairly stable between 1977 and 1985. (Table A.4.4.)

The Tuliblock is the smallest wildlife area and relatively best documented (Table A.4.5.) especially the numbers of Wildebeest and Zebra seem to have decreased during the recent drought from several thousands to hundred or less in 1984.

2. Migration Patterns

Especially Wildebeest and Hartebeest are migratory - migration patterns most distinct in dry years

In wildlife regions annual migration patterns have been found. In the central and southern Kgalagadi, these patterns become most distinct during drought periods. DHV (1980a) did not find clear migration patterns before the drought but later studies during the recent drought confirm migration especially for Wildebeest and Hartebeest and to some extent Eland and Springbok (Williamson and Williamson, 1985; Ngwamotsoko, 1985). The gemsbok seems to be the most sedentary of the more numerous antelopes. It appears that:

- movements of animals are in general influenced by rain and hence partially erratic.
- in wet season, animals concentrate in an area in the central southern Kalahari, while in the dry season animals disperse (Map 4.3.).

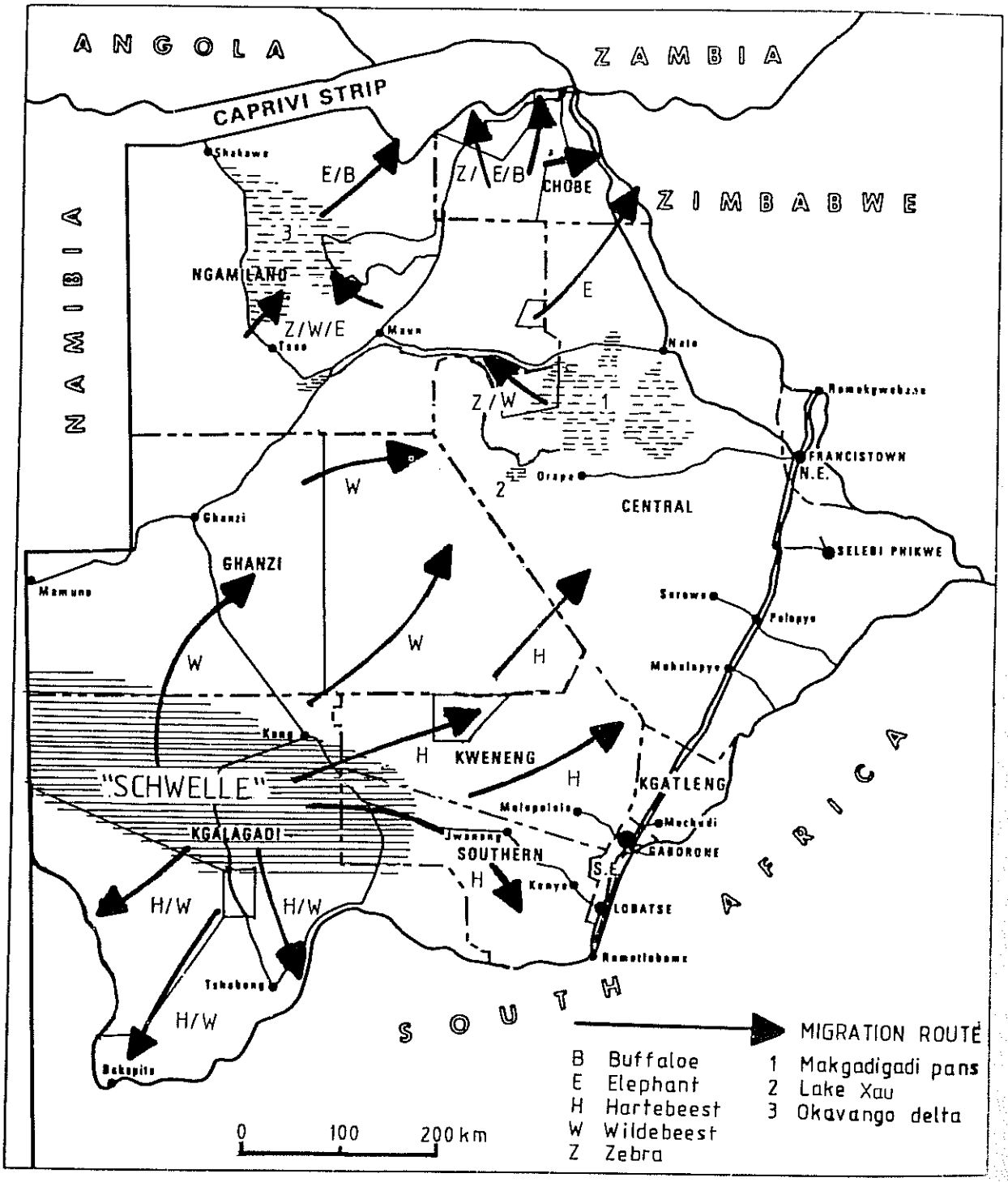
This central area ("the schwelle") has many pans which attract wildlife during the wet season, beause they provide pools of water, grasses and more or less evergreen dwarf shrubs with higher levels of nutrients, mineral soil licks and open space. (Parris, 1970; Parris and Child, 1975).

In the Makgadigadi pans, especially Wildebeest and Zebra show seasonal migration from the grass plains along Twetwe pan in the wet season to the lower Boteti in the dry season (Map 4.3.). In the Okavango delta, local seasonal migration patterns do occur (Botswana Society, 1976; FAO/UNDP, 1977; Kalahari Conservation Society, 1985). During the wet season, animals disperse on the flood plains and some species such as Zebra, Wildebeest, Elephant and Buffalo partially move out of the delta. During the dry season when the water level in the delta is high, animals move gradually back into the delta.

In the Tuli Block a similar pattern of migration to and from the rivers is to some extent still apparent although movements in the area nowadays are restricted by fences.

Map 4.3.

Migration Patterns of Wildlife in Botswana
(Dry Season Movements)



Sources: 1 DHV 1980, FAO|UNDP 1977, Anderson 1985, Williamson and Williamson 1985, Ngwamotsoko 1985

3. Wildlife Utilisation

Hunting for subsistence and recreational purposes Tourism focussed on accessible Parks and Reserves in North

Hunting and tourism are the main activities based on wildlife. Game ranching is hardly practised with the exception of recently established crocodile farms in Maun and Kasane and plans to start ranches for Gemsbok and other game species. Hunting takes place for different purposes:

1. Subsistence hunting: in the remote areas in western and northern Botswana, hunting has traditionally been the main subsistence activity of people. Other income generating activities are hardly feasible (e.g. crop production) or require investments beyond most people's capacity (e.g. cattle). Subsistence hunters can acquire hunting licenses free of charge but are required to hunt by traditional methods and to limit hunting to subsistence needs. Virtually, every part of the killed animal is put to use.

2. Recreational hunting
   Recreational hunting is practised by Batswana and foreigners, and is done for the products such as meat and trophies as well as for pleasure. This category includes hunters on organised safari's. Recreational hunting occurs throughout the country outside National Parks and Game Reserves but is most intensive in areas with abundant wildlife. A number of controlled hunting areas are leased to safari companies as concession areas (Map 4.4.).

Apart from recreational hunting, game and scenery viewing is the major activity of tourists. Therefore, this form of tourism concentrates on National Parks and Game Reserves which are most accessible such as Okavango, Moremi, Chobe and to a lesser extent, Makgadigadi Pan and Nxai Pan. Fowkes (1985) estimates that 93% of the tourists visit Parks on safari by fixed or mobile tour operators (85% and 8% respectively). Accommodation facilities have expanded substantially, particularly in the most touristic area, i.e. Maun (Table A.4.6). The Kasane region is a secondary centre of accommodation but also increases rapidly since the tarring of the Nata-Kasane road. Other facilities in Parks and Reserves such as camping sites and roads are quite minimal.

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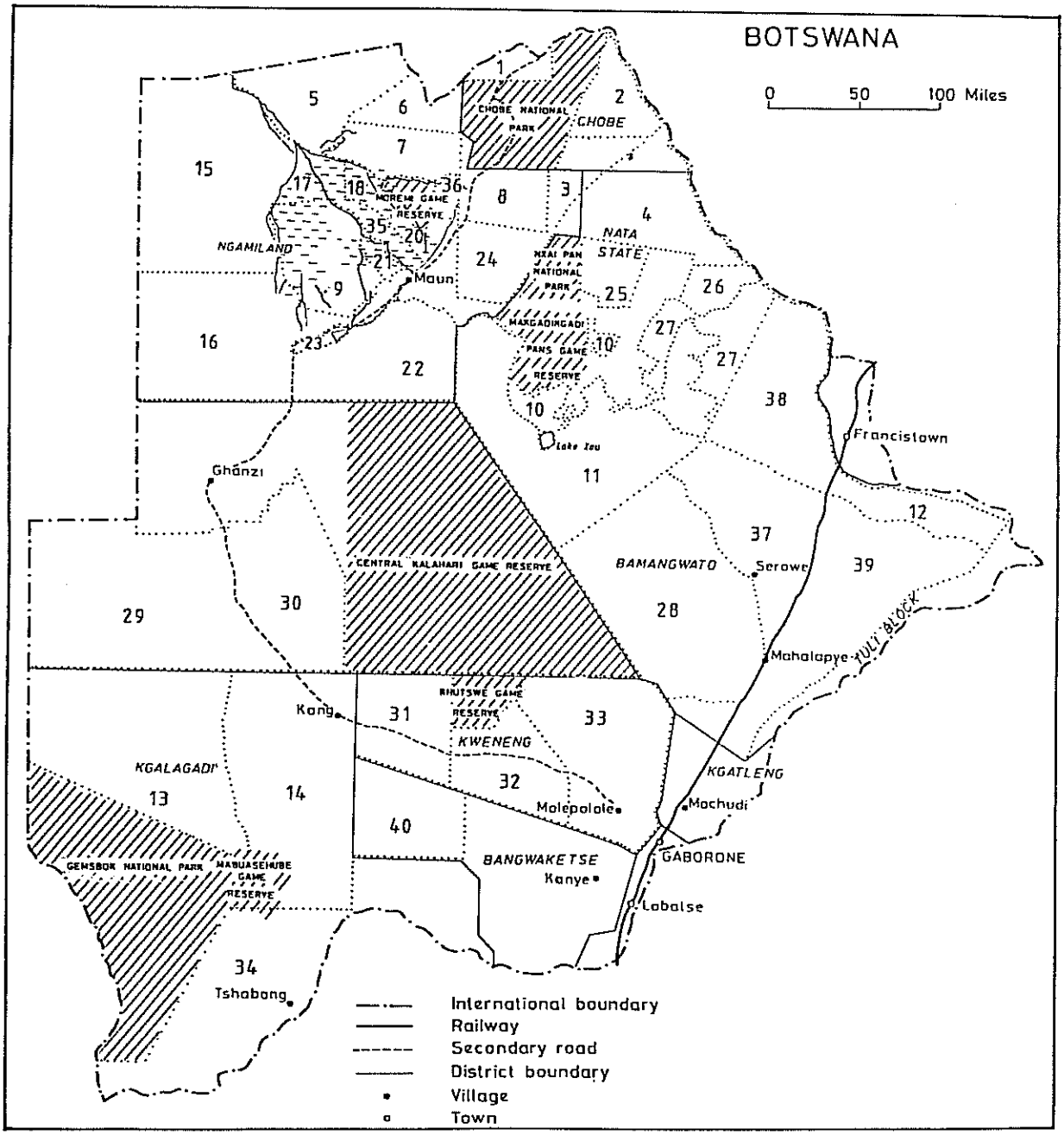
* Central Kalahari Game Reserve and Gemsbok National Park are isolated and have no tourist facilities. A permit is required to enter the former.

Map 4.4.

Controlled Hunting Areas



Source: Department of Wildlife and National Parks

Legenda Map 4.4

CONTROLLED HUNTING AREAS IN BOTSWANA

SAFARI COMPANY CONCESSIONS
1. Kachikau
2. Kasane
3. Masame
4. Tamafupa
5. Kwando
6. Savuti
7. Khwai
8. Mababe
9. Matsebe
10. Boteti
11. Rakops
13. Western Kgalagadi
14. Eastern Kgalagadi

RENTED ANNUALLY BY SAFARI COMPANIES
17. Jao
18. Santantadibe
20. Chitabe

CLOSED TO HUNTING
12. Shashe
19. Maqwee
35. Chief's Island
36. Moremi
39. Eastern Bamangwato

OPEN TO GENERAL BOOKING
15. Sekopa
16. Kuke West
21. Khurunxaraga
22. Kuke East
23. Lake Ngami (birds only)
24. Makalamabedi
25. Odiakwe
26. Nata
27. Soa Pan
29. Okwa
30. Anderssen's Vlei
31. Western Kweneng
32. Middle Kweneng
33. Eastern Kweneng
34. Tshabong
40. Ngwaketse

OPEN TO RESIDENTS OF BAMANGWATO
28. Leburu
28. Lebung
37. Mea
38. Dukwe

4. Participation in and Income from Wildlife Utilisation

Hunting and gathering important source of food and income in western Botswana - tourism benefits from better infrastructure - tourism source of income and employment.

Most people in remote areas in western and northern Botswana rely on hunting and gathering for subsistence purposes. In 1976, hunting was a major activity for 39% of the population (or 17,500) and for an estimated 7,800 remote area dwellers even most important (Murray 1978). The total number of subsistence hunters for the country is not known but lies probably between 10-20,000. Von Richter (1976) estimated the annual income per household from subsistence hunting to be P270 or 44% of the median household income of cattlepost areas small villages and lands areas in 1974 (Government of Botswana, 1976). Hunting and gathering contributed up to 82% of the income in Kgalagadi and Ghanzi. The Rural Income Distribution survey showed that hunting and gathering is the second most important source of income to the poorest households after remittances (Table 1.4). No recent data are available on the contribution by hunting to household incomes. The retreat of wildlife from areas where livestock has encroached, and the gradual increase in alternative income opportunities are likely to cause a decrease in subsistence

hunting. Murray (1978) estimated that in 1976 around 670 tonnes of game meat was derived in western Botswana from some 16,000 large and 28,000 small animals. More recent data are not available.

Recreational hunting involves fewer hunters and smaller numbers of animals killed. Recreational hunters constituted 10% of the total hunters and killed an average 6 animals as compared to 11 by subsistence hunters (Von Richter and Butynski, 1973). In general, therefore, recreational hunting poses less threats to wildlife. However, recreational hunters prefer specific, often more rare, species such as lions, sable and roans (Table 4.2). Subsistence hunters usually select species with good meat whereas recreational hunters also hunt for trophies.

Table 4.2

Hunting Preferences by Group of Hunters (ranked)

Recreational Hunters		Subsistence
Safari	Non-Safari	
Lions	Lion	Giraffe*
Sable	Sable	Eland
Roan*	Elephant	Gemsbok
Eland	Roan*	Kudu
Elephant	Eland	Hartebeest
		Wildebeest
		Springbok

*Conserved animal
Source:

The quota for wildlife to be hunted are set annually by the Department of Wildlife and National Parks. Table 4.3. shows the quota for single game licences (thus excluding safari companies and subsistence hunting) for the period 1982-1986. The drop in quota for some species in 1986 reflects the guestimated reduction in numbers.

No data exist on the actual numbers of licences sold or animals killed, except for Ngamiland. Table 4.4. summarises the data for these areas for 1985, (Ngami Data Services, 1985).

Most quota are not completely filled although overselling also occurs (e.g. Leopard, Steenbock, Hartebeest, Gemsbok). The proportion of animals killed compared to licences sold is relatively low (32% overall). However, around 70% of the licences are not returned and therefore records are far from complete.

Table 4.3.

Recommended Single Game Licence Quota
(Totals for Citizens, Residents and Non-Residents)

Species	1982	1983	1984	1985	1986*	1986C
1. Buffalo	1546	1452	1515	1485	1317	864
2. Bushbuck	36	35	35	47	40	0
3. Crocodile	168	138	138	133 -	50	0
4. Duiker	10383 -	400	89	130	127	0
5. Eland	1319	1290	1211	1200 -	256	112
6. Elephant	104	0	0	0	0	0
7. Gemsbok	4053	3941	3951	3360	2792	2454
8. Hartebeest	12128	14177	13677	13577 -	979	940
9. Impala	2515	+16592	-2473	2418	2396	1995
10. Kudu	2784	2676	2690	3033	2277	1934
11. Lechwe	505	505	524	536	522	235
12. Leopard	209	203	197 -	80	97	28
12. Lion	344	325	319	311 -	137	12
14. Ostrich	3297	3259	3251	2973 -	1883	1538
15. Reedbuck	252	252	254	269	242	45
16. Sable	67	76	78	78	78	5
17. Sitatunga	189	188	210	222	217	66
18. Spotted Hyaena	0	15	23	15	15	0
19. Springbok	3740	3615	4018	3815 -	2687	2100
20. Steenbok	11461	511	98	128	133	0
21. Tsessebe	606	563	608	590	406	85
22. Warthog	1473	1420	1299	1519	1170	746
23. Wildebeest	13294	14108	14557	15303 -	2355	1845
24. Zebra	2550	2140	2439	2490	1960	1335

\+ Denotes substantial increase
\- Denotes substantial decrease
1986* Data are proposed quota
1986C Part of the 1986 quota for citizens
Source: KCS, Department of Wildlife and National Parks

Although hunting is strictly regulated illegal hunting or poaching does occur. Its magnitude is unknown. In 1976, an estimated 13% of the animals were killed by poachers in western Botswana (Table A.4.7). This percentage appears (too?) low and may have been an underestimate. No other figures exist to allow comparison. Murray (1978) indicated that in western Botswana in 1976 40% of poaching is due to overshooting by licensed hunters, 26% by unlicensed village dwellers and 32% by organised poachers. The two former groups mainly hunt for meat purposes whereas the organised poachers usually hunt for trophies from usually rare and often conserved species (e.g lions, leopard, cheetah, elephants, rhinoceros and giraffes). Trophy poaching is particularly attractive because of the high international prices, the abundance of wildlife and the size of the country, which makes it difficult to control illegal hunting. Organised poachers use vehicles and even aircrafts to transport their kills. The percentage of organised poaching is possibly higher in northern Botswana. In western Botswana, the poaching rate

Table 4.4.

Licences Sold and Recorded Animals Killed
(Ngamiland 1985)

Species	DISTRICT TOTALS Quotas	Sales	Kills	CITIZENS ONLY Quotas	Sales	Kills
Buffalo	995	841	361	671	634	217
Bushbuck	25	1	1	0	0	0
Crocodile	35	9	7	0	0	0
Duiker	39	35	1	0	0	0
Eland	184	111	14	108	80	10
Gemsbok	160	177	18	115	109	13
H/Beest	23	44	0	10	0	0
Impala	1243	1020	358	977	839	213
Kudu	509	433	125	369	333	76
Lechwe	406	318	173	199	169	51
Leopard	32	42	11	8	6	3
Lion	90	66	31	19	16	8
Ostrich	273	195	99	188	164	97
Reedbuck	162	113	80	47	44	18
Sable	42	34	24	0	0	0
Sitatunga	167	88	44	56	39	9
S/Hyaena	10	0	0	0	0	0
Springbok	105	105	6	80	43	6
Steenbok	30	52	6	0	0	0
Tsessebe	345	270	142	167	160	49
Warthog	650	460	127	420	331	52
Wildebeest	1282	1040	244	1011	897	157
Zebra	1270	1041	932	938	897	833
Totals	8077	6495	2804	5383	4761	1812

Source: Ngami Data Services, 1985
*Note: Approximately 15% of country total.

was highest among predators, (e.g. 69% of the Lion kills were illegal; 67% for Leopards), some antelopes (Eland: 33% and Gemsbok 32%) and Giraffes. The total value of poached animals was estimated to be P87,936 of which 66% was meat and 34% trophies, representing an average net income of P172 per poacher (Murray, 1978).

The development of the number of tourists visiting National Parks and Reserves is not known. Chobe National Park and Moremi are most popular with 14,551 visitors and 8,136 in 1984/85 respectively (Fowkes, 1985). Nxai Pan attracted 792 tourists whereas data for other Parks are lacking. Few historical data available for Chobe (Kasane Gate) suggest that visitor numbers in 1984 are double the level at Independence but slightly lower than in the mid-1970's. Improved access through tarring the Nata-Kasane road has increased visitor numbers in 1985 (Fowkes, 1985). Most tourists originate from abroad. FAO/UNDP (1977) states that in 1973-1975 89% of the tourists came from abroad: half from southern Africa and half from

overseas. The latter mostly use organised, costly tours, whereas regional and local tourists are more frequently independent travellers (Fowkes, 1985).

On a macro-economic level, the contribution of hunting and tourism to Gross Domestic Product is currently probably not more than 5% (Von Richter and Butynski, 1973; Fowkes, 1985; NDP, 6). Total value added in 1974/75 was estimated to be P 3,8 mln, of which 32% was generated by subsistence hunting, 43% by safari companies and lodges and 25% by trophy dealers and processing. The latter industry has become increasingly important. Although the number of trophies has gone down from 2640 in 1974 to 2055 in 1985, the average value of trophies has increased significantly (P 9 in 1974; P 69 in 1985). This increase in value may reflect a price increase and/or a shift towards more valuable trophies. Table A.4.8. gives an estimate of the development of the wildlife utilisation sector under the new Wildlife Conservation Policy and its effect on government and private sector benefits and employment creation.

Total government revenues (through the Departments of Wildlife and National Parks and Tourism) have increased substantially from a mere P6,845 in 1966 to P614,200 in 1981. The drought has subsequently affected revenues from licenses (total revenues dropped to P366,000 in 1985). Almost 40% accrues to districts, mainly Ngamiland, Ghanzi, Central and Kgalagadi. In Ngamiland and Chobe, tourism provides 38% of the formal employment and also offers various opportunities in the informal sector (e.g. basketry).

Fowkes (1985) estimates that tourism alone is the fourth source of foreign exchange.

5. Government Legislation and Policies

Specially designated areas for wildlife - policy formulation on wildlife utilisation and tourism.

All hunting activities are strictly regulated through the Fauna Conservation Act. Hunting is banned in all National Parks, Game Reserves and sanctuaries. The designated controlled huntingareas cover most of the country. The Department of Wildlife and National Parks regulates hunting in such areas by setting quota and regulating the duration of the hunting season per area and species.

The Fauna Conservation Act specifies conserved animals which, in principle, may not be hunted and protected animals, which may only be hunted with licences (Table A.4.1.). Other licences comprise bird licences, small game licences and special licences for e.g. remote area dwellers. Licences for remote area dwellers are free of charge in view of their heavy reliance on hunting and generally low incomes. Any animal may be killed if it endangers life or damages farming but the trophy cannot be sold. The Act regulates trade in and export of trophies in line with the CITES - Convention on International trade in Endangered Species of wild fauna and flora.

Another element in the Fauna Conservation Act is the establishment of wildlife management areas, where no person can hunt through licences, reside, keep cattle or grow crops unless he/she conforms

to the regulations (Art. 11 (b) and (c)). Such areas have been identified but are not yet operational (e.g. not gazetted, no management plans). They form the centre of the new Wildlife Conservation Policy (Government of Botswana, 1986). This policy aims at the economic development of the wildlife resource for Botswana on a sustainable basis by developing the wildlife industry and providing assistance to rural development through employment and income generation. Government is aware that such utilisation should be on sustainable yield basis and that therefore management of wildlife resources is needed (NDP6, 253).

Government is also preparing a policy paper on tourism. Past emphasis has been on high cost - low volume tourism but improved communication links (e.g. Nata-Kazungala road) create opportunities for expansion of tourism (NDP6). Enforcement of the Fauna Conservation Act has proved difficult. For example, the Kalahari Conservation Society found that only 4% of the licences in Ngamiland are returned within 30 days after killing an animal, as legally required. This enables many licence holders to hunt several times on one license. Penalties are relatively low and wildlife staff is inadequate to patrol the country.

Recently, the Kalahari Conservation Society (KCS) has been established which aims at promoting knowledge about the country's wildlife and environment, to stimulate research into issues concerning these resources and their conservation and finally to promote and support conservation policies. For example, the KCS has started a pilot project to computerise hunting licence data in Ngamiland and now Chobe.

6. Fish Resources and Utilisation

The country's fish resources are located mainly in the water resources in the north (Chobe, Okavango, Lake Ngami and Lake Liambeni). Some fish are found in man-made dams such as Mopipi and Gaborone dam. Main species found in Botswana are tiger fish, bream, tilapia and cat fish (Norplan, 1985). Between 1000-2000 people are involved in fishing for subsistence and commercial purposes. Commercial fishermen catch 20-25 tonnes wet weight per year as compared with only 1 ton for subsistence fishermen.

Data on the actual and potential sustainable production are incomplete. Presently, total annual catch appears to be around 1,000 tonnes whereas 10,000 tonnes is considered the maximum sustainable yields (Rogers, Pers. Comm.). Overfishing has occurred so far only in Lake Liambezi where annual catches dropped from 800 tonnes in the mid-1970s to 180 tonnes now (max. sustainable yield estimated to be 300). This drop is partly the result of the lake's infestation by salvinia. Lake Ngami, the Boteti river and Lake Xau have a high productivity. The large fluctuations in water level in the Okavango system result in corresponding fluctuations in fish resources. Therefore, fish resources are most stable in the northern Okavango. Additional problems for the development of commercial fishing refer to the large distance to consumer markets and lack of financial means. Fishing equipment used is still very simple. Spraying campaigns with endosulfan have had no effect on fish mortality but possible sub-lethal effects need further investigation and monitoring (Norplan, 1985).

4.2. Veldproducts Utilisation and the Environment

> Veldproducts important source of food for poorest - trade and use by rural industries increase

Veldproducts are widely used for a variety of purposes such as food, building and income generation through trade. No data exist on the magnitude of use. Due to the population increase and the increased concentration of the population, utilisation for own household requirements as well as utilisation for trading purposes must have increased. The latter results from local shortages around large settlements (e.g. thatching grass) and the establishment of large enough urban markets to supply products such as mophane worms.

Collection of plants is a major source of food and income (in kind) for the poorest (Table 1.4.) Rural people use a variety of plants which are vital for the diversity and nutritional value of their diet (Grivetti, 1978) and 1979). Table 4.5. lists a number of frequently collected plants.

Taylor and Moss (1982) have identified a number of veldproducts which could be commercially exploited: mophane worm, morula fruits, grapple, papyrus, wood for carving, palm and oretlwa/mogwana. Presently, only four of these are important sources of income and employment: mophane worm (3,000 people involved), mokola palm (67,000), grapple (600) and wood carvers (300).

1. Mopane Worm (Gonimbrosia melima)

Mopane worm occurs only in the mopane tree areas in Northern Botswana. During the good season in 1979, some 750 tonnes of worms were harvested in north-east Botswana. Harvests appear to be on average 300-450 tonnes. Prices fluctuate between P0.25 per kg in 1979 to P1.00/kg in poor years (1982). Mopane worms are mainly bought by farmers from the Tuli Block who export them to South Africa.

2. Mokola Palm (Hyphaene ventricosa)

The Mokola palm is found in some parts of northern Botswana, mainly around the Okavango and Makgadigadi Pans. Young leaves of the palms are used to make baskets in these areas. Basketry is a major source of employment and income. In Etsha, weavers produce an average of 3 baskets per week and earn an estimated P360-370 per year. Total annual sales amount to P100,000 of which 80% is purchased by Botswana Craft from Gaborone and 20% is sold locally. Botswana Craft sells baskets in urban areas as well as overseas.

Table 4.5

Some Important Veldproducts used in Botswana with a Potential for Commercial Use

Fruits of	Scientific name	Distribution
Morama	Tylosema esculentum	Kalahari (K) shrub savanna
Moretologa	Ximenia americana	E. & N.W. shrub savanna and stony slopes.
Morula	Sclerocarya caffra	Tree savanna near hills
Mmilo	Vangueria infausta	E. Tree savanna sand and rock
Motlhatswa magalismontanum	Bequaertiodendron	S.W.-S.E. Shrub savanna rocky hills
Mogorogorwane	Strychnos spp.	K.-E Bush & Tree savanna sand and rock
Mogwana	Grewia bicolor	E. Bush savanna hardveld
Moretlwa	Grewia flava	K. Shrub & Tree savanna riparian woodland and sand
Motsotsojane	Grewia retinervis	E. Shrub & Tree savanna deep sand
Mongongo rautanenii	Ricinodendron	N. Tree savanna
Leaves for spinach (Morogo)		
Thepe	Amaranthus spp.	Villages & kraals
Rothwe	Gyandropsis gyrandra	E. Tree savanna,Bushveld
Leshwe	Pergularia extensa	EW.Tree savanna,Bushveld

Fruits of	Scientific name	Distribution
Roots for medicine		
Makakare procumbens	Harpagophytum sand	K. Shrub savanna and
Shoots for teas		
Kgomo di metseng	Mentha longifolia	E.Tree savanna, Bushveld
Monna o nkgang flabellifolius	Myrothamnus	E.Tree savanna, Bushveld
Vaalbos	Helichrysum sp.	S.W.Kalahari, Sandveld
Fungus		
Mahupu	Terfezia sp.	K. & Ghanzi District
Dried flowers and fruits for florist material		
Molatswe	Combretum sp. savanna. Rocky slopes	K. & E. Shrub & Tree

Source: Millar, undated.
K = Kalahari

3. Grapple (Harpagophytum procumbens)

Grapple is mainly harvested in Kgalagadi District (up to 25 tonnes in 1984) and on a small scale in Southern District. Crop production is difficult in these areas and therefore grapple harvesting is an important activity, particularly for the poorest. For example, female-headed households rely relatively heavily on grapple collection (Kgathi, forthcoming). Prices per kilogram vary between P1.50 - P2.00 in Kgalagadi and P1-P2.50 in Southern District. The amount harvested drops during periods of drought (Kgathi, forthcoming).

District reports suggest that thatching grass has become scarce in many parts of eastern Botswana. This has led to the emergence of trade in suitable species. Generally, little is known about the availability and use of thatching grass.

Given the importance of veldproducts for subsistence needs and as a potential source of income, surprisingly few data are available on relevant aspects such as the impact of drought on the resource availability, the impact of other human activities such as agriculture on the resource, etc. Like wood collection, gathering of veldproducts has so far not been considered as a separate form of land use. Because of emerging shortages, veldproducts deserve and are likely to receive more attention from planners and researchers in the near future.

The responsibility for the protection of veldproducts lies with the district conservation committees and the Agricultural Resources Board (ARB). The ARB handles requests for the commercial exploitation of agricultural resources in cooperation with relevant ministries and departments. According to the Agricultural Resources Conservation Act, the ARB can regulate harvest and trade through the introduction of permits. Presently, permits are required for the grapple plant.

4.3. Development Trends

1. Subsistence hunting is larger than recreational hunting in terms of hunters and animals killed. The threat from recreational hunting, including poaching, is mainly directed towards rare species hunted for trophy purposes. Subsistence hunting may threaten wildlife particularly during drought when wildlife numbers decrease and need for subsistence hunting probably increases.

2. Most wildlife is gradually pushed back into specially designated areas, through the expansion of human activities. Wildlife in National Parks and Game Reserves cannot be utilised other than for game viewing purposes. Wildlife in other areas such as designated wildlife management areas may be used for hunting and processing purposes. Management of such areas will therefore become essential in future.

3. Tourism has so far been concentrated around the Okavango and Chobe. It involved relatively low numbers of wealthy tourists, mainly from abroad. Improved access and a general expansion of facilities are likely to increase the number of tourists, including 'low cost tourists'. Past growth in tourist numbers has been relatively low in Chobe, illustrating the importance of external factors such as the Independence war in Zimbabwe. Such factors include exchange rates etc., and make a prediction of tourist numbers in the future difficult. Improved access and a possible regional SADCC approach may boost tourism in the Kasane region.

4. The use of veldproducts has significantly increased for both subsistence needs and as a source of income and employment (e.g. thatching grass, mokola palm, grapple plant). Commercial use is likely to continue to grow in response to emerging shortages and rural industrialisation efforts.

4.4. Environmental Effects of Wildlife Utilisation

The environmental impacts of wildlife utilisation through hunting and tourism cannot be separated from impacts of other human activities on wildlife numbers. Hunting, tourism and other human activities influence wildlife numbers and their spatial combination enhance their impacts. From the point of view of wildlife utilisation, it is important to retain enough variety and numbers of wildlife in areas which are primarily suited for this form of land use and related rural industries. This requires also that wildlife is able to recover from recurrent droughts as has happened in the past. In this way, wildlife and its utilisation are gaining an independent position in the country's rapid development as envisaged by Government. In contrast, in the past, wildlife outside National Parks and Reserves was mostly considered a rest category using areas not directly needed for other activities.

Various other activities could easily encroach into such areas. Penetration of livestock into western and northern Botswana has been the major form of encroachment in the past. Others comprise mineral exploitation activities, human activities in general following the virtual eradication of the tsetse fly around the Okavango and possibly irrigation activities near the Okavango. Such activities have left less and increasingly fragmented space for wildlife. Wildlife is responding by concentrating in national parks and reserves in large numbers leading to range degradation processes via overgrazing and trampling. The second response is an adjustment of wildlife numbers and species to the new available areas, either gradually or via sudden changes in species composition and/or numbers.

There is no conclusive evidence as yet that wildlife numbers in the country are decreasing permanently. Variations have always occurred based on climatic conditions. However, the present combination of expanded human activities and drought is new and may lead to structural changes in wildlife composition and numbers, necessitating active management.

During the recent drought die-offs have occurred especially among wildebeest at Lake Xau. (Owens and Owens, 1980; Williamson and Williamson 1984 and 1985; Hobbs 1981). During 1985, losses of especially Hartebeest, Wildebeest and to some extent Eland were reported on Botswana's southern border with South Africa. Such die-offs of especially Wildebeest have occurred in the past during periods of drought. Campbell (1981) reports on large die-offs in the early thirties in most of eastern Botswana and in 1963 large die-offs of wildebeest at Nata and Jari pan. In 1964 and 1970 die-offs at Lake Xau occurred. These die-offs caused a temporary collapse of the Kalahari population of Wildebeest.

Generally, fluctuations in wildlife numbers and composition have been related to:

a. droughts. Reported die-offs coincide with drought.

b. habitat changes through climatological changes and human activities (e.g. loss of surface waterpoints in the Kalahari). People have settled around waterpoints and rivers and perennial springs in the Kalahari have dried up possibly because of climatological factors or because of human activities (Campbell and Child, 1971). For example, bush encroachment may cause a drop in the water table (Jennings, 1974). Loss of access to water has led in the past to the disappearance of species in need of open water such as Buffalo, Zebra and Elephant from the Kalahari (Campbell, 1981).

c. human activities leading to reduced and fragmented areas available for wildlife (livestock encroachment and cordon fences). Cattle encroachment into the "Schwelle" area affects migratory species, which use this area during the wet season. Fences may add to die-offs as they may limit "escape routes" although their impact has not yet been assessed. They also protect wildlife against encroachment of cattle (e.g. Khukhe fence and the buffalo fence).

The effect from hunting on current numbers and composition of wildlife is largely unknown because the extent of poaching is not known (Benn, 1983). During recent drought years the number of available licences have been decreased for a number of species (see table 4.3). But some

sources estimate that for every animal shot on a permit, four are shot illegally. Murray (1978) found that poaching comprised 13% of all hunting.

The encroachment of other land use forms, hunting and poaching lead to more pressure on the remaining wildlife areas which may lead to land degradation. Generally wildlife areas are in a better range condition than areas occupied by cattle. Map 2.2 however shows that also within many wildlife areas in western Botswana, range degradation aggravated by harvester termites, is taking place. As no carrying capacity figures exist it remains unclear to what extent the drought, wildlife or harvester termites contribute to the recurrent picture of range degradation in the wildlife areas. In the Chobe National Park the vegetation is badly affected in the vicinity of the river where trees are disrupted and grazing is scarce. The large numbers of Elephants are the main cause (Melton, 1983; Sommerlatle, 1976, and Moroka, 1984). Because of the blocking of migration routes some overgrazing occurs inside the buffalo fence in the Okavango Delta.

1. Environmental Problems in the Okavango Delta

The Okavango is a unique habitat for wildlife and simultaneously a huge source of surface water, which attracts various human activities. Presently, part of the Okavango is a Game Reserve (Moremi) whereas the rest is planned as wildlife management area but does not have special status yet. Encroaching human activities and extraction of water may threaten the habitat for wildlife if no careful planning takes place. Livestock encroachment is due to the drying up of Lake Ngami and the campaign against the Tsetse fly.

Aerial spraying with endosulfan started around 1973. Aerial spraying was combined with ground operations with the insecticide dieldrin (Davies, 1980). Map A.4.2. shows the areas sprayed during the programme (4-5 times with dosages of 6-9 Endosulfan g/ha). High concentration applications (800-1000 g/ha) are harmful for wildlife and endosulfan is known for its toxicity for fish. Monitoring of spraying led to the following results:

a. endosulphan is very effective but it is difficult to eradicate tsetse flies completely (Allsop, 1985).

b. if spraying is not permanent, fish kills are considered to be limited. Endosulfan does not persist more than three weeks and does not accumulate in 'food chains' (ODA, 1981)

Human and technical failures during spraying campaigns result sometimes in higher dosages than intended and therefore may cause more environmental effects. The dieldrin ground spraying programme has never been monitored. The area sprayed is relatively small and therefore although dieldrin is very persistent, its environmental effects are mainly local. Currently the veterinary department is working on alternatives for tsetse flay control (fly traps). However, main environmental effects are indirect, i.e. through the changes in land use made possible. (Veenendaal and Opschoor, 1985). The area concerned is attractive for livestock because of the vicinity to water and molapo farming. Severe overgrazing occurs on the southern and western side of the buffalo fence leading to

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* up to 40,000 (Sommerlalte, 1976; Moroka, 1984; Melton, 1985).

extensive soil erosion. The location of the fence has reduced the space for wildlife and therefore range deterioration, though less serious, also occurs inside the Okavango. Presently, the fence protects wildlife from further encroachment.

Other human activities may reduce the water level of the Okavango through extraction of water for irrigation purposes or for general supply to eastern Botswana. Presently, such plans are only under consideration in the country. Namibia is actually constructing waterworks which will extract water from the Okavango in the Caprivi Strip. It will have a capacity of 2-3 m^3/sec. and be used as a supplementary water supply. The impact of various degrees of water extraction from the Okavango on the water level, vegetation and wildlife is largely unknown.

Finally, wildlife utilisation itself has effects on the habitat of the Okavango. Although in general little information exists about environmental effects of tourism, uncontrolled mushrooming of tourist facilities inside the Okavango and spreading of salvinia appear to cause problems at present. Salvinia (Salvinia molesta) was first found in Botswana (and Africa!) in 1948 at Kazungula. It is fairly common in the Chobe, Lynyatti and Kwando but it was only recently found in the Okavango (Kalahari Conservation Society, 1986). Infiltration must have taken place through animals or more likely tourist boats. Salvinia grows very fast and can quickly cover and block waterways. Reduced light infiltration and decay of plant material underneath reduce available oxygen to 20% or less than the open water level. The Aquatic Weeds Control Unit from the Department of Water Affairs uses mechanical, biological and chemical control measures (traps, weevils and pesticides; Child, 1985).

Lack of control over new tourist facilities in the Okavango (and elsewhere) may lead to negative environmental effects such as disturbance of wildlife by boats and cars and littering. Such effects would become more serious when tourist numbers will increase in future.

The future of wildlife and veld products has a direct impact on activities which depend on wildlife including rural industries, subsistence household activities, particularly of remote area dwellers and tourism. Disapearance of wildlife would further limit the already limited development opportunities particularly in parts of western and northern Botswana. The Wildlife Conservation Policy is based on this realisation.

4.5. Environmental Effects of Veldproducts Utilisation

A number of veldproducts are being overharvested and consequently threatened with depletion. Although subsistence needs have increased along with population numbers, commercial use of veldproducts appears to be the main cause. The Agricultural Resources Board and district officers have identified three main products as threatened: mokola palm, grapple plant, thatching grass.

Almost all basket weavers around Etsha experience an increasing shortage of the mokola palm (97%: Monageng and Terry, 1984). Increased use as well as changed harvesting methods which destroy the entire palm instead of carefully cutting off one or two young leaves from each plant are the

main causes of the shortage. Experience with plantations of mokola palm have not been successful because of lack of knowledge about the germination ecology (Monageng and Terry, 1985: Duncan, 1985). In 1983, the majority of harvesters still claimed to use the traditional, selective method. Trees used for dying of baskets are also getting scarcer: Berchemia discolor (Motsentsila) and Euclea divinorum (Mothlalaoka) (Monageng and Terry, 1985). Harvesting of the grapple plant has depleted this resource around villages in the Kgalagadi District such as Tshabong. Harvesting in Southern District is more recent (1982) and the number of licences issued is restricted unlike in Kgalagadi District. The latter attempts to reduce overharvesting. Research has monitored particularly production ecological aspects from the grapple plant and studied effects of harvesting (see e.g. Veenendaal, 1984; Leloup, 1985). In practice, whole plants were dug out which proved detrimental to the grapple population. Instead, it has been advised to leave the parent tuber so as to increase survival chances of harvested plants. Rotational harvesting around villages (e.g. year shifts) may be used to avoid depletion close to villages. Drought affects the already generally slow growth of plants. Presently, the harvest is still fairly small and depletion, except locally, has not yet occurred. Grapple plants are successfully grown in nurseries, which opens possibilities for more intensive cultivation and safeguarding the future availability of grapple.

Although thatching grass is available throughout the country, it is depleting in more densely populated areas. However, exact figures are unknown. The contribution of drought and overgrazing to such depletion is not know either. Recently, commercial harvesting seems to aggravate shortages.

The stereotype pattern of depletion of veldproducts and wood is that it starts around settlements and gradually spreads. During this process, people have to put more effort into harvesting, traders emerge and less suitable harvesting methods become more frequent. Participation opportunities for poor households diminish because they may be unable to meet the extra efforts required. Ultimately, the process may lead to widespread disappearance of resources, directly affecting rural industries, which depend on these resources.

4.6. Strategies towards Sustainable Utilisation of Wildlife and Veldproducts

An essential step towards sustainable use of wildlife and veldproducts is its recognition as a human activity and form of land use alongside other forms of land use. Depending on environmental conditions and potential and people's characteristics, wildlife and veldproduct utilisation may be more or less appropriate in various parts of the country. Therefore, proper and rapid implementation of the concept of wildlife management areas (WMA) is a major step ahead. Wildlife management areas are in turn the cornerstone of the government's wildlife conservation strategy, which outlines guidelines for the development of a wildlife industry. Rules and regulations for wildlife management areas still have to be agreed upon, and WMA's have to be gazetted. They can be the management instrument for the important grazing areas for wildlife on the Kgalagadi "schwelle". The viability

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* Personal comment Mr. Dipholo

of the wildlife sector in the southern and central Kgalagadi will depend on the establishment of these WMAs including viable development plans for WMAs.

A policy specially aimed at solving problems of reduced migration opportunities of wildlife is the drilling of boreholes in the Kgalagadi (Sweet, 1986). Less need for migration may reduce the number of die-offs. Boreholes for wildlife are not new in Botswana (Child, 1972). Borehole drilling may however, lead to a number of problems:

- increased local overgrazing may occur around boreholes (as with cattle). An assessment of the (varying carrying capacity for various wildlife species will be needed. Overgrazing currently already occurs within national parks and reserves.

- Boreholes may also attract cattle, especially since grazing directly outside parks/game reserves sometimes is not as good as compared to inside the park/game reserves (e.g. Hainaveld ranches versus Central Kalahari game reserve).

The problems related to borehole drilling for wildlife indicate that management/development plans are needed for both WMAs and Game Parks and Reserves. These plans will also have to include the development of tourism. For Chobe National Park Wildlife Reserve and Moremi a first attempt has been made by Anderson (1985). In general, comprehensive land use planning in which wildlife is seen as the basis for various forms of land use, could avoid or at least limit the observed or expected environmental problems.

Solutions to the problems of shortage of veld products are similar to those for wood shortages. The feasibility of the various solutions may differ per species. Possible solutions are:

1. growth in plantations or horticulture plots.

2. improve efficiency of the environmental resource by producing less but higher quality products.

3. control harvesting by requiring licences (as with grapple). For example commercial use could be restricted in size and area and fees could be charged. Areas close to villages could be closed for commercial exploitation.

4. encourage the use of substitutes (e.g. roofing)

The Agricultural Resources Board already reviews permits in cooperation with the district conservation committees. The problems of policing the permits to guard against abuse may be laid in the hands of the local communities.

CHAPTER 5

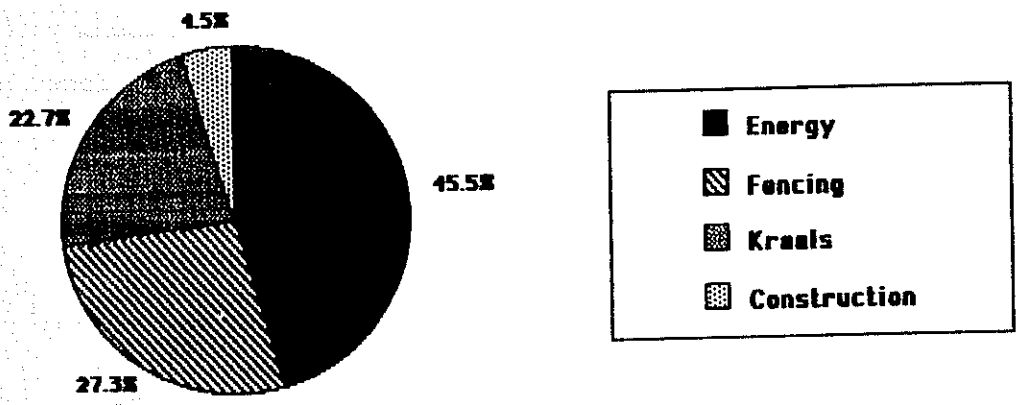
WOOD UTILISATION*

Wood Utilisation and the Environment

Wood is used for a variety of purposes such as energy, construction, fencing and crafts. It is used by households for domestic purposes as well as by enterprises such as restaurants, construction companies, etc. Botswana has forest reserves in the north which provide hardwood and are so far mainly export-oriented. Domestic wood supply depends almost totally on natural vegetation. Construction and fencing wood is imported in considerable amounts, valued at P11 million in 1984, compared with export of hardwood of only P1.9 million (Table A.5.1.)

Figure 5.1.

Wood Use* in Botswana by Purpose



Source: ERL 1985

* (Total Use Estimate = 7.48×10^5 tonnes per annum)

Until recently, data on wood use were extremely limited. Recent concern about deforestation led initially to local and regional studies (Jellenic and Van Vegten, 1981) and subsequently to a country-wide survey (ERL, 1985). These studies focussed almost exclusively on firewood use and therefore very litle is known about use for other purposes. ERL (1985) has used assumptions from other countries on wood use for other purposes. Total wood use in the country is estimated to be 7.48 x 105 tonnes per annum. Figure 5.1. provides a sectoral breakdown.

Most socio-economic data are drawn from an EDL background paper by Mr. D.L. Kgathi.

Until more data are available for Botwana, these percentages can only be considered as indications. Firewood accounts for almost half the total wood use but similar amounts are used for agricultural purposes (kraals and fences). For most purposes, wood is collected locally. Therefore, the spatial distribution of wood collection is closely related to population numbers and settlement patterns. Wood use is thus highest in eastern Botswana where most people live and agriculture is concentrated. Local and even regional shortages of wood are mostly confined to eastern Botswana.

1. Wood Resources in Botswana

> Large fluctuations in standing crop of natural vegetation - small woodlots

Few estimates for the amount of wood resources exist. ERL (1985) used landsatellite imagery to estimate standing crop and annual wood increments in eight regions in eastern Botswana (Table 5.1).

Table 5.1

Estimates of Standing Crop of Wood and Annual Increment of Wood and Firewood in Eastern Botswana

Region (Landsat Block)	Standing Crop (mln ton)	Total annual wood increment (x1000 ton)	Annual firewood increment* (1000 tonnes	Surface Area x 1000km²
1. N.E./Central: Tutume	47.2	3,373	2,950	32.5
2. Central: Serowe Part	28.7	2,481	1,577	26.7
3. Central: Serowe	61.0	3,184	1,536	30.5
4. Central: Mahalapye	52.9	2,898	960	30,6
5. Part Kweneng/Kgatleng	15.3	540	134	10.5
6. Southern	16.4	509	139	10.1
7. South east	4.3	97	28	1.9
8. Barolong	2.1	70	19	1.2
	227.9	13,152	7,343	144.0

* Oven dried
Source: ERL, 1985: p.76 & 82.
Note: District area includes total surface. ERL figures for different vegetation types are shown in table A.5.8. It should also be noted that these figures are based on a relatively small amount of fieldwork and are hence rough indications only.

Average standing crop per hectare ranges from 22.6 tonnes/hectare in South East district to 10.6 tonnes/ha in Central district with an average for eastern Botswana of 15.8 tonnes/ha. Annual wood

increments fluctuate between 0.5 and 1.04 tonnes/ha with an average of 0.91 tonnes/ha. Data on wood production in communal Kgatleng fall in the same range. The standing crop may vary from 0.60 tonnes/ha and annual increments from 0.66-1 tonnes/ha. (Tietema, 1984). Van Vegten (1983) estimates for eastern Kgatleng a lower annual increment (0.33 tonnes/ha). The relatively large variation in the figures is due to two factors:

a. the degree of overgrazing and resulting bush encroachment varies. Standing crop in bush encroachment areas may reach 60 tonnes/ha.

b. the extent of crop production varies regionally. Therefore, different proportions of the regions are cleared of vegetation.

The various forms of wood use are not completely competitive. Firstly, not all species are equally suited and appreciated for the various purposes. For example, morukuru is popular for furniture whereas mopane is so far mainly used for firewood and crafts. Eucalyptus is most suited for fencing but less appreciated, though not unsuited as firewood. A list of preferred firewood species is given in table A.5.2 Secondly sometimes the use of specific parts of trees is required for certain purposes. For example, fencing fields requires branches and bushes, which are normally not used as firewood. An estimated 60% of tree biomass is suited for firewood (Tietema, 1984). Most of the hardwood cut in the forest reserves is not useable for planks etc and left unused. Therefore standing crop and increment figures should in fact relate to specific purposes.

Production of wood in woodlots is not exactly known but it is certainly quite small as a result of the small area covered as well as general poor performance. Table A.5.3. lists the present woodlots in the country.

Standing crop data or the forest reserves are not known.

The impact of drought on wood supply is largely unknown. During droughts, die-off of trees increases which increases firewood supply on the short run but has a negative implication on the long run. The recent drought has a visible negative effect on the Eucalyptus woodlots.

2. Wood Use

1. Firewood

Firewood most important rural energy source - lower per capita urban firewood use

Firewood acounts for an estimated 48% of the total energy supplied and even 60% of the domestically supplied energy. Households are the main users as firewood is the principle energy source, particularly in rural areas and among the low income groups in urban areas. Although firewood is primarily used for cooking, the significantly higher use in winter illustrates its role as a source of heat and light too. Rural firewood consumption varies further as a result of:

a. socio-economic factors: richer rural households, for instance, increase their wood use in winter more than poor ones (ERL, 1985).

b. the size of the households: large households have a lower average wood use per capita.

c. the availability of firewood: firewood shortage may induce household responses which reduce wood use. (e.g. use of substitutes).

Estimates for annual average wood use per person vary from 0.38 tonnes per capita (Jellenic and Van Vegten, 1981) up to 1.13 tonnes per capita (White, 1979). ERL (1985) puts the use at 0.51 tonnes per capita. Methods used to derive these estimates are not clearly specified and can therefore not be compared. Unfortunately, differences in use cannot be analysed in terms of socio-economic and environmental factors. A comparison of the per capita wood use in rural Botswana with other countries, some of which face more acute wood shortages, shows that the ERL estimate appears on the low side and average per capita use may lie between 0.5-1 tonnes per capita. (Table A.5.4.)

Urban wood use is lower than rural. Average wood use in Gaborone was 0.23 tonnes per capita and 0.44 tonnes in Lobatse (Table A.5.5). Urban wood use depends on the same three factors influencing rural wood use. However, unlike that of rural areas, urban wood use is lower among rich households who more frequently use easily available substitutes. Abundance of firewood around Selebi-Phikwe explains the relatively high wood use there. Data are inadequate to indicate the relative impact of each of the above factors separately.

People usually express a clear preference for specific trees which have a high caloric value, have good embers, do not smell badly when burned and can be harvested without too many problems (Moss and Morgan, 1980: Jellenic and Van Vegten, 1981). Specific preferences differ regionally, based on the availability of species in the national vegetation. Some preferred species may have disappeared. Mopane is highly appreciated in the norther parts of Botswana (ERL, 1985). In other parts, combretum species, particularly Combretum imberbe (motswere and acacias such as Acacia mellifera (mongane) and Acacia erubescens (moloto) are among those preferred (Table A.5.2.). Combretum species are most popular for trade to urban areas (Kgathi, 1984). Households usually collect wood as headloads but depletion of firewood near villages leads to the use of donkey carts and mechanised transport too (Arntzen, 1983). ERL estimates maximum distances for transport modes as follows (Table A.5.9):

- head loads	5 km
- 2 wheel donkey cart	20-25 km
- 4 wheel donkey cart	35-45 km
- motorised vehicles	over 45 km

Depletion of wood around settlements is therefore, particularly problematic for households without transport, usually the poor.

Firewood is not only used by households but also by small enterprises and public services in rural areas (e.g. clinics, schools, restaurants). Like households, such institutions use wood mainly for cooking because alternatives are not easily accessible (e.g. Oki and Majaha-Jartby, 1983). For example, electricity is only provided in major rural villages. Hardly any data exist assessing firewood use by other than households. ERL (1985) found restaurants to be the main other users of firewood (along with gas). Firewood consumption by small enterprises accounts for approximately 20% of household firewood consumption in Good Hope to as little as 1% in Masunga.

2. Wood Use for Other Purposes

Other wood use important but poorly documented

Although substantial amounts of wood are used for purposes other than firewood, knowledge about the magnitude and determinants is virtually absent. Few available data are based on parameters from other countries. ERL (1985) states that use of wood for construction purposes equals, in other countries, 10% of the domestic firewood use. For Botswana, this would imply 34,000 tonnes wood per year. Wood used for kraals is estimated to be 170,000 tonnes per year (60,000 kraals); wood requirements for fencing at 204,000 tonnes per annum). Wood is also used for making furniture and crafts. The magnitude of use is unknown; use is mainly confined to a few species such as Acacia burkea (mokgwa), Faura saligna (mohau) and Spirostachys africana (morukuru) (Agricultural Resources Board, 1982).

3. Use and Supply

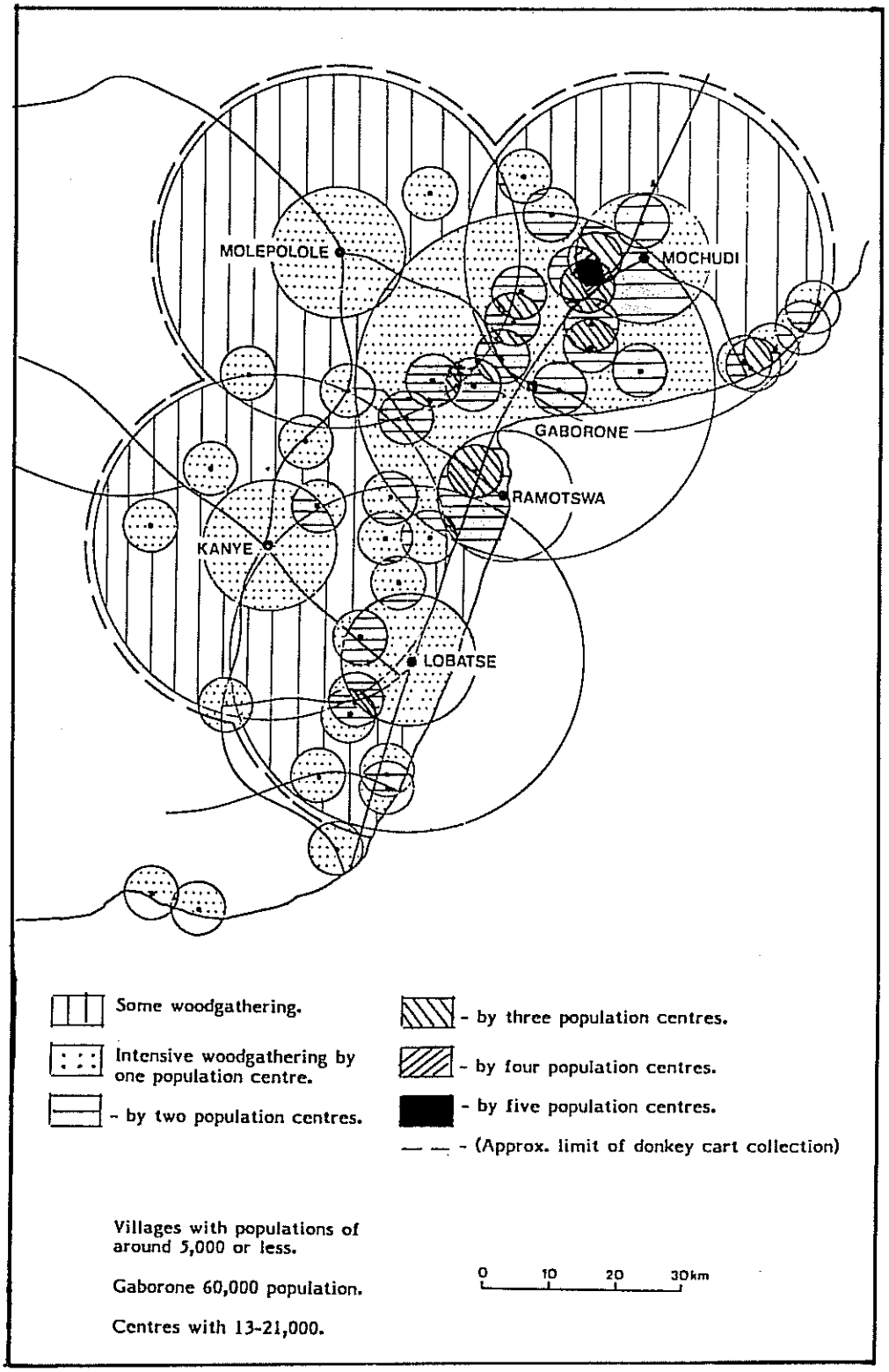
Wood shortages around large settlements and in south eastern Botswana

The rapid population growth has led to corresponding increase in wood use. Although urbanisation leads to a lower overall wood use, it causes larger concentration of wood use around towns and large settlements, which may exceed the regrowth of woody vegetation. Therefore, despite the absence of a nationwide wood shortage, shortages do occur in areas with a high population density. Presently, shortages are confined to South-East Botswana, towns, and large settlements. Figure 5.2. shows conflicts between towns and surrounding villages with respect to firewood collection in south-eastern Botswana.

ERL (1985) estimated wood use and production for eight regions in eastern Botswana. Firewood supply is insufficient in South East district and is just meeting needs in Kgatleng, Barolong and the parts of Southern and Kweneng districts which were studied (Table 5.2).

Figure 5.2

Village and Town Firewood Needs in South Eastern Botwana



Source: ERL 1985

Table 5.2.

Estimates of Use and Availability of Wood Resources in Eastern Botswana (1983; 1000 tonnes per annum)*

Region	Fire-wood** use	Total*** wood use	Recent Removals	Oven dried firewood supply	Oven dried total supply
1	133	293	6853	2950	5373
2	33	73	4182	1577	2481
3	137	301	5023	1536	3184
4	82	180	4915	960	2898
5	127	279	5328	134	540
6	93	205	5197	139	509
7	45	99	934	28	97
8	13	29	670	19	70

Notes:* region number: Table 5.1.

** Table 8.2.A. from ERL increased by 1.67 to include parts of trees which cannot be used for firewood: based on (Tietema, 1984).

*** firewood demand x 2.20 to allow for demand for other purposes gives total demand.

Source: Adapted from ERL, 1985

The shortage in South East distict is aggravated because of freehold areas where in principle no wood can be collected by the rural population (Jellenic and Van Vegten, 1981).

Remarkable is the large difference (factor 2-5 or more) between the estimates for removals of wood over the last 5-10 years* and the estimated total wood demand. Tietema (1986) stresses the large wood needs for the construction of bush fences and estimates firewood consumption to be only 20% of total wood needs. His figures and the estimates for removal by ERL indicate that total wood use is probably much higher than until recently assumed.

4. Responses to Wood Shortages

People adapt to wood shortage in various ways

As mentioned before, most available information refers to firewood collection. People can adopt three groups of strategies to adapt to wood shortage.

* Based on field data. It remains difficult to assess how representative the figures for wood and the field data on wood removal are.

1. to continue to collect wood in the same collection area. This can only be done by collecting less preferred but not necessarily bad species and by harvesting live wood through cutting or even burning down of trees. Both practices are used around towns and villages (Jellenic and Van Vegten, 1981; Kgathi, 1984).

2. to spend more efforts collecting wood. More labour is required when larger distances are to be covered. Alternatively, money is needed to purchase wood. Both adaptations have already occurred in the country (Opschoor, 1981; Kgathi, 1984 and ERL, 1985). For example, people in large settlements such as Shoshong cover larger distances (12km) than people in smaller ones such as Ditshegwane (5km) (Oki and Majaha-Jartby, 1983). Firewood is usually cheaper if not free, in small settlements indicating easy firewood availability. Prices in Gaborone seem to have increased to 10-12 thebe/kg whereas rural prices remain around 2-3.5 th/kg (ERL, 1985; Table A.5.6).

3. to reduce wood consumption.
Reduction of firewood use can be achieved by more efficient use, cooking less meals and an increase in use of substitutes. Stoves are hardly used although some tests indicate that they have an efficiency of 15.3-21.3% as compared with 9.1% for open fires (Geller, 1983). ERL (1985) points out however that a number of uncontrollable factors make efficiency comparisons difficult. There are no data to indicate that households in Botswana cook less meals as a response. In towns and some villages wood is substituted by gas, paraffin and cowdung. ERL found dung to be an important substitute particularly for poor households in areas where cattle are close to villages such as Barolong.

   For purposes other than energy, wood can also be substituted. For example, wire fences have replaced, in many cases, wood fences around compounds in villages.

   A long-term adaptation strategy would be to plant trees. Tree planting in Botswana however is limited and so far initiated mainly by government and brigades; not by local people themselves. Woodlots and nurseries cover a small area (approximately 600ha; ERL, 1985)* and have so far produced mainly fencing poles (Eucalyptus species).

5. Institutions and Legislation

Increased interest in wood issues by government and others

In the past, chiefs could ban cutting of useful trees in their regions (Schapera, 1943). Such rules often no longer operate and have been replaced by various laws. The Town and Country

* 600 hectare is likely to be an overestimation (personal comment, C. Millar). SADCC (1986) estimates woodlots to cover only 10.7 ha in 1981.

Planning Act allows preservation of specific trees and woodland in planning areas. Specific trees in any part of Botswana may be protected; on Tribal Land with the consent of the Land Boards (Forest Act). Nobody is allowed to cut wood on state land beyond subsistence means, or within 10 metres of a river. The Forest Act also specifes Forest Reserves where wood cutting requires a licence. Forest reserves cover 5000 km^2. Three companies hold licences. Chobe Forest Industries processes 12,000m^3* of tropical hardwood annually. Other companies process only 1200-2400m^3 (ERL, 1985). Around 65% of the processed wood is waste and locally available free of charge as firewood. Leftovers are burnt.** Some districts have bye-laws regulating or even prohibiting the export of wood outside the district (Kweneng and Kgatleng respectively). Otherwise wood can be transported between districts.

Until recently, government was mainly involved in wood issues through its Department of Forestry, which operates a number of woodlots. Awareness of emerging wood shortages, however, has increased interest in wood issues. For example, the Energy Unit in the Ministry of Mineral Resources and Water Affairs is involved in firewood problems whereas the Agricultural Resources Board in the Ministry of Agriculture is involved in the conservation of disappearing trees such as morukuru. In 1983, the non-governmental Forestry Association of Botswana was established and it aims, among others, at raising awareness about the rapid depletion of wood resources and at a timely response to the problem through its education and research programmes. As most measures to counteract wood depletion take time to implement (e.g. growth of seedlings) and require involvement of the population, educational effort is crucial to highlight the nature of the problem, its possible solutions and their implications. Special attention could be paid to poor households which are most seriously affected by wood shortages. Recently, government agreed to have an annual tree planting day in order to encourage people to plant trees.

5.2. Development Trends

1. Wood shortage has so far been local around towns and major villages. Development of future demand depends on the population growth, urbanisation and firewood consumption per capita. Two scenario studies for future firewood use show that demand for firewood will increase rapidly in future (Kgathi, 1985; ERL, 1985). Urbanisation implies lower total demand but aggravates shortages around towns and large villages. Urban demand is likely to increase faster than rural demand, despite the considerable lower per capita consumption in urban areas (Table A.5.7.) Therefore, wood shortage around settlements, particularly in the south-eastern part will spread and intensify. As a result, conflicts with surrounding areas will increase too.

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* The actual volume of wood felled must be higher as e.g. defective logs are not transported to the mill.

** Some of it is used for charcoal production.

2. Wood supply relies mainly on the natural vegetation and is therefore heavily influenced by other forms of land use, primarily agriculture. Bush encroachment, e.g. increases standing crop in Kgatleng up to 60 tonnes per hectare whereas clearing for arable purposes reduces standing crop to almost zero. As a result, large differences in woody vegetation occur. In areas with wood shortage, wood is no longer a free commodity but can be purchased at increasing prices.

   People have to and will adjust to scarcity of wood. Adjustment strategies will basically remain the same but will be more frequently used. For example, trade and the use of substitutes will probably increase. Rich households are better able to adjust and have more options than poor households, which may resort to using lower quality wood, have to put in extra efforts, or may even cook less. Therefore, special emphasis on poor households is needed to avoid, or at least limit negative effects for them.

3. Wood use has attracted increased interests from various groups in society (Government and non-Government). This increase is reflected in research and policy efforts which have started to fill up some of the open areas. The preparation of the Energy Master Plan for the country is one example.

5.3 Wood Use and Deforestation

Increased and indiscriminate wood use contributes to deforestation. In practice, the impact of wood use cannot be separated from the effects of human settlements and agriculture on deforestation. Deforestation is enhanced by clearing of arable land but to some extent counteracted by bush encroachment. There are no district maps available which indicate the standing crop of trees, hence the extent of deforestation is unknown. One would expect deforestation to occur in areas heavily used for firewood collection and crop production. Such circumstances can be found around large settlements and in small districts such as South East. In view of the population and settlement trends, the problem will intensify there but also spread to presently little or unaffected areas. Usually, the woody vegetation is reduced to shrubs (e.g. around Gaborone). Large tracts of barren land as a result of deforestation cannot yet be found. The effects of tree cutting on soil erosion are currently most serious on hill slopes, where a reduced vegetation cover causes increased run off and in turn gully forming on the lower sides of the hill. In the Mmankgodi area near Gaborone, such gully erosion is clearly visible. (see Map 2.2). Other potentially endangered areas are the larger villages in the sandveld. Although there is no national shortage of firewood, locally and sometimes regionally, demand exceeds production of firewood in the area (Table 5.2). The combination of cutting of wood and overgrazing around sandveld villages, enhances soil erosion and even desertification locally. The practice of destumping and clearing of arable land contributes considerably to deforestation and subsequently to soil erosion, if clearing and destumping are not followed by regular arable practices.

The practice of burning down live trees forms an additional danger as this harvesting practice prevents regeneration of the tree.

5.4. Strategies to Alleviate Wood Depletion and Deforestation

Since wood depletion is not a countrywide problem yet, strategies should address two issues:

a. measures to ensure that wood depletion does not affect larger areas.

b. measures to alleviate wood depletion in presently affected areas, mainly large settlements and south-eastern Botswana.

It is crucial to consider strategies to solve wood depletion within the overall context of rural development as:

i. various links between wood depletion and other rural activities have been identified.

ii. strategies should be feasible for people. Such feasibility depends among other things, on the availability of economic resources to households and their allocation over various household activities.

Strategies can be directed to increase wood supply or to reduce wood use.

Possibilities to increase wood supply are limited and their possibility is not yet assessed:

A. the establishment of woodlots near large settlements to provide firewood. For example, ERL (1985) proposes the establishment of 30 woodlots of 500 hectare close to large settlements. Such woodlots will aggravate land pressure around those settlements and need to be integrated in settlement plans. Specialised woodlots can also be considered for specific threatened species such as morukuru. In view of poor performance of existing woodlots it seems necessary to analyse problems encountered there before new woodlots could be considered. Especially the poor performance of Eucalyptus during the recent drought makes a reassessment of the choice of tree species necessary, especially if woodlots are not planned for pole production (Tietema, 1986).

B. management of wood of natural vegetation, from a wood production point of view. As natural vegetation presently provides almost all wood, such management appears essential. In practice, conflicts with other forms of land use will occur and consequently compromises have to be made. In analogue with the wildlife management areas, certain areas could be designated Forest management areas (FMAs).

C. tree planting and agroforestry.
Tree planting may have a limited direct effect on the wood supply but has probably large educational benefits in raising awareness about the need for tree conservation. The feasibility of agroforestry in Botswana is presently unclear and needs to be assessed. Low rainfall is likely to be a serious constraint and may cause direct competition between crops and trees for soil moisture.

D. trade of wood from surplus to shortage areas. Trade becomes more feasible and can cover larger distances if wood prices increase. Such trade may reduce bush encroachment when traded wood originates from overgrazed areas (Tietema, 1984) but may at the same time increase soil erosion if overgrazing continues.

To reduce conflicts between towns and surrounding rural areas (conflicts between collection by traders and villagers), Government regulations seem necessary in addition to the proposed comprehensive landuse planning. Such regulations could stop traders from collecting wood within certain distances of villages.

Other possibilities aim at reducing demand for wood by increasing the use of substitutes such as electricity, coal and solar power and by improving the efficiency of wood use. Expansion of the electrification programme to large villages and the availability of coal will decrease wood use by public facilities and enterprises. However, costs for substitutes, certainly electricity, are likely to be too high for most individual rural households. Substitutes have better prospects in urban areas, which can be more easily supplied and require less investment costs on the part of households (e.g. lower connection fee). Stoves and so-called wonderboxes could increase wood efficiency but actual benefits depend on the design, and these in turn, determine the people's willingness to purchase wood-saving devices.

CHAPTER 6

MINERAL PRODUCTION

6.1. Mining and the Environment

> Increased mining backbone of economic growth and Government revenues - exploration expenditures subject to international market factors

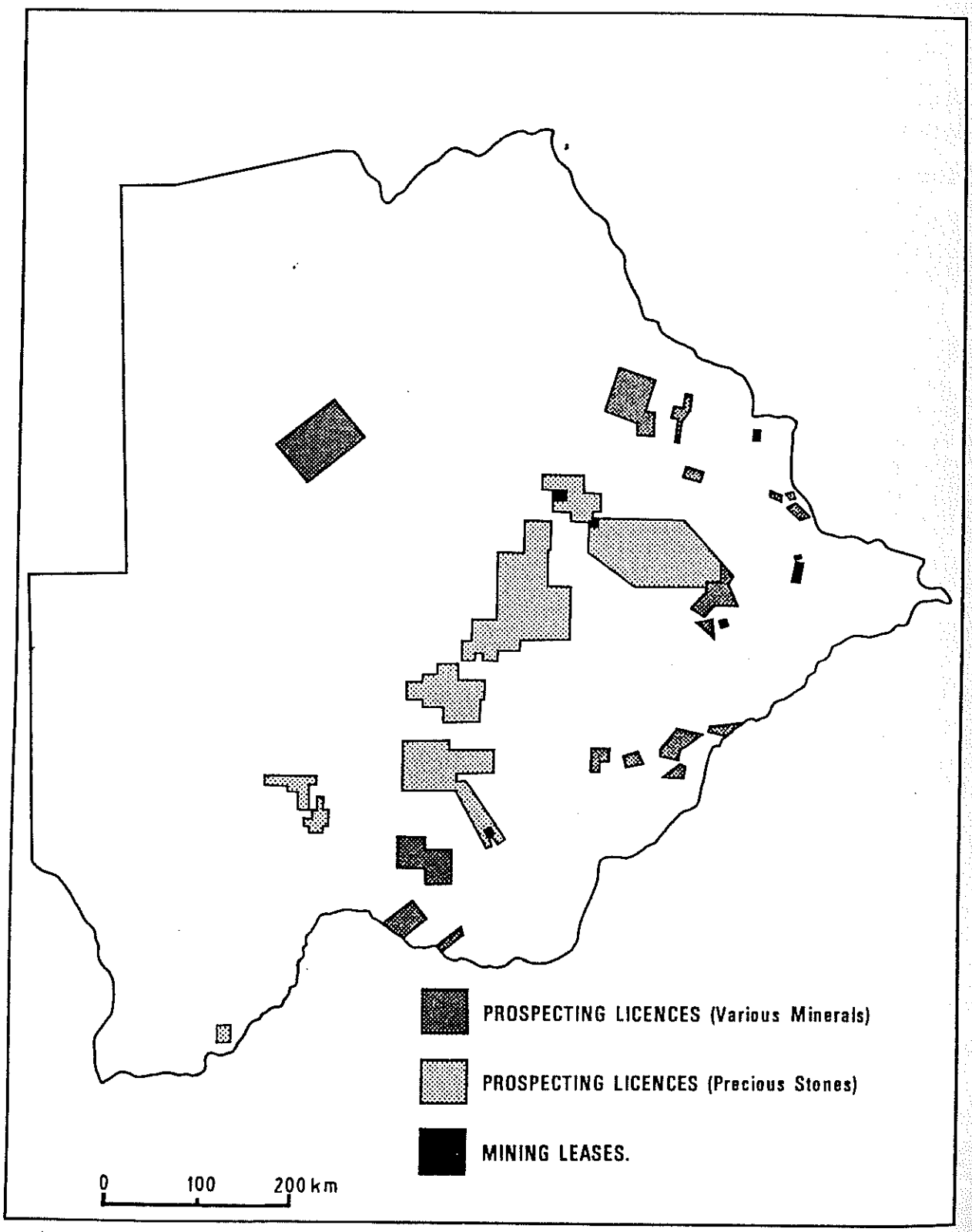
Actual mineral exploitation depends entirely on the existence of non-renewable mineral deposits. A number of activities such as exploration and prospecting have to be undertaken before exploitation can be considered.

Exploration and prospecting were limited and relatively small scale exercises before Independence (e.g. manganese, gold, asbestos, kyanite and talc). Large scale exploitation of diamonds, coal and copper and nickel started in the early 1970's and has grown rapidly since. Most pre-Independence exploitation has ceased because it was no longer economically viable (e.g. manganese in 1973 and asbestos in 1976). The total estimated value of the annual mineral production has increased from P20,000 in 1966 to P961 mln in 1984. The production of diamonds (1984: P874 mln), copper and nickel (P78 mln) and to a lesser extent coal (P5 mln) are most important. Presently, precious metals (gold recovered from old dumps), precious and semi-precious stones, base metals, fossil fuel and building and industrial minerals are exploited (Table A.6.1). In addition, prospecting for various minerals still continues. Mining leases cover a small, almost constant area of 450 to 500 km^2 (Map 6.1). Prospecting is done throughout the country but has decreased substantially in the 1970's. The area held under a prospecting licence in a year dropped from over 300,000 km^2 in 1972, roughly a third of the country, to some 40,000 km^2 in 1982; Johnson and Clarke, 1983 and Figure 6.1.) This downward trend reflects a change in the Mines and Minerals Act limiting prospecting licences to 1,000 km^2. Mineral exploration expenditures fluctuated significantly mainly in relation to international market factors such as diamond sales, energy and copper prices. Exploration expenditures per km^2 varied from a low of 10g $/$km^2$ in 1976 to almost 300 us$/$km^2$.

Most mining activities are concentrated in the middle and eastern parts of the country, particularly in Central District (Figure 6.2). Prospecting activities extend into Kutse and Central Kalahari Game Reserves but no exploitation has occured as yet. Mining has been the backbone for the rapid economic growth since the mid 1970's (Table A.6.2-A.6.5). Mining has boosted exports and the national product and accounts now for almost half of the Gross Domestic Product and 80% of the exports (Department of Mines; Colclough and McCarthy 1980). The sector has become the major source of foreign exchange and government revenues and therefore of most development efforts. During the period 1979-1984, government received 34% of its revenues from the mining sector (even 48.8% in 1984!). As a result the mining sector has

Map 6.1.

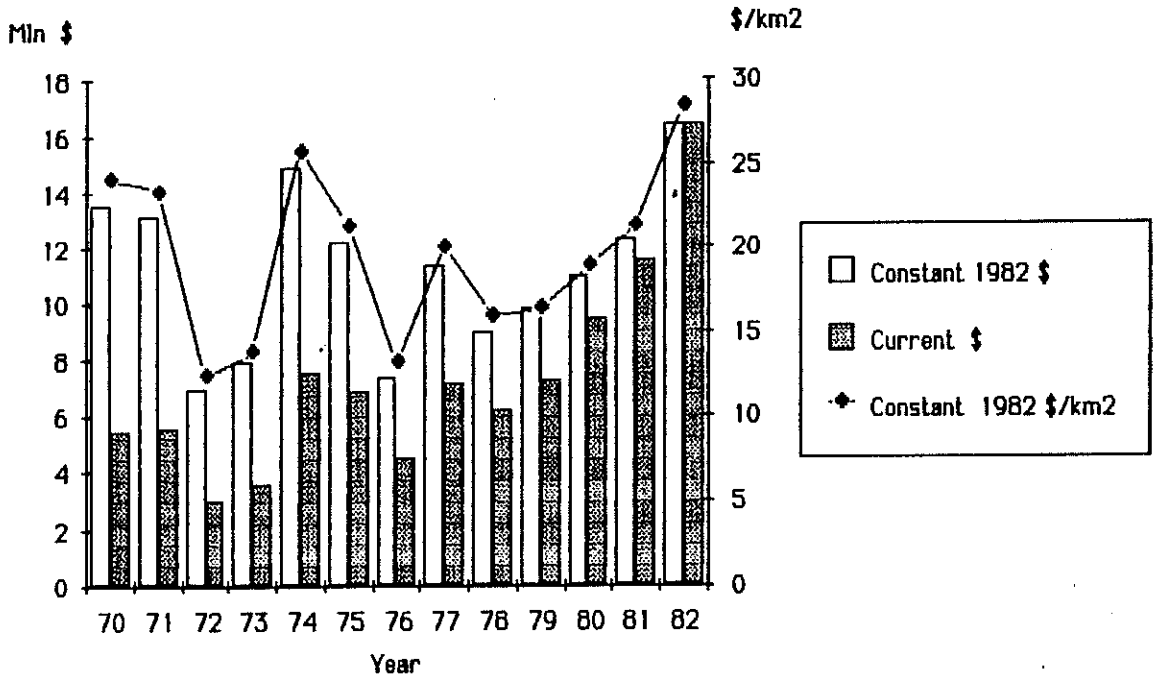
Areas held under Prospecting Licences and Mining Leases
as at 1st January 1985



Source: NDP6

Figure 6.1.

Mineral Exploration Expenditures in Botswana



Source: Johnson and Clark (1983)

contributed significantly to the improvement of rural and urban services and the provision of incentives for other productive sectors (Moremi, 1986).

Government is actively involved in the mining sector. Government acts often as a partner in mining companies (50% share in Debswana, 15% in BCL). The Departments of Mines and Geological Surveys are involved in reconnaissance, exploration and monitoring activities. In addition, they issue licences and leases for prospecting and mining of specific minerals (in accordance with the Mining Act). The latter gives the lessee exclusive users' rights to the surface and is valid for 25 years (with a renewal option). The lessee has the right to exploit minerals, build necessary infrastructure, including drilling of boreholes, and stack or dump waste in an approved way. The former covers a maximum area of 1,000 km^2 and is valid for three years (with renewal option). It gives the holder the right to drill boreholes and erect camps.

Most mining lease areas are part of larger so-called planning areas under the Town and Country Planning Act (1977). For each planning area a development plan has to be prepared and approved and subsequently for all developments permits have to be obtained from the Town and Country Planning Board. Therefore, all developments in such areas can be fully controlled by government. Mining areas are considered controlled areas under the Atmospheric Pollution (Prevention) Act 1971. This act allows standards to be set for air pollution. Presently, however, government has only issued objectives for SO_2 and Total Suspended Particulates in residential areas.

The Water Act requires people and enterprises to seek permission to use water from the Water Apportionment Board. A mining lease gives the right to groundwater for mining operations. In general, use of water is subject to conditions such as:

a. the extracted water should be returned to the main source if possible.

b. extracted water should not be polluted to the extent that it causes danger to public health, animals and crops.

However, no water standards have been set to operationalise the second criterion nor are waste discharge permits needed.

Mining has specific economic and environmental characteristics. On the economic side mining is capital-intensive. For example, between 1973 and 1981, mining absorbed 31.5% of the gross capital formation but provided only 8 to 9% of the formal employment (Central Statistics Office, 1984). Mining projects can be considered as 'enclaves' with limited spin-offs although attempts are being made to turn them into growth centres. Possibilities to do so depend heavily on the location of the mining town. The main minerals are exported and production therefore depends to a large extent on external factors such as demand, prices and exchange rates. The diamond market has proved more stable than that of copper and nickel but it is not immune to world recession. Plans for an additional coal mine for export have been shelved because of the low world coal prices. On the environmental side, mining has to take place where deposits are discovered and therefore the possibilities of avoiding conflicts with other activities are more limited. Links with the environment results from:

i. utilisation of resources. Such use refers to the non-renewable minerals and requirements for land, water and energy to exploit and, in some cases, process the minerals. Mining competes with other activities in this respect.

ii. pollution during mining and processing stages.

Mining has both a one-time and permanent effect on the environment. The former refers to the change in the local environment due to the establishment of a mine and related infrastructure. The latter refers to environmental effects resulting from the operation of a mine.

The actual effect on the environment and vice versa, depends on the location of the mineral deposits (e.g. previous land use, water and energy supply) and on the nature and size of the mining activity (e.g. open cast and underground). It is therefore necessary to discuss the existing mines individually.

1. Diamond Mines

First, Orapa started operations in 1971, followed by Letlhakane (1977) and Jwaneng (1982). The mining lease areas cover 166 km^2, 25 km^2 and 48 km^2 respectively. Aggregate production has increased rapidly since 1979 (Table A.6.1). The size of diamond pipes is not known but deposits are said to be sufficient for a considerable period. Diamonds are mined by the open cast method. The mines in Orapa and Letlhakane receive electricity from the coal-fired power station in Selebi-Phikwe; Jwaneng from the plant in Gaborone and/or

South-Africa. Jwaneng's water supply relies on a specially constructed wellfield. Orapa gets water from Mopipi Dam and presently, because the dam is dry, from a back-up wellfield. These waterworks have been constructed specifically for the mines. Orapa is a 'closed' town with 5,229 inhabitants and depends on the mine. It is located in a predominant grazing area for livestock with some wildlife as well. Jwaneng had 5,567 inhabitants in 1981. It is better located to become a district sub-centre. Although at present the town relies mostly on the mine (e.g. 75% of the local employment). Jwaneng is located in the sandveld mainly used by cattle but near wildlife areas.

2. Copper/Nickel

BCL has been exploiting ore in mines in Phikwe and Selebi since 1973. Since 1980, when the open pit in Phikwe was exhausted, only underground mining takes place. At Selebi-Phikwe, matte is produced and subsequently exported to Zimbabwe and Norway. The estimated production of matte has continuously increased from 6,663 tonnes in 1973 to a record of 51,845 tonnes in 1984 (Tables A.6.1 and A.6.7). Adverse developments of world market prices for copper and nickel, are the main reason for continuous financial losses of the mine, necessitating re-scheduling of debts. However, prospects for the future have recently improved because of the discovery of additional copper and nickel ore* and by the establishment of more favourable marketing arrangements. he additional ore extends the life time of the mines to at least another 22 years compared with the expected 18 years in 1973. The mining lease area covers 256 km^2; BCL holds surface rights over 17 km^2.

In order to supply the mine with water and electricity a dam in the Shashe river, 90km north-west of Selebi-Phikwe and a power plant were constructed next to the mine. About 80-85% of the electricity generated is used by BCL. BCL is by far the largest single water user in the country with an annual consumption of around 6.1 mln m^3. A railway line was constructed to transport coal and ore.

Selebi-Phikwe is located in an agricultural area used previously for livestock and crop production.

The town has grown rapidly closely related to the expansion of BCL. It is the third largest town in the country with almost 30,000 inhabitants. Links with the surrounding area are relatively limited (Department of Town and Regional Planning, 1984). Around half of the formal employment is provided by BCL. The town now has 29,649 inhabitants (Population Census, 1981). The reserved area for the town amounts to 45 km^2. Government has initiated a programme to diversify the town's economy.

3. Coal Mining

Morupule's coal production is used mainly by the power plants in Selebi-Phikwe and Gaborone. Production in the past has reflected local requirements and, for example, the temporary closure of the power plant in Gaborone to save water, has led to a lower production in Morupule. Likewise, the establishment of the large power plant close to the mine, will increase annual production beyond the

* Ore deposits doubled between 1977 and 1984 (Table A.6.8.)

present level of 400,000 tonnes (Table A.6.1). The mining lease covers 21 km^2 mixed farming area but the mining takes place underground. The coal is not treated at the mine (e.g. washing). Transport of coal is possible through a 10 km track of the main railway. Since the mine is close to Palapye, no separate residential developments have taken place but the mine and new power plant contributed to the rapid growth of Palapye. Botswana has large coal deposits at Morupule - Serowe and Mmamabula, estimated at possibly 10,000 mln tonnes each (Baldock, 1977). New mines would have to produce for export purposes. Present low world prices for coal and high transport costs of coal for shipment have led to suspension of plans to establish a coal mine at Kgaswe.

4. **Other Minerals**

Although pre-Independence small mines have closed, some deposits still remain (e.g. 200,000 tonnes of manganese at Kgakgwe mine; Baldock, 1977). Old gold dumps around Francistown are being reprocessed to extract gold through more refined techniques. Crushed stones, sand and gravel are increasingly exploited. Their value is relatively low but the volume is significant. Exploitation is concentrated in eastern Botswana and takes place on a small scale. Plans to mine brine deposits from the Makgadikgadi Pans are being considered. Brine would be pumped into ponds to get a more concentrated product. Subsequently, this product would be processed to derive salt and soda-ash. If the project materialises, additional infrastructural developments (e.g. housing, roads) will be needed in the surrounding area.

5. **Future Deposits**

Exploration for various minerals continues and may prove the existence of new deposits (e.g. oil and platinum). As far as copper/nickel and coal are concerned, presently unmined deposits are known to exist in Phoenix and Selebi/Tati (proven deposit 7 mlm tonnes copper/nickel; Baldock, 1977), Selebi north (4.2 mln copper/nickel proven) and Mmamabula (possibly 10,000 mln tonnes of coal). The Matsitama area also holds copper/nickel deposits (probable deposits: 10 mln tonnes copper/nickel ore) but exploration activities have been abandoned by BCL in 1976 in favour of Selebi-Phikwe. Possible future mining developments depend on a variety of factors, including (e.g. prices, exchange rates) and cost considerations (e.g. mining costs, quality of deposits and transport costs). The location of new mines will determine, to a large extent, their environmental effects. Johnson (1981) states that with exploration levels of the late 1970s "it could take 10 to 20 years to produce a major discovery" (other than diamonds and coal).

Development Trends

1. The mining sector has rapidly become the backbone of the national economy since the early 1970's. It is the main source of government revenues which are used to improve public services and to stimulate developments of other productive sectors. The growth of the mining sector has exceeded projections during 1979-1984 (24.5% versus 15.8% per annum constant prices). However, only a modest growth is

expected over the period 1985-1991: 3.5% p.a., below the average projected growth rate of 4.8%. The establishment of the brine mine at Sua Pans is the only projected development until 1991.

2. Most mining activities are large-scale, capital-intensive and export-oriented. As a result, links with surrounding regions are limited and production is subject to external factors such as world prices, exchange rates and marketing arrangements. National projections are therefore extremely difficult to make and may need frequent revisions.

3. Prospecting activities are continuing but also appear to be subject to world economic developments. New viable deposits may be found and changes in international circumstances may turn unviable deposits into viable ones. Before actual mining can start, a period of at least 5-10 years will probably pass. Therefore, one would not expect major additonal mining projects before the early 1990's.

.3 Environmental Effects

The effects of present mining activities on the environment appear limited and depend on the nature of the mine and its location. Two types of effects can be distinguished:

a. effects through resource use
b. Effects through pollution

1. Effects through Resource Utilisation

Mining activities cover relatively small areas even if one includes the necessary infrastructure and residential areas.

The open pit mines leave large holes in the ground and heaps of waste material. Arrangements could be considered to rehabilitate mines after exhaustion of the minerals. Obviously, land use in the mining areas has locally completely changed. Fossil groundwater is being used in Jwaneng and, irregularly, in Orapa, the extraction of which has no effect on vegetation in surrounding areas. Mopipi dam has probably attracted additional livestock and wildlife, aggravating local overgrazing and competition between both. The mining sector accounts for 12.6% of the total water use in the country (approx. 44,000 m^3/day) and 75.4% of the estimated energy consumption in Botswana. Therefore, environmental effects from coal-fired power plants can, to a large extent, be attributed indirectly to the mining sector.

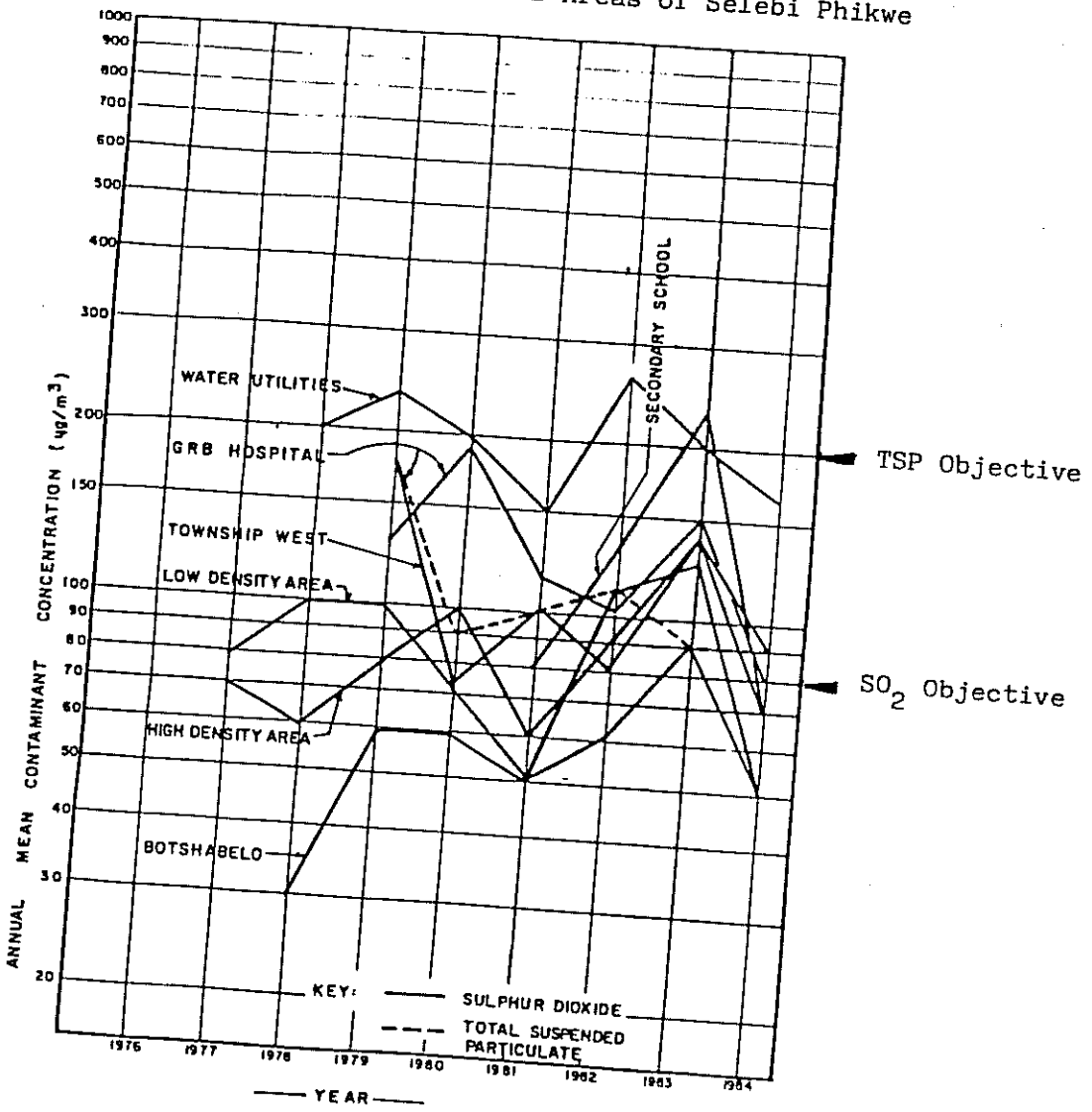
2. Effects through Pollution

Present pollution from mines is confined to Selebi-Phikwe. Diamond mines cause no pollution other than some dust in Orapa. During the production of copper and nickel matte in Selebi-Phikwe, air and water pollution occurs.

Selebi-Phikwe is the country's only town facing air pollution problems. A joint monitoring programme has been established by the Department of Mines and BCL. Government has set SO_2 air quality objectives for residential areas at 80 mg/m^3 for the annual arithmetic average.

Figure 6.2.

Air Quality in Residential Areas of Selebi Phikwe



Source: Department of Mines, 1985

These objectives are in the range of standards used in other countries but are, for instance, more lenient than WHO standards (Table A.6.9). The objective for the annual average of Total Suspended Particulates (TSP) appears more relaxed than in other countries. SO_2 objectives and TSP are reached regularly and even exceeded in some residential areas and public facilities (Figure 6.2 and Table A.6.10). An air pollution abatement programme, aimed at diverting most surface emissions to high stacks, led to lower concentrations in 1981 but pollution has been erratic afterwards. Survey results suggest that inhabitants of the town fall ill more frequently after their arrival, and people believe their health complaints are related to BCL's operations (Mbere, 1981). However, the study was limited and did not, for example, look at health problems and their relationship to BCL's operations in detail. Air pollution problems for inhabitants are also due to the fact that the town is not located east of BCL (off wind). Effects of air pollution on vegetation and livestock have not been established.

Existing data do not reveal any damage to vegetation (Department of Mines, Annual Reports; Kerfoot, 1979). Some cattle around Selebi-Phikwe appear to suffer from lung diseases but the relationship with SO_2 - pollution is not established and no comparison with other regions was made (Matale, 1980).

The company embarked on a water pollution abatement and recycling programme in 1979/80 and monitors the water quality at 14 sampling points on site and along the Mathathane/Motloutse river. Only overflow from a slag granulation cooling pond is discharged into the river. Water from the concentrator is collected in a dam and recycled. This water is of very poor quality compared with the overflow from the pond (Table A.6.1). The Mathathane and Motloutse rivers have relatively high concentrations of TDS, SO_4 and various heavy metals. No data exist for Selebi-Phikwe assessing potential effects of water pollution on human beings, livestock, vegetation and groundwater.

Exploration activities usually improve access to the areas under investigation through the establishment of cut lines. Such lines may bring about positive developments but can also affect wildlife through poaching (Ngwamotsoko, 1985). The extent of poaching facilitated by cut lines is not known.

6.4. Strategies to Alleviate Environmental Problems

Present environmental problems and conflicts with other land use forms are limited. Strategies should concentrate on the alleviation of the air pollution problem in Selebi-Phikwe and attempts to restrict possible future problems as further development of the mining sector is crucial for the country. Pollution problems in Selebi-Phikwe could be restricted by further reductions in emissions and discharge of effluent. Negative effects can be limited by planning the expansion of the town off-wind, particularly public services. The Town and Country Planning Act already equips government with that required planning control. This law can also be used to control air and water pollution by attaching conditions to development licenses in planning areas. Standards for pollution are needed to make such efforts systematic. Monitoring programmes should continue and could be executed by independent institutions (e.g. Government and the University). Emission and effluent standards could be set as well as standards for air and water quality. Finally, conditions could be set, as part of the Mining Act, on waste disposal and if necessary, rehabilitation of the mining area after closure (e.g. open pit). Environmental effects of possible future mining operations depend heavily on the nature of the activity and its location, and therefore cannot be predicted. It seems necessary to strengthen procedures and legislation so as to be able to deal with individual cases adequately. A first step to gain insight in possible effects would be the requirement of an environmental impact assessment prior to the establishment of the mine. Such statements should provide information on the expected use of environmental resources, on possible pollution and measures to restrict undesired effects. Secondly, clear standards could be set for air and water quality or emissions and effluent. Enterprises could be required to apply for permits when their contribution to pollution exceeds a minimum level.

CHAPTER 7

OTHER PRODUCTIVE ACTIVITIES AND CONSUMPTION BY HOUSEHOLDS

7.1. Other Productive Activities, Consumption and the Environment

As the country's economic growth is mainly based on minerals and livestock, and agriculture is the dominant land use form, there is a tendency to pay little attention to other productive activities and consumption in the discussion about environment and development. Although present effects of these activities may be confined mostly to urban areas and be limited in size, continued population growth and diversification of the economy will make them increasingly important in the future. In addition, environmental effects may be limited but possibly serious (e.g. pollution and depletion of groundwater) and therefore cannot be ignored. Unlike in previous chapters, emphasis is not only on resource utilisation but also on pollution.

1. Productive Activities*

The country has relatively large government and trade sectors and only a small manufacturing sector (Table 7.1.). This situation reflects:

- the small domestic market
- the existence of more industrialised neighbours
- the country's incorporation in the customs union

Most consumer and investment goods are imported from South Africa and hence do not make any claim on local environmental resources nor cause pollution during their production. Other productive opportunities contribute 60-70% of the Gross Domestic Product but their major importance lies in the provision of formal employment. In the period 1975-1984, 80 to 90% of the formal employment was created through these activities, mostly in urban areas. The concentration of formal employment in urban areas enhances the process of urbanisation.

The informal sector operates in both rural and urban areas. Few details are known about this sector but it is believed to be small in comparison to other countries. Productive activities include textiles, repairs and maintenance, selling of, for example, fruits and beer brewing. In addition, harvesting and processing of environmental resources such as palms, wood and grapple are locally important activities (see chapter 4). Informal activities often supplement income from agriculture and formal employment and are therefore of particular importance for those who lack access to other productive opportunities and also during droughts.

Growth of other productive activities has kept equal pace with the overall economic growth. Since 1966 manufacturing contributes 8 to 10% of the GDP. Utility corporations (e.g. water, electricity) have

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* Other than discussed in previous chapters.

expanded their share to 3-5%. The trade and hotel sector has also increased to around 20-22% of the GDP. Construction activities fluctuate between 5-10% (Table 1.3).

Although the manufacturing and utilities sectors are small, most environmental effects of other productive activities are likely to originate here as these are prime users of resources such as water and energy and may cause pollution during the production process. Manufacturing is closely linked to agriculture through the abattoirs and other agro-based industries, accounting for 45% of the manufacturing output (Table 7.1). In the 1960s, meat production represented almost the entire manufacturing production (Colclough and McCarthy, 1980). The breweries and textile enterprises are also important sectors. Utility enterprises comprise parastatal activities such as waterworks (e.g. dams, wellfields) and electricity generation in Selebi-Phikwe, Gaborone and Morupule (see Map A.7.1.).

Table 7.1.

The Structure of Productive Activities* (1981/82)

		Gross Output	(mln P)
Manufacturing		210.9	
of which:	meat and meat products	79.5	
	beverages	29.5	
	textiles	24.5	
	dairy/agro-based	14.8	
	village industries	9.2	
	other manufacturing	53.2	
water, electricity			53.9
construction		151.9	
trade, hotels		213.9	
transport, communications			107.0
services, finances			100.0
government, insurances			283.9

* excludes agriculture and mining
Source: National Accounts 1981/82

In view of the projected low growth rate of mining in future, other productive activities will become more important in achieving the planned growth rate of 4.8%. Manufacturing is assumed to grow until 1991 by 8.3% per year. The new abattoir in Francistown and effects of the Financial Assistance Policy are expected to assist in achieving this target. The utility sector will be the second major growth sector. Additional water works and the completion of the Morupule power plant are planned. The additional plant and the established national grid will be adequate to cope with future national electricity requirements. The Water Utilities Corporation provides urban areas with water. Until recently, dams were the main sources of supply. Drought and increases in demand have shown the supply system to be inadequate in the south eastern part of the country. The Ramotswa wellfield overcame shortages but will not suffice in future. New dams and the Kanye wellfield can augment regional water supply but most probably water needs to be

transported from the Francistown region during the 1990's (Figure A.7.1-A.7.3). The latter area has additional good damsites and is likely to have surplus supply. VIAK (1985) proposes construction of new dams, development of wellfields and the construction of a water pipeline connecting major sources of supply and demand. Although the study does not suffice as the basis for detailed investment planning (e.g. demand scenario's are too simplistic and the potential exploitation of wellfields need further investigation), it makes it clear that additional water works are needed, particularly for the south eastern part. The proposed mixture of surface and groundwater increases reliability and flexibility of supply of particular importance during droughts.

2. Consumption by Households

As a result of the economic growth, population growth and changed settlement patterns, consumption has changed in size and composition. The former is illustrated by a continuous increase in final consumption* from P104 million in 1973/74 (56% of GDP) to P466 million in 1981/82 (61% of GDP; see Table A.7.1.) Final per capita consumption has quadrupled in real prices between 1971 and 1981 from P102.90 to P418.60 (increase at constant prices approximately 19%). In the same period, the population increased by 64% and the average per capita income by 349% from P181 to P810 (increase in constant prices approximately 31%).

Increased personal incomes and urbanisation have probably led to changes in consumption patterns but no data exist to substantiate this change. In view of the low average income and the known skewed income distribution, most households will consume basic needs such as food, clothing and shelter. NDP 6 does not include forecasts for the development of consumption by households. However, one may expect a similar growth rate as for GDP and a further change in consumption composition.

3. Resources Use

1. Land

Although the amount of land for other productive purposes is not known, it is believed to be small in comparison with other forms of land use and confined mainly to urban areas. Direct surface needed for dams and wellfields are relatively small but the catchment areas of such water sources can cover large surfaces. For example, the catchment area of the Gaborone dam is some 4,200km^2 and therefore more than twice the size of South East district. Aquifers in Serowe, Mmamabula and Molepolole could involve even up to some 10,000 km^2 (WLPU, 1985; VIAK, 1985).

2. Water

Water use of urban and rural settlements is estimated to be less than 20% of the country's total water use: 40,730m^3/day and 17,900 m^3/day respectively. Unlike in the case of livestock, these water demands are concentrated in towns and large settlements. Urban water demands have increased rapidly as a result of:

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* Consumption of consumer goods.

- rapid urbanisation
- improved accomodation
- establishment of new industries

For example, Gaborone water consumption increased by 12% per annum prior to the drought. Subsequent water restrictions on non-essential use, led to a reduction by 50% to 11,000 m^3/day (Child and Krook, 1985). Similar increases have taken place in the large villages. For example, water use from village standpipes is around 15 litres person/day). When standpipes are present in the yard, average use quadruples and when taps are inside the house water use is around 150 litres/person/day.* Because productive activities have been very limited in rural areas, these have so far been less responsible for increased rural water use. However, they are likely to become a more important factor in future.

As a result of the above, water supply has become inadequate particularly in south-eastern Botswana and some large villages. Expansion of borehole systems for villages were required as well as additional supply for Gaborone and Lobatse. The Department of Water Affairs has expanded various water supply systems in villages (e.g. Mochudi) and the Water Utilities Corporation has embarked on various schemes to increase the urban water supply systems.

3. **Energy**

Coal and coal-generated electricity are the main energy sources of manufacturing and commercial acivities (48.7% and 38% respectively). Transport, government and pumping of water are major users of petroleum. Firewood is mostly used by households and has been discussed in chapter 5. Most coal and electricity are produced locally (91% and 87% in 1982. UNDP/World Bank, 1984). All petroleum is imported (Table A.7.2.) Coal production takes place at Morupule, while electricity is generated at Selebi-Phikwe, Gaborone and Morupule where a new power plant started operations in 1986.

4. **Government and Legislation**

To reduce dependence on minerals and agriculture, government attempts to actively diversify the economy through direct involvement such as BEDU, and factory shell programmes where premises and extensions are made available and through provision of subsidies.

The Financial Assistant Policy (FAP) is now the major incentive for small, medium and large scale industrial activities. New productive activities as well as extensions are subsidised for a limited period. Subsidy levels depend, for example, on the location of the project, e.g. rural projects more subsidised, employment creation, etc. During 1982-1984, 95 projects received assistance with a projected employment of 3216 (NDP6). This included 40 rural projects and 1143 projected jobs, e.g. sewing, knitting, carpentry, welding (Table 7.2).

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* village supply systems are designed to provide 20 litres/person/day

Table 7.2.

Financial Assistant Policy
Summary Results; Medium Scale Industrial Projects,
May 1982-November 1984

Project Sector	No. of Projects Rural	Urban	Total	Projected Employment Rural	Urban	Total
Textiles	4	13	17	42	778	820
Concrete products	5	2	7	121	53	174
Mechanical projects	1	7	8	10	157	167
Woodwork projects	3	5	8	92	157	249
Sorghum Milling	8	1	9	53	8	61
Bakery Projects	5	2	7	178	37	215
Leather & Leather Goods	1	4	5	27	293	320
Meat Products	-	1	1	-	17	17
Paper products	2	4	6	115	144	259
Chemical Projects	1	2	3	8	34	42
Food processing	3	3	6	145	90	235
Other	7	11	18	352	305	657
Total	40	55	95	1143	2073	3216

Source: NDP6

In addition, government is involved in a number of parastatals which are responsible for the provision of water and electricity in urban areas (Botswana Power Corporation and Water Utilities Corporation) and for the encouragement of local industrial development (BDC).

Because of the rapid growth of towns and large settlements, planning and legislation is needed to minimise land conflicts and possible pollution by enterprises and households. All urban areas are so-called "planning areas" under the Town and Country Planning Act and it is under consideration to expand these to large rural settlements. As indicated in chapter 6, developments can be fully controlled by local and central government planning bodies. The Atmospheric Pollution Act sets objectives for air quality in residential areas for SO_2 and NO_x but does not have any restrictions on emissions (see chapter 6). The Water Act requires enterprises to seek permission to use water and hereby gives the Water Apportionment Board a strong controlling power. However, there are no regulations regarding discharge control and protection of catchment areas. Suggestions for revision of the Water Act also include the establishment of a comprehensive institutional structure, dealing with the various authorities involved (various departments and ministries) and the incorporation of feasible enforcement means. (Government of Botswana, 1983).

7.2. Development Trends

1. Productive activities other than mining and agriculture are relatively small, urban oriented and cover mostly trade services and government. However, they are the dominant source of formal employment and their importance is planned to increase in the future, leading to a more diversified economy. If this materialises more demand on environmental resources and increased pollution may occur. Presently meat-based industries, beverages and textiles are the most important industries

2. Household consumption has increased substantially although the increase in constant prices was lower than the population increase. In view of the generally low incomes, the largest share of household income is probably spent on shelter and food. However, urbanisation and increased personal incomes have led to different consumption patterns among the better-of.

3. Urbanisation, general population growth and improved accomodation have led to rapidly increased water use in towns and large villages. The combination of this increase and drought has led to water shortages in south eastern Botswana and some large villages. Attempts have been undertaken to expand the capacity.

   Increased energy use other than firewood has been met through the establishment of an extra power plant in Morupule.

7.3 Environmental Effects

Environmental impacts occur through resource use and pollution. The former refers to the competition for land with other activities and the use of renewable and non-renewable resources.

1. Resource Use

Present land claims are small and mostly in or around urban settlements. In combination with the additional need for residential areas, it contributes to local land pressure around large settlements and to clearing additional areas of vegetation. Even with a rapid growth of industrial activities, the land claim cannot be considered a nationwide problem in view of Botswana's size. However, land needed for waterworks is different in that catchments areas are large and need protection in order to avoid groundwater pollution.

The increase in water use may be a serious problem where it exceeds recharge or where it is based on fossil water. Undoubtedly, too high water use is a crucial problem for any semi-arid country but the extent of the problem in Botswana is not yet known. Little information is available on recharge processes. In general, recharge varies considerably with rainfall fluctuations. In sandveld areas, recharge is low but probably above zero (e.g. 0.5mm per year: de Vries, 1985). In eastern Botswana recharge may average between 1-9mm per annum (Map A.7.2). Extraction of groundwater from aquifers is not likely to reduce the groundwater level or to increase water constraints for the vegetation. However, if development is based on use of fossil water, it becomes crucial to

identify alternative sources in time. Botswana's coal deposits are large enough to satisfy local needs and generate electricty. However, increased use of coal contributes to air pollution.

2. Pollution

Little information exists on the extent of pollution. Manufacturing companies usually contribute mostly to pollution. Their small size in Botswana and the large imports of goods implies that pollution is probably limited. In the event of increased local production, however, pollution may occur more frequently. Pollution is also determined by the type of enterprises. Presently, tanneries and power plants seem to be the main sources of pollution. Tanneries produce salty effluents with relatively high chromium levels. Small tanneries discharge effluent uncontrolled and hence pollution may reach groundwater. In Lobatse, the large BMC tannery presently uses effluent mixed with water from the abbattoir for irrigation and hence is likely to pollute soil and groundwater. This unsatisfactory arrangement will be changed so that tannery effluent will be collected separately in an evaporation pond. (WLPU, 1985). No efforts are known to clean effluent before discharge.

The existing power plants in Selebi-Phikwe and Gaborone emit SO_2 and suspended particulates. In Selebi-Phikwe, BPC contributes 1% of SO_2 emissions and 42% of suspended particulates emissions. (Department of Mines, Annual Report). In Gaborone BPC's plant is the main source of air pollution. Pollution levels in Gaborone are, however, well below the objectives for air quality.* Pollution may also occur in non-manufacturing sectors through careless handling of goods (e.g. trade in chemical products) and or through improper discharge of waste such as oil from garages and chemicals from laboratories. No systematic inventory of pollution and discharge methods by existing companies exists. Effluent probably ends in water ditches along roads or in municipal sewage ponds. The latter work through biological degradation and are not able to purify water from e.g. heavy metals which may accumulate in the sewage slib. Solid waste is mostly collected on dumping grounds. Some pollution may seep through to groundwater level but no information is available.

Household consumption causes two forms of pollution, i.e. groundwater pollution and littering. Since the early 1970s groundwater in various major villages contained too high levels of nitrate caused by human excrements seeping through to the groundwater mainly from septic tanks (Lewis, et al, 1980; WLPU, 1985; interim report water quality monitoring study, 1983). NO_3 concentrations exceed regularly 20mg/lt and in 5-10% of the cases, the WHO standards (Hutton and Lewis, 1980). There was a strong correlation between population density and groundwater pollution outside urban areas. High nitrate levels may cause health hazards, notably metheamoglobinaemia and carcinogenesis. Droughts have a temporary mitigating effect as seepage is more limited.* Septic tanks are not yet common in rural areas but may become so with improved accomodation. Therefore, nitrate pollution will probably become more important in future. Little data exist on waste

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* Based on three monitoring stations only.

± Population Census 1981: up to 5%. Mahalapye: 10% in 1984.

disposal and possible effects on the environment. In urban areas, household solid waste is usually collected by Town Councils and dumped in designated areas, where it is usually burned by open fire. Such open fires, including the ones for cooking etc., are not regulated by the Atmospheric Pollution Prevention Act. Possible effects of water disposal on groundwater are not known. In rural areas, most waste is dumped inside the compound. In Mahalapye, 47% of the plots had a waste pit. Edible parts are usually eaten by animals, the rest is usually burned and dug in. Bottles and particularly tins are thrown away everywhere as settlements and roadsides show abundantly clear.

7.4 Strategies to alleviate Environmental Problems

As presently, environmental problems due to productive and consumptive activities are still limited, the major thrust of strategies would be to avoid and limit such problems in the future. Their future occurrence also probably depends on the type of activities which will be set up. For example, ferro-fertiliser and oil-based industries rank high among polluters. Future use of water is comprehensively discussed in chapter 8.

Undesired environmental effects can be reduced or in some cases, even avoided, by adequate planning and/or the improvement of control mechanisms and treatment facilities. Regarding planning, environmental considerations need to be included right from the start. Examples, already suggested, are the establishment of water-intensive industries in the north and the location of industrial sites offwind of human settlements and other land use forms which may be affected. In addition, protection of the water catchment areas of waterworks is needed. Presently, legislation appears only adequate in planning areas but these do not yet cover all catchment areas. Amendments of the Water Act to this effect have been proposed in 1983.

Such preventive planning could be supplemented by improved control and treatment plans. It is extremely important to make an inventory of pollutants by main sources such as companies, laboratories, etc. Such information would assist to request sources to limit their pollution or to improve the treatment systems of water and solid waste. The former would require criteria for permissible pollution at the source and/or quality criteria for air and water. The latter could imply improved water treatment, for example, through the establishment of a separate sewage system for polluting sources. Regarding solid waste, it could lead to more controlled dumping of pollutants on classified dumping grounds, which have better storage or treatment facilities than ordinary dumping grounds. Industrialisation enhances the need to monitor air pollution by expanding the number of stations and also the number of pollutants registered (e.g. NO_x). There will be need to formalise pollution control measure and their enforcement by law.

Education of workers could also assist to avoid unnecessary pollution (e.g. flushing of chemicals). Such measures are not necessarily costly and in fact they may save costs in future (e.g. prevention of groundwater or surface water pollution). A combination of education and enforcement of laws through fines could assist to curb littering. Charging deposits may also assist to reduce littering and form the basis for increased recycling of materials or for a change to the use of

recyclable products (e.g. refundable glass bottles instead of tins). So far recycling is rare, probably as a result of the abundance of such materials in South Africa.

CHAPTER 8

PRESSURE ON LAND AND WATER RESOURCES

The purpose of this chapter is to provide a cross-sectoral integrated review of major environmental problems. In the analysis, a distinction will be made into causes, impacts of and responses to such problems as summarised in Table 1. Some responses are future causes of environmental problems and hence form the starting point of a new chain of cause-impact and response analysis. Through this categorisation, insights are gained in the identification of data gaps and the relative contribution of various activities to the discussed environmental problems.

The previous chapters have highlighted two main environmental problems:

1. Pressure on land leading to land degradation.

2. Pressure on water resources with a variety of possible but generally less known consequences.

Discussions in this chapter are restricted to these problems but they can also serve as an example and guideline for the analysis of other environmental problems.

8.1. Pressure on Land

Land pressure occurs in Botswana as a result of an expansion of human activities, initiated by rapid population growth, the low productive capacity of land and institutional arrangements. Population has rapidly increased by 3.3% per annum and, to varying degrees, human activities have followed suit. Livestock numbers have increased at a similar rate whereas crop production has expanded at a slower rate.

Botswana's climate is semi-arid and land has a low primary production. Low rainfall and low soil fertility result in an open savanna vegetation with a grass layer production of 200-3000 kg grass/ha per year (DHV 1980 a; Skarpe, 1983, Tietema 1984) and a tree layer production of 0,33-1.0 tonnes/ha per year (Van Vegten, 1983; Tietema, 1985). These figures are rough indications as no systematic data on primary production exist. Drought further lowers production and limits the possibilities of exploiting plant resources on a sustainable basis.

Regional differences in rainfall (250-650mm) and soil quality (e.g. sandveld and hardveld) are responsible for the concentration of human activities in the eastern part of the country: the eastern part holds $\pm$80% of the population and cattle. Land and water allocation are mostly dealt with at district level through the Land Boards. In practice, it has been difficult to acquire land or water rights outside one's district and therefore land pressure is highest in small districts with relatively high population densities (e.g. South East 61, pers/km^2 and North East 13). Pressure on land leads to two events:

a. expansion of prioritised activities at the 'expense' of others. For example, cattle could encroach into areas hitherto the domain of wildlife and arable land was allowed to encroach into areas previously occupied by cattle.

b. land degradation when the resource is over-utilised. This is the start of a vicious circle of lower land productivity and increased land needs.

Facing land pressure, people can adapt in principle in three ways:

i. geographical expansion of human activities
ii. more intensive land use by existing human activities
iii. diversification of human activities to include less land consuming activities such as manufacturing

The sectoral analyses showed that all three options occur in Botwana. With respect to livestock, it remains doubtful whether improved management can lead to higher land productivity. Presently, high stocking rates have not been accompanied by adaptation in management and has led to widespread land degradation.

Below, land degradation and three main cases of competition for land resulting from land pressure will be discussed:

A. livestock encroachment into western and northern Botswana.

B. competition for land between livestock and crop production mainly in eastern Botswana

C. general competition for land around large settlements, mainly in eastern Botswana.

8.2. Land Degradation

Land degradation comprises all processes, which cause bush encroachment, soil erosion and ultimately result in desertification. Range degradation reflects structural over-utilisation of land as well as temporary effects of drought. The preliminary map on land degradation in Botswana, compiled by Ringrose, shows that range degradation processes are ongoing throughout the country (Map 2.2). For the eastern part of the country, data are partially lacking. The size of affected land and its intensity are as yet unknown.

A number of specific regions of severe degradation can be distinguished.

- Mmankgodi/Kanye/Molepolole: Heavy land degradation and even emerging desertification* occurs probably caused by a combination of overgrazing and deforestation of lower hill slopes. For example, Mmankgodi lies within the area where firewood is harvested for Gaborone. The combination of depletion of the grass cover and cutting of trees increases the run-off in this hilly area and results in extensive gully formation.

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* Desertification refers to land degradation which is difficult and/or costly to reverse.

- Letlhakeng: The degradation here is probably mostly due to overgrazing by cattle.

- Matsheng Villages: This example indicates the vulnerability of the environment around growing settlements in the Kgalagadi area. Desertification is occurring. Heavy overgrazing occurs caused by cattle and possibly supplemented by deforestation.

- Bokspits area: Serious desertification occurs here, caused mainly by cattle. The formation of sand dunes may to some extent also be a natural phenomenon here, as rainfall in the area is very low.

- Okavango around Seronga. Denudation is severe and probably related to arable farming, but cattle may also play a role.

- Lake Ngami up to Moremi Wildlife Reserve. Degradation here around Lake Ngami and south of the Buffalo fence is caused by cattle. North of the Buffalo fence land degradation occurs through wildlife. Immigration routes of wildlife are blocked and concentration of grazing by wildlife occurs next to the fence.

- Lower Boteti area - Mopipi dam - Makgadigadi pans. These are probably the worst areas of range degradation in the whole of Botswana. First signs of range degradation north of Lake Xau were reported by Blair Rains and McKay (1968). The amount of cattle and wildlife then exceeded the carrying capacity. Currently, the area is badly overgrazed by cattle.

1. Causes of Land Degradation

Land degradation is caused by most forms of land use and can be accelerated if various activities enhance each other.

The livestock sector has expanded rapidly. Cattle numbers increased from 1.2 mln in 1966 to 2.5 mln in 1985. Grazing areas in eastern Botswana are mostly filled and therefore expansion into western and northern sandveld took place. The magnitude and speed of this expansion are not known* but could be partly retrieved from borehole records and airphotos. Salinity and low yields are the main problems for further encroachment (Map 1.3.). Livestock numbers increased rapidly because:

1. Veterinary services, tsetse control and borehole technology opened new opportunities.

2. Cattle holding was attractive as investment, savings and source of status.

3. Small herd owners have inherent motives to increase the herdsize to at least 20 to have own draftpower and be less vulnerable to droughts.

Small herd owners are mostly confined to mixed farming areas where they can economise on labour by alternating to crops as well as cattle. In addition, large cattle owners have a tendency to restrict access to boreholes and therefore grazing areas under land

* Records are incomplete and airphotos are available for a limited number of years only.

pressure. As a result, stocking rates are usually highest in mixed farming areas. For example the Livestock Management Survey 1982 showed that stocking rates in 'mixed farming' areas were 5.7 ha/LSU as compared with 13.5 ha/LSU in grazing areas. The growth of the national herd has led to a situation where almost throughout the country stocking rates exceed carrying capacity. Although stocking rates decreased by 10% during the present drought, it is likely that the actual carrying capacity increased by more and therefore overgrazing became even more serious.*

Few data are available on land degradation caused by crop production. Arable land use covers around 1% of the total country. In 1980/81, a record 270,000 hectares was under cultivation. If short-term fallow land is included, arable land covers probably 800,000 - 1 mln hectare. Arable land use is much more important in small districts. For example, arable land in North East and South East districts represented 11 and 15.5% of the total area in the mid-1970s (DHV, 1980 b). It is difficult to assess a trend in arable land development as planted areas strongly fluctuate with rainfall and no other historical data are available. Arable land has probably expanded but slower than the population. DHV (1980 b) estimated that gully and sheet erosion would affect future arable production mostly in Kweneng and Southern District, where 7 and 12% respectively of the arable fields were affected. Soil erosion is especially enhanced by activities that leave the topsoil unprotected such as bush clearing and de-stumping, winter ploughing and bare fallowing. The large sizes of fields render the soil more prone to wind erosion. This effect is less where fields are only partly used and vegetation is re-established on the fallow parts. If arable production becomes more attractive in future, sheet erosion may increase. Present farmers and extension activities pay little attention to limiting erosion.

Map 2.2. shows that land degradation also occurs in areas mainly used by wildlife. Such degradation may result from:

a. increased wildlife numbers
b. reduced land available for wildlife
c. drought effects and increased activity of harvester termites.

It is not known how wildlife numbers have developed historically but it seems unlikely that there has been an increase. The encroachment of livestock into the entire eastern hardveld and into the western sandveld has reduced the area available for wildlife**. The combination of livestock encroachment and hunting has led to the withdrawal of wildlife into the areas where human activities are limited. As a result, grazing pressure increases in such areas and may exceed the carrying capacity especially during prolonged droughts. Grazing pressure also becomes more permanent when migratory opportunities are no longer possible. Large areas are set aside for wildlife (e.g. National Parks and Reserves cover 17% of the country) or planned primarily for wildlife utilisation (e.g. wildlife management areas: 8% of the country). However these may

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* Carrying capacity has not been monitored systematically during the drought.

** This reduction mirrors the livestock encroachment area which can be estimated from borehole records and airphotos.

still be inadequate to host present wildlife numbers and therefore a new equilibrium needs to be found. Unfortunately, few data exist about the extent of land degradation by wildlife. In areas such as the lower Boteti, overgrazing is caused by both wildlife and cattle. In such cases, very little information exists about the relative contribution of each 'agent'.

Wood collection is usually not a cause of land degradation on its own. Wood collection can often be combined with other land use activities such as grazing and under such circumstances land degradation may result from simultaneous overgrazing and deforestation. Wood collection on hills, however, can be solely responsible for severe gully erosion at the foot of hills. In south eastern Botswana, the demand for firewood is greater than local supply, the shortage of firewood has resulted in reduction of the tree layer. Large trees of both preferred and less preferred species have been cut around towns and villages. Complete deforestation has not yet occurred but deforestation will be encouraged by the emerging practices of cutting and burning down of live trees and less selective collection of firewood species.

2. Impacts of Land Degradation

A reduction in land suitability usually implies lower productivity and therefore additonal land requirements. This has led to extra competition between various land use forms. The most important effects of land degradation are the reduction of soil suitability and the increased run-off of rainfall water. In the livestock sector, land degradation affects mostly cattle. In combination with variations in rainfall and herdsize, land degradation explains high mortality ratios and lower birth ratios (see e.g. Livestock Management Survey). Goats are known to do relatively well in degraded areas and this is evidenced in the rapid increase in goat numbers during the recent drought in sharp contrast with a drop in cattle numbers. Between 1981 and 1984, goat numbers increased by 38.9% whereas cattle numbers dropped by 9.5%. Land degradation affects particularly small cattle owners as they keep their cattle in the most congested mixed farming areas and are likely to lose access to boreholes in grazing areas.

In the arable sector, soil erosion leads to reduced soil fertility, reduced rainfall infiltration in the soil and difficulties caused by gully forming to work the land. The magnitude of these effects has not been studied. Soil erosion within arable lands may be enhanced by land degradation outside the fields especially in hilly areas where overgrazing and deforestation contribute to increased run-off and gully forming (e.g. Mmankgodi area). Overgrazed wildlife areas probably encourage migration. Where migration fails, a decrease in numbers as well as species of wildlife will occur. Species whose niche requirements are no longer met disappear or their biological performance is affected until a balance between numbers and areas is restored.

The other major effect of land degradation is increased run-off of rainfall water. Such an increase occurs mainly in the eastern hardveld but quantitative data to demonstrate the extent are lacking. Increased run-off has two effects:

i. the loss of water further limiting the growth of grass, crops, etc. Most rivers in eastern Botswana cross borders with neighbouring countries and only a small portion of the run-off from rivers is stored in dams.

ii. the enhancement of gully erosion and loss of soil. Therefore, land degradation becomes a self-surporting process which is difficult to control.

3. **Responses to Land Degradation**

Although most people are aware of ongoing land degradation, responses have been inadequate and often even absent. For example, 59% of the people in North East district noticed an increase in the number of dongas but the same percentage believes that dongas cannot be prevented and 41% believe that they cannot be repaired (Fortmann, et.al, 1983). Only 26% of the respondents could make specific suggestions as to how to prevent dongas and only 32% knew how to repair them. Almost all respondents (98%) stated that grazing had become worse and fewer trees existed compared with 10 years ago. Almost 70%, however, did not know how to improve this situation in the communal areas. Fortmann et.al (1983, 227) conclude that "failure to follow certain range management practices would appear not the result of ignorance but of the genuine limitations of options for actions."

Land rehabilitation is based on addressing the causes of land degradation and these lie beyond the control of individuals or individual communities. One response by people has been to acquire exclusive land or water rights. If such rights are not accompanied by improved stock control and management practices, no land rehabilitation will take place (e.g. Nojane ranches). Increased exclusivity in communal grazing areas may improve the range situation locally but increases pressure on already overcrowded mixed farming areas.

Government has responded to land degradation by increased land use planning efforts and by starting a number of specific land rehabilitation projects through the District Conservation Committees.

Most land rehabilitation projects are small-scale and scattered over the country. Relatively limited funds are available for these projects. It appears that most projects suffer from problems related to community involvement, continuity and local skills. However, a systematic evaluation has not taken place.

8.3. Three Cases of Competition for Land

Land degradation is often the result of increased pressure on land. Increased land pressure, however, also causes more direct competition for land without necessitating land degradation. Therefore, the three main forms of competition for land warrant separate discussion even though they are linked to land degradation.

1. Competition between cattle and wildlife

Causes

Competition between cattle and wildlife presently occurs mainly in western and northern Botswana. The immediate cause is penetration of cattle into areas which were previously mainly occupied by hunter-gatherers and wildlife. The extent and speed of the process are, however, hardly documented. The reasons for increased cattle numbers and the expansion westwards have been summarised before. Livestock encroachment implies an implicit prioritisation of livestock production over wildlife and hunting-gathering in the concerned areas. The Tribal Grazing Land Policy assumed such areas to be mostly empty. Subsequent zoning exercises and population surveys proved this to be wrong. As a result, 28% of the demarcated ranches had been dezoned.

Effects

The expansion of grazing areas has various effects on people and wildlife. Smaller and increasingly fragmented areas are left for wildlife. As a result, migration of wildlife became more difficult, which may threaten survival chances particularly during droughts. The role of fences in this respect has not yet been properly assessed. As cattle are more sedentary around boreholes, overgrazing probably increases in the encroached areas. Subsistence activities for hunter-gatherers decrease because of the decrease in wildlife and as in the case of ranches, loss of formal access to specific areas. For the livestock sector, expansion implies more extensive land use as the sandveld areas have a lower carrying capacity. Hence, the gains for this sector were less than proportional to the expansion of grazing area. No research has as yet compared the productivity of wildlife and cattle on a sustainable basis in these marginal areas.

Responses

Affected people are mostly remote area dwellers, depending on hunting and gathering. Little is known about their reponses. In the case of TGLP ranches, resettlement opportunities are offered in Communal Services Centres (Morapedi, 1986). The livestock sector itself does not provide adequate alternative income opportunities for them. For example, the need for herding is limited, particularly for fenced farms. Another response has been the establishment of the Kalahari Conservation Society (KCS) as a wildlife lobby group. The KCS stresses the importance of wildlife as a national resource for development which needs to be protected for the future. Government has addressed the issue by planning, in addition to traditional Parks and Reserves, wildlife management areas (WMA's) where wildlife utilisation is the primary land use form and cattle holding is restricted. Unfortunately, none has been gazetted as yet and therefore WMAs have not been able to regulate livestock holding. Incorporation of wildlife and veldproducts into land use planning should be based on recognition of environmental and socio-economic realities in the areas concerned.

2. Competition for Land between Livestock and Crop Production

Particularly in small districts and some parts of other districts such as Barolong, encroachment of arable land into grazing land is seen as a serious problem (e.g. Gulbrandsen, 1984). In such areas, the proportion of arable land is usually already high (e.g. South East 15.5% and North East 11% in 1975). Hardly any data exist on the speed of the process. In Kgatleng, encroachment was found to be rather slow between 1963 and 1982 (less than 3%).

Causes of arable encroachment into grazing areas are:

1. expansion of the cultivated area and the trend towards mixed farming.

2. institutional rules which have not set boundaries between grazing and mixed farming areas and so far treat grazing claims subordinate to arable claims.

The effects have been twofold. Firstly, crop damage has increased significantly. For example, in Kgatleng district 80% of the farmers complain about crop damage (Arntzen and Opschoor, 1982). The effect on the arable production however is not known. Secondly, less grazing areas remain. This has contributed to the drive toward exclusive rights in grazing areas, the confinement of smaller herds to mixed farming areas and moving of cattle towards the west. However, its contribution to overgrazing has been very small compared with the increase in livestock numbers. Arable expansion does not appear to have led to the cultivation of less suitable soils, although this may happen in the future, particularly in small districts.

People's response has been to start fencing individual fields or to construct drift fences which separate grazing land and fields during the growing seson. Although fencing has become very popular and is encouraged by government the majority of fields are not yet adequately fenced (60-70%). Arable encroachment is likely to stop in the proximity of established livestock boreholes. Therefore, there is a need for cross-sectoral comprehensive land use planning.

3. Land Competition around Large Settlements

Large settlements have increased in number and have grown faster than the total population. With the exception of Maun, all settlements of over 10,000 inhabitants are located in eastern Botswana. The percentage of people living in such settlements increased from 17.3% of the total population in 1971 to 28.8% in 1981. Large settlements are particularly important in South East District where three quarters of the population is now living in large settlements (Table 8.1). In North East District, almost half of the population stays in Francistown.

Table 8.1

Population in Settlements of over 10,000 Inhabitants by District*

	ABSOLUTE NUMBERS 1971	1981	PERCENTAGE 1971	1981
Southern District	10,664(1)	20,215(1)	13.1	15.5
South East	29,649(2)	91,970(3)	59.6	74.9
Kweneng	0	20,565(1)	0	17.6
Kgatleng	0	18,836(1)	0	41.4
Central District	26,741(2)	73,842(3)	12.0	20.6
North East	18,613(1)	31,065(1)	41.9	45.9
Ngamiland	13,637(1)	14,925(1)	28.6	21.9
Chobe	0	0	0	0
Ghanzi	0	0	0	0
Kgalagadi	0	0	0	0
	99,304(7)	270,698(11)	17.3	28.8

* Numbers of large settlements in brackets.
Source: Population Census 1971 and 1981

The speed of the expansion in terms of land is not exactly known. Residential land is in general still a small portion of total land but relatively more important in South East and North East district. Residential expansion is caused by:

- urbanisation
- concentration of rural population in large villages
- expansion of productive activities and utility services in such settlements.

Its effect is increasing competition for environmental resources between (urban) settlements and their surrounding areas which may lead to local depletion of resources. The latter becomes manifest in wood and thatching grass shortages. The former in abandonment of arable land for residential purposes, and/or public services such as dams. The impact of waterworks can be particularly significant. For example, the Gaborone Dam covers only a few km^2 but its catchment area includes the larger part of South East District (1218 km^2 or almost 70%) and a significant part of eastern Southern District (1344 km^2 or 5% of the entire district).

In response to resources pressure around settlements, trade has emerged to supply inhabitants with scarce resources. For example, Gaborone absorbs monthly, some 47 tonnes of firewood from Kweneng (Kgathi, 1984). Increasingly, substitutes for scarce local resources are used such as zinc roofs, wire fences and paraffin.

Government has declared all towns planning areas under the Town and County Planning Act. Developments in such areas can be fully controlled and so-called development plans have to be prepared.

Presently, the declaration of planning areas for most large rural settlements is being considered. Earlier, physical planners have been placed in each district to initiate settlement planning.

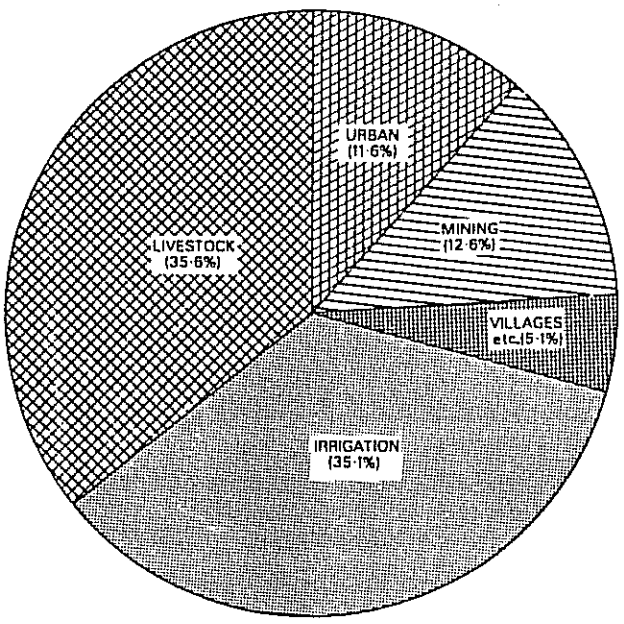
8.4. Pressure on Water Resources

Water forms a serious constraint for the nature and size of human activities in semi-arid countries. Total water use in Botswana is presently estimated to be approximately 350,000 m^3 day. It is not known what the maximum sustainable water consumption is because data on acquifers and recharge are inadequate.

Figure 8.1. shows that irrigation and livestock are the main water users. Water requirements for irrigation, even for as little as around 1,000 ha, are extremely high and irrigation can therefore be only considered in a few areas (Map A.8.1.). The mining sector consumes a relatively large amount of water too. The water use of the copper and nickel mine in Selebi Phikwe exceeded that of Gaborone and Lobatse in 1985 (6.1 mln m^3 versus 4.6 ml m^3)

Figure 8.1.

Water Consumption by Type of Use



Source: NDP6

Urban use and village use comprise industries, government and households. No data are available on the development of total water use in time; nor on a sectoral breakdown. Irrigation water use depends on the irrigated area and crops grown. The former has been fairly constant. The latter has changed to include cotton, etc., in the Tuli Block. Livestock water requirements have increased proportional to livestock numbers. Water use by mines has increased with the opening of additional mines. BCL has used between 6-6.5 mln m^3 since its opening.

Urban and village water use has probably increased fast due to population growth (3.3% per annum), urbanisation (10.2% per annum), better accomodation (water consumption standpipes: 15ℓ/person/day, on site ± 60ℓ/p/day and water inside the house: 150ℓ/p/day) and industrial growth (at equal pace with overall economic growth). The increase of water consumption has been highest in Gaborone where the water consumption in 1985 was seven times the level of Independence (1966:1356 m^3/day and 1985:9,492 m^3/day Table A.8.1.) One can safely assume that the total water consumption has grown by at least 3-5% per annum apart from the sudden huge increase due to the establishment of the copper and nickel mine. Obviously water consumption is highest in the eastern part of the country where human activities are concentrated. VIAK (1985) shows that in 1981 consumption was highest in north eastern Botswana (285ℓ/c). Consumption has however, grown most rapidly in South Eastern Botswana and its water consumption is expected to overtake North-Eastern Botswana soon.

The sectors differ, apart from the magnitude of use, also in spatial pattern of water use (Table 8.2.) Sectors are more likely to compete if it concerns concentrated large consumption in each others proximity. Despite roughly equal water consumption of livestock and irrigation, the latter may cause more local problems as it is concentrated unlike livestock production.

Table 8.2.

Characteristics of Water Consumption by Sector

Sector	Magnitude of Use	Spatial Distribution			
		Scattered		Concentrated	
		Rural	Urban	Rural	Urban
Livestock Production	Large	X			
Irrigated crop Production	Large			X	
Wildlife Utilisation	Small/Med	X			
Mining	Medium			X	X
Other Productive activities	Small			X	X
Household consumption	Small			X	X

Various institutions are involved in the supply of water. Water for livestock and irrigation is mainly the owners' concern although permission is required in accordance with the Tribal Land Act and Water Act. Mines may arrange their own water supply subject to provisions of the Water Act or, in the case of the copper and nickel mine, receive water from the Water Utilities Corporation (WUC). The WUC is otherwise mainly responsible for water in urban areas. Its supply has increased rapidly from 2 mln m^3 in 1973 to 17.4 mln m^3 in 1985, supplied by three dams (Shashe, Gaborone and Lobatse) and one acquifer at Ramotswa. The Department of Water Affairs is responsible for the water supply in the large villages whereas the District Councils deal with the other villages.

Water supply depends on groundwater and surface water. Botswana's largest perennial surface water sources are located in the north (Chobe and Okavango) (Map 8.1.) The largest operating dam site and sites for potential dams are located in the north eastern part of the country. Additional natural and artificial surface water sources exist throughout the country but these are mostly seasonal and smallscale.

Surface water sources have the following characteristics:

1. high evapotransportation occurs (up to 2 meters per annum).

2. largest sources occur where demand is presently low.

3. catchment areas of most large sources ar partly outside the country.

4. actual storage of water is positively related to rainfall and size of catchment area. During droughts, dams may dry up.

Groundwater is vital for livestock during the dry season (Roe and Fortmann, 1980) and the supply of villages. Boreholes are scattered throughout the country. So far, few aquifers have been exploited (Jwaneng, Paje and Ramotswa). Groundwater resources have not yet been fully investigated. Hydrogeological maps indicate prospects of groundwater development (Map 1.3). More detailed information on groundwater resources only exist for eastern Botswana and mining areas (Map 8.1.) Aquifers are more evenly spread over eastern Botswana than good damsites.

Although large parts of western Botswana have low yielding or saline groundwater, the presence of a few high yielding boreholes shows the need for further groundwater exploration in the western parts* Groundwater sources have the following characteristics:

a. no evapotransportion occurs and therefore aquifers are efficient for water storage.

b. known aquifers in eastern Botswana are more evenly spread.

c. data on recharge are inadequate and therefore it is difficult to estimate their lifespan.

d. groundwater extraction requires large investments. Treatment costs are generally lower.

In decreasing order, basalt/cave sandstone, Ecca, dolomites and Walsberg are promising as potential aquifers. Recent data on recharge show large fluctuations in recharge related to rainfall. In wet years recharge may reach 100mm whereas in dry years recharge is almost zero (VIAK, 1985). Recharge does occur in western sandveld but it is very low. No data exist on sectoral water use by type of water source. Livestock production and industrial acivities and household consumption rely primarily on groundwater. The mining sector uses dams (Mopipi and Shashe) and groundwater (Jwaneng, Paje) as primary water sources. Until the establishment of the wellfield in Ramotswa, urban areas relied exclusively on surface water. Irrigation and wildlife depend mostly on surface water.

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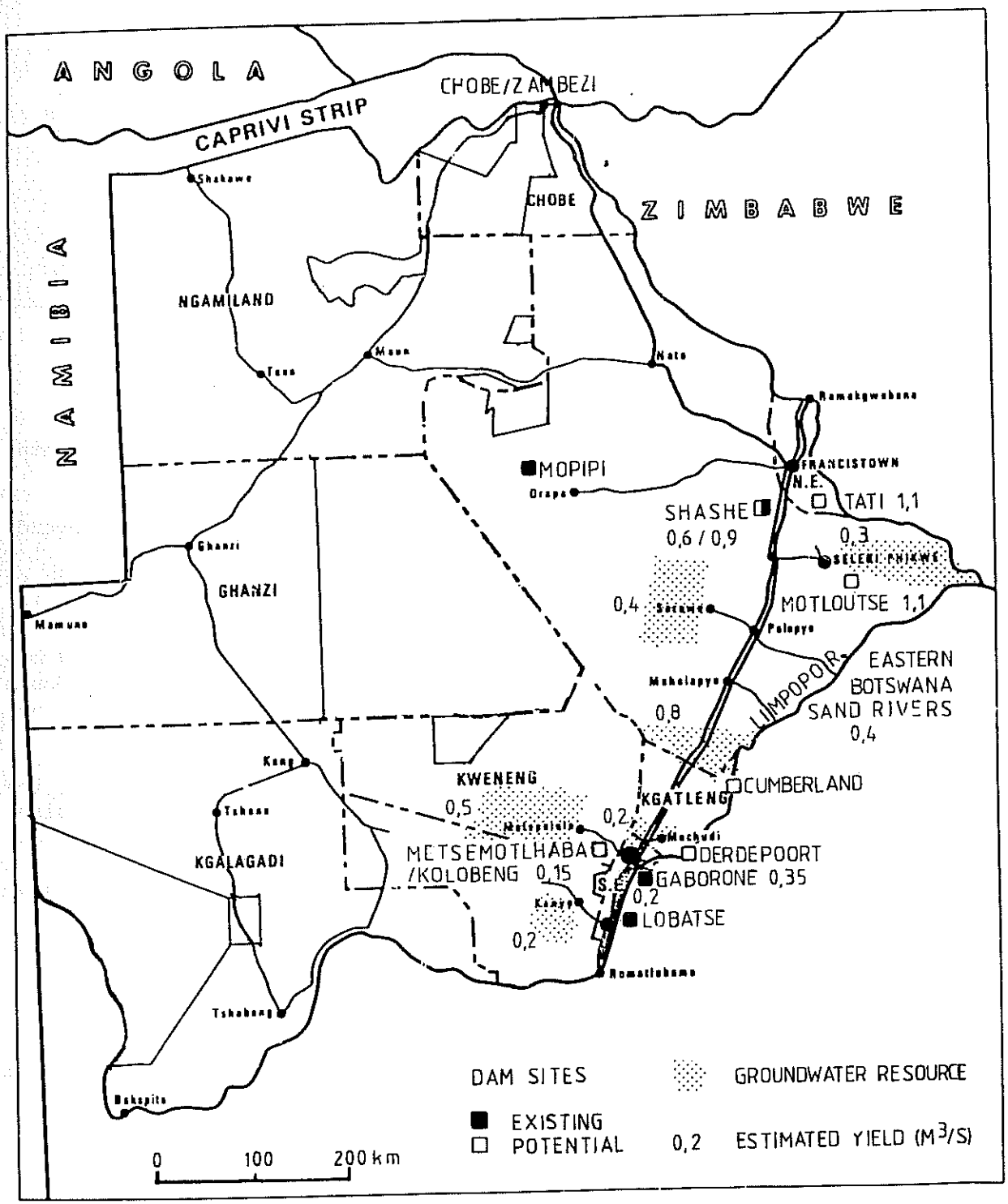
* Pers. Comm. Dr. Keller, Department of Geological Surveys.

Map 8.1.

Major Water Sources and Capacity



Source: VIAK

Note: Currently the Chobe does not flow but holds water from the Zambezi

Table 8.3.

Reliance on Watersources by Type and Sector

Sectors	Groundwater	Surface Water		
		Rivers, Swamps	Dams	Pans, Haffirs
Livestock	1	2	2	2
Irrigated Crop Production	2	1	1	
Wildlife	2	1	2	1
Mining	1		1	
Other productive activities	1	2	1	
Household consumption	1	2	1	2

1. primary source
2. secondary source

Presently, one could distinguish three regions with different water characteristics:

i. Northern Botswana: large sources of surface water with a low demand.

ii. Western Botswana: No major perennial sources of water are known as yet but demand is presently very low.

iii. Eastern Botswana: Surface and groundwater sources are available but supply will soon be unable to copewith the requirements in South Eastern Botswana. North Eastern part can be a surplus area if new damsites are exploited.

The main water problem facing the country therefore is to satisfy the increasing demand in a sustainable and affordable manner. This requires not only additional water works but also raises the issue of how much water can be supplied on a continued basis. Scarcity of water in the livestock sector encourages exclusive use and therefore access to water becomes an issue.

The causes of water shortage are related to:

aa. population growth and concentration.

bb. settlement of most people in the east and increasingly south eastern part of the country.

cc. rapid expansion of human activities, particularly in south eastern Botswana.

dd. location of suitable surface water far away from the demand.

ee. limited knowledge of groundwater resources and recharge.

ff. higher incomes and improved accomodation, leading to increased water consumption per capita.

In the absence of sectoral breakdowns over a number of years, it is difficult to assess sectoral contributions to increased water demands. Pollution of water has so far hardly affected the water supply but such pollution may become more important in future.

The effects are partly unknown. For example, it is not known whether the past and present use has decreased groundwater resources for the future. Residential developments and economic activities have been hampered by water shortage, mostly in south eastern Botswana and in large villages. In the livestock sector, expansion within existing grazing areas* has become difficult as locations for new boreholes are hard to find. The establishment of dams in the rivers may influence vegetation and land use downstream as the waterflow is reduced. Effects of groundwater extraction on vegetation are probably absent as most vegetation relies primarily on rainfall.

The responses to water shortages can be threefold:

aaa. to reduce demand

bbb. to expand waterworks

ccc. to re-address regional imbalances by transport of water into shortage areas or to re-direct human activities towards surplus areas.

Until now, emphasis has been placed on expansion of waterworks and as a temporary measure on reducing demand. The former is illustrated by the drilling of additional boreholes, the establishment and expansion of dams and the use of wellfields such as Ramotswa. The latter has occurred in some large villages and in Gaborone. In Gaborone, water restrictions introduced in 1983, led to a 50% reduction in water consumption. This decrease shows that the efficiency of water consumption can be increased fairly easily.

VIAK (1985) suggests that industries using large amounts of water should be encouraged to settle in the north eastern surplus area. However, spatial redirection of population and activities has not yet been incorporated in development planning. VIAK (1985) recommended a package of measures to solve future water shortage problems:

A. to develop a combination of additional dams and aquifers so as to increase the total capacity and reliability (aquifers could be used when drought depletes surface water).

B. to link the major supply and demand points through a water axle similar to the national electrical grid. Such a link may be more economical and reliable than attempting to establish adequate water supplies in each region at possibly very high costs. Large villages in eastern Botswana could also be linked to the system and hence cease to rely on a relatively small number of local boreholes.

Water shortages have led to increased planning activities such as the preparation of a Water Master Plan and to increased awareness of the need to protect water resources from possible pollution. The former is

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* Water and grazing are closely linked in case of livestock production. The 8km distance rule for boreholes is mainly based on grazing constraints.

also reflected in the recommendation to establish a national Water Policy (Cooke and Campbell, 1985). The latter refers to control over activities in catchment areas of dams and aquifers. Institutional arrangements are also subject of revision in an attempt to improve the efficiency of water-related planning activities. Presently, responsibilities are divided over a large number of departments and institutions within and outside government.

Economic aspects are important in deciding on responses to water shortage. The feasibility to develop additional water resources depends on the returns to be generated by the users, unless subsidies are considered. This becomes visible in Jwaneng where only diamond mining warrants the construction of a wellfield. Government does not subsidise urban water supply in an attempt to discourage urbanisation.

8.5. Conclusion

In general, increased land pressure leads to more conflicts and mutually negative impacts unless land use planning improves and is made more comprehensive. Presently, implicit priorities are given to certain sectors such as cattle over wildlife outside specially designated areas and arable over cattle in eastern Botswana. Some forms of land use which are in principle not exclusive, such as wood and generally vegetation collection, are often, but wrongly neglected.

The major challenge for land use planning is to organise land use more efficiently by:

- allowing as many additional land use claims as possible without undue damage to land and related resources.
- minimising the negative impacts of claims on each other.
- discouraging over-utilisation leading to reduced land suitability.
- arranging access to land in such a way as to safeguard the interest of the poor households.

In general, adequate knowledge exists to describe land pressures, their causes and effects as well as responses to such pressures. However, basic data are lacking to assess the magnitude of land pressure in its various settings and to describe its development in time, including future perspectives. This data gap can only be filled by establishing a systematic data base of the variables essential for land use planning and regular updating (e.g. boreholes). Land pressure around large settlements seems so far to have received relatively little attention from researchers, perhaps because it is a fairly recent phenomenon. With respect to competition between crop and livestock production, no data indicate the magnitude of crop damage by cattle. Finally, no research has compared land and biological productivity of livestock and wildlife in the most marginal, western, areas.

The main problem related to water is the satisfaction of increased demand in a sustainable and affordable manner. Botswana is now in the position that rapidly growing water demands in south eastern Botswana can only be met at high expenditures. Alternatives such as establishments of large water users in the north east and the establishment of a linked eastern water network may become feasible.

Whatever solution is chosen, users must be able to afford the expenditures involved. Such affordability depends on the profitability and incomes out of various human activities. Although the general causes of pressure on water resources are known, the overall trend and the sectoral contributions are not fully documented. Gaps in knowledge also concern the potential of groundwater and its recharge. It is therefore not yet possible to assess all effects of present water consumption levels. As in the case of pressure on land, management of water resources has become a matter of urgency. Such management has not only to be concerned with all aspects of water supply but also with pollution hazards. Hopefully, plans towards the preparation of a water master plan will contribute to more integrated water planning and management.

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APPENDIX A.1

BOTSWANA'S ENVIRONMENT AND DEVELOPMENT

Table A.1.1.

Past and Future Development of Human Population (1904-2001)

	Enumerated population	Annual intercensoral growth rate	Population density ratio	Urbanisation
1904	120,776	-	.2	-
1911	125,350	.5	.2	-
1921	152,983	2.0	.4	-
1936	265,756	3.8	.5	-
1946	296,310	1.1		-
1956	306,175	0.4		-
1964	515,833	7.2	1.0	2.4
1971	596,944	2.3	1.1	8.2
1981	941,027	4.9	1.8	15.9
1990	1,375,454 H	3.8	2.4	
	1,355,458 M	3.0	2.3	
	1,337,601 L	2.4	2.3	
2001	1,999,269 H	3.8	3.4	
	1,894,178 M	3.0	3.3	
	1,798,144 L	2.4	3.1	

* adjusted growth rate is estimated to be 3.3%
Source: Population Census, (past.) Growth scenario's from NDP6.

Table A.1.2.

Population Density by District
(1981)

	Rural Population pers/km²	Total Population pers/km²
Southern	4.5	4.5
South East	16.9	60.6
Kweneng	3.2	3.2
Kgatleng	5.8	5.8
Central	2.2	2.5
North East	7.0	12.9
Ngamiland	0.6	0.6
Chobe	0.4	0.4
Ghanzi	0.2	0.2
Kgalagadi	0.2	0.2
	1.4	1.6

Sources: Population Census, 1981.

Table A.1.3.

Population by District (1981)

	Rural Population			Total population		
	1964	1971	1981	1964	1971	1981
Southern	83,302	91,310	119,653	83,302	91,310	119,653
South East	21,031	22,691	30,469	32,499	54,047	109,160
Kweneng	74,000	72,093	117,127	74,000	72,093	117,127
Kgatleng	33,100	35,752	44,461	33,100	35,752	44,461
Central	209,565	228,627	323,328	209,565	240,828	358,026
North East	25,795	28,524	36,636	35,316	48,427	67,701
Ngamiland	42,572	53,870	68,063	42,572	53,870	68,063
Chobe	5,120	5,411	7,934	5,120	5,411	7,934
Ghanzi	16,366	17,352	19,096	16,366	17,352	19,096
Kgalagadi	16,636	17,289	24,059	16,636	17,289	24,059
	527,487	527,919	791,006	548,476	636,379	941,021
Total de jure	527,487	527,919		548,476	636,379	983,090
de facto			791,006	514,378	590,644	941,027

Sources: CSO, 1976; CSO, 1982.

Table A.1.4

Annual (July–June) Rainfall Records for 9 Stations in Botswana

	Station	Mahalapye	Mochudi	Gaborone	Kanye	Tsabong	Gantsi	Maun	Kasane	Francistown
	Year									
	1909/10		559.5							
	1910/11		929.3							
	1911/12		N/A							
D	1912/13	248.8	N/A							
D	1913/14	202.2	245.1							
	1914/15	592.3	476.1							
	1915/16	N/A	367.4							
	1916/17	N/A	395.4							
	1917/18	806.8	545.4							
	1918/19	628.2	N/A							
	1919/20	425.5	N/A							
	1920/21	635.2	N/A							
	1921/22	450.9	N/A							
	1922/23	558.3	N/A				540.0	501.5	748.4	581.9
D	1923/24	342.7	N/A				216.5	313.2	461.1	292.5
	1924/25	646.4	N/A				642.8	N/A	1066.6	897.9
D	1925/26	225.5	463.6	406.0	364.6		258.6	299.8	440.3	432.6
D	1926/27		293.9	N/A	474.1	406.9		529.2	266.1	566.2 269.5
	1927/28	458.1	N/A	574.5	528.3		536.4	312.0	582.0	395.5
	1928/29	379.8	404.6	538.3	488.8		279.5	345.0	778.2	777.3
	1929/30	490.6	645.1	604.5	656.5		485.8	347.5	933.5	560.3
	1930/31	461.8	369.4	421.5	418.4		604.3	432.9	374.2	417.9
	1931/32	557.2	N/A	357.5	540.3		414.0	587.1	772.8	700.9
D	1932/33	269.0	290.4	384.3	270.4		124.4	193.0	421.7	321.7
	1933/34	440.8	589.3	616.1	567.4		692.8	500.7	635.8	462.7

	Station	Mahalapye	Mochudi	Gaborone	Kanye	Tsabong	Gantsi	Maun	Kasane	Francistown
	1934/35	373.7	N/A	537.5	520.4		542.0	269.2	565.0	342.6
	1935/36	463.3	256.7	564.8	654.7		357.8	612.0	839.8	268.0
	1936/37	528.6	669.8	537.2	503.6		N/A	380.0	884.8	481.7
	1937/38	529.0	N/A	422.2	413.2		N/A	313.9	455.0	234.2
	1938/39	483.4	485.5	601.1	669.5		391.5	571.1	578.0	N/A
	1939/40	498.4	564.6	494.6	541.5	332.1	656.2	539.6	857.5	537.9
	1940/41	613.3	538.4	582.2	468.8	229.9	352.3	294.9	794.1	413.6
	1941/42	484.7	463.0	473.8	507.6	187.7	378.0	380.8	650.4	342.7
	1942/43	354.2	719.2	761.2	665.1	N/A	593.4	391.6	610.8	424.2
	1943/44	643.5	888.8	779.0	856.5	N/A	575.4	591.7	931.7	500.0
D	1944/45	362.4	487.4	562.6	483.5	134.0	122.3	318.1	361.2	327.8
	1945/46	516.4	497.8	510.0	458.0	170.7	664.4	639.7	938.3	642.1
D	1946/47	294.8	417.4	360.9	436.1	132.3	211.1	289.4	446.9	114.1
	1947/48	595.4	382.4	439.6	476.0	266.5	557.6	720.5	777.7	684.2
	1948/49	521.1	370.7	468.4	544.5	149.6	375.2	334.3	469.3	428.6
	1949/50	376.4	361.3	547.3	530.8	555.9	620.0	526.7	452.9	228.7
	1950/51	543.9	718.0	603.8	578.9	323.0	489.8	424.1	593.5	520.3
D	1951/52	320.8	434.2	395.5	250.1	183.9	399.3	441.4	1037.4	336.5
	1952/53	891.3	560.6	491.8	827.7	N/A	534.7	629.6	872.9	779.6
	1953/54	412.6	484.1	420.2	104.7	357.0	503.0	560.5	843.4	184.0
	1954/55	842.7	634.8	637.0	691.2	340.7	530.3	863.5	998.4	755.9
	1955/56	533.0	486.3	633.5	593.1	348.4	441.0	427.4	592.0	337.7
	1956/57	432.3	550.8	542.7	431.3	157.9	N/A	408.0	514.0	486.8
	1957/58	640.3	616.0	624.0	729.3	464.5	433.3	602.3	1405.6	383.5
	1958/59	549.1	546.8	507.7	476.0	172.6	360.5	483.0	600.0	497.2
D	1959/60	143.9	278.8	343.8	456.7	227.3	273.9	316.8	642.2	268.9
	1960/61	560.4	706.8	720.9	778.2	447.2	325.6	533.1	882.6	522.9
D	1961/62	372.9	244.8	315.0	316.9	247.6	288.4	314.5	482.0	386.7
	1962/63	301.8	389.0	372.2	496.6	294.3	603.2	535.0	564.0	416.8

	Station	Mahalapye	Mochudi	Gaborone	Kanye	Tsabong	Gantsi	Maun	Kasane	Francistown
D	1963/64	301.4	319.5	330.3	362.7	185.6	412.2	504.3	513.5	254.8
D	1964/65	229.8	N/A	430.7	N/A	263.9	227.9	267.7	500.2	228.2
	1965/66	208.7	N/A	503.9	N/A	149.0	284.3	552.3	855.5	388.2
	1966/67	623.2	851.8	925.3	970.6	394.1	662.0	605.1	N/A	743.5
	1967/68	326.5	425.4	492.3	827.9	234.3	596.6	579.5	721.3	339.5
	1968/69	389.9	321.5	425.2	386.2	168.9	287.6	480.1	636.8	430.0
	1969/70	340.7	402.8	353.5	373.2	137.3	234.4	276.7	548.6	546.4
	1970/71	400.2	496.6	531.6	384.5	247.4	348.0	426.8	757.7	321.4
	1971/72	601.1	518.4	652.7	668.3	413.6	472.5	697.0	844.9	647.6
D	1972/73	219.9	296.5	292.6	347.3	219.8	309.6	242.7	598.0	264.5
	1973/74	632.6	767.5	700.3	922.2	616.9	926.1	1186.6	N/A	741.7
	1974/75	605.5	766.7	836.4	747.8	287.7	461.7	632.2	N/A	740.3
	1975/76	714.9	555.0	755.2	835.9	706.0	617.4	379.3	638.7	588.6
	1976/77	622.2	752.0	752.6	642.0	437.0	398.0	512.1	750.6	517.6
	1977/78	621.2	678.4	483.9	403.8	374.9	693.2	734.0	762.2	762.7
D	1978/79	446.6	387.9	360.3	310.6	277.8	267.3	291.7	394.3	430.0
	1979/80	497.3	539.3	644.7	565.6	286.8	498.7	508.7	477.0	448.2
	1980/81	601.6	601.0	710.1	695.3	257.8	395.0	496.1	770.0	658.8
D	1981/82	425.3	418.0	404.3	447.7	228.1	420.4	209.2	298.7	297.8
D	1982/83	308.9	404.4	481.1	423.5	351.3	298.6	391.3	594.5	432.3
D	1983/84	516.8	397.1	322.6	308.8	297.3	314.6	355.8	451.7	383.7
	Average 1965/66–1983/84	436	491	529	305	438	477	684	473	

Table A.1.5

Plant Communities of the Okavango

Plant Communites after Biggs (1976)	Unit Descriptions after Heemstra (1976) Communities	Wildlife Habitat Identifiable
Aquatic communities: divided according to Channel distribution	Cyperus papyrus	x
	Phragmites australis	x
	open water	x
Foodplain communities:		
(a) primary	Miscanthidium	x
	Sedgeland & aquatic Sedgeland	x
(b) secondary	Tall wet grassland	x
	Short wet grassland	x
Island Grassland	Short dry Grassnamd	x
Closed Riverine Woodland	Riparian Woodland	x
Marginal Riverine communities:	"	
Acacia nigrescens - Croton megalobotrys		x
Hyphaene ventricosa -		x
Combretum imberbe -		x
Dryland Vegetation Types:		
Acacia tortilis savannah woodland	Acacia woodland	x
Acacia erioloba Combretum		x
Terminalia sericea - collinum savannah and woodland		x
Colophospermum mopane Woodland and Scrub savannah.		
	Bush Encroachment (Lake Ngami)	

Source: SMEC (1986)

APPENDIX A.2

THE LIVESTOCK SECTOR

Table A.2.1.

Cattle and Smallstock Numbers in Botswana (x1000)

	Cattle	Smallstock
1904	139	
1911	324	
1921	495	
1936	541	
1950	1,050	
1966	1,237 (178)	550
1971	2,092	1,391
1975	2,512 (350)	1,820
1981	2,967	761
1984	2,685 (380)	1,057 (48)

Figures in brackets indicates livestock in freehold areas.
Sources: Hubbard, 1983; Mhlanga, n.d.;
Population Census 1904-1936.

Table A.2.2.

Livestock per Person:
Regional Division (Rural Population) (1981)

	Cattle Ratio	Goat Ratio	Sheep Ratio
Southern	2,78	0,89	0,29
South East	0,75	0,39	0,07
Kweneng	2,15	0,58	0,13
Kgatleng	2,47	0,65	0,09
Central	3,3	0,58	0,10
North-East	3,9	1,06	0,11
Ngamiland	5,2	1,65	0,10
Chobe	0,6	0,13	0
Ghanzi	2,3	0,73	0,10
Kgalagadi	2,5	1,37	0,83
	3,2	0,76	0,21

Source: Agricultural Statistics, 1981: Pop. Census 1981

Table A.2.3.

Distribution of Cattle over Freehold Blocks

	1971	1976	1983	Size Area (km^2)
Ghanzi/Xhanagas	29,2	34,8	29,2	17.080
Molopo	40,7	28,4	8,3	130
Lobatse)	3,2	4,9)	15,3	990
Gaborone)		1,6)		
Tuli	15,2	17,0	26,4	5.370
Tati	11,2	13,2	19,4	2.900
Setlibeng	0,4	-	1,4	-
	100	100	100	32.970

Sources: 1971 Freehold Farm Survey
1976 McDonald, 1980
1983 Pers. Comm. Mr. Singh, Agric. Statistician, MoA
Surface: Hitchcock, 1981 (Carl Bro. Int: total 27,600 see p.2.03 resp. blocks 11,010 km^2, 6490, 980, 6050, 3070).

Table A.2.4.

Traditional Herd according to Herdsize Categories

Herdsize Category	% of farms				% of nat. herd			
	1972	1979	1981	1984	1972	1979	1981	198
1-10	27.7	16.7	23.2	29.7	5	2.5	3.4	3.9
11-20	24.6	25.0	24.3	20.7	13	9.9	8.5	7.6
21-40	26.8	32.3	25.5	23.8	26	24.9	17.1	16.4
14-60	11.2	9.5	10.0	9.5	17	12.4	11.6	11.4
61-100	6.5	8.3	7.8	8.0	16	16.5	14.0	15.3
101+	3.4	8.2	9.2	8.1	23	33.8	45.4	45

Source: Agric. Statistics.

Table A.2.5.

Productivity Comparisons
Communal versus Ranch System

	Ranch	Communal	Comm. ES*
Calving %	74,0	,50,0	
Mortality %	8,5	12,0	
Weaning rate (%)	67,7	44,4	
Weight 12 months calf (kg)	200	132,5	
id /cow/year	135,4	58,3	
Stocking rates (LSU/ha)	0,086	0,167	0,086
Cow-stocking (cow/ha)	0,0375	0,082	0,042
Weight 12 month calf/ha/year (kg)	5,01	4,78	2,45
Milk/draught power		3,2	3,2
Total Productivity	5,01	7,98	5,65

Source: Wagenaar and de Ridder, 1984.

Table A.2.6.

Calving, Mortality and Off-take Rates 1981-1984

		Herd size (Trad.) 1-10	11-20	21-40	41-100	+100	Total Trad.	Total Comm.
Calving rates	1981	65,8	69,8	64,8	58,8	53,0	57,5	54,1
	1982	63,2	66,6	61,9	60,1	56,6	59,4	61,0
	1983	54,2	63,0	60,7	50,8	45,7	51,8	56,2
	1984	54,6	63,1	62,3	57,5	44,5	52,5	61,3
Mortality Rates	1981	30,1	15,7	15,8	16,8	10,0	13,6	4,0
	1982	30,4	20,2	17,6	16,2	15,6	17,0	5,9
	1983	54,1	30,1	21,0	14,5	11,3	17,8	8,9
	1984	65,0	42,7	27,6	18,9	8,3	19,3	10,0
Sales Rates	1981	7,4	6,9	6,6	7,6	8,5	7,8	23,7
	1982	8,0	7,9	7,7	7,8	8,6	8,2	33,7
	1983	12,3	9,0	5,7	6,0	11,2	8,5	39,9
	1984	13,0	8,0	8,7	6,9	6,4	7,3	38,8

Source: Agricultural Statistics, 1981-1984

Table A.2.7.

Beef Cattle Productivity under Cattlepost and Ranch Management

Trait	Cattlepost	Ranch
Calving percentage	47,3	74,8
Calf mortality %	,10,2	8,5
Weaning percentage	42,5	68,4
Weaning mass kg	123,5	180,4
Post-weaning gain (7-18 month) kg	89,7	105,9
Mass of weaner calf/cow/year kg	52,5	123,4
Mass of 18 month calf/cow/year kg	90,6	195,8

Source: APRU 1980, 9

Table A.2.8.

Cattle Slaughtered for Local Consumption and Export

	Off-take for: Local Consumption	Export	% Off-take
1984	46.900?	239.000	10,7
1983	55.400?	234.000	10,3
1982	30.300?	237.000	9,0
1981	35.800?	202.000	8,0
1980	86.000	140.783	7,8
1979	61.000	229.000	10,2
1976	50.000	211.987	10,4
1972	40.000	156.510	9,0
1969	23.000	103.776	6,0
1966	17.000	148.654	13,4

Source: Agricultural Statistics 1981-1984; Hubbard, 1983; BMC Annual Reports 1981-1984.

Table A.2.9.

Total Exports in tonnes and as %

	Sales to EEC in Tonnes	EEC Sales as % of total	Sales S.A. in tonnes	Sales to S.A. as % of total	Sales to Others in tonnes	Sales to Others as % of total	Total
1966	6821	97	219	3	0	0	7040
1967	7459	92	453	6	189	2	8101
1968	3132	55 FMD	1001	17	1590	28	5723
1969	2512	60 FMD	539	13	1164	28	4215
1970	8850	70	948	8	2762	22	12560
1971	7730	48	2308	14	6226	38	16264
1972	10640	65	724	4	4917	30	16281
1973	17710	59	588	2	11879	39	30177
1974	5337	30	7638	44	4485	26	17460
1975	11694	51	8658	38	2398	25	22178
1976	16143	62	6589	25	3173	13	25905
1977	16821	61	5844	21	4751	17	27418
1978	4497	21 FMD	6336	30	6233	49	21034
1979	15038	47	3800	12	13009	41	31847
1980	1073	6 FMD	4339	25	11705	68	17117
1981	5182	20 FMD	11232	44	6102	36	25453
1982	11761	45	9634	37	4276	18	26270
1983	14299	47	9797	32	6578	22	30473
1984	16285	55	9529	33	3663	12	29511

Source: Fidzani, 1985, 13

Table A.2.10.

Average Net Income Earned by Survey Farmers
from Crops and Livestock in Current and Constant Prices,
1978–1983

Item	Unit	1978	1979	1980	1981	1982	1983
Current Prices							
Crops	Pula	41,96	10,56	142,66	139,22	7,14	-19,05
Change from 1978	%	-	-74,8	240,0	231,8	.83,0	-145,4
Livestock	Pula	298,31	345,37	419,34	772,88	1229,20	1032,70
Change from 1978	%	-	15,8	40,6	159,1	312,0	246,2
TOTAL	Pula	340,27	355,93	562,00	912,10	1236,34	1013,65
Change from 1978	%	-	4,6	65,2	168,0	263,3	197,9
Constant Prices							
Crops	Pula	41,96	9,44	116,55	100,73	3,59	-22,23
Change from 1978	%	-	-77,5	177,8	140,1	-91,4	-153,00
Livestock	Pula	298,31	310,85	305,20	550,51	678,18	503,50
Change from 1978	%	-	4,2	2,3	84,5	127,3	68,8
TOTAL	Pula	340,27	320,29	421,75	651,24	681,77	481,27
Change from 1978	%	-	5,9	24,0	91,4	100,4	41,4
Livestock as % of total agric. income							
Current prices		87,7	97,0%	74,7	84,7	99,4	101,9
Constant prices		87,7	97,1%	72,4	84,5	99,5	104,6

Source: FMS, 1983

Table A.2.11.

Bush Density under Fire Management (Plants/ha)

Height class(m)	Burning Interval (years)						
	1	2	3	,4	5	Control	Mean
0,5	450	410	1140	810	940	440	700
0,5 - 1,0	540	650	660	900	1050	360	700
1 - 2	80	90	70	140	160	300	140
2 - 3	0	0	0	10	0	100	20
3	130	90	0	100	30	80	70
Total	1200	1240	1870	1960	2180	1280	1630

Source: APRU, 1980.

Table A.2.12

Nutrient Value of Some Grass Species

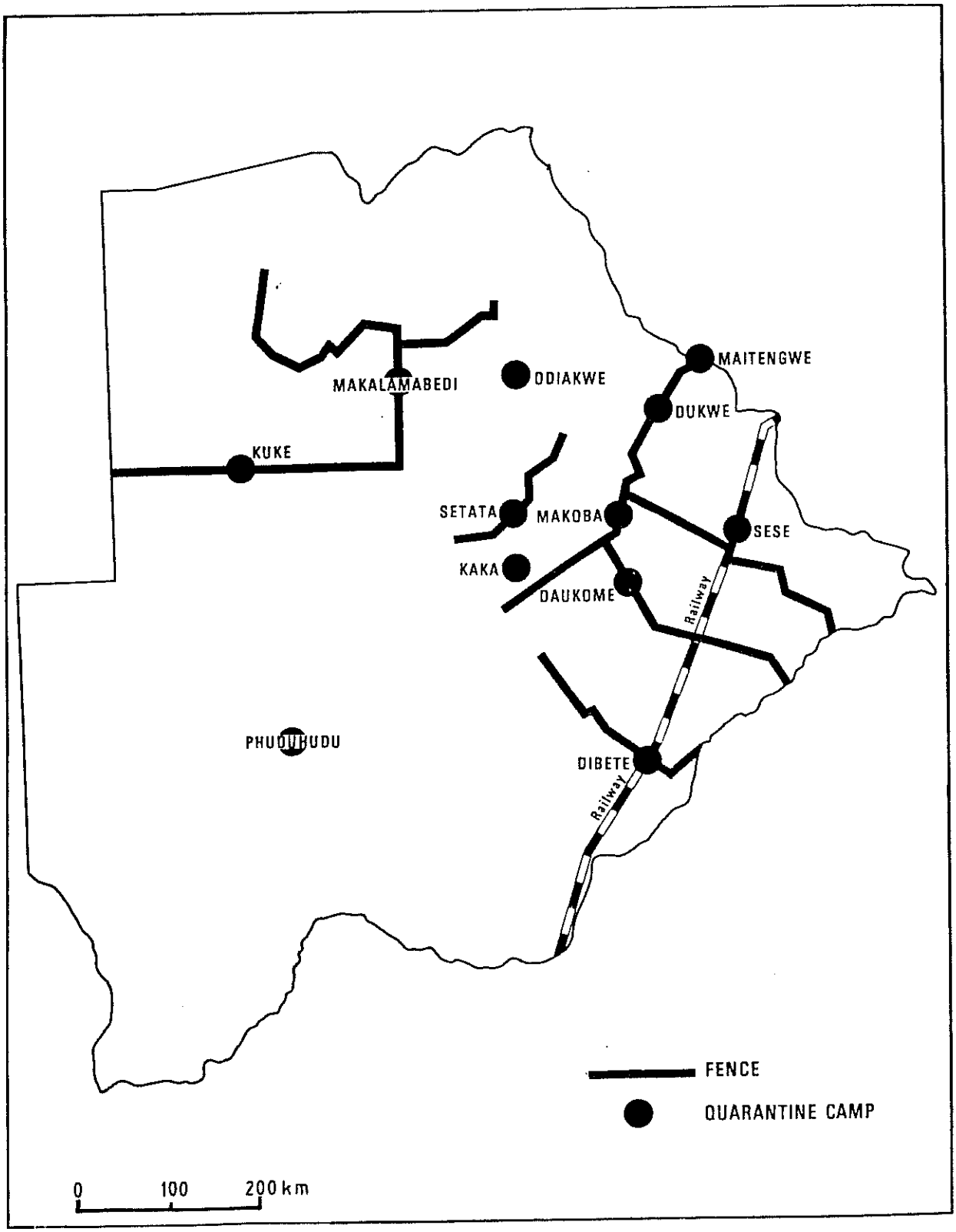
	Crude Protein Content						Phosphorous Content					
	Feb		June/July		Oct	Dec	Feb		June		Oct	Dec
GRASSES												
Stipagrostis Uniplumis	6,93		2,65		2,91	3,34	0,010		0,056		0,059	0,048
Schmidtia Pappophoroides	6,70		2,58		3,10	3,15	0,009		0,047		0,055	0,042
UrochloA Brachyura	7,91		2,74		2,83	2,91	0,043		0,044		0,037	0,034
Rhyncelytrium Repens	7,19		3,30		3,28	2,98	0,069		0,070		0,041	0,037
Eragrostis Lehmanniana	6,04		2,58		7,47	9,25	0,010		0,040		0,103	0,105
	Leaf	Twig	Leaf	Twig			Leaf	Twig	Leaf	Twig		
SHRUBS												
Acacia Erioloba	16,9	7,6	13,2	5,6			0,14	0,10	0,10	0,07		
Acacia Hebeclada	25,9	14,3	-	-			0,33	0,25	-	-		
Bauhinia Petersiana	16,5	10,3	11,5	5,2			0,15	0,11	0,08	0,05		
Boscia Albitrunca	20,3	16,9	15,5	10,6			0,10	0,10	0,07	0,05		
Grewia Flava	19,5	12,4	12,1	4,3			0,22	0,10	0,19	0,09		
Colophospermum Mopane	13,7		11,5		11,6	12,6	0,18		0,116		0,117	0,187
	In weight %											

Note: Digestibility of grasses is generally higher than of bushes

Sources: Skarpe 1981 (Dongdong, 1978) and
Voorthuizen, 197(

Map A.2.1.

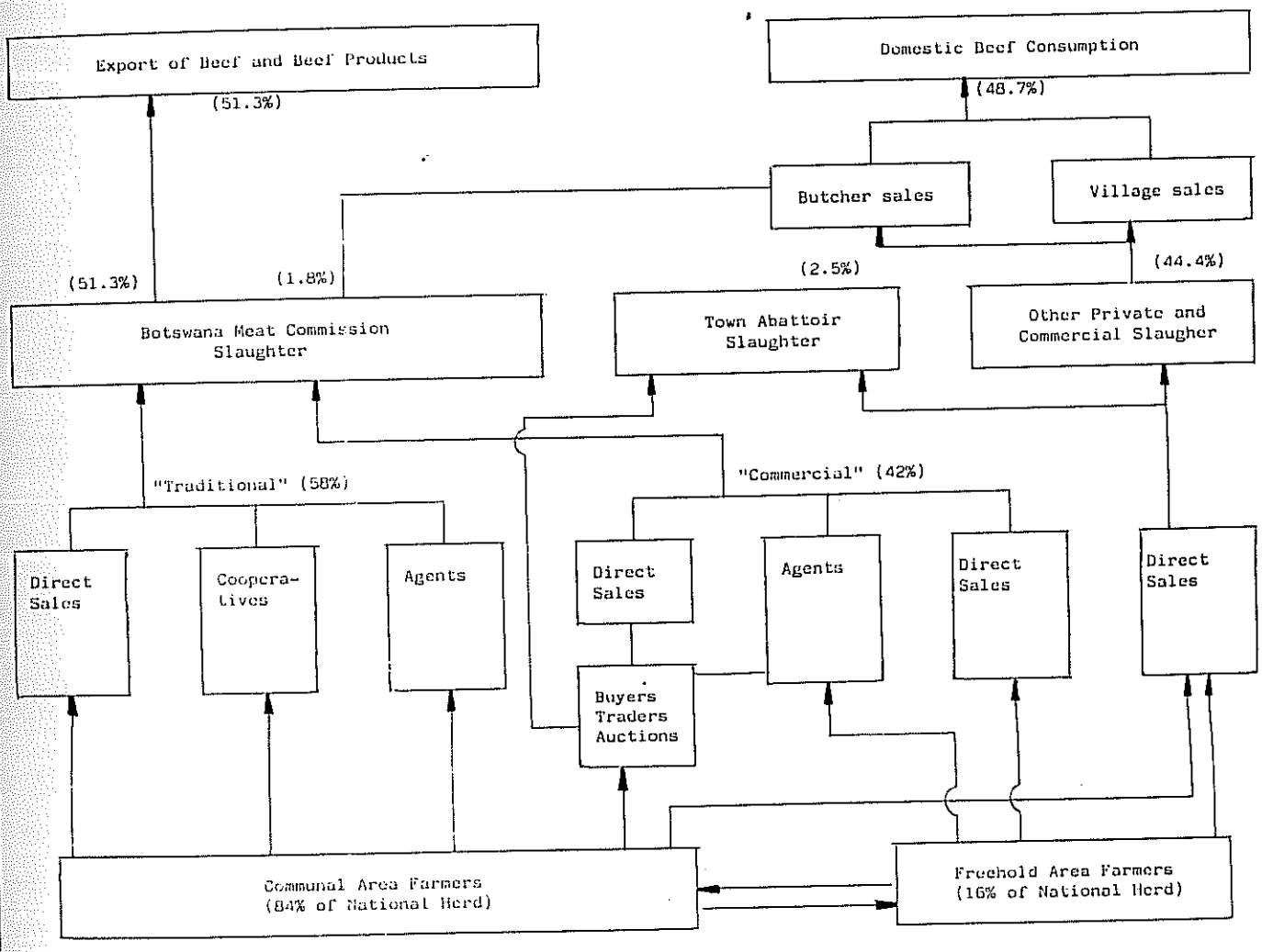
Foot and Mouth Disease Control including Buffalo Fence



Source: NDP6

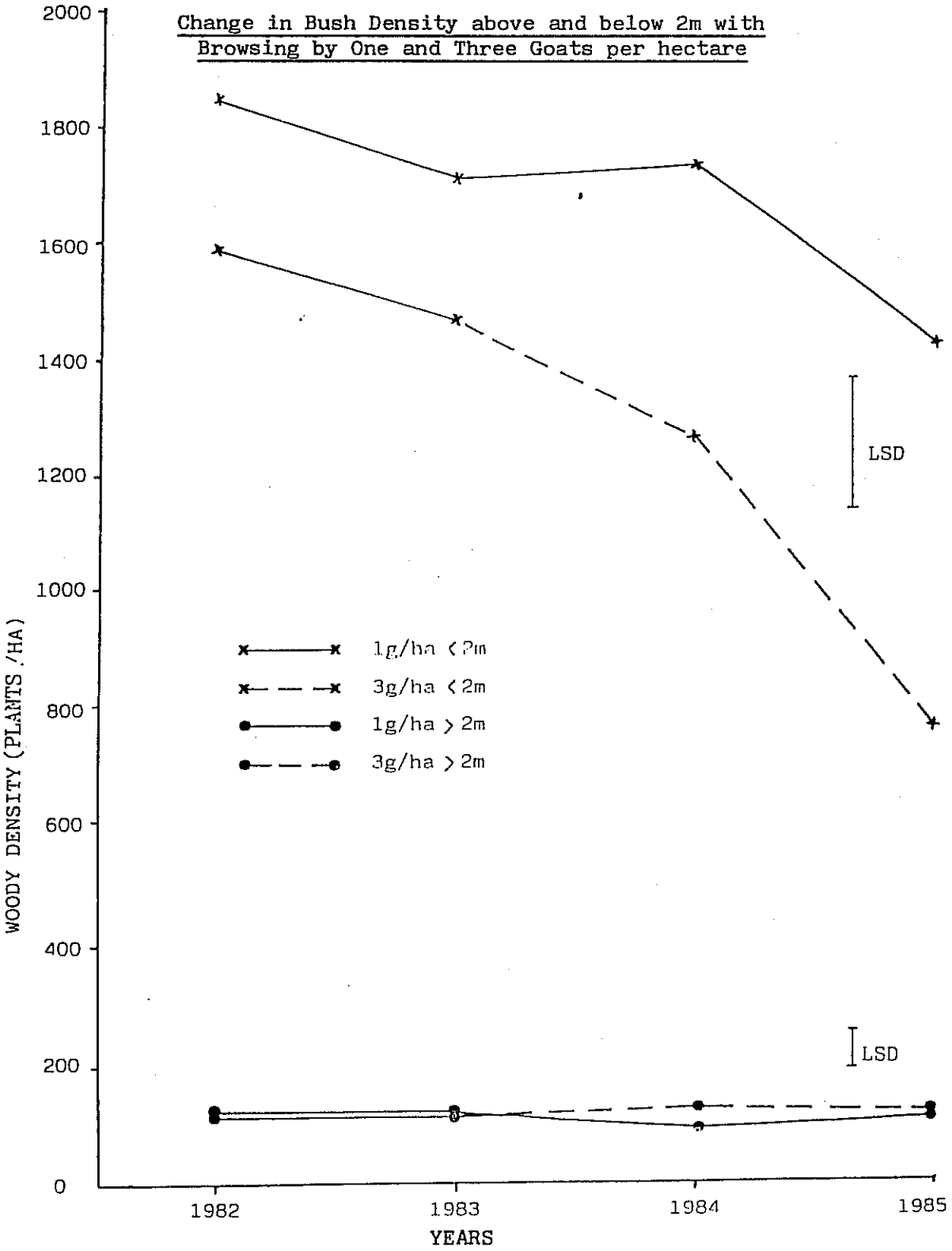
Figure A.2.1.

Botswana's Beef Marketing System



Source: Bailey, 1982

Figure A.2.2.



Source: Sweet and Mphinyane (1985)

APPENDIX A.3

CROP PRODUCTION

Table A.3.1.

Some Indicators of Arable Development

	Rainfall (in mm)	Total area Planted (1000 ha)	Production Sorghum/ maize (trad.) (1000mt)	Productivity sorghum (kg harvested/HA	Average Planted crop farm HA
1965/66	330.0	72	22.0	400	N.A.
1966/67	689.3	33	8.7	258	N.A.
1967/68	413.0	121	17.8	183	4.6
1968/69	445.3	216	42.6	289	4.0
1969/70	370.9 D	187	9.9	65	4.9
1970/71	453.0	254	89.9	455	4.3
1971/72	600.8	258	78.6	379	3.3
1972/73	272.1 D	97	32.6	114	N.A
1973/74	743.3	N.A.	106.2	400	N.A.
1974/75	686.5	N.A.	62.5	338	N.A.
1975/76	574.0	N.A.	118.2	311	N.A.
1976/77	594.4	N.A.	N.A.	308	N.A.
1977/78	609.1	260	29.5	155	4.6
1978/79	328.2 D	171	5.4	91	2.6
1979/80	506.0	271	34.1	215	4.1
1980/81	603.3 D	270	42.9	195	3.2
1981/82	308.2 D	185	7.2	41	3.7
1982/83	366.3 D	224	8.5	35	4.7
1983/84	377.5 D	188	5.3	48	4.0
1984/85	290.7 D	203	12.5		-

Source: Opschoor, 1983; Agricultural Statistics 1981-1984; Meteorological Services.

Table A.3.2

Cultivated Land by District, Botswana.

District	Total Area (Km^2)	Cultivated Area (hectares)	% of District cultivated	% of National Cultivation
Ngamiland	109 337	40 662	0,4	5,0
Chobe	20 750	2 839	0,1	0,4
Ghanzi	117 910	8 548	0,1	1,0
Central	147 730	325 065	2,2	39,9
North East	5 300	58 315	11,0	7,2
Kgalagadi	110 110	14 202	0,1	1,7
Kgatleng	7 600	52 494	6,9	6,4
Kweneng	38 122	137 965	3,6	16,9
Southern	26 876	152 426	5,7	18,7
South East	1 492	23 110	15,5	2,8
National Total	585 227	815 625	1,4	100,0

Source: DHV, 1980

Table A.3.3

Indicators of Development of Freehold Arable Sector

	with arable land	no farms ploughed	Tot. area (x 1000 ha)	average area ploughed (ha)
1970/71	n.a	n.a	10.6	n.a
1978/79	340	115	8	70
1979/80	140(38.9%)	135	16	119
1980/81	155(43.1%)	150	20	133
1981/82	160(44.4%)	60	19	317
1982/83	150(41.7%) of total)	100	6.5	65
1983/84	180(46.2%)	120	15.2	127

Source: Agricultural Statistics; Freehold Farm Survey, 1970/71.

Table A.3.4

Spatial Distribution Indices Arable Sector (1981)

Arable region	(1)	(2)	(3)
Southern	-11.8	53.8	172.3
South-East	4.0	-40.1	-49.3
Kweneng	2.2	- 3.2	5.5
Kgatleng	13.3	6.8	-14.2
Central/Tati	3.4	4.8	-16.4
Ngamiland	7.6	-59.3	-85.4
Chobe	5.4	66.2	-63.8
Ghanzi	-59.0	-81.9	-95.9
Kgalagadi	-50.8	-82.3	-97.1
Barolong	-23.2	+214.4	+895.7
Tati	10.6	7.4	56.9

$$(1) = \left(\frac{CF_R/F_R - CF_N/F_N}{CF_N/F_N}\right) \times 100$$

$$(2) = \left(\frac{TAP_R/CF_R - TAP_N/CF_N}{TAP_N/CF_N}\right) \times 100$$

$$(3) = \left(\frac{TP_R/CF_R - TP_N/CF_N}{TP_N/CF_N}\right) \times 100$$

CF = Crop Farm
F = Farm
TAP = Total Area Ploughed
TP = Total Production Staple Food
R = Regional
N = National

Table A.3.5

Arable Involvement of Households

	Households with land (owned)		household ploughing	
	absolute	%***	absolute	%
1965/1966				
1970/71	51,554	99.3%	48,545	93.5%
1970/71*	59,460	86.8%	51,730	75.5%
1978**		90.0%		81.0%
1979	66,600	85.4%	43,000	55.1%
1981	70,800	84.1%	68,500	81.4%
1984	59,200	73.6%	51,100	63.6%

Sources: Agricultural Statistics 1970/71, 1979-1984.
* FAO - constraint study (for Eastern Botswana)
** Odell, Arable Land Survey (bias towards arable areas; higher participation rates)
*** Calculated based on total agricultural holdings.

Table A.3.6

Arable Land Distribution in Botswana (1984)

Size of area	% of farm	% of land
.1 - 1.0 ha	11.5	1.7
1.1 - 2.0 ha	20.9	7.6
2.1 - 3.0 ha	20.0	11.3
3.1 - 6.0 ha	29.0	26.1
6.1 - 1.0 ha	12.6	20.0
10+ ha	6.0	33.3

Source: Agricultural Statistics.

Table A.3.7

Distribution of Ploughed Land

	1970/71		1972/73		1980/81		1983/84	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
-1 ha	28.1	8.2	14.3	2.3	10.8	1.7		
1.1-2 ha	53.8	22.1	20.1	7.7	20.7	7.9		
2.1-3	27.6	19.1	20.4	13.1	20.0	2.4		
3.1-4	15.5	13.6	14.0	12.0				
4.1-6	18.9	17.6	18.2	21.4	16.9	20.7	16.1	16.3
6.1-10	16.9	24.3	15.9	29.4	8.1	14.9	13.2	21.7
10.1+	10.4	35.7	10.2	21.9	4.7	27.7	7.2	28.0

(1) % holders (2) % area
Sources: Agricultural Statistics.

Table A.3.8

Distribution of Stable Food Production

	1980/81			1983/84		
(1)	(2)	(3)	(1)	(2)	(3)	
1 - 1.0 ha	14.3	2.3	2.1	10.8	1.7	2.2
1.1-2.0 ha	20.1	7.7	6.1	20.7	7.9	5.9
2.1-3.0 ha	20.4	13.1	11.0	20.0	12.4	11,7
3.1-4.0 ha	15.5	13.6	10.3	14.0	12.0	9.9
4.1-6.0 ha	16.9	20.7	15.5	16.1	16.3	19.9
6.1-10. ha	8.1	14.9	12.6	13.2	21.7	13.2
10+ ha	4.7	27.7	42.4	7.2	28.0	37.2

(1) % holders (2) % of area ploughed (3) % of crop production.
Source: Agricultural Statistics.

Table A.3.9

Distribution of Households by Type of Draftpower Used

	1971/72 Agr. Stat	1971/72 FAO	1977/78	1980/81	1983/84
Cattle	89	88	77	70.9	54.2
donkeys	4	3	7	9.0	14.0
tractors	4	6	16	16.4	26.0
hand hoeing	3	-	-	.9	0.2
oxen/tractor	-	3	-	2.0	2.7
oxen/donkey	-	-	-	0.8	2.9
own	48*	50*		45.9	49.9
hired	11	24		26.6	27.2
mafisa'd	-	-	-	3.9	3.4
borrowed	28	26		17.2	14.4
others	13	-		6.4	4.7

Source: Agricultural Statistics

Table A.3.10

Ownership of Implements

	1971/72	1983/84
plough single	93% of hh.	79.2
double	16	20.2
planter	11	8.9
harrow	8	2.4
cultivator	5	3.9
tractor	9	27.6
hoe	n.a	100

Source: Agricultural Statistics.

Table A.3.11

Percentage of Planted Crops (%; traditional)

	1980	1981	1982	1983	1984
Sorghum	53.7	51.0	50.0	56.6	57.7
Maize	28.2	30.5	28.6	25.7	23.5
Millet	6.4	7.4	8.8	7.4	8.9
Beans/pulses	8.8	9.7	11.0	9.6	8.7
Groundnuts	0.9	1.0	1.1	0.5	1.0
Sunflower	2.0	0.4	0.5	0.2	0.1

Source: Agricultural Statistics.

Table A.3.12

Income from Agricultural Activities (1978-1983)

	1978	1979	1980	1981	1982	1983
average farm income (net)						
crops P	42	11	143	139	7	-19
	12.4%	3.1	25.4	15.2	0.6	0.02
livestock (P)	298	345	419	773	1229	1033
	87.6%	96.9	74.6	84.8	99.4	99.98
Total (P)		340	356	562	912	1236 1013
net income per Man day						
crops	0.43	0.32	1.57	1.95	0.22	-0.87
livestock	1.90	2.70	3.20	5.84	10.88	8.40

Source: Farm Management Survey, 1983.

Table A.3.13

Effects of Drought on Crop Production

	area planted (1)	4 crops area harvested (2)	yields/ (3)	planted harv.ha	harvested area	production area	
1978	260(100)	n.a	n.a	100	100	100	
1979	D	171(66)	92(54%)	133	47	26	32
1980		268(103)	205(76% of 1)	196	90	89	149
1981	274(105)	210(77%)	237	76	74	268	
1982	D	193(74)	69(36%)	146	82	45	89
1983	D	229(88)	64(28%)	154	78	37	67
1984	D	202(78)	56(28%)	109			

Sources: Agricultural Statistics (colums 1-3); FMS.

Table A.3.14

ALDEP Packages

	1979/80*	1981/82	1982/83	1983 (to October)	Oct. 83-Oct 84*
draftpower	49	109	82	273	510
implements	534	266	313	550	727
fencing	79	245	229	604	1579
water tanks	138	83	58	116	56
total	800	703	682	1543	2872

* pilot phase ** down-payment.
Source: RDU, 1985.

Table A.3.15

Combined Data from Intercropping Studies

Source		Details Trial		Effective rainfall	Mean yield in intercrop as percentage of respective sole crop		
				mm	Sorghum	Cowpeas	Total LER
Lightfoot (1983)		79/80	Sebele	282	109.3	25.4	1.31
			Mahalapye	315	142.1	27.5	1.70
			Motopi	166	72.7	21.7	0.94
			Moshu	322	78.2	12.0	0.90
		80/1	Sebele	569	97.1	10.2	1.07
			Good Hope	574	119.0	12.7	1.32
			Mahalapye	440	73.2	41.4	1.15
			Motopi (i)	446	86.7	36.0	1.23
			Moshu	401	105.7	15.8	1.21
		81/2	Sebele	223	79.4	23.4	1.03
			Good Hope	470	103.5	32.5	1.36
			Mahalapye	144	49.9	39.5	0.89
			Motopi	182	132.6	50.9	1.83
			Motopi (i)	308	85.1	32.1	1.18
			Moshu	157	58.7	47.3	1.06
			Moshu (d)	157	115.7	26.3	1.42
DLFRS	1	81/2	Sebele	187	105.5	22.2	1.28
	2		Sebele	214	67.4	20.8	0.88
	3	82/3	Sebele	98	21.3	84.9	1.06
	4		Sebele	140	54.0	14.5	0.69
	5		Sebele	56	77.3	51.3	1.29
	6		Sebele	76	85.0	45.8	1.31
	7	83/4	Sebele	46	23.3	30.1	0.3
	8		Sebele	97	90.3	51.1	1.41
	11	82/3	Good Hope	188	59.1	29.2	0.88
	12		Mahalapye	96	40.1	9.6	0.50
	13		Good Hope	128	56.0	53.1	1.09
	15		Motopi	71	53.1	11.1	0.64

Source: DLFRS: 1985 Final Report Vol.III.

i. - with supplemental irrigation
d - dryland (sandveld), as opposed to molapo (valley bottom) land used in other Moshu trial.
= Land Equivalent Ratio

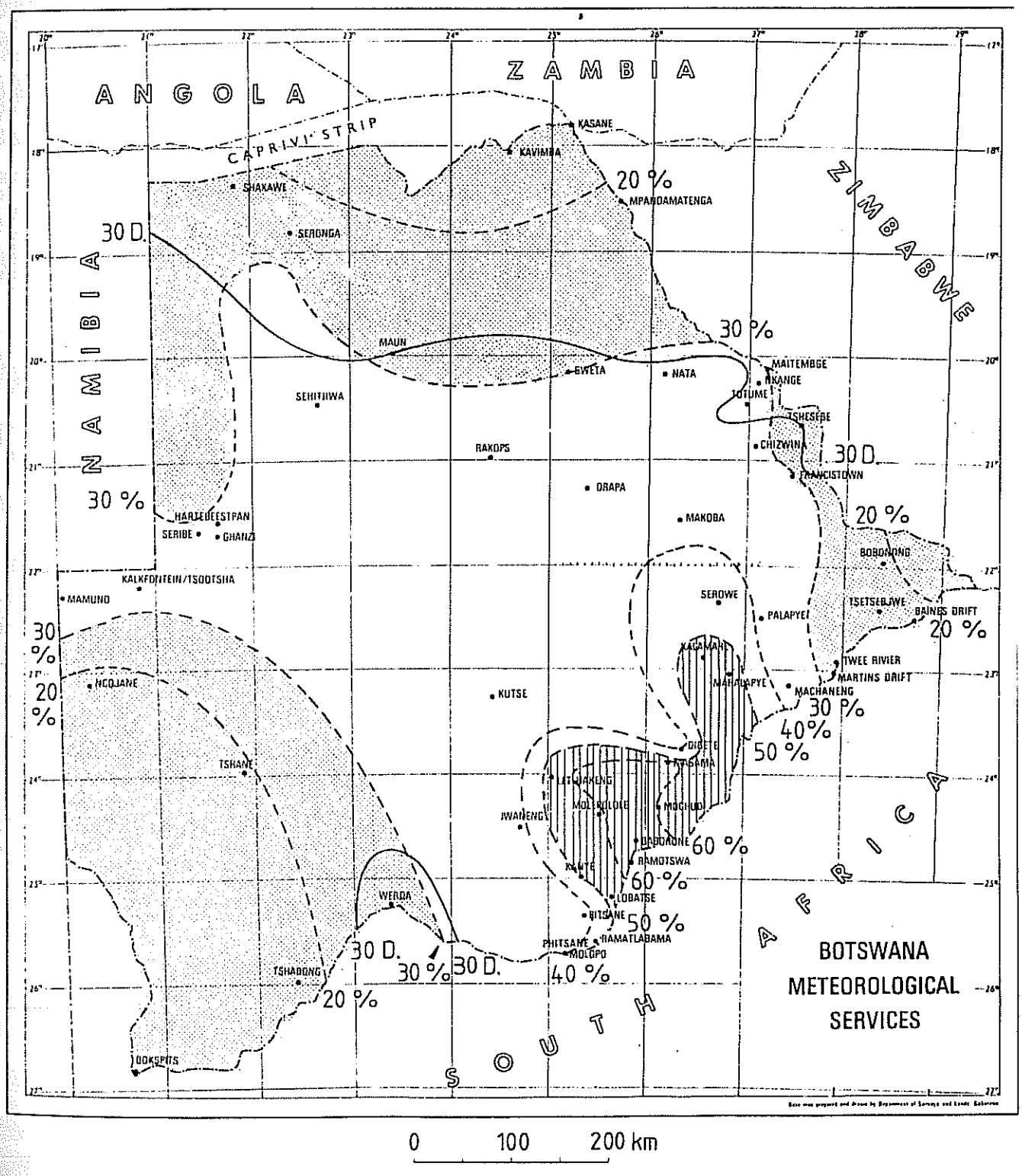
$$LER = \frac{\text{YIELD/HA INTERCROP A}}{\text{YIELD/HA SOLE CROP A}} + \frac{\text{YIELD/HA INTERCROP D}}{\text{YIELD/HA SOLE CROP D}}$$

Effective rainfall: TOTAL rainfall amounting from more than 10mm during two consecutive days during growing season.

Map A.3.1.

Length of a Dry Period between the First and Second Growing Season
(Source: Dambe 1986)

vertically lined areaindicates a chance of occurrence of higher than 50%
shaded area indicates a chance of less than 30%



APPENDIX A.4

WILDLIFE AND VELD PRODUCTS UTLISATION

Table A.4.1.

Globally Threatened Species found in Botswana

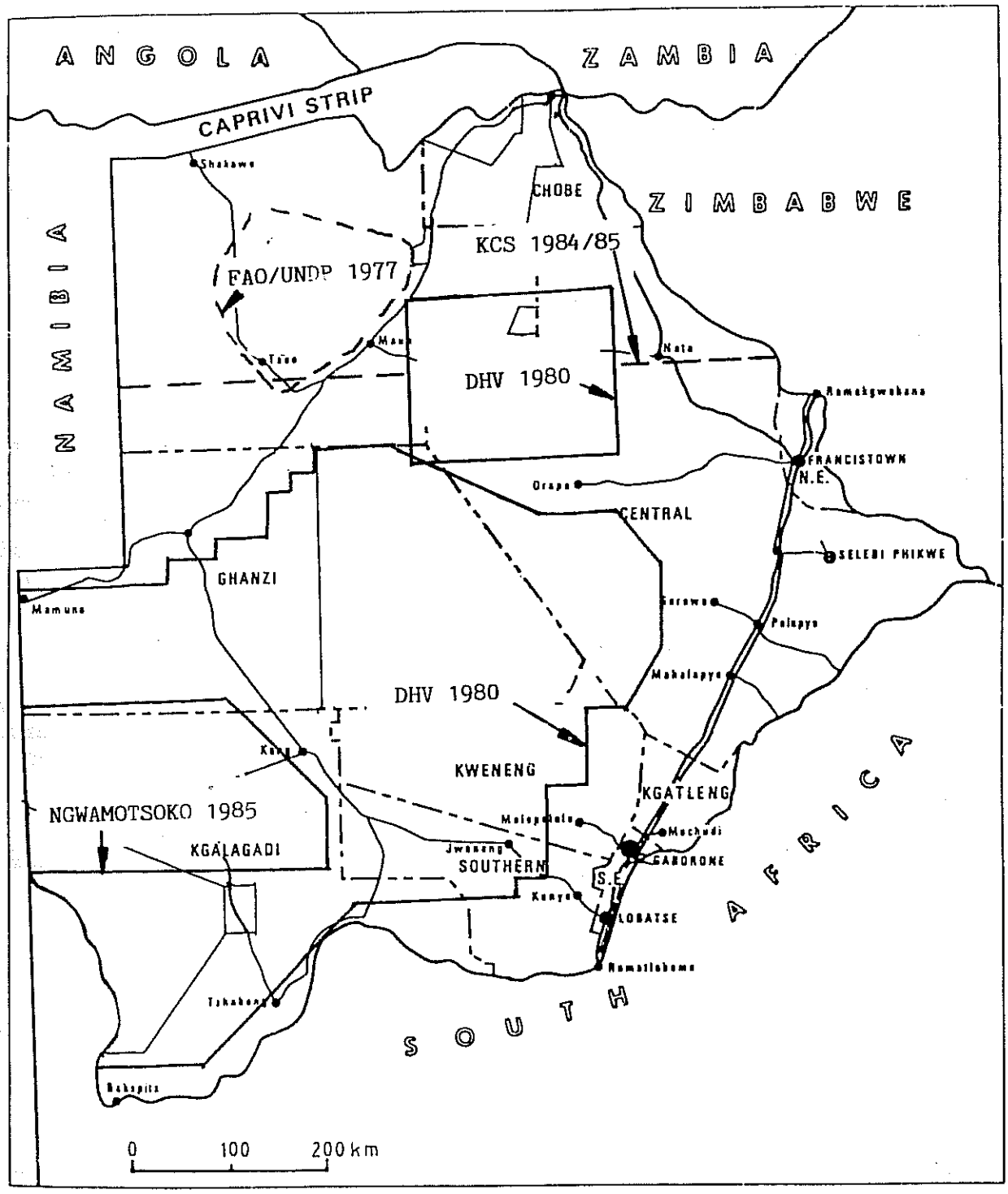
MAMMALS		
Order CARNIVORA		
Family Canidae		
Lycaon pictus	Wild Dog, African Hunting	Vulnerable
Family Hyaenidae		
Hyaena brunnea	Brown Hyaena	Vulnerable
Family Felidae		
Panthera pardus	Leopard	Vulnerable
Acinonyx jubatus	Cheetah	Vulnerable
Order PROBOSCIDEA		
Family Elephantidae		
Loxodonta africana	African Elephant	Vulnerable
Order PERISSODACTYLA		
Family Rhinocerotidae		
Diceros bicornis	Black Rhinoceros, Hooklipped Rhinoceros	Vulnerable
Order ARTIODACTYLA		
Family Bovidae		
Kobus leche	Lechwe	Vulnerable
BIRDS		
Order CICONIFORMES		
Family Ardeidae		
Egretta vianceigula	Slaty Egret	Indeterminate*
Family Balaenicipitidae		
Balaeniceps rex	Shoebill	Of Special Concern
Order FALCONIFORMES		
Family Accipitridae		
Gyps coprotheres	Cape Vulture	Rare
Family Falconidae		
Falco peregrinus	Peregrine Falcon	Vulnerable
Order GRUIFORMES		
Family Gruidae		
Bugeranus carunculatus	Wattled Crane	Of Special Concern
Order PSITTACIFORMES		
Family Psittacidae		
Agapornis nigrigenis	Black-cheeked Lovebird	Rare
REPTILES		
Order CROCODYLIA		
Family Crocodylidae		
Crocodylus niloticus	Nile Crocodile	Vulnerable

Indeterminate = Endangered or vulnerable or rare, but insufficient data.

Source: IUCN

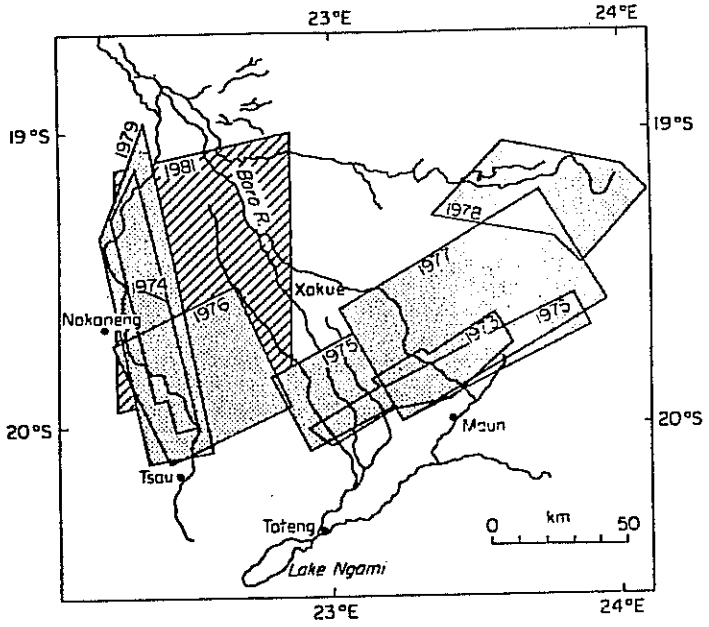
Map A.4.1.

Areas of Wildlife Counting



Map A.4.2.

Spatial Coverage of Tsetse Spraying Campaign (1977–1981)



Source: Allsopp, 1985

Table A.4.2.

Populations and Biomass Estimates for the Central and Southern Kgalagadi and the Makgadikgadi Pans

Species	POPULATION NUMBERS		POPULATION BIOMASS (KG)	
	Kalahari	Makgadikgadi	Kalahari	Makgadikgadi
Zebra	–	100 295	–	17 050 150
Hartebeest	293 462	–	36 682 750	–
Wildebeest	262 076	52 991	31 973 272	6 464 902
Gemsbok	70 174	1 249	11 157 666	198 591
Eland	18 832	–	4 463 184	–
Springbok	94 513	6 895	2 835 390	206 850
Ostrich	69 383	2 903	5 828 172	243 852
Giraffe	4 406	–	3 304 500	–
Kudu	5 386	1 043	689 408	133 504
Duiker	6 594	–	79 128	–
Steenbok	2 122	–	19 098	–
Warthog	878	–	37 754	–
Totals	827 826	165 376	97 070 322	24 297 849

Source: DHV 1980

Table A.4.3.

Wildlife Population Estimates North Eastern Kgalagadi District.

	1983			1984			
Sept.	Nov.	Jan.	Apr.	June	Aug.	Sept.	
Eland	1822	22863	4721	21425	9750	400	2700
Gemsbok	24743	38780	20594	30175	36775	26875	19300
Hartebeest	12726	245152	86323	72225	160575	80375	17000
Wildebeest	20872	100334	64932	91975	110275	57350	51000
Springbok	43996	73008	80291	293025	168475	89650	24300
Ostrich	23832	23895	27191	26375	22175	16825	15075
Kudu	759	3475	1932	1975	7400	2525	1300
Cattle	42251	86444	49194	89650	83300	78650	49600
Horse	582	3219	1574	1375	1925	2125	1425
Donkey	2075	3777	1603	2600	2900	3450	2175

Agr.Stat		1983	1984
Cattle	Ghanzi	41200	41000
	Kgalagadi	62700	59500
Horses	Ghanzi	1900	2200
	Kgalagadi	1400	1600
Mules	Ghanzi	3400	3300
Donkeys	Kgalagadi	5200	3800

Source: Ngwamotsoko (1985).

Notes
- Counting area only a small portion of Kgalagadi
- Agricultural statistics included as reference

Table A.4.4.

Wildlife Population Estimates Northern Botswana

Species	OKAVANGO DELTA* 1975/1976 Concentrated in the Delta	Dispersed from the Delta	NORTHERN BOTSWANA** 1984 April	October November
Buffalo	34900	34900	35190	57536
Cattle	21700	21700	14236	8390
Crocodile			100	243
Eland			133	1097
Elephant	4100	200	26121	85584
Gemsbok			50	1707
Giraffe	6600	6600	5201	6780
Hippo	2700	2700	1750	2926
Impala	24200	24200	17453	16414
Kudu	14600	14600	1833	1658
Lechwe	36600	36600	17703	31048
Ostrich	1800	700	1533	3365
Reedbuck	2400	2400	283	1268
Rhino			116	
Roan			816	536
Sable	2400	100	6067	5439
Sheep/Goats			3367	-
Shoats	-	-	3367	-
Sitatunga	-	-	950	853
Tsetsebe	9200	9200	5501	18658
Warthog	5600	5600	2617	3731
Waterbuck	-	-	133	902
Wildebeest	14400	9100	7218	13316
Zebra	14100	10900	63446	15658
Springbok	-	-	-	121
Baboon	219000	219000	-	-

Source: * UNDP FAO (1977)
: ** KCS (1984/1985)

Table A.4.5.

Wildlife Population Estimates Eastern Tuli Block

Species	1973*	1976**	1977**	1982*	1983*	1984 I*	1984 II**
Impala	14000	2039	3020	12000	i) 11000 ii)22300	15000- 20000	6027
Kudu	1000	168	562	1800	i) 700 ii) 1925	1200-1500	820
Eland	600	251	730	600	257	600-700	482
Waterbuck	100	-	42	200	-	70- 75	30-40 (?)
Warthog	400-500	-	154	500	-	100-150	46
Wildebeest	800	1341	1291	3200	-	50-100	110
Zebra	1200	946	1676	1250	i) 2500 ii) 166	50-100	52
Elephant	590		1009	350-680	400	400-500	625
Buffalo	-	-	-	-	-	-	-
Ostrich	-	72	84	-	-	-	80
Cattle	-	-	-	-	-	-	-
Donkeys	-	-	-	-	-	-	-
Goats	-	-	-	-	-	-	-

recorded as "incidentals" steenbok, bushbok, bushpig, grey duiker, klipspringer, hyena, lion, jackal and baboon troops.
I and II ground and aerial assesments.

Source: JOUBERT (1984)*
: NCHUNGA (1978)**

Table A.4.6.

Number of Rooms in Tourist Accomodation

Region	1970	1983	1984
Maun	52	108	239
Kasane	46	84	
Tuliblock	35	27	40
Total	133	219	279

Table A.4.7.

Number of Animals killed and the Contribution of each Species to the Total Amount of Game Meat (made available through Licenced and Unlicenced Traditional, and Illegal Hunting in Western Botswana - 1976)

Species	Licenced Tribal Hunting (1790 Hunters)			Unlicenced Subsistence Hunting (±813 hunters)			Illegal Hunting, Poaching (±415 Hunters)			Total (±3018 Hunters)		
	No. Killed	Kilos GameMeat Provided	% of Total Meat	Est. Number Killed	Kilos GameMeat Provided	% of Total Meat	Est. Number Killed	Kilos GameMeat Provided	% of Total Meat	Est. Total Killed	Kilos GameMeat Provided	% of Total Meat
Wildebeest	1,328	114,208	34	,633	54,438	23	,132	11,320	15	2,093	179,966	27
Hartebeest	1,952	109,312	32	,632	35,392	15	,126	7,039	9	2,710	151,743	23
Springbok	2,573	51,460	15	1,505	30,100	12	,410	8,200	11	4,488	89,760	4
Gemsbok	,100	9,000	3	,231	20,790	9	,157	14,150	18	,488	43,940	7
Eland	, 45	9,000	3	,108	21,600	9	, 77	15,456	20	,230	46,056	7
Ostrich	,498	9,960	3	,486	9,720	4	,112	2,249	3	1,096	21,929	3
Kudu	, 26	3,120	1	, 77	9,240	4	, 26	3,120	4	,129	15,480	3
Duiker	,380	3,040	0.6	1,533	12,264	5	,453	3,628	5	2,366	18,932	3
Steenbok	,483	2,898	0.4	1,427	8,562	3	,447	2,685	4	2,357	14,145	2
Giraffe	-	-	-		, 15	4	, 6	3,900	5	, 21	13,650	2
Warthog	, 18	,684	-	, 30	1,140	-	, -	, -	-	, 48	1,824	-
Lion	, 19	-	-	, 8	-	-	, 59	, -	-	, 86	, -	-
Leopard	, 10	-	-	, 5	-	-	, 30	, -	-	, 45	, -	-
Sub-Total	7,432	312,682	92	6,690	212,996	88	2,035	71,747	94	16,157	597,425	91
Small Game	12,023	25,683	8	13,334	28,230	12	3,059	4,718	6	28,416	58,631	9
Total	19,455	338,365	100	20,024	241,226	100	5,094	76,465	100	44,573	656,056	100

*Includes: Jackal, Bat-eared Fox, Springhare, Ganet, Caracal, Hare, Porcupine, Baboon, etc.
Source: Murray, 1978.

Table A.4.8.

Estimated Wildlife Conservation Policy Related Changes in Annual Benefits at the end of Assumed Transition Period

	Actuals 1983-84 (P000)	Assumed Percentage Point changes in the Growth rates attributable to policy change		Projected Value 1990-91 (P000)		Increase over 7 year period (P000)	
GROWTH RATE		Low	High	Low	High	Low	High
GOVERNMENT SECTOR							
1. Game licences fees	229.5	5	10	332.9	447.2	103.2	217.7
2. Export tax for game trophies	58.4	NA	NA	159.6	215.0	101.2	156.6
3. Taxes on income to industry	60.0	NA	NA	159.6	215.0	99.6	155.0
Sub-Total	347.9			652.1	877.1	304.2	529.3
PRIVATE SECTOR VALUE ADDED							
4. Value of game meat obtained for subsistence	11,250.0(2)	10	15	21,923.1	29,925.2	10,673.1	18,675.2
5. Commercial uses of tropies skins and meat	600.0(3)	15	20	1,596.0	2,149.9	996.0	1,549.9
Sub-Total	11,850.0			23,519.1	32,075.1	11,669.1	20,225.1
TOTAL	12,197.9			24,171.2	32,952.3	11,973.3	20,754.4
JOBS Estimated jobs in private sector (line 5)	230			612	824	382	594
Value added per worker (Pula)	2609			2609	2609	2609	2609

Source: Government of Botswana, 1986.