BOT/91/001
Field Document 15

Land Use Planning for Sustainable Agricultural Development

BOTSWANA

AGRICULTURAL LAND USE PLAN

FOR

LETLHAKANE AGRICULTURAL DISTRICT

CENTRAL REGION

Food & Agriculture Organization of the United Nations

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by

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United Nations Development Programme

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EXECUTIVE SUMMARY

Objectives and contents

1. This report is the result of a two-year study of Letlhakane Agricultural District (LetAD), carried out by the Agricultural Land Use Planners of the Ministry of Agriculture (Central Region). The main objective of the study is to provide planners, agricultural extension staff and community leaders with sound recommendations for improved and sustainable agricultural production and possible solutions for major land use problems and conflicts. The study includes an inventory of the natural resources, population, farmer groups and economy of the area, the identification of major land use problems and possible solutions, a land suitability evaluation and final recommendations. This report is accompanied by a series of thematic maps, showing land resources, land suitability, present land use and recommended land use.

Consultations

2. The present study was requested by the District Land Use Planning Unit (DLUPU) of Boteti sub-District and was carried out in close co-operation with DLUPU members, which include technical staff and administrators from the Land Board, District Council, District Administration and the Ministry of Agriculture. Some of the most important findings and recommendations of the study were discussed with DLUPU members, senior tribal authorities, councillors, senior technical staff from various ministries and other interested parties, during a three-day workshop. The results of this workshop have been incorporated in the final recommendations.

Land resources and population

3. Letlhakane Agricultural District covers an area of 29 170 km^2 and includes most of the administrative Boteti sub-District. The area stretches from the Central Ngwato cordon fence (Makoba) in the east to Ngamiland cordon fence (Makalamabedi) in the west and borders on the Central Kalahari Game Reserve in the south-west and the Makgadikgadi Pans National Park in the north.

4. The climate is semi-arid with summer rainfall and high rainfall variability. Three rainfall zones have been distinguished with a mean annual rainfall for the period 1968 - 1990 of 351, 370 and 458 mm respectively, the latter only occurring in the extreme north-west. The area is mostly flat with sandy soils of low nutrient status. Surface water is limited to semi-permanent pools in the Boteti river and seasonal stagnant water in shallow depressions. The Boteti river has experienced a significant flow in one year only in the period from 1983 to 1996. Deep groundwater of varying quality occurs in the south and west; shallow, perched groundwater tables locally occur in the north and north-east and in the Boteti river. The vegetation is predominantly shrub savanna, with grasslands and bare pan surfaces near the Makgadikgadi and dense savanna locally in the west (Gidikwe ridge), along the Boteti river and in the north-east.

5. The total population of LetAD (including Orapa) in 1991 was 44 286, with an annual growth rate of around 3%. Major settlements include Orapa, Letlhakane, Rakops, Mopipi and Xhumo. The main economic activity in LetAD is diamond mining, although only a small number of households is directly involved. In addition to mining, households derive cash income through government employment, businesses and remittances. Half of the households are seriously involved in crop and/or livestock production, mostly at subsistence level.

Crop production (general)

6. Even in a good season, only a small part of LetAD (around 0.3%) is used for cultivation. Rainfed cropping of maize, sorghum and/or millet with cowpea and watermelon is the most common form of cultivation. About one-third of the households are seriously involved in rainfed cropping. Most farmers have access to draught power in the form of donkeys or oxen. Farms are relatively small with an average of 2 to 3 ha and production is low and variable, with an annual average of 200 to 300 kg of grain and beans per farm. Rainfed cropping, without drought subsidies, does not generate much cash income and is practiced mainly at subsistence level. Molapo farming in the Boteti river has not been possible since the early eighties. Irrigated crop production is almost insignificant and has little potential.

7. Low and unreliable rainfall and the lack of a reliable source of surface water or groundwater of good quality is the most important physical constraint for the development of arable farming.

Rainfed cropping

8. Productivity of rainfed cropping is increased more easily by improved management of traditional crops than by the introduction of new crops. Sorghum is the most suitable crop, although, with present producer prices, maize may give a better gross margin in areas with the highest rainfall and the best soils.

9. The most effective improvement of the present system of rainfed cropping is early planting, which means dry planting during late November, or planting immediately after the first significant rains from mid November onwards. If planting is not possible before the end of the year, millet or varieties of sorghum and maize with a short growing cycle should be planted with the first opportunity in January. The use of chemical fertilizer gives only modest returns and only if applied selectively, close to healthy plants or in permanent rows. The optimal plant density for sorghum, millet and maize is around 15 000 plants per hectare, with the plants evenly distributed over the field.

10. Although the use of tractors makes early ploughing of large areas possible and increases yield considerably, maintenance and depreciation of tractors and fuel costs are higher than the value of produce in most years.

11. A farm household with at least two adult or adolescent members full-time available for farm work from November to January and with access to (animal) draught power and a cart in October can improve the gross margin of rainfed sorghum, maize and millet production three-fold, through manuring, early planting, timely weeding, thinning and replanting (if necessary).

12. An average farm family with one or two members full-time available for farming activities and with one span of oxen or donkeys can not efficiently manage more than 5 ha and land allocations should be limited to that size to avoid unnecessary ploughing and excessive land claims.

13. Some of the large lands areas with perimeter fence are only partly used for cultivation and may include many livestock. Individual fields often have their own fence, creating a double-fence situation. Although many fields may be located in pockets of good soil, the lands areas of Mosu (Nthane), Letlhakane and Mopipi (south-west of Mokobaxane) as a whole have a high proportion of shallow soil. Detailed land use plans of lands areas, drawn up in co-operation with the communities concerned, are recommended.

Molapo farming

14. The Boteti river has experienced a significant flow in only one year in the period from 1983 to 1996 and molapo farming has not been practiced much in recent years. Some of the molapo fields are suitable for rainfed cropping and could be used for that purpose. For this to happen the Land Board will have to revise its policy on land allocation in the Boteti river. A further investigation into the potential of the riverbed for both rainfed cropping and molapo farming is recommended.

Backyard gardening

15. Provided a small but cheap source of water is at hand, year-round or seasonal gardening is recommended for all households. Intensive gardening of very small plots (less than 100 m2) is recommended with or without poultry and beekeeping. Simple and locally applicable guidelines are needed for this activity. The MoA should take this form of crop production more seriously.

Beekeeping, poultry and backyard nurseries

16. Beekeeping, small-scale poultry and backyard tree nurseries can be profitable activities for a limited number of households, provided supervision is on a daily basis and continuous. These activities are ideal for people tied to their home, such as single woman with children and the elderly.

Animal production (general)

17. The main present land use is extensive grazing, with communal grazing along the Boteti and near major villages, and with individually owned cattle posts in remote areas. In 1993 the area supported 8.6% of the national cattle herd and 7% of the national stock of goats. Almost half of all households are seriously involved in animal production. Herds are relatively large with an average of almost 60 head of cattle per cattle farm. Annual offtake is around 10% for both cattle and goats. Livestock losses are very high, particularly in dry years.

18. The livestock carrying capacity of the area varies enormously from one year to the other, depending on rainfall. For this reason, the on-farm production and preservation of hay is essential for the long-term survival of the herd. The hay is preserved for supplementary feeding during periods of exceptionally low rainfall and lack of grazing. Another management intervention which will greatly improve livestock productivity is the timely sale of unproductive cows and of steers at the age of four years. Controlled breeding is also recommended, but is only possible on fenced farms.

Cattle posts and ranching

19. If the farmer is not prepared to live on the cattle post, the farm should be left to a qualified manager. Several farms in the same area could be supervised by a single manager if provided with transport and connected by radio.

20. The whole of LetAD is covered with boreholes and wells, with very few opportunities for new waterpoint allocations if a minimum distance of 8 km between waterpoints is maintained.

21. The over-all benefits of fenced ranching over free-range cattle posts has not been established beyond doubt. The land allocation and fencing scheme in the Kaka area should be implemented and evaluated before ranching is initiated elsewhere in the area.

Boteti State Land

22 Parts of Boteti State Land in the north-central part of LetAD are intensively used for grazing with cattleposts established around open wells. Tribalization of those areas is recommended.

Waterharvesting for livestock and wildlife

23. In areas without surface water and without shallow groundwater of good quality, rainwater harvesting techniques may help to maintain small numbers of livestock or wildlife. Experiments with water harvesting techniques are proposed in areas with gentle slopes or small natural pans. Fossil dune formations, valleys and beach ridges could be used for harvesting water from artificially sealed surfaces. Locally, water could also be harvested from small, natural pans, by increasing their waterholding capacity and reducing evaporation.

Wildlife and tourism

24. Although historically a prime area for migrating ungulates, their predators and many other forms of wildlife, LetAD has now become a hostile environment for most species because of the numerous veterinary cordon fences, diminishing sources of open water, increasing use of the natural vegetation for animal production, and increasing mobility and hunting and poaching capabilities of residents and visitors. The area has remained attractive for many forms of birdlife, particularly in wet years.

25. Despite a diminishing wildlife population, LetAD has potential for tourism in the form of (photo)safaris, because of its vicinity to the Central Kalahari Game Reserve and the Makgadikgadi Pans National Park and its unique scenery, particularly along the Boteti river and in the Makgadikgadi. It is essential that the local population is involved in the development of the tourist sector, both in communal land and nearby nature reserves.

Game ranching

26. Ostriches are amongst the most ubiquitous forms of wildlife still present, and ostrich farming is one of the most promising forms of wildlife utilization in the area. An ostrich farm has been in operation for a number of years in an adjacent area. The potential for small-scale, stall-fed ostrich production should be investigated. Although there may be opportunities for other forms of intensive wildlife utilization, very few residents will have the skill, resources and motivation to embark on such an enterprise.

Land use conflicts along the western boundary of the Makgadikgadi Pans National Park

27. The western boundary of the Makgadikgadi Pans National Park runs along the channel of the Boteti river from Moreomaoto to Sukwane. The river is used for animal production and cropping by communities living on the west bank and by wildlife for water and forage. Crop damage by wildlife is common and some animals pose a threat to both humans and livestock. Large numbers of livestock stray into to National Park or are deliberately taken there to graze. In agreement with the Makgadikgadi/Nxai Pans Management Plan it is proposed to fence the western boundary of the National Park. Such a fence could cross the river at several points, leaving some sections of the channel (e.g. hippo pools) to the National Park and other sections (e.g. cultivable land) to the villages. This is called the "give and take" fence and needs further study and consultation.

Desertification, land degradation

28. The soils in and around the Makgadikgadi depression have a high content of silt and fine sand and are very susceptible to wind erosion. Dust storms are a natural phenomenon in and around the pans and not necessarily prove of desertification. Degradation of the vegetation is most evident along the Boteti river (decrease in tree and grass cover), around waterpoints (less grass, more weeds) and around Rakops (poor ground cover). These forms of degradation are caused by drought, increased population density and more intensive land use, and are not easily reversed. A partial solution may be provided by natural woodland management and improved village environment (see below).

Natural woodland management

29. Although most of LetAD is covered with shrub savanna, areas of dense savanna with valuable forestry resources occur. Examples of such resources are the "morukuru woodland" near Khwee, the "riverine woodland" along the Boteti and the mopane dense savanna around Mosu and Nthane. It is recommended that inventories are made of these resources and management plans drawn up in co-operation with the communities concerned.

Village environment

30. Villages like Rakops, Xhumo, Toromoja and Mopipi are exposed to dusty winds. An improved micro-climate could be provided by an intensive programme of tree, shrub and hedge plantation around compounds and public places. Low mud walls and reed fences could also provide shelter. Natural creeping grasses and harmless creeping weeds should be allowed to grow throughout the compound, together with indigenous shrubs and trees along the edges. Remaining trees in the village should be protected.

District Land Use Planning Unit

31. The District Land Use Planning Unit, both at District and sub-District level, is a good forum to discuss various land use issues, but should be taken more seriously by the heads of the various departments and institutions involved. Major issues should be taken to an inter-ministerial technical committee, such as the Land Development Committee.

ACKNOWLEDGEMENTS

The vegetation survey of the present study was carried out with assistance from the Range Ecologist of the Regional Agricultural Office in Francistown (Mr D. Tshosa). The land evaluation for animal production was done with assistance from our colleagues in the LUPSAD project, Messrs M.J. Powell (Livestock Evaluation Specialist) and J.H.M. Pulles (Agricultural Land Use Planner).

Throughout the study, technical and logistical support was received from the Regional Agricultural Office (Central Region) in Serowe and the Letlhakane Disrict Agricultural Office.

A high level of co-operation was received from the District Administration (Central District and Boteti sub-District), the local administration and from the Department of Wildlife and National Parks.

TABLE OF CONTENTS

LIST OF TABLES (in main text)

LIST OF TABLES (in Annexes)

LIST OF MAPS

LIST OF FIGURES (in main text)

LIST OF FIGURES (in Annexes)

LIST OF ABBREVIATIONS AND ACRONYMS

AD	Agricultural Demonstrator
AEA	Agricultural Extension Area
ALDEP	Arable Land Development Programme
ALUP	Agricultural Land Use Planner (MoA)
approx.	approximately
ARADP	Accelerated Remote Area Development Programme
APRRU	Animal Production and Range Research Unit
APSRAMB	Animal Production Simulation and Range Assessment Model for Botswana
ARAP	Accelerated Rainfed Arable Programme
ARB	Agricultural Resources Board
asl	above sea level (altitude)
ASPIC	Agricultural Sector Policy Implementation Committee
BAMB	Botswana Agricultural Marketing Board
BCU	Botswana Co-operative Union
BDC	Botswana Development Corporation
BMC	Botswana Meat Commission
BOC	Botswana Orientation Centre
CC	carrying capacity
CDW	cold dressed weight
CEC	cation exchange capacity
CFDA	Communal First Development Area
CHA	Controlled Hunting Area
CSO	Central Statistics Office
CYSLAMB	Crop Yield Simulation and Land Assessment Model for Botswana
DA	District Administration
DAHP	Department of Animal Health and Production
DAO	District Agricultural Office(r)
DC	District Commissioner
DCPF	Department of Crop Production and Forestry
DDC	District Development Committee
DDP	District Development Plan
DLUPU	District Land Use Planning Unit
DM	dry matter
DO(D)	District Officer (Development)
DO(L)	District Officer (Lands)
DTRP	Department of Town and Regional Planning
DWNP	Department of Wildlife and National Parks
FAO	Food and Agricultural Organization of the United Nations
FAB	Forestry Association Botswana
FAP	Financial Assistance Policy
FPDP	Forestry Protection and Development Project
GIS	Geographical Information System
Govt.	Government (of Botswana)
ha	hectare
HH	household(s)
ICES	Interministerial Coordinating Environmental Subgroup
ILWIS	Integrated Land and Water Information System (GIS)
INCD	Intergovernmental Convention to Combat Desertification
IUCN	International Union for the Conservation of Nature
KCS	Kalahari Conservation Society
LAC	Livestock Advisory Centre
LetAD	Letlhakane Agricultural District (= study area)
LGP	length of growing period
LSU	livestock unit
LU	land unit
LUO	Land Use Officer (MoA)
LUPSAD	Land Use Planning for Sustainable Agricultural Development
MCI	Ministry of Commerce and Industry

MFDP	Ministry of Finance and Development Planning
MLGL	Ministry of Local Government and Lands (now MLGLH)
MLGLH	Ministry of Local Government, Lands and Housing
MoA	Ministry of Agriculture
NCS	National Conservation Strategy
NDP	National Development Plan
NGO	Non-Governmental Organization
NRMP	Natural Resources Management Project
PET	potential evapo-transpiration
pH	an indication of (soil) acidity
pl/ha	plants per hectare
ppm	parts per million
PTB	Permaculture Trust Botswana
RAD	Remote Area Dweller
RAO	Regional Agricultural Office(r)
SI	Stock Inspector
SLOCA	Services to Livestock Owners in Communal Areas
TDS	total dissolved solids
sp	species
UB	University of Botswana
UNEP	United Nations Environment Programme
VEA	Veterinary Extension Area
VA	Veterinary Assistant
VDC	Village Development Committee
WMA	Wildlife Management Area

CHAPTER 1

INTRODUCTION

1.1 LAND USE PLANNING FOR SUSTAINABLE AGRICULTURAL DEVELOPMENT

In co-operation with the United Nations Development Programme (UNDP) and the Food and Agricultural Organization of the United Nations (FAO), the Ministry of Agriculture initiated Land Use Planning for Sustainable Agricultural Development (LUPSAD) in 1992. The LUPSAD project is executed by the Land Utilization Division of the Department of Crop Production and Forestry in the Ministry of Agriculture. The main activities of the LUPSAD project, which in its present form will run until the end of 1996, are the development of a method of agricultural land use planning, training of Agricultural Land Use Planners in the Ministry of Agriculture and the preparation of agricultural land use plans for selected areas.

1.2 AGRICULTURAL LAND USE PLANNING

Agricultural land use planning is the systematic assessment of land and water potential, present and potential land use and social and economic conditions, for the purpose of selecting agricultural land uses which are most beneficial to farmers, without degrading the environment.

Agricultural land use planning also considers land uses which are not strictly agricultural, for the purpose of finding alternatives to farming in areas with low agricultural potential, to solve or avoid conflicts between agricultural use and non-agricultural use, or to describe or promote multiple use of the land.

1.3 STUDY AREA

The study area is Letlhakane Agricultural District (LetAD), which covers most of the administrative Boteti sub-District in Central District (for location see Section 3.1). A request for an agricultural land use plan came from the District Land Use Planning Unit (DLUPU) of Boteti sub-District and the area was selected in consultation with the Regional Agricultural Officer (RAO) of the Central Agricultural Region. The main reasons for selecting LetAD as a study area were the interest shown by the Boteti sub-DLUPU and the need for a pilot study area which differed in scale and natural environment from a previous study carried out by the Agricultural Land Use Planners of Central Region of Ratholo Agricultural Extension Area in the east of the country.

1.4 OBJECTIVES

The present study has two main objectives:

The first objective is to provide planners, agricultural extension staff and community leaders with sound recommendations concerning improved and sustainable agricultural production in the study area. The recommendations will be specific for the various agro-ecological zones in the area as well as for the various farmer groups with different resources and different priorities.

The second objective is to test planning methodology at district level and to provide specialists in the Ministry of Agriculture with an example of a study at district level.

1.5 TERMS OF REFERENCE

The terms of reference as agreed upon by the Regional Agricultural Officer (Central Region) and the Boteti sub-DLUPU early 1995 are as follows.

Planning Area

The Agricultural Land Use Plan will cover Letlhakane Agricultural District.

Objectives

The main objectives of the land use plan are the improvement of the standard of living of the rural population of the Agricultural District through increased land productivity and the preservation of the natural resource base through appropriate and sustainable land use.

Major outputs

Major outputs of the land use planning exercise will be

a) an inventory of land resources (soils, landforms, vegetation, climate and water), including maps at a scale of approx. 1:500 000
b) an inventory of present land use, including a map at a scale of approx. 1:500 000
c) a land suitability evaluation for rainfed cropping, molapo farming, irrigated farming, livestock (grazing), and game ranching
d) an inventory and analysis of population, farming systems and socio-economic conditions
e) a summary and analysis of constraints and conflicts related to present land use
f) possible solutions for existing conflicts and possible measures to combat mis-management of land resources
g) advice concerning improved farming (crops and livestock), specified for various groups of farmers (farmers with various levels of resources and skills) and various agro-ecological zones
h) a map at a scale of approx. 1:250 000 showing recommended land use

CHAPTER 2

METHODOLOGY

2.1 DATA COLLECTION AND ANALYSIS

2.1.1 Inventory of land resources

- Geographical Information System

For the analysis of geographical information and the production of maps use was made of a computer programme called ILWIS (ITC, 1992) which is a Geographical Information System (GIS). Information was entered either by copying already processed data (e.g. soil map) or by digitizing from hard-copy maps. The ALUP office in Serowe is equipped with a desktop computer, a digitizing table (size A2) and a colour printer (size A3). Maps larger than A3 were produced by pasting individual A3 sheets.

- Topography, basemap

A basemap at scale 1:250 000 was produced with information from topographic maps at scale 1:250 000 and 1:50 000 (Dept. of Surveys and Lands, 1973-1990), satellite imagery and fieldwork. The existing topographic maps are mainly based on aerial photography of the 1971 to 1979 and had to be updated with information from recent satellite imagery (Landsat 5, scene 173-075 of 7/6/94) and extensive fieldwork (1995). A list of relevant topographic maps, aerial photographs and satellite imagery is given in Annex 1.

- Climate

Climatic data were derived from the Meteo database of the Land Utilization Division, supplemented with recent data from the Department of Meteorological Services.

- Geology and geomorphology

Information on geology and landforms was derived from literature quoted in Section 3.3. Map 2 showing Major Landforms was produced by the authors.

- Soils

Soil information is mostly based on the Soil Map at scale 1:250 000 of the Soil Survey Section of the Land Utilization Division (Soil Survey Section, 1984-1990) and the Revised General Soil Legend (Verbeek and Remmelzwaal, 1990). The relevant sheets of the Soil Map are given in Annex 1. Information for the southern part of LetAD was derived from the Soil Map of Botswana at scale 1:1 000 000 (De Wit and Nachtergaele, 1990). The original soil data were somewhat simplified, with very similar soils grouped together. A modification was made in one case (Unit L22c-KS6-3 of the Orapa sheet was found to be dominantly sandy). Minor errors and inconsistencies in the maps were also corrected. The soils were classified according to the Revised Legend of the Soil Map of the World (FAO, 1990). The final result is presented on the Soil Map (Map 3) of this report.

- Water

Waterpoint data were derived from the inventory carried out by Wellfield Consulting Services (1995). The original data are in the form of DBase files and were transferred to ILWIS. Map 4 of this report shows the distribution of the waterpoints as in 1994. Flow data of the Boteti river were obtained from the Dept. of Water Affairs.

- Vegetation

A vegetation survey of LetAD at reconnaissance level was carried out by the authors with assistance from the Range Ecologist from the RAO in Francistown. Fieldwork was carried out in the months April and May of 1995. Preliminary vegetation units were identified on satellite imagery (see Annex 1 for details of imagery used) and a total number of 53 sites were described in detail. Data were entered into the Vegetation Database of the project. Some information from the vegetation survey of the Kedia Baseline Survey (Van der Maas, ed., 1995b) was incorporated into the final Vegetation Map (Map 5) of this report.

- Present land use

Information on present land use at reconnaissance level was obtained through field work, interpretation of satellite imagery, interviews with Agricultural Demonstrators and other specialists, and literature. Hansen and Lillethun (1986) have mapped land use at scale 1:100 000 in the north-western part of LetAD, but this information was not available except for areas studied by Bastiaanssen (1990). Map 6 of this report shows the Present Land Use.

- Land units

Two types of land units were defined, one for crop production (shown on Map 7) and one for animal production (shown on Map 8). Land units for crop production (Map 7) are based on climate (three rainfall zones are distinguished), soils (Map 3 was further simplified for this purpose) and landform. Land units for animal production (Map 8) are a combination of vegetation (Map 5), climate (same three rainfall zones as for crops), and a broad indication of water availability and soils.

2.1.2 Socio-economic information

Population data were derived from publications of the Central Statistics Office (1993, 1994) with results of the 1991 Population and housing census. The CSO data also give some insight into the economic activities of the population. Information on arable farming was obtained from the DAO and ADs; drought relief data proved to be particularly useful. Data on cropping and livestock were also obtained from the 1993 Botswana Agricultural Census (MoA/CSO, 1995), which gives information for agricultural districts. The Department of Animal Health and Production in Letlhakane (Veterinary Officer) and Serowe (Animal Production Officer) provided additional information in livestock. Much knowledge was gained from recent socio-economic surveys in the western part of LetAD (Boteti CFDA, phase 1), including those of Van der Maas (1995a, b), Bastiaanssen (1990) and Hansen & Lillethun (1986). Mars (1996) carried out research in Mokobaxane in the middle of LetAD. Interesting facts also emerged from the Participatory Rural Appraisals in Kedia (BOC, 1996) and Rakops (Marata & Keakile, 1996) and the study of the Kaka area in the south of LetAD (ASPIC, 1996).

2.1.3 Inventory of land use problems

Some land use problems were identified by the DLUPU of Boteti sub-District in its request for an agricultural land use plan. The recent baseline surveys of North-west Boteti and Kedia (Van der Maas, 1995a, b), the Makgadikgadi/Nxai Pan Management Plan (MCI, 1995) and the desertification study of the mid-Boteti river area (MoA/UB, 1994), and other studies (see Section 2.3) reveal many problems. Additional problems emerged from informal interviews with farmers and local specialists and administrators, or were deduced from field observations.

2.1.4 Land suitability evaluation

The land suitability evaluation of the present study largely follows the methodology of the Guidelines for Agricultural Land Use Planning (LUPSAD, 1996). A brief summary of the methodology is given below. More detail is included in the relevant sections of Chapter 6 of this report.

- Crop production

  For the evaluation of five selected rainfed crops a crop yield simulation model (CYSLAMB) was used. CYSLAMB is explained in some detail in Section 6.2. The land units evaluated are indicated on Map 7. The result of the CYSLAMB evaluation for several actual and potential production systems is given in Annex 7. The result of the evaluation of a few of the most relevant production systems is presented on Map 7 of this report. The results of the evaluation are expressed in yield (kg/ha). For a number of production systems a gross margin calculation has been carried out.

  The evaluation of selected rainfed crops not included in CYSLAMB and of molapo farming is done in a more qualitative manner, as explained in the relevant Sections of Chapter 6.

- Animal production

  For the assessment of potential biomass production the biomass module of an animal production model (APSRAMB) was used. APSRAMB is explained in some detail in Section 6.5. The land units evaluated are indicated on Map 8. The potential biomass production for the various land units are given in Section 6.5.3, Annex 10 and is shown on Map 8. The livestock module of APSRAMB was used to simulate cattle production under various management systems. The suitability of the various management systems has been expressed in simple financial terms.

- Hunting, gathering, wildlife utilization, tourism, residential

  The land suitability for veld products, wildlife, tourism and settlement were carried out in a quantitative manner. The methods used are explained in the relevant sections of Chapter 6.

2.1.5 Agricultural land use plan

The agricultural land use plan consists of recommendations, extension messages, a land use zoning exercise and a number of proposed projects. The recommendations reflect the outcome of the land suitability evaluation of Chapter 6. An attempt has been made to select the most suitable solutions for the

problems identified in Chapter 5. The process of problem solution carries a great subjective element, as various physical, social and economic parameters of different magnitude have to be considered. Recommended land use is shown on Map 11 and reflects present land use, ongoing developments, existing plans and possible improvements. The proposed projects mainly concentrate on areas for further study.

2.2 CONSULTATIONS

The most important consultations carried out were the following:

i) various progress reports and discussions with DLUPU Boteti sub-District
ii) informal interviews and discussions with farmers, government officials and specialists
iii) Boteti Land Use Workshop (14-16 August 1996). Selected themes and projects were presented and discussed during the Workshop with local leaders, councillors and Land Board, and specialists from DWNP, MoA, PTB and NCS. Presentations, discussions the action plan of the Workshop are presented in a report for the sub-DLUPU (Boteti sub-DLUPU, 1996).

2.3 PREVIOUS STUDIES

The first phase of the Boteti Communal First Development Area (CFDA), covering the western part of LetAD, has been well covered with environmental and socio-economic studies. The second phase of Boteti CFDA, covering the eastern part of LetAD, never materialized and the area has never had much attention except from geologists and hydrologists in the Orapa-Letlhakane mining area and from archaeologists in the area south of Sua Pan. The southern part (Kaka area) has also been studied by various specialists recently in connection with the Agricultural Sector Policy Implementation Committee (ASPIC). The following studies include a major element of land use planning:

- A *Desertification Control Seminar* was held in Rakops in 1988 (ICES/UNEP, 1988). The seminar was organized by the Interministerial Coordinating Environmental Subgroup (ICES) and sponsored by the United Nations Environment Programme (UNEP) and attended by village leaders and members of the Village Extension Team. A number of resolutions were made.

- Hansen and Lillethun (1986) of the University of Trondheim (Norway), in a study called *"Resource utilization in the Central District"*, describe the farming systems of Boteti CFDA (phase 1), in particular those of Toromoja, Rakops and Khumaga, and conflicts in resource management. They give recommendations related to arable farming, range management and wildlife management. The results of the study include land use maps at scale 1:100 000 (which could not be traced).

- Bastiaanssen (1990) studied the *"Potential and constraints for communal grazing activities in west-Boteti"*. This consultant's report for the District Land Use Planning Unit (DLUPU) of Central District deals with the ecological and social feasibility of communal grazing management projects in Toromoja, Mmadikola and Sukwane at the request of Central District DLUPU. The study describes the resource management in the three areas, and in particular animal husbandry, and gives

development options.

- The *Central District Planning Study* (Environmental Consultants, 1992) is a database of land resources, infrastructure and administrative boundaries of Central District. Existing data have been edited and entered into a Geographical Information System (GIS); hard-copy maps, mostly at a scale of 1:1 500 000, are presented in Volume 2.

- Volume I of the *Central District Settlement Strategy* (Swedeplan, 1994) of DTRP and District Council gives an inventory of natural resources, population, economy, infrastructure and administrative institutions of Central District and identifies a number of issues. Volume II formulates strategy proposals.

- The Division of Planning (MLGL&H), in co-operation with the University of Utrecht (The Netherlands), carried out a baseline survey of Boteti CFDA (phase 1) in two parts: *"North-west Boteti baseline survey"* (Van der Maas et al, 1995a) and *"Kedia baseline survey"* (Van der Maas et al, 1995b). The surveys cover natural resources, population characteristics, socio-economic infrastructure, agriculture (livestock and crops), wildlife and tourism. The survey of North-west Boteti gives a detailed account of soils and land suitability for crop production along the Boteti River. The Kedia survey includes a vegetation map at scale 1:400 000 and carrying capacity estimates. Both studies give recommendation related to area development.

- In the context of the Intergovernmental Convention to Combat Desertification in Botswana (INCD) the Ministry of Agriculture (MoA), with the University of Botswana (UB) carried out a case study in the Mid Boteti area (Rakops) (MoA/UB, 1994). The study is called *"Desertification and possible solutions in the mid-Boteti river area"* and determines the extent and elements of desertification, assesses the perceptions of desertification by the local population and proposes rehabilitation measures which involve the local people.

- Land resource and development studies covering specific areas include the *"Proposed Kedia Wildlife Management Area Waterpoint Survey* (Environmental Services, 1989) south of Kedia, and the various papers, minutes and proceedings of ASPIC in connection with the *Kaka area* (ASPIC, 1996).

- Although covering an area mostly outside LetAD, the *"Makgadikgadi/Nxai Pan Management Plan"* carried out by the IUCN for the Ministry of Commerce and Industry (MCI, 1995) gives useful suggestions with respect to wildlife management, tourist development and possible solutions for conflicting interests of farmers and wildlife conservationists.

CHAPTER 3

LAND RESOURCES

3.1 LOCATION

The study area covers Letlhakane Agricultural District, which includes Boteti sub-District (MLGL&H), with exception of Makgadikgadi Pans National Park and the Ntwetwe and Sua Pan and adjacent areas (see Map 1). The area is situated between longitudes 23° 53'E and 26° 18'E and latitudes 20° 12'S and 22° 25'S. The total area is 29 170 km^2 (2 917 000 ha), which is about 5% of the total land area of Botswana. In this report, the study area as defined above will be indicated with the acronym LetAD.

The eastern and south-eastern boundary of LetAD is the Central Ngwato veterinary cordon fence (Kaka-Makoba-Thalamabele-Dukwe), the south-western boundary is shared with the Central Kalahari Game Reserve, the eastern boundary is the Ngamiland veterinary cordon fence (Makalamabedi), and the northern boundary runs along the Boteti river from Makalamabedi to Sukwane, along the southern boundary of the Makgadikgadi Pans National Park from Sukwane to Tjai and along the west-east veterinary cordon fence from Tjai eastward to Sua Pan (north of Mosu) and Moana gate.

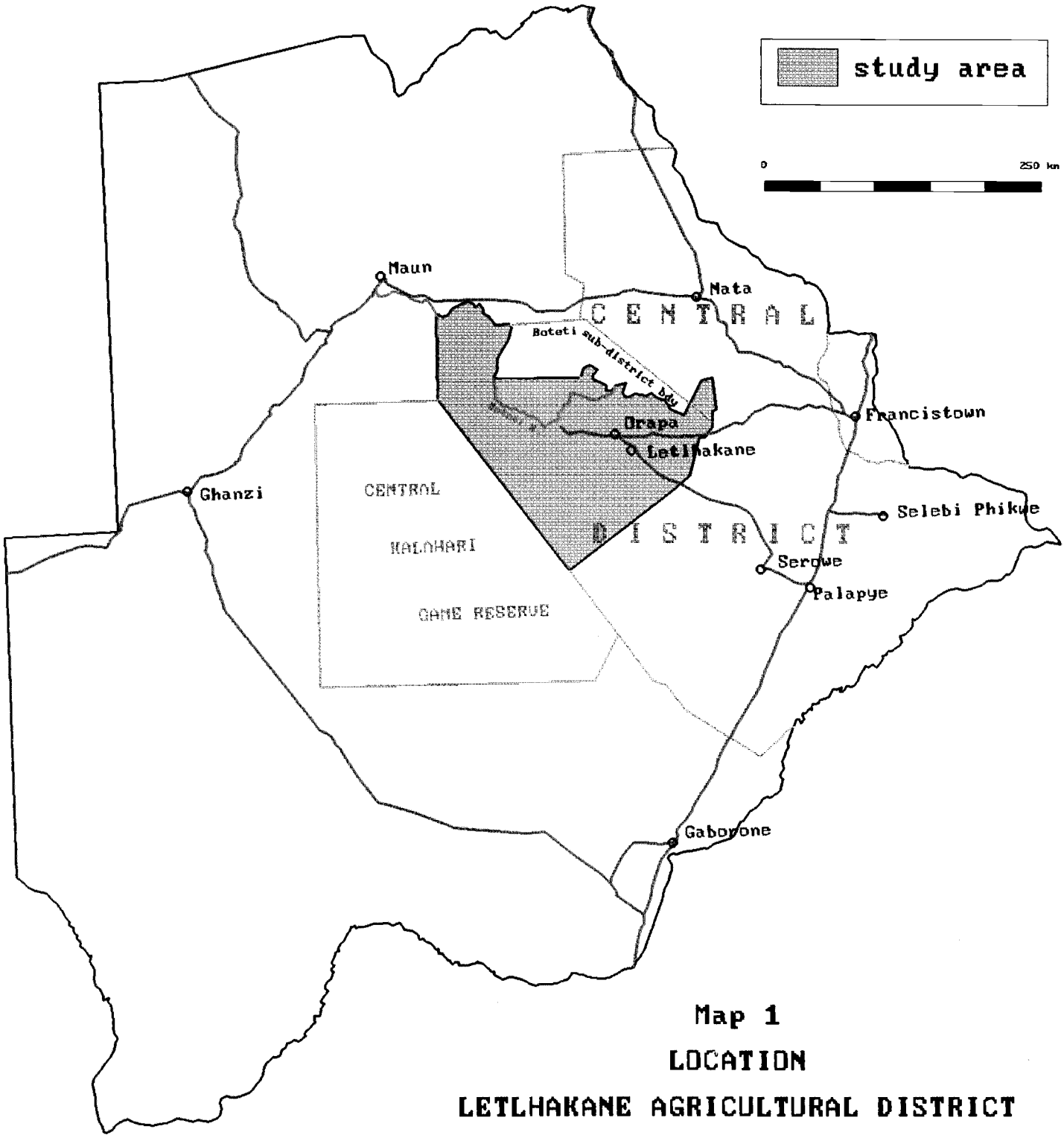
Letlhakane Agricultural District, west of the Setata veterinary cordon fence, coincides with the Boteti Communal First Development Area (CFDA).

3.2 CLIMATE

3.2.1 Weather stations and available data

The nearest weather station which records a range of climatic variables (synoptic station) is Maun with records since mid 1922. Maun is situated 60 and 320 km west of respectively the north-western corner (Makalamabedi) and eastern boundary (Makoba) of LetAD. Interpolated synoptic data are available for Rakops (Meteorological Data Base, MoA). Relevant stations which record rainfall only, include Makoba (records from 1959 to 1991, with gaps), Letlhakane (since 1983), Orapa (since late 1968) and Makalamabedi (from late 1973 to late 1988). With the exception of rainfall, average values of most climatic variables do not vary much within LetAD and the data from Rakops are considered to be representative of the whole study area, with exception of the extreme north-western corner of the District which is better represented by data from Maun.

Although mean annual rainfall does not vary much within LetAD and only slightly increases from south to north, there seem to be significant differences in rainfall variability, with Rakops having a higher variability than the other stations. As far as rainfall data are concerned, Orapa is assumed to represent most of LetAD, including the area east of Kedia, Mopipi and Toromoja, and a small area west of Tsoe and Khumaga. Rakops is taken to represent a limited area from Kedia in the south to Sukwane in the north; and Maun is assumed to be representative for a small corner in the north-west between Makalamabedi and Moreomaoto. The records of Makalamabedi and Letlhakane are not sufficient to be included in the



Map 1

LOCATION

LETLHAKANE AGRICULTURAL DISTRICT

analysis and Makoba is very similar to Orapa.

From an analysis of all available seasonal rainfall data from a number of stations in and around LetAD, it appears that there may be a periodicity in seasonal rainfall with a period of approximately ten years of mostly low seasonal rainfall followed by a ten year period of mostly high seasonal rainfall (see Figure A2.1, Annex 2). The seventies and the eighties are such periods of relatively high and low rainfall respectively. In the analysis of rainfall data in this chapter and Chapter 6 (land suitability) rainfall data from the period 1968 to 1990 have been used to include the assumed rainfall "cycle" of 20 years.

3.2.2 General description of the climate

The climate can be described as semi-arid with summer rainfall. Three seasons can be distinguished: spring, summer and winter. Spring starts in August or September with temperatures rapidly increasing from cool to hot, until November when the first significant rains fall and periodical cloudiness causes slightly lower average daytime temperatures. The summer covers the period from November until March or April and is characterized by high temperatures and occasional rainfall in the form of brief thunderstorms or, incidentally, prolonged showers. The winter is cool and dry and lasts from May to August. Early morning frosts may occur during that period.

3.2.3 Synoptic data

Table 3.1 gives the interpolated synoptic data for Rakops. The rainfall figures given in this Table are averages for the period 1959 to 1988.

Mean daily temperature (the average of mean maximum and mean minimum) varies from 15 °C in June and July to 25 °C in the period from October to February. Extreme maximum temperatures occur in November and reach 41.5 °C. Light frost may occur in the early morning hours during the period from May to August.

The relative humidity in the afternoon varies from almost 50% in summer to less than 25% in spring. The diurnal variation is quite large throughout the year; relative air humidity is much higher in the early morning as compared to the early afternoon.

Average annual day-length is almost 12 hours and varies from 10.7 hours in June to 13.4 hours in December. The mean monthly hours of bright sunshine is the highest in spring (10 hours/day) and the lowest in summer (8 hours in January and February).

The average wind velocity does not vary much throughout the year and main wind direction is from the north-east. In winter time winds are mild and fairly constant and most frequently from the east and north-east. The highest average wind speed is in spring, when the soil is dry and grass cover at its lowest and dustbowls may occur. In summer both wind speed and wind direction are more variable, particularly during rainstorms and periods of atmospheric instability. Whirlwinds are common throughout the year.

The potential evapotransiration (PET) is highest in late spring and early summer (October - December) when it reaches almost 200 mm/month, or 7 mm/day. In winter PET is much reduced at around 100 mm/month (3.5 mm/day) in June and July. In all months, PET greatly exceeds rainfall. Rainfall never exceeds half of PET, although the month of January comes very close.

Table 3.1 INTERPOLATED SYNOPTIC CLIMATIC DATA FOR RAKOPS
(for mean monthly rainfall see Tables 3.2 and 3.3)

Month	Temperatures (°C)				Humidity (%)		Sunshine (hrs/day)	Wind (km/h)	PET (mm) (1)	Frostdays	
	Mean		Extreme								
	Max	Min	Max	Min	8 am	2 pm				air	ground
JAN	31.4	19.3	40.2	8.8	73	48	8.0	10.0	181		
FEB	30.9	18.6	38.1	9.3	76	48	8.1	9.6	160		
MAR	30.7	17.3	39.2	5.0	74	43	8.4	9.7	158		
APR	29.1	14.4	35.5	3.2	72	38	8.8	8.6	133		
MAY	26.7	9.0	33.6	-1.4	67	30	9.8	8.1	115		1.4
JUN	24.1	6.0	30.5	-6.1	66	31	9.2	8.5	97	2.1	10.4
JUL	24.3	5.7	30.7	-5.2	64	27	9.8	9.2	106	1.9	7.6
AUG	27.2	8.6	35.1	-0.6	54	23	10.2	10.1	138	0.6	2.4
SEP	31.3	13.4	37.9	2.0	44	22	9.9	12.1	173		
OCT	33.3	17.3	40.9	6.4	48	26	9.4	13.6	199		
NOV	32.5	18.4	41.5	7.0	57	34	8.5	12.3	196		
DEC	31.9	19.0	40.2	7.9	67	41	8.4	11.0	194		

(1) PET = potential evapotranspiration ("modified Penman")

3.2.4 Rainfall

Available monthly rainfall figures from 1959 onwards, are given in Tables 3.2 for Rakops and in Annex 2 for Maun and Orapa. The figures are arranged into seasons (July one year to June the next year), rather than calendar years. For the definition of rainfall zones, data from Maun, Rakops and Orapa for the seasons 1968/69 to 1989/90 have been used (see also Section 3.2.1). Mean and standard deviation (in percentage) of monthly and seasonal rainfall for that period are given for Rakops in Table 3.3 and for Maun and Orapa in Annex 2. For the land suitability evaluation (Chapter 6), rainfall totals of 10-day periods (dekads) have been used of the seasons 1968/69 to 1989/90.

The mean seasonal rainfall increases from south to north and is 351 and 381 mm for Rakops and Orapa respectively and 458 mm for Maun. Rainfall is confined to the period October to April and more than 85% falls in the period November to March. In Rakops and Orapa most rain falls in January; in Maun the period with the highest rainfall covers both January and February. Seasonal rainfall varies considerably from on year to the other. The standard deviation (SD) of seasonal rainfall is 57% for Rakops, 48% for Orapa and 47% for Maun. The lowest and highest seasonal rainfall totals for Rakops were 105 mm (81/82) and 719 mm (73/74) respectively.

Table 3.2 MONTHLY AND SEASONAL* RAINFALL (mm): RAKOPS (59/60 – 95/96)

STATION: RAKOPS STATION NO: 195					Height: 914 m asl		Latitude: 2103.S Longitude: 2424 E						
YEAR	J	A	S	O	N	D	J	F	M	A	M	J	SEASON TOTAL
59/60	0.0	0.0	0.0	0.0	4.6	56.0	28.2	40.4	31.0	29.5	7.5	0.0	197.2
60/61	0.0	0.0	0.0	0.0	77.5	51.0	35.0	54.5	231.0	41.0	22.1	0.0	512.1
61/62	5.8	0.0	0.0	2.0	24.6	37.0	50.1	32.4	33.3	38.2	0.0	0.0	223.4
62/63	0.0	0.0	0.0	9.0	113.5	162.0	104.0	0.0	47.0	26.0	0.0	5.5	467.0
63/64	0.0	0.0	0.0	35.7	27.0	198.0	13.5	33.0	18.0	0.0	0.0	0.0	325.2
64/65	0.0	0.0	0.0	20.5	38.5	150.0	36.0	9.0	1.0	26.0	0.0	0.0	281.0
65/66	0.0	0.0	2.5	0.0	9.5	19.9	126.4	184.0	9.5	33.4	2.0	57.0	444.2
66/67	0.0	0.0	20.5	5.0	24.0	89.0	229.0	42.4	0.0	75.5	1.5	0.0	486.9
67/68	0.0	6.5	0.0	2.5	18.2	32.5	28.3	43.0	136.4	50.5	56.0	0.0	373.9
68/69	0.0	0.0	0.0	1.0	24.5	48.0	45.0	60.5	126.5	23.3	0.0	0.0	328.8
69/70	0.0	0.0	24.5	37.5	16.5	8.5	17.7	41.5	35.0	0.0	0.0	0.0	181.2
70/71	0.0	0.0	0.0	0.0	95.5	71.5	263.6	0.0	77.3	0.0	0.0	0.0	507.9
71/72	0.0	20.7	0.0	0.0	95.0	49.0	192.8	14.0	59.3	25.0	0.0	0.0	455.8
72/73	0.0	0.0	0.0	1.7	5.0	27.4	58.5	205.5	36.0	0.0	0.0	0.0	334.1
73/74	0.0	0.0	0.0	107.5	57.0	136.5	213.5	125.5	22.0	50.0	7.0	0.0	719.0
74/75	0.0	0.0	5.0	0.0	90.4	37.5	121.0	64.0	79.5	38.0	0.0	0.0	435.4
75/76	0.0	0.0	0.0	0.0	0.0	158.0	151.0	54.5	71.0	0.0	0.0	0.0	434.5
76/77	0.0	0.0	16.1	31.1	59.5	35.2	113.5	76.5	15.0	134.5	0.0	0.0	481.4
77/78	0.0	0.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
78/79	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
79/80	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2.0	NA
80/81	0.0	1.0	19.0	3.0	55.5	46.0	226.4	65.0	85.0	0.0	0.0	0.0	500.9
81/82	0.0	0.0	2.0	0.0	47.6	22.4	18.0	9.0	6.0	0.0	0.0	0.0	105.0
82/83	0.0	0.0	0.0	66.0	76.0	65.0	25.0	30.0	0.0	20.0	18.1	3.0	303.1
83/84	0.0	0.0	0.0	6.0	28.0	16.3	0.0	32.4	69.7	5.2	0.0	0.0	157.6
84/85	0.0	0.0	2.0	0.0	100.2	16.0	33.0	8.0	31.1	0.0	0.0	0.0	190.3
85/86	0.0	0.0	0.0	11.4	9.0	62.0	43.0	23.8	5.2	46.4	0.0	0.0	200.8
86/87	0.0	0.0	5.0	32.9	43.3	13.0	20.0	14.8	11.0	0.0	0.0	0.0	140.0
87/88	0.0	0.0	0.0	14.0	41.3	119.9	18.0	228.0	124.2	30.0	0.0	0.0	575.4
88/89	0.0	0.0	5.0	49.2	0.0	39.4	238.7	57.5	12.0	58.0	0.0	0.0	459.8
89/90	0.0	0.0	0.0	25.0	25.0	3.0	52.0	22.0	7.0	23.0	0.0	0.0	157.0
90/91	0.0	0.0	0.0	0.0	0.0	0.0	224.0	197.5	8.1	0.0	0.0	0.0	429.6
91/92	0.0	0.0	6.0	85.0	3.0	75.0	39.0	10.0	0.0	0.0	0.0	0.0	218.0
92/93	0.0	0.0	0.0	3.0	65.0	26.0	14.0	61.0	0.0	11.0	0.0	0.0	180.0
93/94	0.0	0.0	0.0	35.0	0.0	13.0	220.0	0.0	0.0	0.0	0.0	0.0	268.0
94/95	0.0	0.0	0.0	9.0	40.0	16.0	8.0	0.0	50.5	0.0	0.0	0.0	123.5
95/96	0.0	0.0	0.0	14.5	41.0	36.0	122.0	215.0	NA	NA	NA	NA	428.5
MEAN	0.2	0.8	3.2	17.4	38.7	55.9	88.4	54.1	43.6	23.8	3.5	2.0	329.4
SD %					87.0	92.0	96.0	112.1	115.2				54.2

Table 3.3 MEAN (mm) AND STANDARD DEVIATION MONTHLY AND SEASONAL* RAINFALL: RAKOPS (68/69 – 89/90)

STATION: RAKOPS STATION NO: 195					Height: 914 m asl		Latitude: 2103.S Longitude: 2424 E						
	J	A	S	O	N	D	J	F	M	A	M	J	SEASON TOTAL
MEAN	0.0	1.1	4.1	20.3	45.8	51.3	97.4	59.6	45.9	23.9	1.3	0.3	350.9
SD %					75.0	84.2	89.8	101.8	86.0				56.5

* SEASON = Period from 1st of July one year to 30th of June the next year
SD % = Standard Deviation in percentage NA = Not Available

On the basis of differences in mean seasonal rainfall and variability in seasonal rainfall, three rainfall zones can be distinguished within LetAD, which are named "Rakops", "Orapa" and "Maun". These zones have no distinct boundaries, but gradually merge into each other.

(i) The Rakops zone is confined to the area surrounding Rakops, between Kedia to Sukwane. This zone extends south-westward into the Central Kalahari Game Reserve and has a relatively low mean seasonal rainfall (351 mm), and a relatively high rainfall variability (57%).

(ii) The Orapa zone covers most of LetAD and includes the area east of Kedia, Mopipi and Toromoja, and a small area west of Tsoe and Khumaga. This zone is characterized by relatively moderate seasonal rainfall (370 mm) and relatively low rainfall variability (48%).

(iii) The Maun zone is confined to the extreme north-eastern corner of LetAD, from Moreomaoto to Makalamabedi. This zone extends northwards across the Boteti River to Maun and is characterized by a relatively high mean seasonal rainfall (458 mm) and a relatively low rainfall variability (47%).

3.3 GEOLOGY AND LANDFORMS

3.3.1 Underlying geology

LetAD is underlain by fine-grained sandstone and basalt of the Karoo Group (Late Carboniferous to Late Jura), except for a small area in the north-west, which has sedimentary rocks (mainly sandstone) of the Precambrian Ghanzi Group (Map 2, unit L3). These rocks are overlain by Kalahari Beds of Tertiary and Quaternary age, consisting of aeolian sand, alluvium, and hardened materials such as calcrete, silcrete and ferricrete. The Kalahari Beds reach a thickness of more than 100 m in the north, west and south, but are very thin or absent in the east-central area between Kedia and Thalamabele where Karoo sandstones and basalt are close to the surface (O.D.A., 1978) (Map 2, units S3 and S4).

3.3.2 Landforms and superficial deposits

LetAD is situated on an almost flat plain at an altitude of 895 to 1060 m above sea level (asl). The most prominent topographic features in the area are the incized valley of the Boteti river in the north-west, and the southern edge of the Makgadikgadi Basin, which includes the Ntwetwe Pan and the Sua Pan, in the north and north-east.

The northern half of LetAD (Map 2, units L) was once part of a large lake, the Greater Lake Makgadikgadi. This super lake attained its maximum expansion approximately 50 000 years ago and again 40 000 to 35 000 years ago reaching level of approximately 940 m asl. The most visible evidence of this former lake is the Gidikwe strandline, a sand ridge several kilometers wide and 30 m high (Map 2, unit L3). Since the time of its maximum expansion the lake experienced several phases of recession, leaving behind strandlines at 920 and 912 m asl (Breyer, 1983). The lake has completely disappeared in recent times and the various salt flats (pans), which remain at the lowest points, only have surface water during times of high rainfall and/or flooding of the Boteti river or other seasonal rivers which drain towards the Makgadikgadi. The south-eastern corner of the Makgadikgadi depression at Mosu and Nthane is marked by a steep escarpment formed by sedimentary rocks; elsewhere the edge of the depression is less distinct.

The Boteti River is one of the outlets of the Okavango Delta and enters LetAD in the north-western corner. The river has cut into the old lake deposits and is confined to a channel 200 to 300 m wide and 10 to 20 m deep until it reaches Rakops, after which it changes into a broad floodplain with more than one shallow channels with a depth of a few meters. The Boteti river empties into the Ntwetwe Pan which forms part of the northern boundary of LetAD. Presently the river rarely carries water up to this point because of low discharge from the Okavango Delta in recent years, the construction of the Mopipi dam and other human activities along the river and its catchment (see also Section 3.5).

The southern half of LetAD is an almost featureless plain, very gently sloping from the south-east (with Khwee and Makoba at an altitude of approximately 1060 m asl) towards the north-west (with Kedia and Mmatshumo at 950 m asl). There is very little run-off in LetAD, except locally towards small pans. There are a number of fossil valleys which were formed in periods of higher rainfall and which all drain towards the Makgadikgadi Depressions. Presently these valleys have little or no surface water at any time of the year. The most significant of these valleys is that of the Letlhakane river which originates east of LetAD and drains towards the north-west through Letlhakane village. An area with distinct fossil sand dunes occurs south of Kedia. These are so-called transverse dunes which run parallel in a south-north direction and are remnants from a time which was drier than the present.

The main physiographic units are listed in Table 3.4 and shown on Map 2.

3.3.3 Mineral occurrences

The most important mineral occurrence is diamond, which occurs in the Kimberlite Field situated in the Orapa-Letlhakane-Mmatshumo area. Diamond is presently mined at Orapa and south of Letlhakane (Letlhakane Mine). Sodium carbonate, sodium chloride, and other salts are present in the pans, but are presently not mined commercially within LetAD. Small scale mining of building and road construction materials such as sand, gravel and calcrete is common along the main roads and around towns, villages and mines. Large parts of LetAD have been given out as Prospecting Concessions to various companies in search of precious stones.

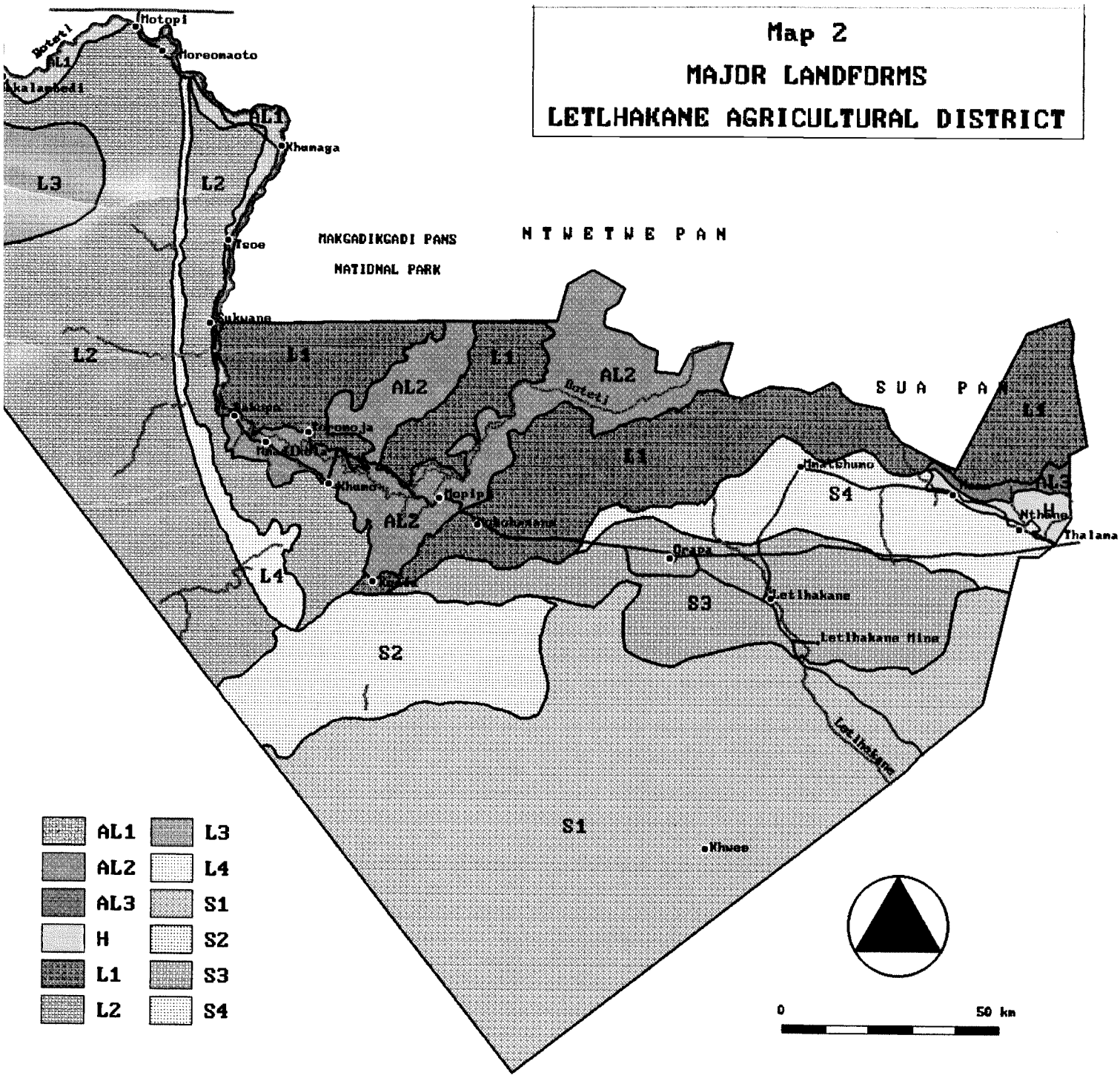

Map 2
MAJOR LANDFORMS
LETLHAKANE AGRICULTURAL DISTRICT
Motopi
Moreomaoto
Khamaga
Tsoe
MAKGADIKGADI PANS
NATIONAL PARK
NTWETWE PAN
SUA PAN
Sukwane
Khumo
Mopipi
Letlhakane
Orapa
Letlhakane Mine
Thalana
Khwee
AL1
AL2
AL3
H
L1
L2
L3
L4
S1
S2
S3
S4
0
50 km

Table 3.4 MAJOR LANDFORMS LETLHAKANE AGRICULTURAL DISTRICT (Legend Map 2)

AL Alluvial and Lacustrine landforms

AL1 Flat to almost flat lacustrine plain with fossil river courses and present channel of the Boteti river with recent fluvial deposits. Locally sheet and rill erosion on sloping river banks.

AL2 Flat to almost flat floodplain Boteti river superimposed on lacustrine plain. Man-made bunds now limit flooding to the main channel and Mopipi dam.

AL3 Gentle footslope with recent fluvial deposits over lacustrine plain; few rock outcrops. Moderate sheet erosion and deposition; few rills and gullies.

H Hardveld

H Sandstone escarpment and flat-topped hill; locally minor footslopes with recent alluvium. Common rill and gully erosion.

L Lacustrine landforms

L1 Flat to almost flat lacustrine plain with aeolian reworked plains and major pans with islands and minor shorelines. Seasonal flooding of low-lying pans, e.g. Sua Pan north of Mosu. Minor wind erosion and formation of small dunes and hollows.

L2 Flat to almost flat lacustrine plain with superficial aeolian deposits. Minor wind erosion in overgrazed areas. Fossil valleys run from west to east.

L3 As L2, but underlain by sandstone of the Precambrian Ghanzi Group

L4 Gently undulating major (fossil) shoreline (Gidikwe ridge)

S Sandveld

S1 Flat to almost flat sandveld plain; superficial aeolian deposits over Kalahari Beds

S2 Gently undulating sandveld plain with fossil transverse dune system

S3 Flat to almost flat sandveld plain; superficial aeolian deposits over basalt

S4 Gently undulating sandveld plain; superficial aeolian deposits over sandstone

3.4 SOILS

The nature of soils in LetAD is complex, with many variations in soil properties occurring over short distances. Variations in soil depth are particularly common in the northern half of LetAD and variations in soil fertility occur everywhere, not only from place to place but also from time to time. The description of the soils given in this chapter is of a generalized nature and the soil conditions found at a specific site and at a specific time may differ from the general description given here.

3.4.1 Soil distribution

Nineteen soil units have been distinguished. Map 3 shows the distribution of the dominant soil units. A few soil complexes and associations have been mapped, mostly to indicate inclusions of arable soil within an area of predominantly non-arable soils. Map 3 is derived from the Soil Map series at scale 1:250 000 (Soil Survey Section, 1984-1990). The General Soil Legend for the 1:250 000 series is given by Verbeek & Remmelzwaal (1990). The correlation between the units of the 1:250 000 series and those of Map 3 of the present study is given in Table 3.5 (column "SLB"). In addition to classification, Table 3.5 lists the main physical and chemical characteristics of the 19 soil units and their coverage in square kilometers. The legend of Map 3 gives a description in plain language.

In general terms, the nature and distribution of the soils can be described as follows:

The area south of the axis Makoba-Orapa-Kedia is characterized by very deep, well drained, coarse textured soils. The most common soil is a very deep, well drained, yellowish brown sand to loamy fine sand with low inherent chemical fertility (Soil Unit 9, Ferralic Arenosol). Another important soil is very similar, but has a slightly higher clay content and slightly higher chemical fertility (Soil Unit 10, Eutric and Luvic Arenosols). The latter are most frequent in the area south of Kedia in inter-dunal depressions.

The eastern part of LetAD, enclosed by the axis Makoba-Orapa-Mmatshumo-Ntane-Makoba, is characterized by moderately deep, well drained, yellowish brown, coarse textured soils. In most cases soil depth is limited by the occurrence of calcrete or a gravelly layer of highly calcareous material at a depth of 50 to 100 cm from the surface (Soil Unit 3, Areni-Petric Calcisols). Locally soil depth is less than 50 cm (Soil Unit 1, Leptosols and Regosols). Pockets of shallow to moderately deep medium textured soils (Soil Unit 5, Petric Calcisols) occur south of Letlhakane and south of Mmatshumo respectively.

The western part of LetAD, south and west of the Boteti river from Makalamabedi to Xhumo mainly has moderately deep to deep, well drained, yellowish brown coarse textured soils. North and west of Sukwane the soils are mostly deep (Soil Unit 7, Haplic Arenosols), further south soil depth is more variable with frequent inclusions of moderately deep and shallow soils (Soil Units 3 and 1 respectively). In the channel and the floodplain of the Boteti river recent sediments occur (Soil Unit 14, Eutric Fluvisols). The soils in the channel have a texture of loamy fine sand to fine sandy loam over fine sand. These soils only cover a small area, but are of importance for molapo farming. The floodplain between Xhumo and Mopipi has soils with a finer texture, including silt loam and silty clay.

The north-central part of LetAD, north of the axis Rakops-Xhumo-Kedia-Orapa-Mmatshumo-Ntane is characterized by the occurrence of salt pans and slightly elevated areas with calcareous soils. The pans have poorly drained, dark grey soils of variable texture and with high content of salts and sodium (Soil Unit 15, Solonchacks). Away from the pans the soils are all calcareous, but vary in depth, drainage and texture (Soil Units 1, 5, 6, 8 and 11). Shallow soils with calcrete (Soil Unit 1) are common north of Orapa and Mokobaxane. Deep, well drained, coarse textured soils (Soil Unit 8, Calcaric Arenosols) occur north-

Table 3.5 SOIL UNIT DESCRIPTION

SOIL UNIT	AREA (km2) (1)	AREA (%)	CLASSIFICATION (FAO, 1990)	SLB (2)	TYPICAL PROFILE (3)	TEXTURE (topsoil) (4)	TEXTURE (subsoil) (4)	DRAINAGE	DEPTH m	AWC mm/m	AVAIL P ppm	pH (H2O) (topsoil)	EC (mS/cm) (topsoil)	ESP (%) (topsoil)
1	2386	8.2	Petrocalci–Eutric Leptosols & Calcaric Regosols (lithic phase)	C2 C3 C1 C1a C3a B1b	NX0119	S – SCL	–	well	< 0,25	100	5	7.5	0.1	1
2	113	0.4	Eutric Regosols	S1	M0315b	S – LS	S – LS	well	0.25–0.50	80	6	6.6	0	1
3	6276	21.5	Areni–Petric Calcisols	L12b L12 L12a A21a C3b S13 S13a	GW0046	FS – LFS	FS – LFS	well	0.50–1.00	70	3	7.4	0.1	3
4	334	1.1	(Areni–)Eutric Regosols	S1a A34	–	S – SL	S – SL	well	0.50–1.00	70	3	6.5	1	1
5	729	2.5	Petric Calcisols	C5 L15a D1b	NX0009	SL – SC	SL – SC	mod.well	0.50–1.00	130	10	8.3	0.1	1
6	524	1.8	Calcisols & Calcic Luvisols	C4 C4a A4d A9b L24e	NX0090	SL – SCL	SL – CL	imperfect	0.50–1.00	130	5	7.9	0.1	2
7	4277	14.6	Eutri–Haplic Arenosols	L16 L16a A40 S17 S17c	–	FS – LFS	FS – LFS	s.exc.	>1.00	70	2	6.8	0	0
8	1398	4.8	Calcaric Arenosols	L10 L11 L11a L12 S15	NX0109	S – LFS	S – LFS	well	>1.00	80	3	8.6	0	1
9	8017	27.5	Ferralic Arenosols	S3 S6 ARo21* ARo22*	NX0130	S – LFS	S – LFS	s.exc.	>1.50	70	2	5.6	0.1	4
10	1948	6.7	Eutri–Luvic Arenosols	L22c ARl15* A15a	NX0089	S – LS	S – SL	mod.well	>1.00	80	0	6.4	0	0
11	326	1.1	Calcic Luvisols & Calcisols	L13 L14 A10 D9	N 0901	SL – SCL	SL – SC	mod.well	>1.00	130	2	8.1	0.6	1
12	115	0.4	Calcicols & Calcaric Cambisols	A4 L24 L20 A4a	NX0026	SL – SC	SL – SC	imperfect	>1.00	130	6	8.7	0.1	3
13	142	0.5	Luvic Calcisols (sodic phase)	L24d	NX0090	SL	SCL	imperfect	>1.00	110	5	7.9	0.1	4
14	103	0.4	Eutric Fluvisols	A24, A24b A24d	–	LFS – SiCL	FS – LFS	imp.–poor	>1.50	90	3	7.0	1	1
15	1598	5.5	Sodi–Gleyic Solonchaks	L1 L2 L3 L4	GW0049	SiL – SiCL	SiL – SiCL	poor	>1.50	150	4	10.6	7.3	100
16	254	0.9	Areni–Sodic Solonchaks	L5	–	S – LS	S – LS	imperfect	>1.00	70	4	10.6	7.3	100
17	204	0.7	Calcic Gleysols (sodic phase)	L6	–	SC – C	SC – C	imperfect	>1.50	150	4	10.6	1	10
18	257	0.9	Eutric & Calcaric Fluvisols	L8 L8a L9	–	variable	variable	poor	>1.50	100	4	7.0	4	1
19	169	0.6	Calcic & Haplic Solonetz (salic phase)	L21	–	SiCL – C	SiCL – C	imperfect	>1.50	150	4	10.6	7.3	100

(1) Total area is 29 170 km2
(2) Correlation with units of the Revised General Soil Legend of Botswana (Verbeek & Remmelzwaal, 1990); units with * are from the Soil Map of Botswana scale 1:1,000,000 (1990)
(3) From the Soil Data Base (SDB) and Verbeek (1990)
(4) FS = fine sand, S = sand, LS = loamy sand, LFS = loamy fine sand, SL = sandy loam, SCL = sandy clay loam, SC = sandy clay, SiL = silt loam, SiCL = silty clay loam, C = clay

east of Rakops. Of particular importance for arable farming are well drained, medium textured soils of sufficient depth, such as Soil Unit 11 (Calcic Luvisols).

3.4.2 Soil characteristics

As mentioned in Section 3.4, soil characteristics vary considerably, even within one soil unit. Average and approximate values of the most important soil characteristics are given in Table 3.5. These values are used in land evaluation procedures (Chapter 6).

3.4.3 Soil degradation

Three types of soil degradation can be distinguished: soil erosion caused by water, soil erosion caused by wind and deterioration of the physical and chemical properties of the upper part of the soil which is used for plant growth. All soil properties change over time and only those changes which are induced directly or indirectly by man, and which have a permanent negative effect on soil productivity for plant growth are considered as degradation. Soil degradation phenomena are discussed in detail in the Mid-Boteti desertification study of the MoA (MoA/UB, 1994).

- Soil erosion by water

The flat topography of most of LetAD, in combination with the high permeability of the sandy soils, severely restricts overland flow (runoff) of rain water. Significant soil erosion by water has been observed in only a few areas. The most severely affected area is unit AL3 of Map 2, comprising of the footslopes of the Mosu escarpment, south of Sua Pan. Erosion is predominantly in the form of sheetwash and rills of light to moderate degree and affecting at least one-third of LetAD. The same erosion features occur along the eastern edge of Sua Pan, along the veterinary cordon fence from Thalamabele northwards. Sheetwash and rill erosion and occasional gullying occur on both steep and gently sloping banks of the Boteti river between Makalamabedi and Mmadikola. Erosion in this case is induced by frequent movement of livestock and molapo farming.

Elsewhere soil erosion by water is limited to sheetwash and rill erosion on cultivated land with a slope of more than 1%. Erosion of moderate degree was observed on some fields within the Letlhakane lands area. Sheetwash and rill erosion also occur along the edges of major and minor pans.

- Soil erosion by wind

Although dust storms and whirl winds (dust devils) are quite common in LetAD, particularly in the dry months of winter and early spring, the total amount of soil transported by wind is probably limited. Moderate wind erosion was observed along the southern rim of Ntwetwe Pan and Sua Pan and in major villages. In the major pan areas (units L1 and AL2 of Map 2), the lack of vegetation and the presence of silt and fine sand in the topsoil facilitate the movement of soil by wind and the formation of isolated sand ripples and low dunes. Of the cultivated land in LetAD, dryland fields between Rakops and Mopipi are the most exposed to strong winds and may experience light to moderate erosion. Dust storms occasionally make out-door life uncomfortable and probably unhealthy in population centres with many open spaces (e.g. Rakops, Mopipi, Toromoja and Xhumo). With exception of the localities mentioned above, wind erosion does not greatly affect soil productivity in LetAD generally.

- Physical and chemical deterioration

Physical and chemical changes of the soil occur in areas of overgrazing and/or frequent movement of livestock, and in regularly cultivated areas. In both cases the protective vegetative cover of the soil is removed and the naturally present soil aggregates break down. Poor soil structure leads to loose and easily erodible soil particles after trampling or cultivation and to topsoil crusting and sealing after rain. In cultivated land, crop produce is removed without the return of significant amounts of manure or fertilizer and the amounts of certain nutrients is likely to decrease in case of good harvest. However, under good management, the soil changes mentioned above can be reversed and both physical and chemical soil fertility restored. Permanent deterioration of the physical and chemical properties of the soil is largely limited to road construction sites, mining sites, cattle tracks and major villages.

3.5 WATER

3.5.1 Surface water

- Rivers and pans

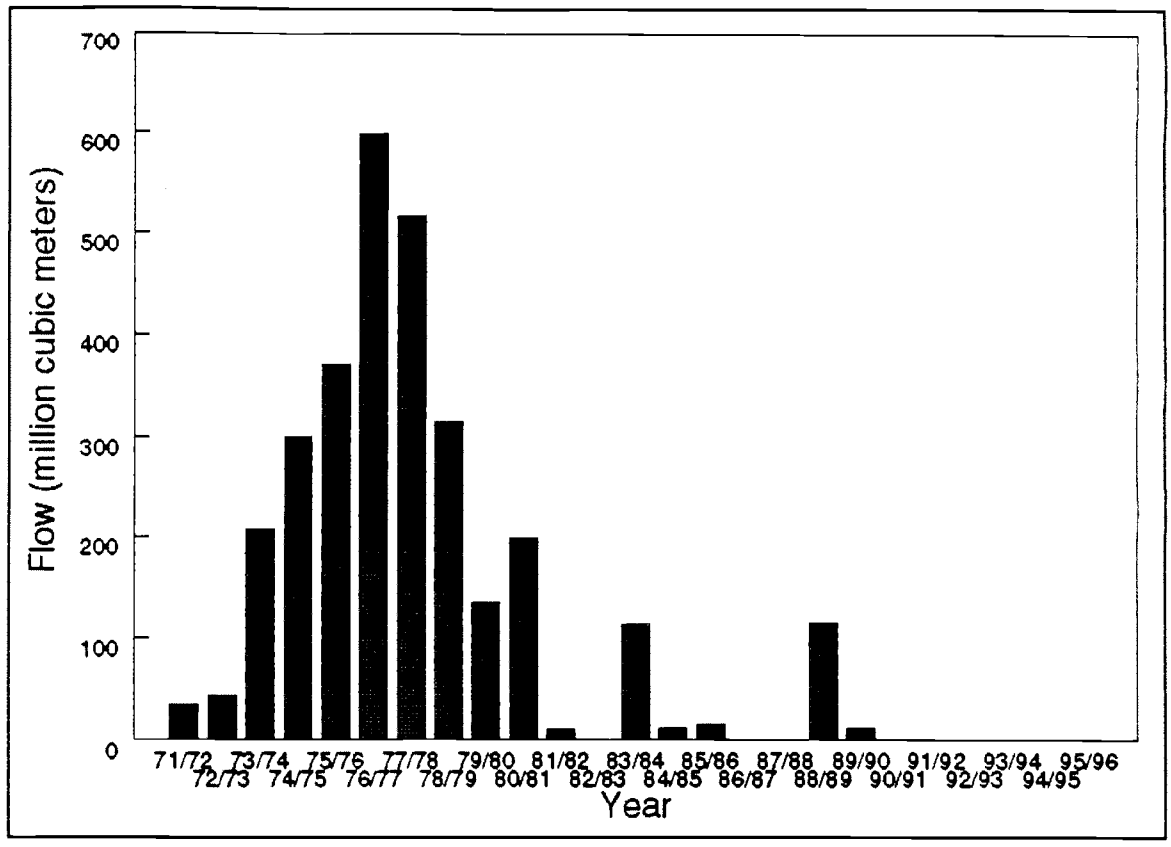
Because of its low rainfall, flat topography and permeable soils, LetAD experiences very little surface flow of rainwater (runoff). The only exception is the escarpment and footslopes of Mosu and Nthane and the south-eastern edge of Sua Pan where runoff occurs for brief periods after local showers. The only significant river is the Boteti, which originates from outside LetAD. The Letlhakane river only carries water for short periods after exceptional high rainfall. The river originates east of LetAD and peters out north of Letlhakane village. Other valleys occur, but they are mainly fossil and rarely experience flooding.

The Boteti river enters LetAD in the north-western corner near Makalamabedi and drains into Ntwetwe Pan (see Map 4). The river is one of the outlets of the Okavango Delta which is fed by the Okavango river which originates in Angola and runs through Namibia before it enters the north-western corner of Botswana. The outflow of the Okavango Delta is highly variable, depending on rainfall in the catchment of the Okavango River and on rainfall over the Delta, and may be negligible in some years. As a consequence of the irregular outflow of the Okavango Delta, the Boteti river may be dry the whole year, or even a number of years, or may have two distinct flow periods within a year. In the latter case there is a low flow period from January to May (lowest flow in February) and a high flow period from June to December (highest flow in August). The annual flow of the Boteti River at Rakops is shown in Figure 3.1. Mean annual flow was 261.5 million m^3 at Samedupi (60 km upstream of Makalamabedi) and 168.7 million m^3 at Rakops over the period from 1970 to 1989 (UB, 1994). Even in years without flow stagnant pools remain at a few sites.

In the early seventies, waterworks were carried out in the rivers feeding the Boteti river and in the river itself with the aim to increase the flow and fill Mopipi dam (see below) for use by Orapa and Letlhakane diamond mines. The waterworks near Mopipi, consisting of bunds and diversion channels, now channel all water to Mopipi dam and prevent the remaining part of the floodplain between Xhumo, Mopipi and Kedia (including Lake Xau) from flooding, although rainwater may occasionally fill some of the depressions.

Much of the agricultural and other activities of the people living near the Boteti river depends on the flow of the river. Although the absence of a flow in the river for the last few years may only be a downturn

Figure 3.1 SEASONAL FLOW BOTETI RIVER AT RAKOPS



in a recurrent cycle of low and high flows (UB, 1994), economic activities which rely heavily on water from the river have become increasingly unsustainable.

- Dams

The only dam of significance is Mopipi dam, south of Mopipi. This dam is a large shallow depression, bunded on its lowest sides, into which water is pumped from the Boteti river when it contains water. The dam belongs to Orapa mine and has not been productive since 1984. There are a few other dams in LetAD which are all ineffective. Near Letlhakane is a dam in the Letlhakane river, but the river rarely carries water and the site of the dam lacks sufficient slope. Elsewhere there are small dams which are not more than large dug-outs in shallow depressions which only hold water in the rainy season.

- Springs

The only springs in LetAD are found along the escarpment near Mosu. Most of these springs have been developed and have a reservoir although mostly in a poor state of repair. The National Museum wants to protect some of the sites because of their historical value.

3.5.2 Groundwater

- Boreholes

LetAD as a whole has a flat topography and is covered in the south and west with thick layers of superficial deposits which prevent recharge to any underlying aquifers and hinder exploration (Wellfield Consulting Services, 1995). Confined aquifers occur where Karoo sandstones are capped with basalt near the contact zone between the two rock formation. Otherwise the basalts and sandstones have a moderate groundwater potential. Sandstone and basalt are found close to the surface in the east-central part of LetAD between Kedia and Thalamabele (see also Section 3.3.1 and Map 4). The wellfields of Orapa and Letlhakane mines are located in this area. The Kalahari Beds of LetAD generally have poor groundwater potential.

Map 4 shows the location of the 710 boreholes mapped by Wellfield (1995) in Boteti sub-District, 707 of which are located in LetAD. The boreholes are evenly distributed over LetAD, except for the area south of the Makgadikgadi depression where there are few boreholes. Borehole sites are allocated by the Land Board and a minimum distance of 8 km between each borehole is required, unless they are used for industrial or residential purposes. With the present Land Board requirements, a further increase of boreholes for animal production is not possible. However, some of the present de-funct or poorly yielding boreholes could be re-drilled or re-located.

- Wells

Locally shallow ground water may occur where thin permeable layers rest on impermeable materials. This water is tapped through handdug wells in the north-central and north-western part of LetAD. Another source of groundwater is the Boteti valley. Even if the river has not flown for some years, groundwater is found at shallow depth in the valley bottom at some locations.

A total number of 1260 wells was mapped by Wellfield (1995), as shown on Map 4. Rest water levels are generally less than 10 m and water is usually drawn by hand operated chain-bucket systems. Few wells are equipped with engine driven pumps; those used in the Boteti river are small, portable petrol pumps. Wells are used for both human consumption and livestock, and are privately owned.

Many wells are situated in State Land north of Mopipi, as can be seen from a comparison between Map 4 (Waterpoints) and Map 6 (Present Land Use).

- Groundwater quality

Outside the major pan areas, groundwater quality is generally good for human consumption with Total Dissolved Solids (TDS) of less than 1 500 mg/l (Wellfield, 1995). In major pans a TDS of 10 000 to 180 000 mg/l is found.

3.6 VEGETATION

A vegetation survey was carried out in the first half of 1995. Vegetation boundaries for most of LetAD were derived from satellite imagery at a scale of 1:250 000 (LANDSAT-5 TM, scene 173-075 of 7 June 1994). Field observations were made in April and May 1995 and again in the first half of 1996. Some of the results of the vegetation survey of the Lower Boteti Area (Van der Maas et al, 1995b) were incorporated in the Vegetation Map (Map 5). The site descriptions have been entered into the Vegetation Database of the LUPSAD Project and the terminology used to describe vegetation structure corresponds with the one used in the Database.

Nineteen vegetation units have been distinguished, as defined in the legend of the Vegetation Map (Map 5 and Annex 3) and Table 3.6. In some cases the units are too small to map separately and are presented as an association of two units (e.g. mapping units 1/2 and 18/19).

Table 3.6 also gives an indication of the distribution of veld product and poisonous plants. Because of limited fieldwork, neither inventory should be considered complete. The occurrence and importance of veld products are also discussed in Sections 3.7.2 and 4.3.6.

The major vegetation units of LetAD can be grouped as follows:

- Mopane shrubland and savanna (units 10, 11, 15 and 16; 28% of LetAD)

The centre and north-east, from Kedia to Mosu, is characterized by the occurrence of mopane (*Colophospermum mopane*), either in the form of shrubs or small trees. Some large mopane trees occur in units 15 and 16 around Nthane and east of Sua Pan which provide firewood and timber. Although the mopane leaves have good forage value, the trees and shrubs occur in a dense stand and suppress the growth of grasses (e.g. unit 10). Unlike mopane vegetation in the eastern part of Botswana, the edible caterpillar of the mopane moth (*Gonimbrasia belina*) does not occur in large numbers and "phane" collection is insignificant in LetAD.

- Mixed savanna (with mopane) (unit 14; 5% of LetAD)

Mixed savanna with mopane and *Acacia*, *Terminalia* and *Combretum* spp occurs south of Ntwetwe Pan and a few other small areas. In the area near Ntwetwe Pan grass cover was very poor in 1995 due to overgrazing and relatively low rainfall in previous years.

- Acacia low shrub savanna (unit 6; 27% of LetAD)

The south-east, from Kaka to Makoba, is covered with an uniform low shrub savanna. Similar vegetation occurs locally in the west. Common shrubs are *Acacia mellifera*, *Catophractes alexandri*, *Lonchocarpus capassa* and *Grewia flava*. The latter provides edible berries (moretlwa). One of the grasses occurring in this unit (*Stipagrostis uniplumis*) is used for thatching.

- Acacia shrub savanna and mixed savanna (units 9 and 13; 16% of LetAD)

The west, from Kedia to Makalamabedi, is covered with shrub savanna and savanna (units 9 and 13). Some of the common trees and shrubs are *Acacia erioloba*, *A. leuderitzii*, *A. mellifera*, *Boscia albitrunca* and *Grewia flava*.

Table 3.6 VEGETATION UNIT DESCRIPTION

VEG. UNIT (1)	AREA (km^2) (2)	DESCRIPTION (3)	VALUABLE PLANTS (4)		POISONOUS PLANTS (4)
			Name	Use	
1	1 553	Bare pan surface			
2	1 549	Halomorphic grassland			
3	833	Grassland & tree savanna	*Acacia erioloba*, etc.	poles, firewood	
4	564	Mixed low shrub savanna (I)	*Grewia spp*	fruit (moretlwa)	
5	677	Mixed low shrub savanna (II)	*Grewia spp*	fruit (moretlwa)	
6	8 269	Acacia low shrub savanna	*Grewia spp* *Ximenia spp* *Stipachrostis uniplumis*	fruit (moretlwa) fruit (moretologa) thatch	*Geigeria ornitens*
7	554	Acacia open shrub savanna			
8	616	Mixed low shrub savanna	*Grewia spp* *Stipachrostis uniplumis*	fruit (moretlwa) thatch	
9	1 765	Acacia shrub savanna	*Grewia spp* *Ipomoea spp* *Stipachrostis uniplumis*	fruit (moretlwa) tuber (kgane) thatch	
10	1 690	Mopane dense shrub savanna	*Grewia spp* *Stipachrostis uniplumis*	fruit (moretlwa) thatch	
11	5 144	Mopane shrubland	*Grewia spp* *Ximenia americana* *Ipomoea spp* *Stipachrostis uniplumis*	fruit (moretlwa) fruit (moretologa) tuber (kgane) thatch	*Solanum incanum*
12	120	Terminalia shrubland	*Grewia spp* *Stipachrostis uniplumis*	fruit (moretlwa) thatch	
13	2 945	Mixed savanna (I)	*Grewia spp* *Cucumis spp* *Stipachrostis uniplumis* *Acacia, Combretum, Terminalia spp*	fruit (moretlwa) vegetable (morogo) thatch poles, timber, firewood	
14	1 380	Mixed savanna (II)	*Grewia spp* *Ximenia spp* *Acacia, Combretum, Terminalia spp* and *Colophospermum mopane*	fruit (moretlwa) fruit (moretologa) poles, timber, firewood	
15	478	Mopane mixed dense savanna	*Sclerocarya caffra* *Stipachrostis uniplumis* *C. mopane* and other trees	fruit (morula) thatch poles, timber, firewood	
16	732	Mopane dense savanna	*C. mopane* and other trees *Stipachrostis uniplumis*	poles, timber, firewood thatch	
17	60	Morukuru woodland	*Spirostachys africana*	handicraft, building	
18	187	Riverine dense savanna	various trees	poles, timber, firewood	
19	46	Channel Boteti river	*Phragmites australis*	fencing (lethaka)	

(1) See Map 5 (2) total area = 29 170 km^2 (3) for dominant species see legend Map 5
(4) List of valuable and poisonous plants is not exhaustive

- Morukuru woodland (unit 17; 0.2% of LetAD)

A small area of open woodland occurs near Khwee with *Spirostachys africana* (morukuru) as dominant tree. The morukuru trees do not seem to regenerate either because of relatively low rainfall in recent years or the presence of large numbers of livestock. Morukuru is of special interest as it offers a valuable source of wood for timber and handicraft.

- Middle Boteti river with riverine dense savanna (units 19 and 18; 0.8% of LetAD)

The Boteti river from Makalamabedi to Mmadikola is characterized by a distinct channel (unit 19), flanked by banks with dense savanna (unit 18). In (exceptionally) wet years the valley bottom may be temporarily under water, or may support a vegetation of reeds (*Phragmites australis*) and grass, or may be cultivated (molapo). In dry years most of the valley bottom is bare or covered with weeds and grasses (*Cynodon dactylon*). The reeds are used for fencing and construction. The narrow strip of riverine dense savanna provides firewood and timber. Locally the riverine vegetation includes many dead trees, probably due to a lack of flooding and groundwater recharge in recent years.

- Lower Boteti river with open shrub savanna and grassland (units 7, 2 and 3; 5.3% of LetAD)

The Boteti river and its floodplain below Mmadikola has a sparse vegetation, with areas of open shrub savanna (unit 7) and mostly halomorphic grassland (unit 2). Although the grazing potential is low, the number of livestock is relatively high due to the presence of water points (open wells) in the river. Further away from the river, towards the west, grasslands of variable composition and grazing potential occur (unit 3).

- Pans and halomorphic grasslands (units 1 and 2; 10% of LetAD)

Bare salt flats (pans) and associated halomorphic grasslands occur in and around the Makgadikgadi depression. This land has little potential for grazing and offers no veld products of economic significance.

3.7 PRESENT LAND USE

Spatial variation in present land use is presented on Map 6 and described in Table 3.7. Map 6 also shows areas with an unique status (e.g. State Land) and areas which have been reserved for a specific use (e.g. Quarantine Camps). The various units of Map 6 are described in Section 3.7.1. Agricultural activities, such as molapo farming, rainfed farming and extensive grazing are described in more detail in Section 4.3.3 and 4.3.4. Hunting and gathering takes place throughout the area and are briefly discussed in Section 3.7.2 and in more detail in Section 4.3.6.

3.7.1 Mapping units (Map 6)

Eleven land use units have been distinguished, as described in the legend of the Present Land Use Map (Map 6). Present land use units have been grouped under crop production, animal production, and residential & mining respectively (see also legend Map 6). Pan areas (salt flats) within the units have been indicated as sub-unit "p" (e.g. 8p).

- Crop production

Most arable farming can be described as rainfed cropping, although the attention may shift towards molapo (flood-recession) farming in the Boteti river in exceptional years of flooding. Consolidated lands areas surrounded by a perimeter fence (unit 2) occur near Mopipi (Mokobaxane-west 3500 ha and Mokobaxane-east 1600 ha), Mmatshumo (6600 ha), Mosu (Nthane 4100 ha) and Letlhakane (9500 ha). It is estimated that only 20 to 30% of these lands areas are under cultivation, even in a year with good rainfall. The remaining part of fenced-in area is used for grazing and the collection of veld products. Concentrations of isolated and individually fenced fields (unit 3) occur along the Boteti river from Makalamabedi to Mopipi and west and south of Mosu. Very few fields occur elsewhere. The total area used for rainfed cultivation at least once in four years covers not more than 0.3% of LetAD. The total area ploughed in the 1994/95 season was 6450 ha, which includes molapo fields used for rainfed cropping (see below).

Molapo farming is limited to the channel and the floodplain of the Boteti River from Makalamabedi to Mopipi (unit 1). The number and size of molapo fields is relatively low between Makalamabedi and Motopi where the river channel is narrow and deep, and is relatively high below Xhumo, where the river forms a floodplain with several wide and shallow channels. The total area which can be used for molapo farming in years of favorable flooding is estimated at 1500 ha (this does not include the now de-funct molapo around former Lake Xau).

- Animal production

By far the most common land use in LetAD is extensive grazing. All land which carries some form of vegetation is used for grazing at one time or another, with the exception of some enclosed residential plots and mining areas. Mostly, the animals graze freely around a particular water point during the day and are kept in enclosures (kraals) at night.

Under the heading of animal production, six areas have been distinguished on the basis of their legal status or designation. The largest area is taken up by unit 8, which is communal land used for grazing and designated as Controlled Hunting Area (CHA) by DWNP. Unit 6 is similar, except that the area has been proposed as a Community Controlled Hunting Area (see Section 3.7.2). The Kaka area in the southern corner (unit 5) has been set aside by the Land Board for the development of fenced commercial lease-hold ranches. Presently no new borehole allocations are approved in the area until a development plan has been finalized. A similar freeze on borehole allocation is in force in an area south of Kedia (unit 7). This area is also awaiting a development plan mainly for the benefit of Basarwa from the surroundings. The various Quarantine Camps (unit 9) are under control of the Veterinary Department. The various veterinary cordon fences and corridors could also be included in this unit. Illegal grazing takes place in State Land south of Makgadikgadi Pans National Park (unit 4). The area is part of the (ungazetted) Boteti State Land Wildlife Management Area. Despite the fact that no developments are allowed in State Land without permission of MLGLH, many cattleposts have been established around open wells in the eastern half of the area.

Units 4 and 8 include almost bare salt flats or pans (sub-units 4p and 8p respectively), which have no productive use except as seasonal watering points in wet years. The south-eastern part of Sua Pan (north of Mosu) is permanently wet; other pan areas may flood after heavy rainfall. When wet, some pan areas may be visited by birds and other wildlife.

- Residential and mining

The area taken up by permanent buildings and mines (unit 10) is relatively small, covering not more than

0.3 % of LetAD. Orapa is the largest build-up area (2200 ha), including the residential area, mine and dump. Other significant build-up areas are Letlhakane, Letlhakane Mine, Rakops and Mopipi. Surrounding Orapa and Letlhakane mines are large "precious stones protection and security areas". There is an inner zone which is fenced and used by the mines only, and an outer zone marked by a cutline only and locally used by roaming livestock. The protection and security area around Orapa mine includes a ranch and a nature reserve.

Mopipi dam (unit 11b) is a pan leased by Debswana Diamond Company for water storage but has not contained sufficient water for that purpose since 1984.

3.7.2 Hunting and gathering

Hunting and the collection of veld products takes place throughout the LetAD, with the exception of enclosed mining areas. Within LetAD, the DWNP distinguishes Controlled Hunting Areas, a Community Controlled Hunting Area and a (proposed) Wildlife Management Area, which have numbers as indicated on Map 6 (Present Land Use). CT8, CT13, CT19 and CT21 are Controlled Hunting Areas, one of which is presently closed for hunting (CT19). There is one proposed Community Controlled Hunting Area (CT20) but no community controlled hunting is taking place at present. Individual residents and non-residents hunt throughout LetAD with or without licenses. The strip of State Land (unit 4 on Map 6) is part of the proposed Boteti State Land WMA. This WMA has not yet been gazetted. The area has a low wildlife population and is mainly used for grazing (see Section 3.7.1). For more details on wildlife and hunting see Section 4.3.6.

Main veld products in LetAD are firewood, poles and timber for fencing and construction, and thatching grass. These products are collected in the immediate surroundings of any type of settlement.
Other popular veld products are edible fruits, vegetables and roots of various plants, collected for home consumption or cash. Few people collect medicinal products of plants and (small) animals. The Boteti river, during and after flooding, offers specific products such as reeds for fencing, edible waterlilies and fish. The distribution of some common veld products is indicated in Section 3.6 (Table 3.6). A comprehensive list of veld foods and medicinal plants of LetAD and surroundings is given in Annex 6. The use of veld products is discussed in Section 4.3.6.

3.7.3 Sites of archaeological or historical significance

The only National Monument of the area are Lekhubu Island and Khama House. Lekhubu Island falls outside LetAD but is still within Boteti sub-District. The site has a number of stonewall ruins of the Zimbabwe Period (1250 - 1450 AD) and baobab trees of scenic value. In addition to Lekhubu Island there are numerous sites of archaeological interest in LetAD. Most consist of finds of stone tools, bones or pottery, or foundations of early settlements. Khama House is situated in Mosu and consists of the remains of the house in which King Khama III was born (around 1840).

Table 3.7 LAND USE UNIT DESCRIPTION

LAND USE UNIT (1)	AREA (2)		DESCRIPTION	
	(km^2)	(%)		
1	44	0.2	Boteti floodplain, locally with molapo cultivation	Flood recession cultivation in the channel and active floodplain of the Boteti River. Floods occur in less than 50% of years and approximately 35% of the channel is cultivable. Few fields are used for rainfed cultivation in years without flooding. Area used for grazing in dry years.
2	280	1.0	"Lands" areas, partly used for rainfed cropping	Rainfed cultivation of maize, sorghum, millet, cowpeas and melons. Lands area in most cases surrounded by perimeter fence. The area ploughed in years of sufficient rainfall varies from 20 to 30 % of the total lands area. Area used for winter grazing and locally for year-round grazing.
3	716	2.4	Rainfed cropping (scattered fields)	As unit 2, but fields are scattered and less than 15 % of total area is ploughed during years of sufficient rainfall. Area also used for communal grazing of goats, donkeys and cattle.
4, 4p	1 940	6.7	Extensive grazing - State Land - Wildlife Management Area	Extensive grazing of free-range cattle and goats for meat and (minor) milk production and as capital investment. The animals are managed and watered from individually owned "cattleposts" with open wells, located both inside and outside the area. The area is State Land and designated as Wildlife Management Area (part of CT10)
5	3 635	12.5	Extensive grazing - Proposed Kaka Ranches - Controlled Hunting Area	Extensive grazing of cattle and goats for meat and (minor) milk production and as capital investment. The animals are managed and watered from individually owned "cattleposts" with boreholes. The area has been set aside for the development of enclosed commercial ranches. Area designated as Controlled Hunting Area (part of CT21).
6	3 018	10.3	Extensive grazing - Community Controlled Hunting Area	Extensive grazing of free-range cattle and goats for meat and (minor) milk production and as capital investment. The animals are managed and watered from individually owned "cattleposts" with boreholes. Part of proposed Community Controlled Hunting Area (CT20).
7	387	1.3	Extensive grazing - Proposed Kedia Reserved Area - Community Controlled Hunting Area	Extensive grazing of free-range cattle and goats for meat and (minor) milk production and as capital investment. The animals are managed and watered from individually owned "cattleposts" with boreholes, located outside the area. Area provisionally reserved for the use by Basarwa from Kedia and surroundings and part of proposed Community Controlled Hunting Area (CT20).
8, 8p	18 335	62.8	Extensive grazing - Controlled Hunting Area	Extensive grazing of free-range cattle and goats for meat and (minor) milk production and as capital investment. The animals are managed and watered from individually owned "cattleposts" with open wells or boreholes. Area designated as Controlled Hunting Area (CT8, part of CT13, CT19 and part of CT21).
9	366	1.3	Quarantine Camp	Enclosed holding grounds for livestock, managed by the Veterinary Dept.
10	60	0.2	Build-up area	Towns, major villages and mines
11	370	1.3	Precious stones protection and security area	Reserved area around diamond mines, mostly fenced and used for animal production, wildlife and recreation.
11p	19	0.1	Mopipi dam	Pan area leased to Debswana Diamond Company for water storage.

(1) See Map 6; p = pan (2) total area LetAD = 29 170 km^2

3.8 LAND UNITS

Land units are areas of land which are relatively homogeneous in terms of land resources and are defined for the purpose of land evaluation. The most important land resources with respect to land suitability for rainfed crop production are climate, topography and soils. The most important land resources with respect to land suitability for animal production are climate, vegetation and water resources.

In the case of LetAD it proved to be impossible to present all the variations of climate, topography, soil, vegetation and water on one map. Therefore, instead of one land unit map, two maps were prepared: one based on variations in climate, topography and soil for the purpose of land evaluation for rainfed crop production and one based on variations in climate, vegetation and water resources for the purpose of land evaluation for animal production.

3.8.1 Land units for evaluation for rainfed crop production

Land units for the evaluation for rainfed crop production are presented on Map 7. Eighteen units have been distinguished, based on variations in climate, topography and soils as presented in Table 3.8. A full description of the climatic zones, landforms and soil units is given in Sections 3.2 to 3.4. One of the tools used in land evaluation for crop production is a computer model called CYSLAMB. This model, which is explained in Section 6.2.2, requires a specific set of data to produce results. The required CYSLAMB input data for each of the 18 land units is given in Table 3.9.

3.8.2 Land units for evaluation for animal production

Land units for the evaluation for animal production are presented on Map 8. Twenty-one units have been distinguished, based on variations in vegetation, climate and water resources as presented in Table 3.10. A full description of the vegetation units, climatic zones and water resources is given in Sections 3.2 and 3.4 to 3.6. One of the tools used in land evaluation for animal production is a computer model called APSRAMB. This programme, which is explained in Section 6.5.2, requires a specific set of site information. The required site data for each of the 21 land units can be derived from Table 3.10.

Table 3.8 LAND UNITS FOR EVALUATION FOR RAINFED CROP PRODUCTION

LAND UNIT (1)	CLIMATE		TOPOGRAPHY	SOILS	
	Reference Synoptic Station	Reference Rainfall Station		Brief Description	Soil Unit(s)
A	Rakops	Orapa	Almost flat plains	Very shallow	1
B	Rakops	Orapa	Sloping escarpment	Shallow, coarse textured	2
C	Rakops	Rakops	Almost flat plains, locally with fossil dunes and ridges	Moderately deep to deep, coarse textured	3 (7,8)
D	Rakops	Orapa	Almost flat plain	Shallow to moderately deep, medium textured	5
E	Rakops	Orapa	As above	Shallow to moderately deep, imperfectly drained, medium textured	6
F	Maun	Maun	Almost flat plains, locally with fossil dunes and ridges	Moderately deep to deep, coarse textured	7
G	Rakops	Orapa	as above	as above	9 (3,4,7,8,10)
H	Rakops	Orapa	Shallow depressions; Fossil river courses (water receiving sites)	Deep, moderately well drained, coarse to medium textured	10
J	Maun	Orapa	as above	as above	10
K	Rakops	Rakops	Almost flat plain	Deep, medium textured	11
L	Rakops	Orapa	as above	as above	11
M	Rakops	Orapa	Almost flat lowlands (water receiving sites)	Deep, imperfectly drained, medium textured	12
N	Rakops	Orapa	Almost flat plains	Deep, imperfectly drained, medium textured, high sodium content	13
P	Rakops	Rakops	Channel Boteti River Occasional floods (moving water)	Deep, imperfectly drained, coarse to medium textured	14
Q	Rakops	Orapa	as above	as above	14
R	Maun	Maun	as above	as above	14
S	Rakops	Orapa	Channel and floodplain Boteti River. Occasionally flooded (moving water)	Deep, poorly drained, coarse to medium textured	18 (14)
T	Rakops	Orapa	Pans, depressions and floodplain Boteti River. Occasionally flooded (stagnant water)	Imperfectly to poorly drained, high sodium and/or salt content	15 (16,17,19)

(1) see Map 7

Table 3.9 LAND UNIT DESCRIPTION FOR CYSLAMB INPUT

LAND UNIT	SYNOPTIC STATION	RAINFALL STATION	SOIL UNIT	TEXTURE (topsoil)	DRAINAGE	DEPTH	AWC	AVAIL	pH (H2O)						EC (mS/cm)						ESP (%)					
								P*	0	25	50	75	100	125	0	25	50	75	100	125	0	25	50	75	100	125
						m	mm/m	ppm	–25	–50	–75	–100	–125	–150	–25	–50	–75	–100	–125	–150	–25	–50	–75	–100	–125	–150
A	Rakops	Orapa	1	coarse	well	0.25	100	3	7.5	–	–	–	–	–	0.1	–	–	–	–	–	1	–	–	–	–	–
B	Rakops	Orapa	2	coarse	well	0.50	80	3	6.6	5.8	–	–	–	–	0	0	–	–	–	–	1	1	–	–	–	–
C	Rakops	Rakops	3	coarse	well	0.90	70	3	7.4	8.0	7.2	7.2	–	–	0.1	0	0.1	0.1	–	–	3	0	3	3	–	–
D	Rakops	Orapa	5	medium	mod.well	0.90	130	3	8.3	8.4	8.3	8.3	–	–	0.1	0.1	0.1	0.1	–	–	1	3	2	2	–	–
E	Rakops	Orapa	6	medium	imperfect	0.90	130	3	7.9	8.0	8.0	8.0	–	–	0.1	0.2	0.2	0.2	–	–	2	3	4	4	–	–
F	Maun	Maun	7	coarse	s.exc.	1.25	70	3	6.8	7.6	7.3	6.7	6.5	–	0	0	0	0	0.1	–	0	0	0	0	0	–
G	Rakops	Orapa	9	coarse	s.exc.	1.70	70	3	5.6	5.9	5.1	4.9	4.9	–	0.1	0.2	0	0	0	0	4	3	5	0	0	0
H	Rakops	Orapa	10	coarse	mod.well	1.25	80	3	6.4	6.4	6.5	6.7	6.7	–	0	0	0	0	0	0	0	0	0	1	1	–
J	Maun	Maun	10	coarse	mod.well	1.25	80	3	6.4	6.4	6.5	6.7	6.7	–	0	0	0	0	0	0	0	0	0	1	1	–
K	Rakops	Rakops	11	medium	mod.well	1.25	130	3	8.1	8.5	8.3	8.5	9.8	–	0.6	0.4	3.4	10.0	13.2	–	1	2	16	50	70	–
L	Rakops	Orapa	11	medium	mod.well	1.25	130	3	8.1	8.5	8.3	8.5	9.8	–	0.6	0.4	3.4	10.0	13.2	–	1	2	16	50	70	–
M	Rakops	Orapa	12	medium	imperfect	1.25	130	3	8.7	8.7	9.0	9.0	9.0	–	0.1	0.1	0.1	0.1	0.1	–	3	5	7	7	7	–
N	Rakops	Orapa	13	medium	imperfect	1.25	110	3	7.9	8.0	8.0	8.0	8.0	–	0.1	0.2	0.2	0.2	0.2	–	4	6	8	10	10	–
P	Rakops	Rakops	14	medium	imperfect	1.50	80	3	6.5	6.5	7.0	7.0	7.0	7.0	1	1	1	1	1	1	1	2	2	2	2	2
Q	Rakops	Orapa	14	medium	imperfect	1.50	80	3	6.5	6.5	7.0	7.0	7.0	7.0	1	1	1	1	1	1	1	2	2	2	2	2
R	Maun	Maun	14	medium	imperfect	1.50	80	3	6.5	6.5	7.0	7.0	7.0	7.0	1	1	1	1	1	1	1	2	2	2	2	2
S	Rakops	Orapa	18	medium	poor	1.70	100	3	6.5	6.5	7.0	7.0	7.0	7.0	1	1	1	1	1	1	1	2	2	2	2	2
T	Rakops	Orapa	15	medium	poor	1.70	150	3	10.6	10.7	10.7	9.4	9.4	9.4	7.3	0.1	0.1	0	0	0	100	100	100	100	100	100

* Available phosphorus varies considerably within soil units and land units; an average of 3 ppm has been assumed in case no fertilizer or manure has been applied

Table 3.10 LAND UNITS FOR EVALUATION FOR ANIMAL PRODUCTION

LAND UNIT (see Map 8)	VEGETATION		CLIMATE		WATER RESOURCE (see Map 4)	SOILS	
	Brief description	Vegetation Unit(s) (see Map 5)	Reference Synoptic Station	Reference Rainfall Station		Units (see Map 3)	weight (%)
1	Bare pan surface	1	Rakops	Orapa	Wells (saline)	15	100
2	Halomorphic grassland	2, 1	Rakops	Orapa	Wells (saline)	15	100
3	Grassland & tree savanna	3	Rakops	Rakops	Wells	3	100
4	Grassland & Acacia low shrub savanna	3, 6	Rakops	Rakops	Boteti R. Wells	3 8/9 1	40 40 20
5	Mixed low shrub savanna	4	Rakops	Orapa	Boreholes	1 3 5	40 40 20
6	Mixed low shrub savanna	4	Rakops	Rakops	Wells	6	100
7	Acacia low shrub savanna & Acacia shrub savanna	6, 5, 9	Rakops	Rakops	Boreholes	7 8/9 3	60 20 20
8	Acacia low shrub savanna	6	Rakops	Orapa	Boreholes	9 3	80 20
9	Acacia shrub savanna, grassland & riverine dense savanna	6, 3, 9, 18, 19	Rakops	Orapa	Boteti R. Wells	7 9	70 30
10	Acacia open shrub savanna, grassland & open pan surface	7, 2, 3, 1	Rakops	Rakops	Boteti R. Wells	3 14 - 19	50 50
11	Acacia shrub savanna	9	Rakops	Orapa	Boreholes	7 8/9	80 20
12	Mopane low shrub savanna	8	Rakops	Orapa	Boreholes	11	100
13	Mopane dense shrub savanna	10	Rakops	Orapa	Boreholes Wells	3 5/6 7	50 40 10
14	Mopane shrubland	11	Rakops	Orapa	Boreholes	9/10 3/4 1	60 30 10
15	Mixed savanna	13	Rakops	Rakops	Boreholes	3 7	60 40
16	Mixed savanna	13	Rakops	Orapa	Boreholes	7	100
17	Mixed savanna, grassland & riverine dense savanna	14, 3, 18, 19	Maun	Maun	Boteti River	7 8/9/10	60 40
18	Mixed savanna	14	Rakops	Orapa	Wells	1	100
19	Mopane mixed dense savanna	15	Rakops	Orapa	Wells, Springs	2/3 11 15/17	50 25 25
20	Mopane dense savanna	16	Rakops	Orapa	Wells	11/12	100
21	Morukuru woodland	17	Rakops	Orapa	Boreholes	9	100

CHAPTER 4

SOCIO-ECONOMY

4.1 POPULATION

Population data are available from the 1991 Population and Housing Census (CSO, 1992-1994). The Census gives data for Boteti sub-District, which is somewhat larger than LetAD (see Map 1, page 10). However, almost all people of Boteti sub-District live in the area covered by LetAD and in this Chapter the figures of Boteti sub-District are assumed to be representative for LetAD. The closed mining town of Orapa is described separately. The Population and Housing Census does not give information on the ethnic origin of the people; information on this subject was gathered from other sources.

4.1.1 History and ethnic origin

LetAD has a long history of settlement. Tools of the Early, Middle Stone and Late Stone Age (130 000 to 1500 years ago) have been found along the prehistoric shores of the Makgadikgadi. From the archaeological finds it appears that the early settlers were hunters, gatherers and fishermen (Tlou and Campbell, 1984).

The oldest ethnic group in the area are the Basarwa (Bushmen). They used to be hunter-gatherers but now often work as "herdboys" on cattleposts owned by other ethnic groups. Khwee is a Basarwa settlement and other relatively large communities occur in Kedia and Letlhakane. Also long-time inhabitants are the Bakgalagadi, which have a similar occupation and distribution as the Basarwa. Groups of Bakgalagadi are also found in Rakops, Khumaga and Moreomaoto. The floodplains of the Boteti river have long been inhabited by the Bateti. The Bateti are distant cousins from the Basarwa, but have given up their hunting-gathering mode of subsistence a long time ago and have become pastoralists. Numerically and economically the most important people are the Bakalanga which have moved into the area from the north and north-east since the 1930's. One-third of the people in North-west Boteti are Kalanga and Rakops has more than 50% Kalanga (Van der Maas, 1995a). Also relatively recent arrivals are the Baherero which have come from Namibia and which have established small but coherent communities in villages which include Mopipi, Herero (north of Rakops), Toromoja, Mmatshumo and Mosu. There are numerous other small ethnic groups in the area, including Bananjwa and Bayei in the north-west, and Bangwato.

4.1.2 Total population, population growth and settlement pattern

The total population of Boteti sub-District in 1991 was 44 286, including the 8827 who lived in Orapa. Population is very sparse, even as compared to the country as a whole (Table 4.1). The population density of LetAD in 1991 was approximately 1.2 person/km^2 without Orapa and 1.5 person/km^2 including Orapa. Population in the area has been traditionally concentrated along the Boteti river (from Makalamabedi to Rakops and Mopipi), but has shifted in recent years to areas near mining sites (Orapa, Letlhakane) (see Map 6, Present Land Use). More than 70% of the people live in settlements of more than 200 people (as listed in Table 4.2, columns A and B), the remaining 30 % residing in small localities along the Boteti river, near major villages or at remote "cattle posts".

Table 4.1 POPULATION AND POPULATION DENSITY (1991)

AREA	POPULATION		DENSITY
	NUMBER	% OF TOTAL BOTSWANA	(person/km^2)
LetAD (without Orapa)	approx 35 000		1.2
LetAD (with Orapa)	approx 43 750		1.5
Boteti sub-District (without Orapa)	35 459	2.7	1.0
Boteti sub-District (with Orapa)	44 286	3.3	1.3
Central District (without Orapa, Selebi-Phikwe)	412 970	31.0	2.8
Botswana	1 326 796	100.0	2.3

Source: CSO, 1994

Comparing census data from 1981 with those of 1991, gives a annual population growth of 3% for Boteti sub-District (without Orapa). This is well above the national average for rural areas (2.7%). Extrapolating an annual growth of 3% for the years after 1991, gives an estimated population of Boteti sub-District (without Orapa) of approximately 41 000 in 1996 and 46 000 in the year 2000. Population growth is very uneven over the area. Rapidly growing villages are Letlhakane (66% growth between 1981 and 1991), Rakops (61%), Makalamabedi (64%) and Mopipi (47%). Other villages remain stagnant or do not keep up with the overall population growth, e.g. Xhumo with a growth of 27% between 1981 and 1991, and Mosu and Mmadikola with a negative growth of -4% and -2% respectively. There is clearly a move away from small communities based on agriculture to larger population centres with employment opportunities and services. The high number of abandoned homesteads along the main road between Mopipi and Xhumo are witness to this development. This does not mean that everybody wants to move to the main villages. New small settlements are still being created in remote areas, as was observed during fieldwork in 1995. Some people, particularly the Basarwa, are very mobile. They may move from one cattle post to another, depending on employment opportunities and the availability of water.

4.1.3 Age structure and gender of total population

The age structure of the total population of Boteti sub-District (Annex 3, Figure A3.1) shows a common distribution with a wide base of children below 15 (46% of total), a sizeable middle group of people aged 15 to 54 (44% of total) and a small group of people above the age of 55 (10% of total). The distribution between the sexes is fairly even, although there are slightly more female in all age groups. However, if individual villages are studied, a different picture emerges. Two "typical" situations will be illustrated below:

(a) Age structure of the "stagnant" village or settlement from young adults have emigrated. Mmadikola, located 10 km east of Rakops, is a good example of such a village. In this village there are relatively many children below 15 (51% of the total population) and few people in the middle group (38%); the group of people above the age of 55 is the same as for the whole District (10%). Below the age of 20 there are more male than female, above that age there are more female. (See Table A3.2 and Figure A3.2 in Annex 3).

(b) Age structure of a growing village, which attracts young adults from elsewhere. Letlhakane is a good example of such a village. In Letlhakane village there are relatively few children below 15 (38% of the

Table 4.2 POPULATION BOTETI SUB-DISTRICT (1991) BY TOWNS, VILLAGES AND LOCALITIES

MAIN VILLAGE OR TOWN (A)		ASSOCIATED MAIN LOCALITIES (B)		ASSOCIATED MINOR LOCALITIES (C)	ASSOCIATED LOCALITIES TOTAL (B + C)	VILLAGE OR TOWN + LOCALITIES TOTAL (A + B + C)
Letlhakane	8583	Metsiaela Mapetla	276 206	3409	3891	12474
Rakops/ Tsienyane	3122	Mmadikola Xauga Herero Sukwane	646 383 309 246	1272	3026	5978
Mopipi	2262	Mokobaxane	614	2398	3012	5274
Mokalamabedi	883	Motopi	791	1142	1933	2816
Xhumo	1145			995	995	2140
Mosu	557	Nthane	469	1074	1543	2100
Mmatshumo	759			751	751	1510
Toromoja	445			582	582	1027
Kedia	618			16	16	634
Moreomaoto	245			227	227	472
Khwee	158					158
Khumaga	397			479	479	876
Boteti sub-District (excl. Orapa)						35459
Orapa	8827					8827
Boteti sub-District (incl. Orapa)						44286

Source: CSO, 1994

total population), the middle group (15 to 54 years) is well represented, taking up 54%, and the group of people above the age of 55 is similar to that of the whole District (8%). Below the age of 30 there are more female than male; in the age group of 30 to 54 there are more male than female; the age group of 55 and above has more female than male. (See Table A3.3 and Figure A3.3 of Annex 3).

4.1.4 Number of households, household size and gender household head

4.1.4.1 Number of households[1], household size and gender household head of total population

The total number of households (HH) in Boteti sub-District in 1991 was 8444, including the 1805 of

[1] A household is any unit or family or group "eating from the same pot" and/or "living under the same roof".

Orapa. Table 4.3 gives the number and average size of HH and sex of HH head for the main settlements in the area. The average HH size of the main settlements varies from 4.4 to 6.3 and is often lower than the average of the whole sub-District (5.3), which means that the small localities have an average HH size mostly higher than the sub-District average (i.e. higher than 5.3). A female headed HH is usually larger than a male headed HH (Table 4.3).

As with age structure, the most common gender of the HH head varies considerably between the relatively small communities and the expanding main settlements. In the largest population centres the HH head is mostly male (51% in Letlhakane and 72% in Orapa). In the rural areas most HH are run by a woman; in villages of 500 to 4000 people the percentage of female headed HH is between 62 and 75, except for Mokobaxane which has a percentage of 47 female headed HH. In Botswana the traditional HH head is male, and the high percentage of female headed HH in rural areas reflects the emigration of adult males to urban centres.

4.1.4.2 Age and gender of farm holders[2]

Farming operations are mostly run by men. The 1993 Botswana Agricultural Census counted 3888 farms in LetAD, 80.5% of which were operated by a man and the remaining 19.5% by a woman. Of the farm holders, nearly 80% live on site and 20% live elsewhere. Most of the female farmers are widowed (46%) or never married (31%). The average age of the farm holder is 45 to 54 years; there are very few farm holders below the age of 30.

Table 4.3 NUMBER OF HOUSEHOLDS, SEX OF HOUSEHOLD HEAD AND AVERAGE HOUSEHOLD SIZE (1991), FOR SETTLEMENTS OF 500 OR MORE PEOPLE

	Letlhakane	Rakops	Mopipi	Xhumo	Makalamabedi	Motopi	Mmatshumo	Mmadikola	Kedia	Mosu	Mokoboxane	Boteti (1)	Orapa
Total no. of HH	1812	569	503	215	185	158	143	122	116	114	89	6639	1805
% Female headed HH	49	74	69	75	64	74	62	74	71	63	47	54	28
% Male headed HH	51	26	31	25	36	26	38	26	29	37	53	46	72
Average HH size	4.7	5.4	4.5	5.3	4.8	5.0	5.3	5.3	5.3	4.9	6.3	5.3	4.4
Average size female headed HH	5.2	5.8	4.9	5.4	5.4	5.4	4.9	5.4	5.6	5.1	6.5	5.6	4.8
Average size male headed HH	4.2	4.2	3.7	5.1	3.7	4.0	5.9	4.9	4.6	4.6	6.1	5.0	3.0

Source: CSO, 1994 (1) Total Boteti sub-District without Orapa

[2] A farm holder is a person who makes the day-to-day decisions for the agricultural holding. A holder does not necessarily live on-site.

4.2 LAND TENURE

There are two main types of tenure in LetAD: tribal land and state land.

- Tribal land

Most of the land in LetAD is communally owned. This land is administrated by the Land Board, as specified in the Tribal Land Act of 1970. The main Land Board is the Ngwato Land Board of Central District, with offices in Serowe. There are two subordinate Land Boards in Boteti sub-District, one in Rakops and one in Letlhakane. The boundary between the two is the veterinary cordon fence which runs south of Kedia and east of Mokobaxane village. The Land Board allocates land under customary law for rainfed cropping and leases land under common law for various purposes. Allocations of waterpoints are also made by the Land Board. No agricultural land or water points are allocated in and near rivers, although traditional right to land (molapo) and waterpoints (wells) in the river exist. The allocation of land in major villages, such as Letlhakane and Rakops, is guided by Village Development Plans, prepared by the Department of Town and Regional Planning (DTRP).

Major areas of tribal land under lease are quarantine camps and mines. These areas are controlled by the lessee under conditions stated in the lease.

- State Land

State Land is land owned by the Republic of Botswana. The only State Land in LetAD is situated south of Makgadikgadi Pans National Park, covering 1940 km^2 or 6.7% of LetAD. The State Land Act of 1966 regulates the ownership and sale of State Land but does not say anything about the use. Presumably permission of the Government, represented by the President or MLGLH, is needed for use of the land. Planning within State Land is the responsibility of DTRP. The area has been designated as Wildlife Management Area by DWNP, but has not yet been gazetted as such. At present, much of the State Land of LetAD is used for grazing and wells have been dug in the eastern part.

The site of Orapa township, Orapa and Letlhakane mines and the site of Mopipi Dam has been transferred from the Tribal Authority of the Bamangwato Tribe to the President on behalf of the Republic of Botswana under the Bamangwato Land Grant Act (1969) and leased to DEBSWANA Diamond Company.

4.3 ECONOMY

4.3.1 Main economic activities

In macro-economic terms, the main economic activity in LetAD is mining. The economy of the country is largely based on diamond mining and two of the three diamond mines of the country are situated in LetAD (see Map 6, Present Land Use). Agriculture is the second most productive activity in the area, although it is possible that the government invests more money into the area in the form of subsidies, agricultural infra-structure and salaries than it receives from tax and export earnings. The main agricultural produce is beef. The only crops produced are foodcrops and are by far not sufficient to feed the population.

At local level mining is also important. Most of the HH of Orapa are directly or indirectly dependent on mining. Also, of the major villages near Orapa, a significant percentage of the economically active population is directly involved in mining (22% of Letlhakane and 14% of Mopipi). Elsewhere in LetAD mining is of very little importance (see Table 4.4).

Almost 30% of the population of Boteti sub-District is economically active (CSO, 1992), which is slightly above the figure for the whole of rural Botswana (26.6%).

Of villages of more than 500 people (excl. Orapa), 39% of the economically active population is engaged in agriculture, 17% in construction, 14% employed by government and 12% engaged in other activities (Table 4.4). Small settlements are likely to have a much higher percentage of economically active people engaged in agriculture.

4.3.2 Income and subsistence of rural population

Over 60% of the HH of Boteti sub-District have direct access to cash income. In addition, at least a third of the HH receive remittances and a few HH benefit from pensions and drought relief (CSO, 1994). The primary sources of cash income are formal employment, livestock sales and beer sales.

Other sources of income are remittances, construction work and other piece jobs, drought relief, sale of crops, veld products and home-made products other than beer (e.g. fatcakes) and hawking. About half of the HH in the Rakops - Khumaga area have members working elsewhere (MoA/UB, 1994). In the 1994/95 season nearly 3000 farmers in LetAD, probably almost half of all HH, received drought relief in the form of ploughing subsidy and free seed (Table A4.1, Annex 4). Since most farmers in LetAD plough themselves, the ploughing subsidy directly contributes to HH cash income. The maximum ploughing subsidy in the 1994/95 season was 600 Pula per farmer for 5 ha ploughed, but most farmers ploughed only one or two hectares and received considerably less. The ploughing subsidy and all other forms of drought

Table 4.4 POPULATION AGED 12 YEARS AND OVER BY MAJOR INDUSTRY, FOR SETTLEMENTS OF 500 OR MORE PEOPLE (1991)
(figures in percentage, columns add up to 100%)

MAJOR INDUSTRY	Letlhakane	Rakops	Mopipi	Xhumo	Makalamabedi	Motopi	Mmatshumo	Mmadikola	Kedia	Mosu	Mokoboxane	Boteti (1)
Agriculture	10	15	17	26	30	16	36	39	11	24	21	39
Mining	22	2	14	2	0	5	2	3	0	4	3	7
Construction	16	23	17	31	26	19	18	16	3	42	23	17
Government, Education, Health, Utilities	20	24	15	11	16	21	24	12	67	11	28	14
Other (2)	32	36	37	30	28	39	20	30	19	19	25	23

Source: CSO, 1994

(1) Total Boteti sub-District without Orapa
(2) Manufacturing, Wholesale, Transport, Business Services, Domestic Services, Community, Other

relief are temporary forms of government assistance and may be withdrawn any time in the future.

The main sources of HH cash income in Mokobaxane village are formal employment (60% of HH), drought relief labour projects (40%), remittances (33%), casual labour (29%) and self employment (2%) (Mars, 1996). Most HH had more than one source of cash income. In addition, some HH made money from selling various produce, such as beer (38%), cattle (36%), wild fruits and vegetables (27%), thatching grass and poles (20%), fat cakes (18%), small stock and milk (17%) and crops (11%). Crops sold in Mokobaxane in the (dry) 1994/95 season include watermelon, maize, millet and beans.

Nearly all HH have sources of subsistence, although they may be small or absent in years of drought. Of the HH of settlements with more than 500 people in Boteti sub-District more than 50% planted one or more crops in the relatively wet season of 1990/91 (Table 4.6) and 57% owned cattle and 71% owned goats respectively (Table 4.7). Additional sources of subsistence are veld products, work parties (food for work) and government hand-outs. The latter include "destitute feeding" and "under-five" rations. In 1993, 656 persons in Boteti sub-District were classified as "destitute" and received government assistance, making up approximately 2% of the population of LetAD (MoA/UB, 1994). Destitute adults receive consumer items worth P76 each month; destitute children receive assistance in the form of school uniforms, toiletries and other. Under-five rations are made available monthly to all children aged less than five years, representing 16.5% of the total population of LetAD. Mars (1996) found in Mokobaxane more than 25% of the *de jure* female headed HH (mainly widows and divorcees) and 10% of the male headed HH living on government hand-outs. Surprisingly, none of the *de facto* female headed HH were dependent on government rations.

From October 1996 onwards, persons of 65 years and over are receiving an old-age pension of 100 Pula per month. In 1991 there were 2324 persons aged 65 years or more in LetAD (without Orapa), representing 6.5% of the population.

4.3.3 Farming, farmer groups

As will be demonstrated in Sections 4.3.4 and 4.3.5, most households in LetAD engage in some form of agriculture but the amount of time spent on farming activities varies enormously from one HH to the other and may also vary considerably from year to year. Traditionally farming in LetAD includes both crop and livestock production and engages at least one member of the farm household throughout the year. In this traditional farming system crop production and livestock production are dependent on each other to some extent: oxen or donkeys provide draught power and livestock may forage on crop residues after harvest and leave manure. However, in the last few decennia, new farming systems have developed whereby a household is only part-time involved in agriculture and/or only engages in one production system. Examples of part-time farmers are government employees with a cattle post in a remote area, or households without livestock and engaged in seasonal cropping during years of sufficient rainfall only. Some "farmers" only keep a few animals or plant crops as a hobby or out of tradition, without a clear economic motive. In 1993, only 65% of all farm holders in LetAD were full-time farmers (MoA/CSO, 1995).

Five farmer groups have been distinguished based on main farming activities and the availability of draught power, capital (including livestock) and labour. These differences determine the ability of the farmer to respond to proposed improvements and extension messages. With respect to cropping a distinction has been made between farmers who have access to both molapo and rainfed fields and those who have access to rainfed fields only. There are no distinct boundaries between one group and the other, and some farm HH may fit into more than one group. Also, the situation of a farm HH may change

abruptly, for example through marriage, deaths and droughts.

A brief description of the farmer groups, as they occur in LetAD, is given below. A definition in more quantitative terms is given in Table 4.5. No attempt has been made to find out exactly how many farmers belong to each group. However, from existing surveys in and around LetAD (Bekker 1996, Van der Maas et al 1995a & 1995b, Bastiaanssen 1990) a rough estimation can be made of the relative importance of each group. A description of the various production systems is given in Sections 4.3.4 and 4.3.5.

Farmer group I — Farmers of group I have little labour, no cattle and few other resources and would not be able to farm at all without ploughing subsidies and/or assistance from relatives or neighbouring farmers with more resources. Many *de facto* female headed HH, with small children only, belong to this group. Farming is only a part-time occupation. Less than 10% of the farmers belong to group I.

Farmer group II — Farmers of group II have few assets, except a few donkeys, some goats and possibly few head of cattle. However, there is enough labour in the HH to cultivate a few hectares of land. In most cases farm implements have to be borrowed or shared. Approximately one-third of the farmers belong to group II.

Farmer group III — Farmers of group III have a small herd of cattle and/or have small but regular income from employment, remittances, pensions or other sources. They have sufficient draught power or can afford to hire it. Approximately one-third of the farmers belong to group III.

Farmer group IV — Farmers of group IV have a sizeable herd of cattle and other livestock and may have additional income from other sources. They are actively engaged in both livestock and crop production and can afford the necessary inputs for both. A few farmers of this group own a tractor which is also hired out. About 20% of the farmers belong to group IV.

Farmer group V — Farmers of group V are mainly concerned with livestock production and have a herd of at least 50 cattle. They usually have other sources of income and leave day-to-day management to herdboys. Only a few percent of the farmers belong to group V.

4.3.4 Present system of crop production

This Section describes the various systems of crop production. The distribution of various types of crop production is discussed in Section 3.7.1 and shown on Map 6 (Present Land Use).

Of the HH of settlements with more than 500 people, more than 50% planted one or more crops in the 90/91 season (Table 4.6). This is quite a high figure and probably also includes gardening. For settlements of 200 to 500 people this figure may be even higher, but in small localities near cattleposts little cropping is practiced. In North-west Boteti 90% of all studied HH had access to arable land (Van der Maas et al, 1995a). The 1993 Botswana Agricultural Census counted 2103 farm holdings with land in LetAD, which is 33% of all HH in LetAD (without Orapa). Drought relief figures show 2874 arable farmers in the 1994/95, which represents 43% of all HH (without Orapa). The two main crop production systems are rainfed cropping and molapo farming. Molapo farming is limited to the Boteti River from Makalamabedi to Mopipi. Only seven farmers were engaged in irrigated cropping in 1995.

Table 4.5 DEFINITION OF FARMER GROUPS

FARMER GROUP	PRODUCTION SYSTEM	Available DRAUGHT POWER	Available CAPITAL (1)	Available LABOUR UNITS (2)	Area cultivated (ha) (3)	Number of cattle
Ir	Rainfed crops (& smallstock)	Nil	low	< 1	< 2	nil
Im	Molapo & rainfed crops (& smallstock)					
IIr	Rainfed crops (& smallstock)	Donkeys	low	2 - 3	2 - 3	< 5
IIm	Molapo & rainfed crops (& smallstock)					
IIIr	Rainfed crops (& smallstock)	Donkeys/Oxen	moderate	> 2	3 - 4	< 20
IIIm	Molapo & rainfed crops (& smallstock)					
IVr	Livestock & Rainfed crops	Donkeys/Oxen (or Tractor)	moderate or high	> 2	4 - 5	> 20
IVm	Livestock & Molapo & Rainfed crops					
V	Livestock	n.a.	high	> 2	n.a.	> 50

(1) Capital = relative indication of wealth, based on livestock ownership, other assets (implements) and/or regular income from employment, business, remittances or pensions
(2) Labour Units: adult (full-time) = 1.0, adult female (with child-care) = 0.6, teenage child (school-going) = 0.2
(3) Area cultivated is, one average, 70 - 80% of area owned

- Rainfed crop production

Rainfed cropping is widely practiced in Mosu (Nthane), Mmatshumo, Letlhakane and Mopipi (Mokobaxane), but also along the Boteti River. Over 70% of the farmers with access to molapo, also had one or more dryland plots (Van der Maas et al, 1995a), although farmers with limited resources may concentrate on their molapo field in years with sufficient flooding. In dry years some of the molapo fields are used for rainfed cropping. Farmers along the Boteti river practice rainfed cropping on isolated fields, mostly with a bush fence, located not more than a few kilometers from the river. Old fields are often located in depressions where soil moisture conditions are slightly better, but recent fields seem to have been allocated regardless of topography and soil. Farmers in the north-eastern part of LetAD mostly have their fields in a lands area, surrounded by a wire perimeter fence. Within the lands area individual fields are also fenced. Some farmers have two residences: a permanent home in a major village and a temporary home on the lands for the duration of the cropping season.

Ploughing and planting takes place simultaneously, any time between mid November and late February, and may be carried out in two or three phases, depending on rainfall and farmer's resources and inclination. Dryland holdings usually consist of one field and can be as small as 1 to 2 ha or as big as 10 to 15 ha. The average holding for LetAD is 2 to 3 ha, and is considerably lower than the average for Botswana (4.8 ha). Of any field, only a portion may be ploughed and planted in single year. Traditionally a mixture of seeds is broadcasted. Only 20% of the major field crops are grown in pure stands. After

Table 4.6 HOUSEHOLDS THAT PLANTED ONE OR MORE TYPE OF CROP IN THE 90/91 SEASON, FOR SETTLEMENTS OF 500 OR MORE PEOPLE
(figures in percentage, columns do not add up to 100 %)

TYPE OF CROP PLANTED	Letlhakane	Rakops	Mopipi	Xhumo	Makalamabedi	Motopi	Mmatshumo	Mmadikola	Kedia	Mosu	Mokoboxane	Boteti (1)
Crops (any type)	36	59	53	71	70	71	83	71	49	61	45	52
Maize	28	54	51	70	50	65	62	69	47	51	44	45
Sorghum	30	24	9	15	55	62	81	11	29	56	21	31
Water melons	20	18	10	47	22	60	69	62	42	50	32	28
Beans (cowpea)	24	19	11	46	34	39	73	46	30	49	23	26
Millet	12	16	4	3	42	36	11	5	2	11	18	16
Sweet reed	5	3	7	15	0	2	0	15	1	3	6	5
Pumpkins	1	8	2	1	0	2	0	38	0	0	16	4
Groundnuts	< 1	0	< 1	1	1	0	0	1	0	0	0	< 1
Vegetables	< 1	1	< 1	0	0	1	0	0	0	0	0	< 1
Fruits	< 1	< 1	0	0	0	0	0	1	1	0	0	< 1

Source: CSO, 1994 (1) Total Boteti sub-District without Orapa

broadcasting, the soil is ploughed with a mouldboard plough, drawn by a span of four to eight donkeys or oxen. Few farmers use a planter or a plough-planter. There are only a few tractors in the area; of the land ploughed in 94/95 only 7% was ploughed by tractor and mainly in Letlhakane. Weeding is carried out once, by hand. Main crops are sorghum, maize, cowpea, pearl millet and water melon. Minor crops include sweet reed (*Sorghum dochna*), pumpkin, jugo bean, groundnuts, sunflower, sweet melon, and cucurbits (gourds). The harvest of green produce, such as cowpea leaves, pumpkin leaves, green maize and water melon, will commence two to three months after planting. Dried heads of sorghum and millet and cobs of maize will be harvested by hand four to five months after planting and carried to the homestead. Yields are low, due to unreliable rainfall, low inputs (no fertilizer and rarely manure), pests and poor management. The average yield over a long period of wet years and dry years is around 150 kg of grains and beans for each hectare planted. This figure does not including fresh produce harvested during the course of the growing season. Potential crop yields are discussed in detail in Section 6.2. Nearly all produce is used for home consumption, although some surplus may be marketed in years of exceptionally good rainfall.

A special form of rainfed cropping is backyard gardening. In this case small plots near the homestead are cultivated by hand with a hoe for the production of maize and vegetables. In Kedia village almost half of the HH have a backyard garden (Van der Maas, 1995b).

- Molapo farming

Molapo farming, also called flood recession farming, is limited to the active floodplain of the Boteti river. There used to be some molapo farming around Lake Xau, but the flow from the Boteti river was

artificially channelled away from this area towards Mopipi Dam in the early seventies. In an ideal situation, the river fills up in June or July, inundating fields situated in the river and adjacent floodplains. Ploughing and planting takes place immediately after fields fall dry in the early summer months. In the early stages seedlings make use of residual soil moisture, the roots extending towards the falling watertable. In mid summer additional moisture is provided by rainfall. The size of a molapo fields varies from less than 0.2 ha to more than 8 ha, but is mostly around 1 ha. Molapo fields are mostly smaller than dryland field because of shortage of land for molapo and higher labour requirements with respect to weeding and pest control. Molapo fields are traditionally owned and not allocated or registered by the Land Board who considers molapo as "river". Individual plots are fenced by cut (thorny) bushes to keep out wildlife and livestock. These fences have to be repaired or replaced with every cropping season. Maize is the preferred crop, mixed with one or more of the following minor crops: sorghum, millet, cowpea, sweet reed, watermelon, groundnut, sweet melon, cucurbits (gourds). Because of better moisture availability and higher soil fertility molapo fields are potentially more productive than dryland fields. Under optimum conditions, sorghum and maize yields of more than 1000 kg/ha can be achieved (Lillethun, 1990). However, the floods of the Boteti river are very irregular and may be absent for a period of many years (see Section 3.5.5). The total area taken up by molapo fields between Makalamabedi and Xhumo was estimated at 1591 ha by Lillethun (1990). If the molapo fields downstream of Xhumo and around Lake Xau (dry since 1982) are also included, the total area of molapo fields in LetAD is around 1800 ha.

- Irrigated cropping (horticulture)

Irrigated cropping in LetAD is limited to a few small-scale horticultural projects totalling less than 10 ha. All these schemes are centered around a borehole or well and several experience water shortages. The main crops are cabbage, tomato, potato, beetroot, choumollier, rape, onion, spinach and green maize (mealies).

4.3.5 Present system of animal production

This section describes the various systems of animal production. The distribution of livestock and land use for animal production is discussed in Section 3.7.1 and Annex 5 (Stocking density of VEA) and shown on Map 6 (Present Land Use).

- Cattle

Of the HH of settlements of more than 500 people, 57% owns cattle (Table 4.7). This does not mean that all these HH are actively engaged in cattle production, as many have given their animals in the care of relatives (even half of the HH of Orapa own cattle). The 1993 Botswana Agricultural Census gives 2640 farm holdings with cattle, which is 40% of all HH in LetAD (without Orapa). Paradoxically, in remote cattlepost areas, the percentage of HH owning cattle is relatively low: 33% in Lower Boteti (Rozenga, 1995). In these areas, the cattle owners live somewhere else and the residing caretakers usually do not own livestock. The Veterinary Department counted more than 100 000 head of cattle in LetAD in 1995 (see Annex 5). This figure represents number of cattle brought to crush locations for vaccination or dosing and owners' estimates of additional animals. The actual figure may be significantly higher as not all owners show up at the crush. In the 1993 Botswana Agricultural Census 156 000 head of cattle were counted, representing 8.6% of the total cattle herd of Botswana at that time. The average herd size is 59 animals per cattle holding, which is much larger than the average for Botswana (34 animals/cattle holding).

There are two major types of cattle production: communal grazing and cattleposts. Communal grazing

takes place near villages and traditional and communally owned sources of water, such as the Boteti river, lake Xau (now dry) and the springs near Mosu. Small and large herds of various owners mingle on communally owned land. Cattle posts are mostly located in more remote areas and animals graze around a privately owned source of water, such as a borehole or a well. Cattle posts are also communal land, but an individual who owns a waterpoint also controls the grazing around it. The allocation of waterpoints to individuals is done by the Land Board since the early seventies, and a minimal distance of 8 km between waterpoints (usually boreholes) is maintained. Recently developed cattleposts areas in the south of LetAD show a fairly even distribution of waterpoints; older cattlepost areas in the north show an uneven distribution and very high concentrations of waterpoints (see Map 4, Waterpoints).

The aim of cattle owners in both communal grazing and cattle posts is to produce and keep as many animals as possible. Cattle is produced mainly as a form of wealth accumulation and as a status symbol. Animals are consumed, sold or exchanged occasionally but not in a systematic way and with little regard to the optimal condition and composition of the herd and to the grazing potential of the area. Off-take rates were around 7% in North-west Boteti in the period from 1978 to 1989 (UB, 1994). The 1993 Agricultural Census gives somewhat higher figures, with an off-take of 10.3% for sales and 1% for home slaughter for the whole of LetAD. Large cattle owners are more likely to sell animals than small cattle owners. Sales are to BMC mainly, either directly or through an agent. Very few animals are sold to the local butchers or to traders. Milk is produced as a by-product and consumed by people in daily care of the animals. Some farmers use oxen for ploughing, but others prefer donkeys even if they have cattle. If grazing is scarce, animals are moved to better areas if possible, or left to die. Many cattle are owned by persons living far away from the actual grazing area and watering and herding is left to poorly paid herdboys. Few cattleposts are managed on a daily basis by their owners or a manager.

- Goats and sheep

Of the HH of settlements of more than 500 people, 71% owns goats and 15% owns sheep (Table 4.7). In remote cattlepost areas less than half of the HH owns smallstock (Rozenga, 1995). The 1993 Botswana Agricultural Census counted 2995 farms with goats, which means that about half of all HH in LetAD own

Table 4.7 HOUSEHOLDS OWNING ONE OR MORE TYPES OF LIVESTOCK IN 1991, FOR SETTLEMENTS OF 500 OR MORE PEOPLE
(figures in percentage, columns do not add up to 100%)

TYPE OF LIVESTOCK OWNED	Letlhakane	Rakops	Mopipi	Xhumo	Makalamabedi	Motopi	Mmatshumo	Mmadikola	Kedia	Mosu	Mokoboxane	Boteti (1)
Livestock (any type)	76	81	77	87	89	88	88	82	79	84	90	82
Goats	65	67	66	78	82	77	83	78	60	75	81	71
Cattle	54	50	73	62	57	60	73	64	42	68	62	57
Poultry	50	52	54	65	64	62	55	34	48	67	62	54
Donkeys/horses	25	44	50	59	55	56	48	43	36	46	43	47
Sheep	11	12	24	17	1	1	11	12	2	17	19	15
Pigs	< 1	< 1	< 1	1	0	1	0	0	0	0	0	< 1

Source: CSO, 1994 (1) Total Boteti sub-District without Orapa

goats. Goat herds are large, with an average of 43 animals per goat farm, almost double the average size of goat herd in Botswana. The distribution of goats between HH is very uneven. In North-west Boteti 50% of all goats is owned by 10.6% of all goat-owning HH (Van der Maas et al, 1995a). The largest goat herds are owned by large cattle owners. As with cattle, goats are mainly owned by male headed HH. The Veterinary Department counted nearly 64 000 goats and 6400 sheep in LetAD in 1995 (see Annex 5). This figure is based on estimates from cattle owners during vaccination campaigns. The actual figure is significantly higher as farmers who own smallstock only are not counted. The 1993 Botswana Agricultural Census counted 127 700 goats and 13 600 sheep in LetAD. Although also found at cattle posts, most goats and sheep are kept near villages. The animals are closed in at night and taken out during the day. They are occasionally herded by children and/or dogs but left on their own most of the time. Apart from watering and protection at night they are given little care. Smallstock is rarely sold to BMC, because of the transport costs. The annual off-take in 1993 was 4.2% for local sales and 5.5% for home slaughter. Goatmilk is not consumed much.

- Donkeys and horses

Of the HH of settlements of more than 500 people, 47% owns donkeys and/or horses (Table 4.7). The Veterinary Department counted more than 6000 donkeys and 2300 horses in LetAD in 1995 (see Annex 5). The 1993 Botswana Agricultural Census gives a much higher figure of 19 300 donkeys, or six per donkey-owning farm. Donkeys are kept for draughtpower and occasionally for riding or for pulling carts. Horses are used for herding cattle over long distances. Horses are mainly kept by large cattle owners and usually well cared for. The ownership of donkeys is more widespread and stimulated by the ALDEP draughtpower package. Donkeys roam around villages and are mostly left on their own if not needed. Unproductive and sick animals are left to die. Some donkeys fall victim to predators.

- Poultry

Of the HH of settlements of more than 500 people, 54% owns poultry (Table 4.7). The ownership of poultry in smaller settlements is likely to be higher. In North-west Boteti 55% of all HH own chickens with an average flock is 7 to 8 animals (Van der Maas et al, 1995a). The 1993 Botswana Agricultural Census gives similar figures for the whole of LetAD. Most poultry consist of free-range chickens and very few ducks and are mainly kept for meat and rarely for eggs. The animals forage around homesteads, breed freely and are preyed on by birds, snakes and small mammals (e.g. mongoose).

4.3.6 Hunting and gathering

- Veld products

There are numerous veld products in LetAD, most of which are for private use. The most common products are firewood, poles for construction and fencing, thatching grass, fruits and vegetables (merogo). Products with some commercial value are firewood and poles, thatching grass and certain fruits. Campbell et al (1991) list many tubers, bulbs, roots, succulents, nuts, beans, fruits, leaves, cucumbers, melons, fungi and gums, and a few medicinal plants collected by residents of the area south-east of LetAD. Mars (1996) identified a large number of veld products found near Mokobaxane. The occurrence of veld foods and medicinal plants in and around LetAD is summarized in Annex 6. Potentially valuable, but relatively rare plants include the grapple plant (*Harpagophytum procumbens*), also known as devils claw or sengaparile, and the morama bean (*Tylosema esculentum*). Animal products include ostrich eggs, termites (nato), flying ants (dikokobela) and honey. Although the mopane tree (*Colophospermum mopane*) dominates the vegetation in the centre and north-east of LetAD, the edible caterpillar of the mopane moth (*Gonimbrasia*

belina) does not occur in large numbers. The most common veld products are listed in Table 4.8. The distribution of valuable plants is indicated on the vegetation map (Map 5 and Table 3.10 of Section 3.6).

Although the commercial value of veld products is very low at present, they play a major role in the life of the rural population. The availability of veld products is one of the attractions of living on the land and reduces the cost of living.

- Hunting

Wildlife populations have declined rapidly in LetAD over the last few decades. Reasons of decline include increased hunting with modern weapons and transport, increased accessibility, veterinary cordon fences and other barriers, and drought.

LetAD is divided into five Controlled Hunting Areas and one (proposed) Wildlife Management Area (see also Section 3.7 and Map 6). One CHA (numbered CT20) has been set aside for "Community managed wildlife utilization" and a hunting license can only be given to the community. Another CHA (CT19) is closed for hunting. For the remaining three areas (CT8, CT13 and CT21) hunting licenses for limited

Table 4.8 MOST IMPORTANT VELD PRODUCTS

LOCAL NAME	USE	PLANT SPECIES	PLANT PART	REMARKS
tshikitshane motsikiri seloka rathathe	thatching	*Stipachrostis uniplumis* *Eragrostis pallens* *Aristida congesta* *Eragrostis rigidior*	stems & leaves (grass)	Minor sales (permit needed for transport across vet. cordon fences)
various	firewood	many trees and shrubs	trunk, branches	Sales
various	construction, fencing	many tree species	poles	Sales
mogwana moretlwa motsotsojane mokgomphata	food, wine (khadi) food food food	*Grewia bicolor* *Grewia flava* *Grewia retinervis* *Grewia flavescens*	fruit	Sales (particularly khadi)
motlopi	food	*Boscia albitrunca*	fruit	
morula	food, wine ("beer")	*Sclerocarya caffra*	fruit	Sales
moretologa	food	*Ximenia spp*	fruit	Minor sales
ditodi	ropes & baskets	various trees	bark	Minor sales
mokolwane	baskets	*Hyphaene ventricosa* (palm)	leaves	Minor sales
merogo	food	*Cucumis* spp *Amaranthus* spp *Cleone gynandra* and other herbs	leaves	Minor sales
lethaka	fencing, mats	*Phragmites australis*	reeds	In Boteti river during floods only (not since early eighties) Minor sales
various	food	fish		
tswii	food	*Nymphaea caerulea* (water lily)	roots	

numbers of duiker, steenbok, springbok, ostrich, kudu, baboon and spotted hyena are issued to individuals. Most licenses are issued to residents at a fee varying from P 0.25 for a duiker to P10.00 for an ostrich. If all licenses in LetAD were taken up by residents, including those of the Community CHA, a total annual revenue of around P 1500.00 would result. This amount is unlikely to cover the administration cost of DWNP in Serowe. Non-residents pay much higher fees, but very few licenses are taken up by this category. Traditional hunters can get a Special Game License which allow them to kill a specified number of animals with traditional weapons. The system of Special Game Licenses is presently being reviewed by DWNP.

- Tourism

A limited number of tourists pass through LetAD on their way to Lekhubu Island, Makgadikgadi Pans National Park, Central Kalahari Game Reserve or Maun. Very few stay overnight in the area and the income from tourism is negligible at the present moment.

4.4 INFRASTRUCTURE

4.4.1 Major roads, power and water supply

Major roads and some of the most travelled tracks are shown on Map 6 (Present Land Use) and some of the other maps. Access to LetAD and the Boteti region in general has improved enormously since the early eighties with the construction of the tarred Francistown - Orapa road, the Serowe - Orapa - Mopipi road and the Nata - Maun road. The first two roads were primarily built to serve the diamond mining industry at Orapa, the third to improve access to Ngamiland (Maun). A rather narrow and winding tarred road runs from Mopipi to Rakops and a wide dirt road from Rakops to Motopi where it links up with the main Nata - Maun road. The Rakops - Motopi connection is scheduled for upgrading and surfacing and with its completion the most economical connection by road from Gaborone to Maun will no longer run via Francistown but via Serowe, Letlhakane, Mopipi and Rakops.

There are a number of dirt roads maintained by the Roads Department and the District Council, providing access to major villages such as Mosu, Mmatshumo, Toromoja and Kedia. Maintenance is partly carried out by local villagers under the Rural Roads Programme or the Drought Relief Programme. In addition to these all-weather roads there are numerous un-official tracks connecting cattle posts and small localities. Many of these tracks make use of cut-lines constructed in connection with geological exploration or veterinary cordon fences. These tracks are mostly sandy and may have muddy section during the rainy season. They can only be negotiated with light trucks with high ground clearance or four-wheel drive vehicles. Tracks going north through the Ntwetwe and Sua Pans may be closed for much of the rainy season due to wetness.

Public transport to and within LetAD is very poor. Some private minibuses operate on tarred roads from Serowe and Francistown to Orapa and between Letlhakane and Rakops. Mine authorities provide daily transport to Mopipi and Letlhakane for workers.

There is a secondary government airstrip at Rakops and a private licensed airstrip at Orapa.

Water supply

Orapa town, Orapa Mine and Letlhakane Mine are linked up with a reticulation system fed by boreholes in six wellfields maintained by mine authorities. The requirement of the mines was 14 000 m^3/day in 1995 and will be 39 000 m^3/day in 2010 (Swedeplan, 1994). Villages with a population of more than 500 people (see Table 4.2, Chapter 4) depend on water supplied by the Water Unit of the District Council or Department of Water Affairs from local boreholes. If no groundwater is found near a village, water has to be piped over a long distance, as in the case of Kedia. If the local water supply system fails, water is trucked in. Government institutions and some businesses and residents may have a private water connection, but the majority of villagers make use of public standpipes. At small localities and cattle posts residents rely on hand-dug wells, privately owned boreholes and open water in pans and pools during rains. At some cattle posts the water is too salty for human consumption and water has to be brought in from distant places. Owners of private boreholes and wells may limit access their water supply or may sell it.

Power

Orapa and Letlhakane are linked to the national power grid through an overhead line. Rakops has its own generators. Most other villages do not have electricity. In Orapa the main source of energy for cooking and lighting is electricity. In Letlhakane and Rakops government institutions, and some businesses and affluent residents use electricity or gas for cooking and have electric light. Otherwise, the main sources of energy for cooking and lighting are fuel wood and paraffin. Permanently installed waterpumps at boreholes mostly run on diesel. Water from shallow wells is usually drawn by hand; in the Boteti river some wells are equipped with a portable petrol pump. Draught power for ploughing is provided mostly by donkeys and oxen, and occasionally by tractors (in 1995 there were seven tractors in Letlhakane and two in Rakops).

4.4.2 Agricultural infrastructure, markets

Infrastructural support for cropping is provided by the Botswana Agricultural Marketing Board (BAMB) with depots in Letlhakane and Rakops and the Tsienyane Multi-purpose Co-operative in Rakops. BAMB both sells and buys maize, sorghum, millet, sunflower, shelled groundnuts and various other beans and peas. BAMB also sells fertilizer and seeds. A limited number of implements and pesticides are available from the Co-op and various hardware stores and merchants in the area. Specialized tools and chemicals can only be obtained from suppliers outside the area in Serowe, Palapye or Maun.

Local markets for horticultural produce include informal public markets at Letlhakane and Rakops, schools and health facilities at Letlhakane, Rakops, Mopipi and Makalamabedi and restaurants in Letlhakane. Orapa is also a potential market, but access and business are controlled by the mine.

Animal feeds and supplements, vaccines, drugs and various veterinary and fencing requisites are sold at subsidized prices by the Livestock Advisory Centres (LAC) of the DAHP in Letlhakane and Rakops.

The main markets available to livestock owners are the abattoirs of the Botswana Meat Commission (BMC) in Maun (cattle only) or Francistown, the Rakops Co-operative and some local butcheries, slaughter-houses and traders in Rakops and Letlhakane. In addition, farmers can sell animals to other farmers and residents or use them as payment for various services and obligations. Smallstock is mainly sold locally, as transport costs make sales to BMC Francistown unattractive.

- Veterinary Control Zones and Quarantine Camps

The marketing of live animals and meat is made complicated by the existence of disease control measures in the form of cordon fences and quarantine requirements. The main disease to be controlled is foot and mouth disease and, since 1995, lung disease. Boteti sub-District has four veterinary disease control zones with quarantine camps, as shown on Map 10 (page 55):

Zone 4a:	Vaccination zone, linked with corridor to Setata Quarantine Camp
Zones 4b and 3c:	Buffer zone with Setata, Orapa and Mmatshumo Quarantine Camps
Zone 5:	Non-vaccination zone with Kaka and Makoba Quarantine Camps

Meat from Zone 5 can be sold to the EEC; the other Zones are so-called Non-EEC areas. All cattle to be transported outside any of the zones have to be quarantined for three weeks. Grazing and water are provided at no cost. Transport from the quarantine camps to BMC Francistown is exclusively done by a company called Botswana Road Services. Transport cost is born by the farmer (40 - 50 Pula per head of cattle). From the north-western corner of LetAD some animals are sold to BMC at Maun and partly transported on foot, otherwise BMC Francistown is preferred because of better prices (price difference between BMC Maun and Francistown approx. 12.5%).

4.5 PRESENT INSTITUTIONS, LEGISLATION, POLICIES AND PROJECTS

The Central District has four officially recognized institutions within the Ministry of Local Government, Lands and Housing (MLGL&H), namely the Tribal Administration, District Administration, District Council and Tribal Land Board. In addition there are institutions representing other Ministries, such as the Department of Wildlife and National Parks (DWNP, Ministry of Commerce and Industry) and the Departments of Animal Health and Production (DAHP), Crop Production and Forestry (DCPF) and Co-operatives of the Ministry of Agriculture (MoA). All the institutions listed above are represented in the District Development Committee (DDC) which is responsible for District development planning. In addition to Government Institutions there are a number of Non-Governmental Organization (NGOs) active in the area.

4.5.1 Institutions at national, district and sub-district level; extension areas

- Tribal Administration

The Tribal Administration is a traditional institution comprising Chiefs, Sub-Chiefs, Tribal Authorities and village Headmen. Their main function is to administer justice under customary law. The principal Tribal Authority, the Ngwato, is headed by the Paramount Chief and his Deputy and based in Serowe, the administrative capital of Central District. Both Rakops and Letlhakane have a Senior sub-Tribal Authority and a sub-Authority, headed by a Senior Chief and a Chief respectively. In addition there are ten Headman, based in other major villages in Boteti sub-District. An important component of the Tribal Administration is the "kgotla", which is a forum of public consultations.

- District Administration

Headed by the District Commissioner (DC), the District Administration (DA) performs co-ordinative,

administrative and judicial functions. The DC is assisted by a District Officer Lands (DOL) and a District Officer Development (DOD). The DC co-ordinates all development projects in the District and chairs the District Development Committee (DDC) which includes representatives from Ministries, the Council, the Land Board, Tribal Authority, parastatals and other development agencies in the District. The DDC approves and, through the DC, oversees the District Development Plan (DDP). The District Land Use Planning Unit (DLUPU), with representatives from Ministries, DA, Land Board and Council, gives technical guidance and advice on issues related to land.

At sub-District level the DA is headed by a District Officer (DO) and also assisted by a DOL and a DOD. The DA of Boteti sub-District is based in Letlhakane. The sub-District has a sub-DLUPU, meeting once a month in Letlhakane.

- District Council

The District Council is responsible for the provision of primary education, primary health care, ungazetted roads, drinking water, social welfare services, housing and business licenses. There is a Boteti sub-District Council in Letlhakane.

- Tribal Land Board

Tribal Land Boards were created by the Tribal Land Act of 1970 to administer and manage tribal land. The Land Boards are empowered to allocate land and boreholes and to cancel land allocations made under customary and common laws. They can terminate any land grant for failure to observe proper land use and other restrictions. The Land Boards consist of elected members and persons appointed by MLGLH and are supported by technical staff.

The main Ngwato Land Board is based in Serowe. Boteti sub-District has two subordinate Land Boards, based in Letlhakane and Rakops respectively. The boundary between the two is the veterinary cordon fence which runs south of Kedia and east of Mokobaxane.

- Government Departments, extension areas

The Department of Wildlife and National Parks (DWNP) of the Ministry of Commerce and Industry is responsible for wildlife policy formulation and administration supported by the National Parks Act and the Fauna Conservation Act. The main District Office is in Serowe, Game Scouts are based in Letlhakane and Rakops. The Makgadikgadi Pans National Parks and the Central Kalahari Game Reserve fall under the Francistown and Ghanzi District Offices respectively.

The Department of Crop Production and Forestry (DCPF) of the Ministry of Agriculture provides extension services covering rainfed cropping, horticulture, irrigation, soil conservation, soil survey, forestry, plant protection, land use (planning), bee-keeping and marketing. The Department is also responsible for the 4B movement (educational youth clubs) and the Agricultural Resources Board (ARB). The Regional Agricultural Office of Central Region covers most Central District and is based in Serowe. This office is headed by the Regional Agricultural Officer (RAO) and has a team of technical support staff covering the subjects mentioned above. The Letlhakane District Agricultural Office is based in Letlhakane and headed by a District Agricultural Officer (DAO). The DAO is supported by a District Agricultural Supervisor and specialists in crop production, forestry, beekeeping, plant protection and youth education (4B movement). LetAD has 11 Agricultural Extension Areas (AEAs) with an Agricultural Demonstrator (AD). The boundaries and names of the AEAs are shown on Map 9. In recent years DCPF at all levels has played a major role in the distribution and administration of drought relief funds.

The Department of Co-operative Development of the Ministry of Agriculture encourages the formation of rural co-operatives. One such co-operative is Tsienyane Multi-purpose Co-operative in Rakops. This co-operative sells various agricultural inputs and acts as an agent for the Botswana Meat Commission (BMC) (see also Section 4.4.2).

The Department of Animal Health and Production (DAHP) of the Ministry of Agriculture is primarily responsible for the prevention and control of animal diseases. The Department also provides extension to farmers involved in animal production. The main DAHP office of the western part of Central District is in Serowe; the DAHP office of Boteti sub-District, based in Letlhakane, has a veterinary division headed by a Senior Veterinary Officer. Boteti sub-District has 16 Veterinary Extension Areas with a Veterinary Assistant. The Veterinary Extension Areas of Boteti sub-District are shown on Map 10. Both Rakops and Letlhakane have a Livestock Advisory Centre (LAC), providing advice and inputs for farmers involved in livestock production (see also Section 4.4.2).

- Non-governmental organizations

The Permaculture Trust of Botswana (PTB), based in Serowe, is active under Basarwa in Khwee and Letlhakane with support of the Netherlands Volunteer Organization (SNV). The Forestry Association of Botswana (FAB) has been promoting natural woodland management and tree planting in various villages in LetAD. Veld products are promoted by an organization called Thusano Lefatsheng and by Veld Products Research. Both IUCN and UNEP have been involved in studies and seminars in and around LetAD (see Section 2.3).

4.5.2 Institutions at village level

Of the traditional institutions at village level the kgotla, which is a forum of public consultation, is the most universally respected. In addition to the kgotla, strong village wards may exist locally, led by influential headmen. Other traditional institutions, such as the overseer system and the regiments, are in decline (MoA/UB, 1994).

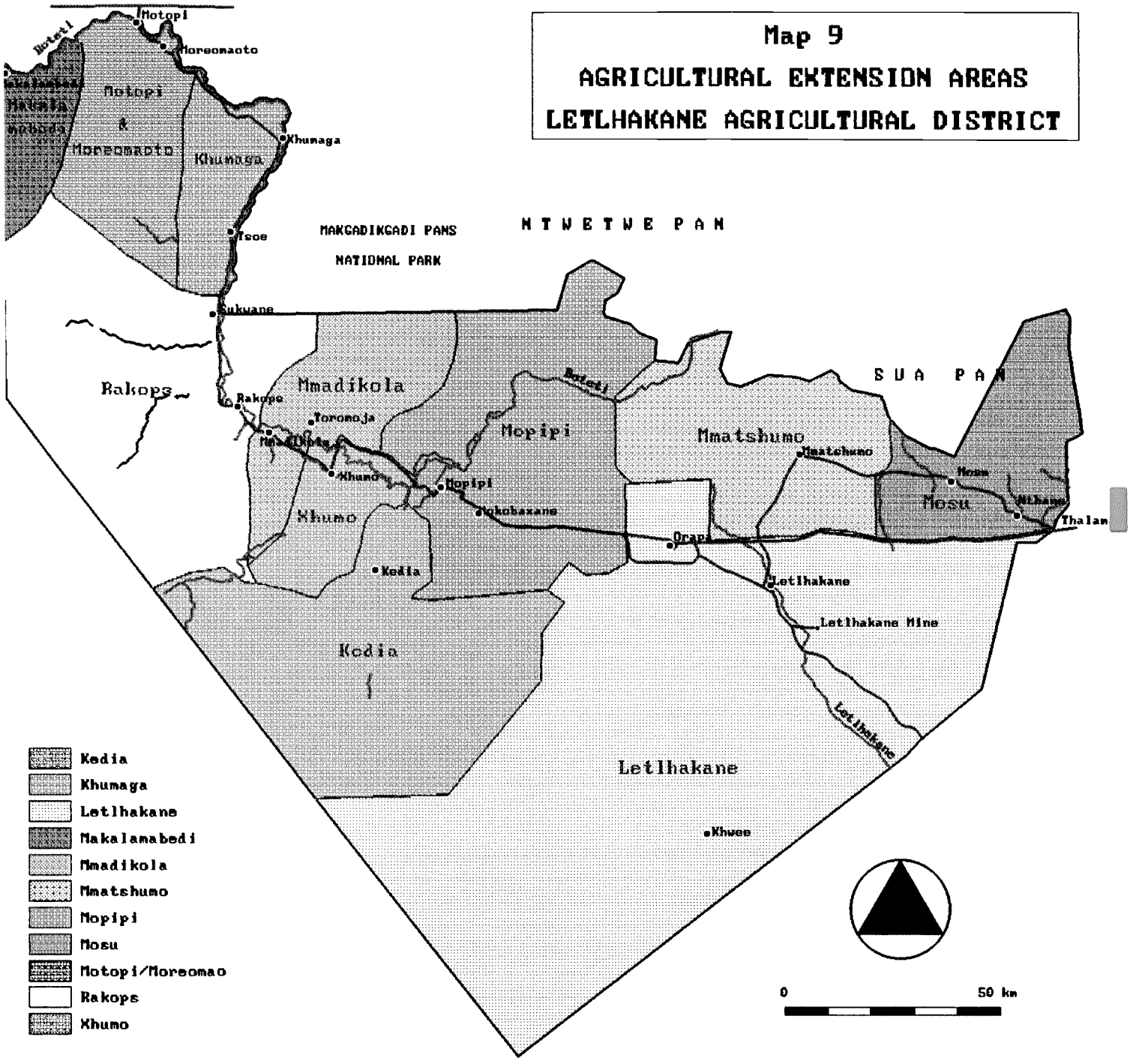
Modern institutions at village level include the Village Development Committees (VDCs), Farmer's Committees and various interest groups, syndicates and self-help committees. The VDCs are operational in many villages. They are closely related to the kgotla which elects its members biannually. The VDC is the only village institution paying sitting allowances to its members. Many Farmer's Committees were formed in LetAD, but very few are functioning. Interest groups often center around an agricultural enterprise or infrastructure, such as fencing or waterpoints.

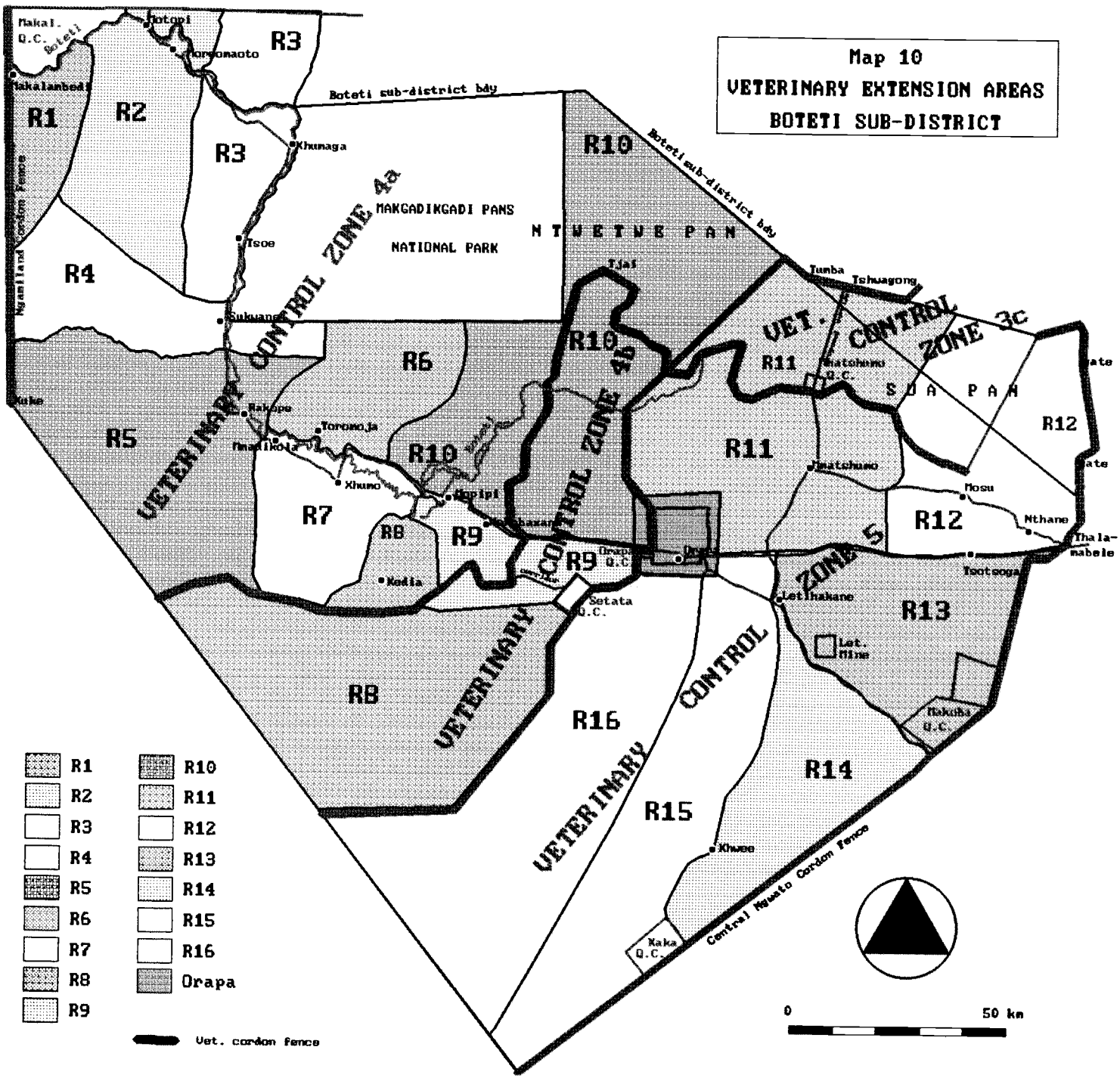
4.5.3 Legislation

Botswana has a comprehensive set of laws, regulating land use. The following Acts are the most relevant to land use planning in LetAD.

- Tribal Land Act (1970): provides for the establishment of tribal land boards and for the issue of land under both customary and common law

- Agricultural Resources Conservation Act (1974): makes provisions for the conservation, improvement and better utilisation of the agricultural resources of Botswana and establishes and regulates the Agricultural Resources Board


Map 9
AGRICULTURAL EXTENSION AREAS
LETLHAKANE AGRICULTURAL DISTRICT
Motopi
Moreomaoto
Khumaga
Motopi & Moreomaoto
Tsoe
MAKGADIKGADI PANS
NATIONAL PARK
NTWETWE PAN
Sukwane
Rakops
Mmadikola
Rakops
Toromoja
Mopipi
Botetsi
Khumo
Mopipi
Ngobaxane
Khumo
Kedia
Kedia
SUA PAN
Mmatshumo
Mmatshumo
Mosu
Mosu
Mthane
Thalan
Orapa
Letlhakane
Letlhakane Mine
Letlhakane
Khwee
Kedia
Khumaga
Letlhakane
Makalamabedi
Mmadikola
Mmatshumo
Mopipi
Mosu
Motopi/Moreomao
Rakops
Khumo
0
50 km


Map 10
VETERINARY EXTENSION AREAS
BOTETI SUB-DISTRICT
Makal. Q.C.
Botoni
Mongomaoto
Makalamabedi
Boteti sub-district bdy
Khunaga
Tsoe
Sukwane
Ngamiland cordon fence
MAKGADIKGADI PANS NATIONAL PARK
NTWETWE PAN
Tjai
Tumba
Tshwagong
Matshumo Q.C.
SUA PAN
Rakops
Toromoja
Xhumo
Mopipi
Shaxaxa
Orapa Q.C.
Orapa
Kedia
Setata Q.C.
Letlhakane
Let. Mine
Tsetsoga
Mosu
Nthane
Thalamabele
Nakuka Q.C.
Xhuse
Kaka Q.C.
Central Ngwato Cordon Fence
R1
R2
R3
R4
R5
R6
R7
R8
R9
R10
R11
R12
R13
R14
R15
R16
Orapa
Vet. cordon fence
0
50 km

- Town and Country Planning Act (1980): deals with the constitution of the Town and Country Planning Board, the preparation of development plans, and development procedures

- Fauna Conservation Act (1961): includes regulations concerning Game Reserves, Controlled Hunting Areas, Wildlife Management Areas and hunting licenses and permits.

- National Parks Act (1968): provides for the establishment of National Parks

- Herbage Preservation Act (1978): deals with the prevention and control of bush and other fires.

- Wildlife Conservation and National Parks Act (1992): deals with National Parks, Game Reserves, Wildlife Management Areas, Controlled Hunting Areas and hunting licenses and permits. Gives effect to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and other international conventions to which Botswana is a party.

- Diseases of Animals Act (1977): provides for the prevention and control of diseases of animals and regulates movement of animals and quarantine

Other relevant acts include the Boreholes Act (1956), Agricultural Management Associations Act (1979), Fencing Act (1962), Water Act (1968), Precious and Semi-Precious Stones (Protection) Act (1969), Forest Act (1968), and Control of Livestock Industry Act (1941).

4.5.4 Government policies, schemes and development plans

In addition to the various acts, listed above, the Government has adopted various policies and development strategies. The Ministry of Finance and Development Planning regularly prepares National Development Plans (NDP) for approximately five-year periods. NDP 7 covers the years 1991 to 1997 and NDP 8 is in preparation. The basis for the development of the agricultural sector during NDP 7 is the National Policy on Agricultural Development, approved by the National Assembly in 1991. Two of the major issues addressed in NDP 7 are those of fencing in communal areas and of dual rights. Under certain conditions, individuals and groups should be allowed to fence communal areas for livestock production. However, a farmer or a group of farmers with rights to fenced grazing areas would loose their rights to communal land.

Many government schemes and subsidies apply to the study area; the most relevant are listed below.

- Drought Relief Programme (DRP) (Namola Leuba)

  DRP provides food for nursing mothers, small children (under five) and destitutes, ploughing subsidy and free seed for arable farmers, and water and subsidized stock feed for livestock owners. The programme also includes labour-intensive construction projects. The programme is reviewed every year and was dis-continued after the 1995/96 season.

- Rural Roads Programme

  The Rural Roads Programme employs local residents for the upgrading and maintenance of district roads.

- Arable Land Development Programme (ALDEP)

  ALDEP has helped farmers to fence fields, and purchase animal draught power (donkeys and oxen) and implements. The scheme has been under review for some time and a second phase of the scheme, with more attention to education and training, is expected to come into operation with the 1996/97 growing season.

- Small Projects Programme (AE10)

  The Small Projects Programme is meant for groups of farmers and provides assistance for the construction of drift fences, and agricultural enterprises such as poultry and horticulture.

- Financial Assistance Policy (FAP)

  FAP encourages investments of individuals or companies in productive enterprises, including horticulture and other agricultural projects.

- Services to Livestock Owners in Communal Areas (SLOCA)

  SLOCA provides extension and grants to livestock owners who adopt improved management techniques.

- Accelerated Remote Area Development Programme (ARADP)

  ARADP assists Remote Area Dwellers (RADs) through the provision of basic infrastructure and social services to a number of RAD settlements.

- Forestry Protection and Development Project (FPDP)

  The FPDP (MoA, Francistown) is involved in backyard nurseries, a few of which have been established in Letlhakane and Rakops.

ALDEP, AE10 and FAP application related to crop production are all administrated by the DAO, as well as the agricultural components of Drought Relief (applicable in some years). SLOCA is managed by the Animal Production Division of DAHP. ARADP is managed by the District Council through the RADO.

4.5.5 Existing projects and land use plans

There is no over-all land use plan for Letlhakane Agricultural District or Boteti sub-District. Certain proposals, covering the whole area, have been made in the Central District Settlement Strategy (Swedeplan, 1994). The North-west Boteti and Kedia baseline surveys (Van der Maas, 1995a & 1995b) include proposals covering the western part of LetAD. Various ideas concerning the mid-Boteti area are expressed in the Desertification Control Seminar (ICES/UNEP, 1988), the Desertification study of the MoA (MoA/UB, 1994) and the Makgadikgadi/Nxai Pan Development Plan (MCI, 1995). These and other studies are described in Section 2.3.

The Agricultural Sector Policy Implementation Committee (ASPIC) of DLUPU (Central District) is working on a land use plan for the Kaka area in the southern corner of LetAD. There is also a committee concerned with the development of the Kedia reserved area, south of Kedia (see Map 6).

Village Development Plans have been prepared by DTRP for Letlhakane and Rakops. A Village Development Plan for Kedia is being prepared by the DOD of Boteti sub-District.

CHAPTER 5

LAND USE PROBLEMS, ISSUES AND OPPORTUNITIES FOR CHANGE

5.1 INTRODUCTION

This Chapter lists the main problems in Letlhakane Agricultural District (LetAD) related to land, together with the possible causes of these problems and possible solutions. The list of problems, causes and solutions is based on field observations, literature, and informal interviews with agricultural extension staff, farmers, local administrators and specialists. The problems, causes and solutions are not perceived by everyone in the same way. Within the area, various groups of land users have different concerns. Also, problems may be perceived differently at local level or at national level. Problems may be immediate (e.g. lack of drinking water) or long-term (e.g. land degradation). In this Chapter, an attempt has been made to include the most important problems and issues related to land use from different perspectives. The list of problems and issues is in random order. The solutions given are suggestions only; the most promising solutions and improvements will be will screened and evaluated in Chapter 6. Final recommendations will be made in Chapter 7.

Low and unreliable rainfall and the scarcity of good quality surface water and groundwater are the underlying cause of many problems in the area and a constraint to further development. The limitation posed by lack of water can be summarized as follows:

- rainfed cropping: crop failures and low yields
- molapo farming: only possible in exceptional years
- irrigated cropping: lack of good water at suitable sites
- grazing: low biomass production and high cost for water
- mining: high costs for water extraction and possibly depletion
- residential: lack of drinking water in several villages

Easy solutions for the lack of water are not found, but some partial solutions and land use adaptations are suggested in the following Sections dealing with rainfed cropping and animal production.

5.2 LOW PRODUCTIVITY OF RAINFED CROPPING AND MOLAPO FARMING

The present practice of rainfed cropping and molapo farming is described in Chapter 4.3.4. In pure economic terms the present system of cropping is not profitable. In the last few years the government, under the drought relief scheme, paid 110 to 120 Pula/ha for ploughing alone, which resulted in an average yield of a few bags/ha of grain not worth more than 60 or 70 Pula. Although productivity of rainfed cropping and molapo farming can be increased, it remains a very marginal activity in LetAD in economic terms. Therefore, in addition to improved cropping, some alternatives to rainfed cropping and molapo farming are briefly discussed in Section 5.8.

- Underlying causes (C) and suggested solutions (S)

Rainfed cropping

C1 Low and unreliable rainfall

Rainfall amount and distribution is insufficient for optimal growth of most rainfed crops grown in the area.

S1 Cultivate drought resistant and early maturing crops/varieties.
S2 Plant early (with first significant rain in November or December)
S3 Adjust planting density according to rainfall. Plant seeds in rows, either with a rowplanter or by planting seeds in plough furrows. Thin at time of weeding if rains have been poor; re-plant if necessary.
S4 Select sites with most suitable soils (deep, loamy) and topography (depressions, hollows).
S5 Cultivate valuable plants which occur naturally in the area ("veld products").
S6 Conserve moisture by ploughing across the slope where applicable. (Gentle slopes occur in some lands areas).
S7 Rainwater harvesting for human and animal consumption at lands area. Some adjustment may be needed to the ALDEP water storage tanks because of high soil permeability. Some small depressions and pans may be developed into water storage sites.
S8 Rainwater harvesting for crop production. Certain forms of rainwater harvesting may be possible in areas with sufficient relief.

C2 Inherently poor soils

Nearly all soils are deficient in major nutrients (notably phosphorus and nitrogen) and possibly some micro-nutrient. Most soils are sandy and have a low available water holding capacity. Some of the soils used for cultivation are shallow.

S1 Select most suitable soils (deep, loamy) in case of new allocations.
S2 Use molapo for rainfed cropping.
S3 Re-allocate fields with shallow soil.
S4 Apply manure, with or without fertilizer. Many farmers maintain kraals for small stock and a few cattle in the lands area and have an ample supply of manure near the fields.
S5 Practice crop rotation or inter-cropping with legumes. Increase producer price for legumes; limit amount to be purchased per farmer, to prevent over-production by big farmers.

Rainfed cropping and molapo farming

C3 Crop losses through pests and diseases

Common pests are birds, particularly the red-billed quelea (*Quelea quelea*) in sorghum and millet, army worm, stalk borer, bollworm, aphids and corncricket. A common disease is sorghum head smut. Farmers do not practice pest control or control is ineffective.

S1 Encourage use of botanical pesticides and biological pest control
S2 Educate farmer as to the proper and selective use of pesticides (dosage, handling, timing).
S3 Grow "bird-proof" sorghum.

C4 Crop damage by livestock

In the Boteti river only bush fences occur which are not always effective and have to be renewed every year. Subsidies for fencing of arable land do not cover molapo. Elsewhere existing perimeter fences around large lands areas are not always maintained and gates not properly controlled.

S1 Eligible farmers should be advised to take up ALDEP fencing package.
S2 Maintenance of present perimeter fences to be encouraged. Some of the existing perimeter fences should be reviewed as they seem to include very large uncultivated areas and even cattle posts.
S3 Allocation of new fields only in existing lands areas (not scattered).
S4 Make ALDEP fencing package also available for molapo. A number of small adjoining molapo fields could be fenced together. A special design of wire fences for molapo may be needed to be able to withstand floods and wet soil. Land Board will have to change its policy on allocation of molapo fields (see also C6).

C5 Lack of draught power or draught animals in poor condition

Some farmers do not own sufficient draught power and have insufficient resources or connections to borrow or hire draught power at the necessary moment. Draught animals (oxen, donkeys) may be weak at the end of the dry season and not strong enough for early ploughing. In some areas donkeys are killed by lions and other predators.

S1 Subsidize ploughing for farmers with less than 10 head of cattle and for a maximum area of 2 - 3 ha.
S2 Eligible farmers to be advised to take up ALDEP package for draught power.
S3 Reduce ploughed area and intensify cropping through manure application, optimum planting densities and effective weeding and bird scaring.
S4 Preserve some hay or stalks for supplementary feeding just before and during the ploughing period.
S5 Make available, through ALDEP or otherwise, three-wheeled powered tool-bars (small tractors) which are capable of ploughing, cultivating and pulling a scotch cart.

C6 Subsidies and packages not well-targeted or not relevant

Some subsidies and packages related to arable farming are not relevant or not attractive to certain groups of farmers. E.g. fencing subsidies not relevant for molapo farmers; ALDEP planter not popular; ploughing subsidies encourage the cultivation of large fields which are not properly managed.

S1 Future Drought Relief Programmes, if any, should focus less on ploughing and more on early planting, contour ploughing, use of cultivator instead of mouldboard plough, use of kraal manure, weeding, bird scaring and row planting (by hand or with rowplanter).
S2 Make ALDEP scheme applicable for molapo fields: Land Board to give certificates to molapo fields of limited size, provided they are located on suitable sites (deep soils and gentle slopes only) and not limiting public access to the river.

C7 Inadequate agricultural extension

Agricultural Demonstrators have insufficient transport. Extension workers have been spending too much time on the Drought Relief Programme (measurements of fields, payments, seed distribution). Extension

messages too general. Small, resource-poor farmers not taken seriously.

S1 Improve present motorbike purchase scheme for ADs.
S2 Future Drought Relief Programmes, if any, to be administrated by specially appointed staff and not by ADs.
S3 Make extension messages more specific for various agro-ecological zones and for different farmer groups.
S4 Discourage cropping in remote, isolated areas.

C8 Poor management, lack of commitment from farmer

Poor management may take the form of late planting, insufficient weeding and insufficient pest control (mainly bird scaring), not caused by lack of labour or draught power. Poor management is often caused by insufficient commitment of the farmers to cropping because of low returns or other engagements. Some farmers see better returns in other activities such as animal production, casual labour and possibly the collection of veld products.

S1 Farmers to be encouraged to prioritize and rationalize their activities.

C9 Lack of labour

Many farm households lack labour throughout the cropping season or at crucial moments during the season. Many farmers are reluctant to grow labour-intensive crops such as sunflower, groundnuts and beans. Some households have so little labour that farming is impossible (see also Section 5.6).

S1 Reduce size of field to minimum (less ploughing, weeding and bird scaring).
S2 Apply manure in winter and concentrate on most fertile part of field.
S3 Reduce frequency of ploughing to minimum (ploughing is not always necessary; if there are few weeds use of a cultivator may be sufficient, or direct planting may be possible in sandy soil).
S4 Spread activities, e.g. dry planting of part of field
S5 Do not delay operations, e.g. timely weeding in one year greatly reduces weed infestation next year

C10 Unavailability of inputs

Seed for crops other than maize, sorghum, millet are sometimes not available locally.

S1 Future Drought Relief Programmes, if any, to include seed distribution of cowpea, groundnut and other legumes at request
S2 BAMB and Co-operatives to promote the sale of legume seed.

C11 Poor planting techniques

Although time-saving, the technique of broadcasting seed before ploughing results in an uneven crop stand and requires a large quantity of seed.

S1 Promote purchase and use of planter (ALDEP).
S2 Introduce method of row-planting by hand. Small fields: seeds dropped in holes made by planting stick or hoe. Medium-sized fields: seeds dropped in plough furrow.

Molapo farming

C12 Unreliable flooding

Floods can be absent for many years, or can be prolonged and damaging in other years. Molapo around Lake Xau has disappeared because of waterworks which divert potential waterflows to Mopipi Dam.

S1 Selected molapo fields to be used for rainfed cropping.
S2 Remove bunds which divert water towards Mopipi Dam, as Orapa Mine can function without the potential water storage of Mopipi Dam.

C12 Crop damage by wildlife

Damage by wildlife (wildebeest, hippo, baboon, monkey, porcupine, jackal); molapo fields have only bush fences which quickly deteriorate.

S1 Specially designed and subsidized wire fences for individual molapo fields or groups of adjoining fields.
S2 Fence between Makgadikgadi Pans National Park and cultivated areas (see also Section 5.4)

C13 Shortage of land and uneven distribution

Some farmers have no molapo fields at all or have fields at a great distance from their village (farmers residing in Rakops may have fields as far away as southern Khumaga (60 km) or western Mopipi (45 km) (Hansen & Lillethun, 1986). Other farmers have large molapo fields which they do not use for any type of cropping.

S1 Re-distribute land and Land Board to give certificates.

C14 Soil erosion

The banks of the Boteti River are subject to erosion because of trampling by livestock and cultivation. Both wind and water erosion locally result in sand deposits on molapo fields.

S1 Do not allow cultivation on slopes of 5% or more.
S2 Plough across the slope.
S3 Limit number of cattle tracks into the river; select suitable access roads to water points.

5.3 LOW PRODUCTIVITY OF ANIMAL PRODUCTION

The present practice of animal production is described in Section 4.3.5. The activity does not have a high economic return, mainly because farmers have other priorities than financial gain and the variable rainfall and range conditions. The problem of low productivity of animal production is perceived differently by various farmer groups. The traditional farmer will be mainly concerned with the availability of grazing and water and by losses through diseases and predators. The more business minded farmer will also be concerned about producer prices, quarantine measures and transport costs. The government may see the low off-take as a problem and try to increase beef exports. Finally, farmers with only a few animals may

worry about overstocking of communal grazing areas by large livestock owners.

- Underlying causes (C) and suggested solutions (S)

C1 Low off-take, poor marketing

Farmers do not necessarily keep livestock for capital gain. Many animals are owned by persons who live far away and are not full-time farmers. Quarantine regulations restrict movement of animals. Some quarantine camps have insufficient capacity.

S1 Improved extension: make farmers aware of waste of dying or starving animals and that money well-invested in financial institutions is a better and more reliable savings account than a herd of animals largely left on their own. Promote the timely sale of steers and old cows.
S2 Expansion of Setata Quarantine Camp (already proposed by Veterinary Department).
S3 Make Maun abattoir more attractive: improve prices, improve trekroute with water.

C2 Lack of water and depletion of underground water reserves

Animals may have to walk long distances in search of water during dry season. The problem may worsen in the future as deep boreholes tap underground fossil water which is not being recharged.

S1 Development of small depressions and pans into water storage sites.
S2 Introduce water harvesting techniques in areas with sufficient relief.

C3 Lack of grazing/browsing

Either because of low rainfall or of high stocking rates there may be a seasonal or permanent shortage of fodder.

S1 Over-all stocking rates should be adjusted to actual carrying capacity, unless supplementary feeding is provided.
S2 Rangeland can be improved by measures such as selective bush removal and seeding
S3 Drought-resistant fodder crops could be grown as a single crop or as a relay crop (fodder crop planted late within a standing food crop).
S4 Timely sale of animals to feedlot (see Agrinews of 12/95 for story on feedlots)

C4 Poor management, low investment

Off-take is low, disease control is often insufficient and very little supplementary feeding is given. Common diseases are pasteurella, botulism, black water, eye disease, goiter, lumpy skin, and various tickborn diseases. A recent threat is Contagious Bovine Pleuropneumonia. In the rainy season the animals are scattered and difficult to round up for vaccination and/or treatment. Many livestock owners are only part-time farmers and may live far away from grazing area. Other farmers may be easily distracted by other activities, such as ploughing (see Agrinews 3/95).

S1 Increased extension effort to promote improved management such as rotational grazing and controlled stocking rates by paddocking or herding, supplementary feeding (e.g. bonemeal, salt licks, dicalcium phosphate), disease control and controlled breeding.
S2 Certain aspects of management to be contracted out to professional managers in case of

absentee and/or part-time farmers.
S3 Promotion of SLOCA scheme.

C5 Predators

The main predators are lion, hyena, cheetah, leopard, jackal and wild dog (Hansen & Lillethun, 1986) (see also Section 5.4). Several hundred animals are killed every year in the north-western part of LetAD. Lions and hyenas are resposible for most of the cattle losses, whereas jackals prey mostly on small stock. Crocodile can be a menace locally along the Boteti river.

S1 Controlled hunting of lions and other predators (not necessarily by cattle owners).
S2 Fencing and buffer zones between designated wildlife and grazing areas.

5.4 CONFLICTING INTERESTS OF FARMERS AND WILDLIFE CONSERVATIONISTS

LetAD is bordered by the Makgadikgadi Pans National Park in the north and by the Central Kalahari Game Reserve in the south-west. The channel of the Boteti river between Moreomaoto and Sukwane forms the western boundary of the Makgadikgadi Pans National Park. The river is a major source of water for humans and livestock, as well as many forms of wildlife. The wild animals not only compete for water but occasionally attack people and livestock and destroy crops and fences. On the other hand, encroachment of livestock takes place in the National Park and Boteti State Land and poaching is practiced throughout LetAD, and in particular near and in the Makgadikgadi Pans National Park and Central Kalahari Game Reserve (Hansen & Lillethun, 1986).

- Underlying causes (C) and suggested solutions (S)

C1 Local residents do not profit from wildlife conservation

Whilst farmers have limited access to the Makgadikgadi Pans National Park and the Central Kalahari Game Reserve, they do not profit from their existence.

S1 Involve population in tourism and wildlife management as proposed in the Makgadikgadi/Nxai Pan Management Plan (MCI, 1995). DWNP to employ Community Liaison Officer to facilitate community projects and/or joint ventures.
S2 Residents to be made aware of the fact that they can indirectly profit from the presence of wildlife conservation areas through increased wildlife presence and hunting opportunities in adjacent areas. Residents to organize themselves and manage the designated Community Controlled Hunting Area (CT20, south of Kedia).

C2 Competition for limited resources of water and grazing by farmers and wildlife

There are only a few perennial and easily accessible water resources in the area. They include pools and shallow groundwater in the Boteti river and shallow groundwater in the north of LetAD. Farmers depend on these sources of water for household use and animal production and traditionally settle and farm nearby. Various types of wildlife are either completely dependant on the same sources of water (hippopotamus, crocodile) or make use of them during the dry season. The result is that wildlife may

damage crops, deplete, damage or foul pools and wells and that livestock farmers encroach on land reserved for wildlife.

S1 Adequately and speedily compensate farmers for losses caused by wildlife.
S2 Re-align boundary and construct fence between Makgadikgadi Pans National Park and communal land between Sukwane and Khumaga. Alignment of such a fence to be a compromise between interests of farmers and DWNP respectively.
S3 Boundary Boteti Stateland to be changed to accommodate existing cattleposts.
S4 Limited grazing to be allowed in Boteti State Land and proposed WMA.
S5 Provide water for wildlife in the middle of wildlife reserves and away from settlements

C3 Predators kill livestock

Some predators have large territories and may attack livestock outside wildlife reserves.

S1 Adequately and speedily compensate farmers for losses caused by wildlife.
S2 Farmers to herd their animals adequately and construct and use protective kraals.
S3 DWNP to control wildlife population and identify and remove problem animals.
S4 Fence selected parts of the National Park and Game Reserve

C4 Local residents and outsiders practice illegal hunting

S1 Reinforce DWNP and increase penalties for poaching
S2 Hunting licenses to be limited to local residents and promote community controlled hunting

5.5 MARGINALIZATION OF TRADITIONAL HUNTERS AND GATHERERS

Traditional hunters and gatherers in and around LetAD are faced with restricted movement and dwindling resources through increasing livestock production and other changes of land use. They also face competition from better equipped recreational hunters. Although newly established cattle posts create limited job opportunities, these are poorly paid and of low status. The Drought Relief Programme, destitute feeding, and other government hand-outs prevent starvation but do not help to maintain self-esteem and self-reliance.

- Underlying causes (C) and suggested solutions (S)

C1 Dwindling wildlife resources

Wildlife numbers have drastically decreased over the last few decennia due to fencing, increased livestock production and drought. Livestock now competes with wildlife for water and grazing, wildlife is disturbed by increased human activity and farmers hunt predators and other wildlife.

S1 Remove unnecessary fences (e.g. fence along Makoba-Orapa road) and re-consider alignment present of veterinary cordon fences.
S2 Stimulate growth of selected wildlife species in specific areas through protection and the construction of waterpoints.

S3 Traditional hunters and gatherers to take up livestock production and other productive activities (see also Section 5.8). Specific areas to be reserved for this purpose.

C2 Competition from recreational hunters

DWNP issues licenses for hunting and any citizen can apply for a license to hunt anywhere. People who hunt for recreation pay the same fee as people who hunt for subsistence. In this system resource-poor local farmers lose out to mobile and affluent professional or recreational hunters.

S1 Re-consider licensing system for hunting and give priority to traditional hunters and other local residents.
S2 Promote use of the designated Community Controlled Hunting Area.

C3 Limited access to designated areas

Large tracts of land in LetAD have already been set aside for mining and wildlife conservation and can not be used anymore for hunting and gathering. With the introduction of fenced ranches in the near future even less land may be available. The Veterinary Department does not allow transport of many veld products across veterinary cordon fences.

S1 Permit traditional forms of gathering in all wildlife conservation areas and traditional hunting in Game Reserves and Wildlife Management Areas.
S2 The lease of any future ranches should allow for traditional forms of gathering within the ranch.
S3 Reserve areas for specific use by traditional hunters and gatherers. Identify areas which are most valued by traditional hunters and gatherers.
S4 Allow the transport of veld products across veterinary cordon fences.

5.6 POOR HOUSEHOLDS WITH INSUFFICIENT LABOUR FOR FARMING

Up to 10% of the rural households of LetAD have little labour, no cattle and few other resources (Farmer Group I, see Chapter 4). These households are not able to farm without ploughing subsidies and without assistance from relatives or neighbouring farmers with more resources. Many de facto female headed households, with small children only, belong to this group. These households cannot make effective use of many of the present government support programmes for agriculture because of lack of labour.

- Underlying causes (C) and suggested solutions (S)

C1 Lack of labour

Traditional forms of cropping require high labour input at specific times in the season, particularly for ploughing and planting, weeding and bird-scaring. Some tasks are difficult to perform alone (ploughing) or difficult to combine with housekeeping and child-care.

S1 Drought Relief Programme to concentrate on this group of households. Drought Relief projects to be undertaken outside cropping season. Projects should include infrastructure for

small-scale agricultural projects (see below).

S2 Design and support appropriate form of horticulture with farming concentrated on small area near or around homestead. Such intensive land use would include use of manure/compost, rainwater harvesting, fruit trees, vegetables.

S3 Design and support appropriate form of livestock production, concentrating on small stock (goats, sheep) and fowl (chickens, ducks, geese).

S4 Promote other productive activities (see Section 5.8).

5.7 DESERTIFICATION IN AND AROUND MAJOR VILLAGES

Some major settlements are almost devoid of vegetation, with the possible exception of some weeds and large trees. These settlements experience dust storms, particular in winter. Notable examples are Rakops, Mopipi, Xhumo and Toromoja.

- Underlying causes (C) and possible solutions (S)

C1 Poor and erodible soils and low rainfall resulting in slow regrowth of vegetation

Dust storms are most prevalent in and around the Makgadikgadi Depression where soils have a high content of silt and fine sand particles (most vulnerable to wind erosion are the areas indicated as L1 and AL2 on Map 2).

S1 Plant and protect trees and hedges in and around compounds and public facilities.

S2 Encourage the construction of low walls around compounds or outdoor living areas (patios).

C2 Indiscriminate cutting of trees for firewood and construction

S1 Protection of existing trees in and around village.

S2 Plant and protect trees and hedges in and around compounds and public facilities.

C3 Overgrazing (particularly goats and donkeys) and trampling of (sparse) vegetation by people and livestock

S1 Better donkey management: registration of ownership and sale or removal of excess animals

S2 Better management of small stcok: timely offtake of unproductive animals; herding

S3 Fence off public areas such as schools, hospitals, offices and shops.

C4 Deliberate and indiscriminate removal of grasses, weeds and shrubs in residential compounds.

S1 Less indiscriminate cleaning of compounds: preservation (and cutting) of grasses, harmless weeds and shrubs. Removal of unwanted weeds not by shovelling but by removing individual plants before seeding.

5.8 ALTERNATIVES TO TRADITIONAL FORMS OF LAND USE

Some alternatives to rainfed cropping, molapo farming and beef production are listed below. Most of the activities are not new to the area, but could possibly be expanded or made more productive. Some of the activities mentioned will be evaluated and discussed in Chapter 6.

- Community-based ecotourism and hunting

LetAD borders on the Central Kalahari Game Reserve in the south-west and on the Makgadikgadi Pans National Park in the north. Within the District there is one designated "Community Controlled Hunting Area" (see Section 3.7.2) and the valley of the Boteti river and the Sua Pan area have great scenic value. Presently there are very few facilities for tourists in the area and there should be scope for enterprises based on tourism and/or hunting. These enterprises could take the form of community projects or joint ventures. (See also Section 5.4). See also proposals in Makgadikgadi/Nxai Pan Management Plan (MCI, 1995).

- Crafts

The new Rakops-Motopi road could offer some potential for the sale of locally produced crafts such as painted gourds, painted ostrich eggs, leatherware, pottery and carvings.

- Small-scale irrigation and horticulture

Presently there are a few horticultural projects in the area, totalling less than 10 ha. There is a market for horticultural produce in the major settlements, but water is the main limitation.

- Beekeeping

In general the District is not very suitable for beekeeping because of the rather uniform vegetation of the area and short growing season. The most favourable area for beekeeping may be the dense savanna on the banks of the Boteti river between Makalambedi and Rakops. As with crafts, honey could be sold at specific sites along the (new) Rakops-Motopi road. The District Agricultural Office in Letlhakane used to have a Beekeeping Officer and beekeeping is still promoted by the Ministry of Agriculture.

- Piggery

There are no pigs in the area at present. Although the market for pork within LetAD and in Botswana in general is small, there may be potential for one or two small piggeries.

- Poultry

There are a few poultry projects operational in the area and there could be a market for a few more. The present practice of keeping of free-range chickens around the homestead could be improved and expanded.

- Game farming

The whole of LetAD is the natural habitat of many types of game, including ostrich, springbok, zebra, wildebeest, gemsbok and kudu. Although game farming may be an option for some well-informed and well-connected producers, game farming does not seem to have a distinct advantage over cattle or smallstock production for the average farmer at present. For small farmers, the production of a limited number of stall-fed ostriches has some potential, provided a marketing and extension structure is in place and veterinary services can be provided.

- Marketing of smallstock (goats, sheep)

As with cattle, the off-take and marketing of present smallstock could be improved. There may be a market for goat meat and mutton locally or regionally. Since supply may be irregular, cold storage is essential. Dried meat could be produced (see below).

- Food processing

There are many types of food processing. Beer brewing is one of the most popular types of commercialized food processing at present, but there are many other possibilities. For example sun-dried watermelon (lengangale), dried vegetables and fruits, dried meat (digwapa) and baking.

- Veld products

There are several possibilities for the collection and sale of veld products, including common ones such as firewood, thatching grass, poles and fruits, and more uncommon ones such as ostrich eggs, and the grapple plant (*Harpagophytum procumbens*) and the Kalahari truffle (*Terfezia pfeilii*). (See Agrinews 8/95 for success story on the grapple plant (sengaparile) in Kgalagadi District).

- Processing of hides

There is an international market for well-preserved hides.

CHAPTER 6

LAND SUITABILITY EVALUATION

6.1 INTRODUCTION

In this Chapter the suitability of various forms of land use, both present and potential, will be evaluated. The evaluation will focus on present land use as described in Chapters 3 and 4 and on possible alternatives as indicated in Chapter 5. The outcome of the evaluation will be reflected in the recommendations given in Chapter 7. In addition to the physical suitability of the land for certain types of land use, socio-economic factors are also considered. An attempt has also been made to find the most suitable land use and type of management for various land users and farmer groups with different resources. In the case of rainfed crop production and animal production a gross margin analysis has been included for a few production systems. For other major types of land use this was not possible or meaningful, because of highly variable production (molapo farming), too many unknown variables (irrigated cropping) or the non-commercial nature of the land use type (veld products, wildlife, residential).

6.2 RAINFED CROP PRODUCTION

6.2.1 Relevant production systems

Production systems are defined by produce (crop) and system of management. A total number of 15 crops are evaluated under three to six systems of management. The management systems are defined in such a way that they cover both present farming practices, also called the baseline scenarios, and a realistic range of possible improved practices which are relevant for the present farmer groups as defined in Chapter 4. The management systems are listed in Table 6.1 and described in more detail below.

- Management system Cr00:

  Management system Cr00 reflects the present situation of the resource-poor farmer (farmer group I). The farmer needs help from neighbors, relatives and/or school-going children for ploughing and planting. Ploughing and planting is done late December or early January, largely independent of (previous) rainfall and seeds may be dry-planted.

- Management system Cr0:

  Management system Cr0 represents the present situation of farmers who have sufficient draught power and labour to be able to plant with the first rains from early December onwards (farmer groups II, III and IV).

Table 6.1 DESCRIPTION OF MANAGEMENT SYSTEMS FOR RAINFED CROPPING

MANAGEMENT SYSTEM	PLOUGHING and PLANTING				FERTILIZER AND MANURE	CULTIVATED AREA (ha)	FARMER GROUP (see Ch.4)
	Traction	Planting Occasions	Date (dekad)	Planting method			
Cr00 (present)	animal (borrowed)	1	from Jan1	broadcast	nil	1-2	I
Cr0 (present)	animal (owned)	3	from Dec1	broadcast	nil	2-5	II, III, IV
Cr1 (potential) (intensive)	animal (borrowed or shared)	1[a,b]	from Nov3	by hand in rows	manure	1-2	II
Cr2 (potential)	animal (owned)	2	from Nov3	broadcast (also dry planting)	some manure	4-5	III
Cr3 (potential)	tractor	1[a]	from Nov3	row	nil	10	IV, V
Cr4 (potential)	tractor	1[a]	from Nov3	row	fertilizer (every 3 yr)	10	IV, V

(a) replanting, if possible, in case of early crop failure

(b) ploughing before mid November

- Management system Cr1:

Management system Cr1 is a potential system, characterized by intensive cropping of a relatively small area of 1-2 ha by small farmers who are not completely dependant on children of school-going age for labour. The best part of available land (best soils and moisture availability) is selected for cultivation. This land could also be a molapo field used for rainfed cultivation. The area should be fenced or be part of larger fenced area. The field is ploughed (not planted) in October or early November with borrowed donkeys. Permanent rows, along the contour and 90 to 120 cm apart in loamy soils (incl. molapo) and 120 to 150 cm apart in sandy soils, are staked out any time before November. Manure is applied carefully along the rows at the same time. With the first planting opportunity in November the whole field is planted, with seeds planted in planting holes in the rows. The planting holes are made with a planting stick or with a hoe. Both cereals and legumes are planted, either in alternate rows or in separate sections of the field. In-row planting distance is 50 to 70 cm. A few weeks after emergence, gaps are filled in with new seed. Weeding is carried out by hand 30 days after emergence. If the farmer has sufficient resources, very small amounts of fertilizer may be applied near well-established plants. Crop rotation is practiced, with cereals followed by legumes (cowpea, jugo bean, groundnuts).

- Management system Cr2:

Management system Cr2 is a potential system and in many ways similar to baseline scenario Cr0, except that planting takes place as early as possible (from late November onwards) and in two

occasions instead of three. Manure is broadcasted before ploughing over selected parts of the field. The maximum size of the area which can be ploughed with each of the two planting opportunities is around 2 ha, giving the total farm a size of 4 ha.

- Management system Cr3:

Management system Cr3 is a potential system and meant for farmers with easy access to a tractor and who have at least 10 ha of arable land. A relatively large area (10 ha or more) is ploughed either in winter or at time of planting. The whole field is planted with a row planter with the first opportunity from late November onwards. If an early planted crop fails completely, the whole field is re-planted before the end of the year. Weeding is carried out mechanically. The maximum size of the area which can be ploughed with one tractor at one planting opportunity is around 10 ha, which is assumed to be the average size of the farm.

- Management system Cr4:

Management system Cr4 is similar to Cr3 except that fertilizer is applied in case of a good crop-stand at the time of weeding. The whole field is fertilized at least once every three years.

6.2.2 Evaluation procedures

6.2.2.1 Application of CYSLAMB

The production of maize, sorghum, millet, groundnuts and cowpea are evaluated with the use of a computer programme called CYSLAMB (De Wit et al, 1993; Radcliffe et al, 1994). The characteristics of the various land units in terms of climate and soil (see Table 3.9), weed characteristics and production systems (crop characteristics, target plant densities and management practices) are read from separate databases. Using this input data, CYSLAMB then simulates crop biomass production and yield for every selected year for which rainfall data have been entered. CYSLAMB first calculates the maximum possible biomass yield for the crop under the specified management conditions without constraints due to soils or rainfall. This theoretical maximum yield is determined by solar radiation and temperature only. The model then sets up a moisture balance from the first dekad (10 day period) of each hydrological year (1st - 10th September is normally chosen in Botswana), taking into account incident effective rainfall, bare soil evaporation or weed evapotranspiration and water losses due to percolation or run-off. Criteria for the definition of a planting opportunity are defined based on effective incident rainfall and stored soil moisture. When these criteria are met, the crop/soil water balance is simulated through the crop growth cycle, and periods of moisture stress are accounted for in the calculation of the moisture limited biomass yield. The moisture limited yield is then adjusted for the effects of water logging (drainage), nutrient availability and toxicities. The biomass yield is converted to the yield of economic product by the harvest index.

The yield calculated by CYSLAMB reflects the production of a specified soil type in combination with the climatic conditions of a number of years. In the present study, the model is run over a period of 21 years, from 1968 to 1990. The reasons for selecting this specific period are given in Chapter 3.2. The yields of every single year are analyzed statistically, giving estimates of the yield expressed as dependable yields, which are surpassed in 75% of years, and median yields, which are surpassed in 50% of years.

The yields are expressed on the basis of a "total plot", including all the land planted during the course of a growing season. Many farmers have limited draught power and labour and can only plough and plant

an area of 2-3 ha at each planting opportunity. Therefore, depending on the size of his/her plot, a farmer may require one, two or three (or more) occasion(s) for the ploughing and planting of the full extent of his field. In years, when not enough planting opportunities occur, only a portion of the plot can be ploughed and planted. "Total plot" yields reflect the greater risk, and consequently lower aggregated production, experienced by the farmers who are dependent on multiple planting opportunities. The number of planting opportunities required is specified in the definition of the crop production systems.

6.2.2.2 Evaluation of crops not included in CYSLAMB

So far, only five crops are included in CYSLAMB: sorghum, millet, maize, cowpea and groundnuts. Other crops have to be evaluated in a less quantitative manner. One method which has been used is the comparison the performance of a non-CYSLAMB crop with a CYSLAMB crop with similar requirements. For example, soya bean has requirements in terms of moisture, temperature and nutrients which are very similar to those of maize. Therefore, the relative performance of soya bean can be linked to that of maize. The procedure is explained in the Guidelines for Agricultural Land Use Planning (LUPSAD, 1996). Some crops (e.g. perennial crops) cannot be compared with one of the five CYSLAMB crops and have to be evaluated in qualitative terms, unless sufficient research data from Botswana or similar natural environments are available.

6.2.3 Potential of land units for various production systems

6.2.3.1 Sorghum, millet, maize, cowpea and groundnuts (CYSLAMB)

The dependable yield of sorghum for various management systems, as calculated by CYSLAMB, is given in Table 6.2. A summary of the results for all five crops included in CYSLAMB is given in Annex 7[3]. All five crops have been analyzed for all relevant land units and for 13 management systems which vary in planting date, number of planting occasions, planting densities, time of weeding and fertilizer application. Some of the most important conclusions from the analysis are given below.

- The effect of planting date on crop yield

sorghum, maize:

> Early planting, with the first opportunity from early November onwards, gives the highest yield. For most land units it does not matter whether the crop is planted early November or early December. Exceptions are land units F and J (in the north-western corner of LetAD, nearest to Maun) which give a significantly better result if planted in November as compared to December. On average yields decrease with more than 50% if no use is made of planting opportunities before New Year and crops are planted from early January onwards.

[3] The yield predictions given in Table 6.2 and Annex 7 are based on an analysis of rainfall data from the period 1968 to 1990. The same analysis, but for a different period, may give very different results. For example, an analysis of the period 1974 to 1993 results in significantly lower yield, particularly for maize (see also Bekker, 1996).

Table 6.2 DEPENDABLE CYSLAMB YIELD OF SORGHUM BY LAND UNIT (kg/(ha holding)/year)

Management system				Cr0		Cr3			Cr00
Planting date (from)		DEC1	DEC1	DEC1	NOV1	NOV3	DEC1	DEC1	JAN1
Planting occasions (no)		3	3	3	1	1	1	1	1
Planting density (pl/ha)		15000	15000	15000	15000	15000	15000	25000	15000
Weeding (days after planting)		-	50	30	30	30	30	30	30
Phosphorus level topsoil (ppm)		3	3	3	3	3	3	3	3
LAND UNIT	B	210	200	270	630	630	570	570	210
	C	100	80	160	550	480	480	460	0
	D	210	190	310	820	800	770	810	180
	E	210	190	310	770	770	760	800	180
	F	270	210	400	780	680	660	700	290
	G	220	200	320	720	690	680	720	250
	H	220	200	330	740	740	720	740	250
	J	300	240	450	820	740	680	710	350
	K	100	80	150	500	450	450	450	0
	L	210	190	310	850	800	760	800	120
	M	210	190	310	750	750	750	790	180
	N	210	190	320	770	770	760	800	180

Management system			Cr2			Cr1 Cr4			
Planting date (from)		NOV1	NOV3	DEC1	NOV1	NOV3	DEC1	DEC1	DEC1
Planting occasions (no)		2	2	1	1	1	1	1	1
Planting density (pl/ha)		15000	15000	15000	15000	15000	15000	25000	15000
Weeding (days after planting)		30	30	-	30	30	30	30	30
Phosphorus level topsoil (ppm)		3	3	6	6	6	6	6	10
LAND UNIT	B	400	400	610	860	850	770	810	920
	C	280	240	450	750	650	650	690	780
	D	460	460	240	1100	1090	1050	1110	1210
	E	460	460	640	1050	1050	1030	1090	1190
	F	690	660	640	1060	930	900	950	1070
	G	480	480	510	950	930	930	980	1100
	H	500	500	660	980	980	950	1040	1140
	J	760	700	660	1100	970	920	970	1100
	K	250	220	510	680	630	630	640	750
	L	460	460	450	1120	1090	1030	1090	1190
	M	460	460	640	990	990	990	1080	1180
	N	480	460	640	1050	1050	1030	1090	1190

millet:

Early planting, with the first opportunity from early November onwards, gives the highest yield. For most land units it does not matter whether the crop is planted early November or early December. Exceptions are land units F and J (in the north-western corner of LetAD, nearest to Maun) which give a significantly better result if planted in November as compared to December. On average, yields decrease with 30 - 40% if no use is made of planting opportunities before New Year and crops are planted from early January onwards.

cowpea, groundnuts:

Early planting, with the first opportunity from early November onwards, gives the highest yield, but the difference between early and late planting is not as pronounced as with the three grain crops (see above). For most land units it does not matter much whether the crop is planted early November or early December. On average, yields decrease with 20 % if no use is made of planting opportunities before New Year and crops are planted from early January onwards.

- The effect of number of planting occasions on crop yield

The number of planting occasions refer to the number of staggered plantings the farmer carries out during one season, to cover his/her whole holding. The plantings may be staggered out of necessity (lack of labour or draught power) or out of choice.

sorghum, maize, millet:

Planting the whole holding in one occasion with the first planting opportunity gives the highest yields. If half of the holding is planted with the first planting opportunity and the second half with the second opportunity, yield of the whole holding decreases with up to 50 % in the area around Rakops (land units C and K) and with 30 - 40% anywhere else.

cowpea:

Planting the whole holding in one occasion with the first planting opportunity gives the highest yields. If half of the holding is planted with the first planting opportunity and the second half with the second opportunity, yield of the whole holding decreases with up to 50 % in the area around Rakops (land units C and K) and with less than 10% in the area nearest to Maun (land units F and J); elsewhere yield decreases with 20 - 30%.

groundnuts:

Planting the whole holding in one occasion with the first planting opportunity gives the highest yields. If half of the holding is planted with the first planting opportunity and the second half with the second opportunity, yield of the whole holding decreases with less than 10% in the area nearest to Maun (land units F and J), but elsewhere with 40 - 50%.

- The effect of plant density on crop yield

CYSLAMB calculates the effect of plant density on yield for sorghum, maize and millet. The assumption is that plants are evenly spread over the field (no clusters and gaps) and the crop is grown in a pure stand. A plant density of around 15 000 pl/ha is recommended for all five crops included in CYSLAMB. Significantly higher or lower plant densities give lower yields. Not only is it important that an average plant density of 15 000 pl/ha is achieved, but also that gaps in the field are filled in and that clusters are thinned out. The recommended plant density is the same for fertilized fields as for non-fertilized fields. Crop-specific recommendations can be summarized as follows:

sorghum:

The optimal planting density for sorghum is around 25 000 pl/ha. A plant density of 15 000 pl/ha gives a slightly lower yield, but may be preferred because of lower seed input.

maize:

The optimal plant density for maize is around 15 000 pl/ha. In the area with the most unfavorable rainfall (land units C and K around Rakops) higher plant densities severely reduce yield. In the remaining part of LetAD a plant density of 25 000 pl/ha gives the same or a slightly lower yield than a plant density of 15 000 pl/ha.

millet:

The optimal plant density for millet is around 15 000 pl/ha. There is no significant difference between the yield at 15 000 pl/ha and 25 000 pl/ha respectively and the former is preferred because of lower seed requirements.

cowpea and groundnuts:

CYSLAMB does not differentiate between various plant densities for cowpea and groundnuts. As with the three grain crops mentioned above, a relatively low plant density of around 20 000 pl/ha is probably the best.

- The effect of weeding on crop yield

Weeds compete with the crop for water, light and nutrients and timely weeding will improve yields. Generally, the best time to weed is about 30 days after planting.

sorghum, millet:

Timely weeding is very important for both sorghum and millet. If the crop is weeded late (after 50 days of planting) or not at all, yield reduction will be around 30 - 40% for sorghum and up to 50% for millet.

maize:

Weeding is an essential part of maize cultivation, although the timing is less important as for sorghum and millet. The crop does not compete very well with weeds and if the planted field has a history of poor weed control, yield reduction may be as high as 80%.

cowpea, groundnuts:

Cowpea and groundnuts seem to be less affected by weeds than the grain crops. If no weeding is carried out, yield reduction will be around 20 %.

- The effect of fertilizer application on crop yield

CYSLAMB calculates the effect of the application of phosphorus fertilizer.

sorghum, maize, millet:

The increase of the phosphorus level in the topsoil from 3 ppm to 6 ppm (achieved through the application of approximately 100 kg of single superphosphate per hectare), increases yield with

about 25% for the three grain crops and with about 20% for the legumes. A further increase of the phosphorus level from 6 ppm to 10 ppm, increases yield with another 15% for all five crops.

6.2.3.2 Other crops, not included in CYSLAMB

The potential dependable yield of ten crops, which are not included in CYSLAMB, has been estimated through a method explained in Section 6.2.2.2. Each crop has been evaluated for three management systems, one of which reflects the present situation. The results of the evaluation are given in Table 6.3. A few general conclusions will be given below.

- The effect of planting date and number of planting opportunities on crop yield

As with the traditional cereal crops, the highest yields are obtained if the field is planted in its totality with the first planting opportunity from the first dekad of November onwards (management system Cr1).

- The most suitable crop

The suitability of a crop is not only determined by yield, but also by producer price, labour input, and other factors. Some financial aspects of crop production will be discussed in Section 6.2.4. Of the beans and peas included in the evaluation, cluster bean and pigeon pea are expected to have the highest yield of seed and common bean and castor bean the lowest. However, some legumes are not grown for their seed only, but are also valued as a (green) vegetable.

- Suitability of land units

Map 7 shows the various land units of LetAD. Castor beans, chillies and common bean have requirements for growth which can be compared with those of maize. They do relatively well on land units D, F and J, and perform very poorly on land unit C. Cluster bean, jugo bean and tepary bean have similar requirements as millet and do relatively well on land units F and J, and also perform very poorly on land unit C. Pigeon pea, sesame and sunflower have requirements similar to those of sorghum and are predicted to give the highest dependable yields on land units D, F, G and L, and the lowest on land unit C.

6.2.4 Gross margin analysis

6.2.4.1 Gross margin for sorghum, millet and maize under various management

Tables 6.4 gives the gross margins of 18 production systems (sorghum, millet and maize produced under six systems of management respectively) for land unit G. The gross margin for the same production system for other land units is given in Annex 9. The gross margin is the value of produce (column 4 in Table 6.4) minus variable costs (column 5). The value of produce in Pula per hectare (column 4) is the yield in kilogram per hectare (column 3) multiplied by the producer price in Pula per kilogram. The variable costs (column 5) are costs of seed, fertilizer and fuel. The production is calculated with CYSLAMB and given as the potential dependable yield per hectare. The potential dependable yield is likely to be higher than the actual dependable yield as possible losses from pests and diseases are not considered. The variable costs do not include cost of family labour and depreciation of tools, machinery, buildings and fences. The gross margin is expressed in Pula per hectare (column 6) and in Pula for the total farm (column 8). The farm sizes for the various systems of management (column 7) are approximate. The gross margin does not give the profitability of a production system on a certain land unit, but it gives an indication of the relative suitability of each the combinations of production system and land unit. Some conclusions from the gross margin analysis are discussed below.

Table 6.3 POTENTIAL DEPENDABLE YIELD [1] OF SELECTED CROPS FOR THREE SYSTEMS OF MANAGEMENT AND ALL MAJOR LAND UNITS

PRODUCTION SYSTEM		LAND UNITS							CYSLAMB Reference Crop
Crop	Management System (2)	B	C (and K)	D	F	G (E,H,M,N)	J	L	
Castor bean (3) & Chillies (4)	Cr0	60-30	< 30	110-60	110-60	60-30	110-60	60-30	maize
	Cr1	170-110	110-60	280-240	240-170	240-170	280-240	240-170	
	Cr2	110-60	60-30	110-60	170-110	170-110	170-110	110-60	
Cluster bean	Cr0	130-70	< 70	130-70	170-130	130-70	170-130	130-70	millet
	Cr1	290-170	170-130	370-290	370-290	370-290	460-370	370-290	
	Cr2	170-130	130-70	170-130	290-170	170-130	290-170	170-130	
Common bean	Cr0	70-30	< 30	140-70	140-70	70-30	140-70	70-30	maize
	Cr1	210-140	140-70	350-200	300-210	300-210	350-300	300-210	
	Cr2	140-70	70-30	140-70	210-140	210-140	210-140	140-70	
China pea	Cr0	120-70	< 70	120-70	170-120	120-70	170-120	<70	cowpea
	Cr1	270-220	220-170	320-270	270	320-270	320-270	220-170	
	Cr2	120	120-70	170-120	220	170-120	220	120-70	
Jugo bean & Tepary bean	Cr0	110-60	< 60	110-60	150-110	110-60	150-110	110-60	millet
	Cr1	250-150	250-150	320-250	320-250	320-250	400-320	320-250	
	Cr2	150-110	110-60	150-110	250-150	150-110	250-150	150-110	
Pigeon pea	Cr0	80	< 80	130-80	130-80	130-80	130	130-80	orghum
	Cr1	280-200	280-200	340-280	340-280	280-200	340-280	340-280	
	Cr2	130-80	130-80	200-130	200-130	200-130	280-200	200-130	
Sesame	Cr0	50	< 50	90-50	90-50	90-50	90	90-50	orghum
	Cr1	190-130	190-130	230-190	230-190	190-130	230-190	230-190	
	Cr2	90-50	90-50	130-90	130-90	130-90	190-130	130-90	
Sun-flower	Cr0	100	< 100	170-100	170-100	170-100	170	170-100	orghum
	Cr1	370-260	370-260	450-370	450-370	370-260	450-370	450-370	
	Cr2	170-100	170-100	260-170	260-170	260-170	370-260	260-170	

(1) Yield exceeded in 75% of years expressed in kg/ha ("total plot")

(2) Cr0 = Field planted in three stages with first three planting opportunities from early December, timely weeding, no fertilizer
Cr1 = Field planted in its totality with first planting opportunity from late November, timely weeding, use of manure or fertilizer (P topsoil = 6 ppm),
Cr2 = Field planted in two stages with first two planting opportunities from late November, timely weeding, no fertilizer

(3) Yield for crop grown as an annual

(4) Yield for dried fruit

- Suitability of land units

The land suitability in terms of gross margins is, not surprisingly, similar to the land suitability in terms of dependable yield, as given on Map 7. The highest gross margins for most production systems can be realized on land unit J (fossil river courses and depressions). A favorable environment for sorghum (management systems Cr1, Cr3 and Cr4) is land unit L. Land unit F scores high for both sorghum and millet. The most suitable area for maize (management systems Cr1, Cr3 and Cr4) is land unit D. Land units B and C are the least suitable for all production systems; land unit B because of shallow soils and land unit C because of the relatively low rainfall around Rakops. The other major land units (E, G, H, M and N) fall between the extremes given above. Land unit A (very shallow soils) has not been included in the analysis since it has a dependable yield of zero and therefore a negative gross margin in all cases.

- Suitability of crops

Since the producer price of maize is 20% higher than that of sorghum and 40% higher than that of millet, maize has the highest gross margin in all land units except land unit C [4]. Land unit C, with its relatively low rainfall gives a much higher yield for sorghum as compared to maize, and also a higher gross margin. Of the three crops, millet gives the lowest gross margin under all management systems and in all land units, because of both relatively low yields and low producer price. The gross margin of maize is 40 to 50% higher than that of millet for land unit C and 70 to 80% higher for all other land units. A comparison of maize and sorghum gives a gross margin of maize which is 30% lower than that of sorghum for land unit C and up to 30% higher for the other land units.

- Suitability of various systems of management

To compare the performance of the various management systems, the gross margin per hectare (column 6 of Table 6.3) is used. As mentioned before, the gross margin does not include the cost of labour and fixed costs. For all three crops and all land units the gross margin of management system Cr1 is the highest, followed by Cr4. If the present situation of farmers with draught power is taken as a reference and given a rating of 100, the gross margins of the other management systems have a rating of approximately 70 (Cr00), 350 (Cr1), 160 (Cr2), 180 (Cr3) and 250 (Cr4). This means that the gross margin of management system Cr1 is 3.5 times that of management system Cr0.

The effects of management are not the same for all crops and all land units. Improved management (early planting and use of fertilizer or manure) gives the best results with maize and the least with millet. As far as the land units are concerned, early planting is most effective in relatively dry areas (land unit C).

6.2.4.2 Gross margin for crops not included in CYSLAMB

Table 6.4 shows, as an example, the gross margin for jugo bean, cowpea (china pea) and sunflower for three management systems on one land unit (G). The figures for other crops listed in Table 6.3 and for other land units are in the same range. The gross margin of all three crops is low and compares unfavourably with sorghum, millet and maize grown under the same management system. The gross margin of all crops mentioned above is for the production of dry seed only. Apart from seed, a crop may have additional uses which are difficult to quantify. For example, the residues of some crops can be used for fodder, leguminous crop may improve soil fertility and some legumes are highly valued as a green vegetable. Sunflower, if processed by the farmer into oil, may have a high added value. However, the gross margin calculation of Table 6.4 proves that the large-scale production of beans, peas and sunflower is not attractive for the farmer at present producer prices.

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[4] The gross margin calculations of Table 6.4 and Annex 9 use yield predictions based on a CYSLAMB analysis of rainfall data of the period 1968 to 1990. A CYSLAMB analysis of a different period gives different yield predictions and a different gross margin

Table 6.4 GROSS MARGIN OF SELECTED PRODUCTION SYSTEMS (RAINFED CROPPING) FOR LAND UNIT G (and E,H,M and N)

(1) Production System	(2)	(3) Potential Dependable Yield (kg/ha)	(4) Production Value (a) (P/ha)	(5) Variable Production Costs (P/ha) seed (b)	fertilizer (c)	fuel (d)	(6) Potential Gross Margin (P/ha)	(7) Area farmed (ha)	(8) Potential Gr.Mar. Total (P)
Sorghum	Cr00	250.00	105.00	7.50	0.00	0.00	97.50	1.50	146.25
	Cr0	320.00	134.40	7.50	0.00	0.00	126.90	4.00	507.60
	Cr1 (e, f)	950.00	399.00	4.00	0.00	0.00	395.00	1.50	592.50
	Cr2	480.00	201.60	7.50	0.00	0.00	194.10	4.00	776.40
	Cr3	720.00	302.40	7.50	0.00	81.00	213.90	10.00	2139.00
	Cr4 (e)	950.00	399.00	7.50	20.00	81.00	290.50	10.00	2905.00
Millet	Cr00	380.00	136.80	7.50	0.00	0.00	129.30	1.50	193.95
	Cr0	260.00	93.60	7.50	0.00	0.00	86.10	4.00	344.40
	Cr1 (e, f)	770.00	277.20	4.00	0.00	0.00	273.20	1.50	409.80
	Cr2	390.00	140.40	7.50	0.00	0.00	132.90	4.00	531.60
	Cr3	560.00	201.60	7.50	0.00	81.00	113.10	10.00	1131.00
	Cr4 (e)	770.00	277.20	7.50	20.00	81.00	168.70	10.00	1687.00
Maize	Cr00	250.00	127.50	7.50	0.00	0.00	120.00	1.50	180.00
	Cr0	240.00	122.40	7.50	0.00	0.00	114.90	4.00	459.60
	Cr1 (e, f)	910.00	464.10	4.00	0.00	0.00	460.10	1.50	690.15
	Cr2	560.00	285.60	7.50	0.00	0.00	278.10	4.00	1112.40
	Cr3	650.00	331.50	7.50	0.00	81.00	243.00	10.00	2430.00
	Cr4 (e)	910.00	464.10	7.50	20.00	81.00	355.60	10.00	3556.00
Jugo bean	Cr0	85.00	62.05	15.00	0.00	0.00	47.05	4.00	188.20
	Cr1 (e, f)	285.00	208.05	8.00	0.00	0.00	200.05	1.50	300.08
	Cr2	130.00	94.90	15.00	0.00	0.00	79.90	4.00	319.60
China pea	Cr0	95.00	68.40	15.00	0.00	0.00	53.40	4.00	213.60
	Cr1 (e, f)	295.00	212.40	8.00	0.00	0.00	204.40	1.50	306.60
	Cr2	145.00	104.40	15.00	0.00	0.00	89.40	4.00	357.60
Sunflower	Cr0	135.00	78.30	15.00	0.00	0.00	63.30	4.00	253.20
	Cr1 (e, f)	315.00	182.70	8.00	0.00	0.00	174.70	1.50	262.05
	Cr2	215.00	124.70	15.00	0.00	0.00	109.70	4.00	438.80

(a) Grade 1 for sorghum and maize
(b) 3 kg/ha for planting density of 15 000 pl/ha; 1.5 kg/ha for production system Cr1
(c) Cost of fertilizer spread over three years
(d) 3 operations, 2.5 hours/ha, 10 l/hour, 1.08 P/l
(e) Extra labour for fertilizer and/or manure application and weeding
(f) Extra labour for row-planting by hand

Note: Although some production systems allow for mixed cropping (Cr00, Cr0, Cr2), or inter-cropping (Cr1), all figures are for single crop stands

6.3 IRRIGATED CROP PRODUCTION AND GARDENING

Potential for irrigated cropping for commercial purposes in LetAD is limited by the following factors:

- lack of a cheap and reliable source of water
- high salinity of some underground water sources
- poor soils: low nutrient status, sandy and locally shallow depth
- small and/or distant markets and locally poor roads
- lack of labour (although casual labour may be found to do occasional piece work, there are few workers who are prepared to work on a semi-permanent basis for relatively low wages)
- lack of expertise

Despite the overall low suitability for irrigated cropping, irrigation can play a productive role in certain situations. Two of such situations are described as "small scale irrigation" and "gardening" respectively. Small scale irrigation can only be practiced by a few enterprising farmers, because of limited markets; gardening can be practiced by any dedicated farmer with access to a cheap source of water.

- Small scale irrigation

A potential irrigated crop production system can be described as follows. The farmer has a reliable borehole or another source of water, producing water of low salinity and a few hectares of land with well drained, deep soils. Crops are produced for the local market (schools, hospitals, general public) and the farm is located near one of the main population centres (Makalamabedi, Rakops, Letlhakane) with an all-weather access road. The farm starts off relatively small (< 1 ha) but may grow if successful. Both fruits and vegetables are produced in an intensive manner, making efficient use of water and applied fertilizer. Crops are grown continuously, anticipating demand for specific produce. The irrigation system is carefully designed, reflecting soil conditions and crop requirements.

In the context of the present study it is not possible to do a financial analysis of small-scale irrigation. Important factors such as costs for water and labour and producer prices vary too much from place to place and from time to time. Each project will have to be evaluated individually by a Horticulturist, keeping in mind the limiting factors listed above.

- Gardening

In the case of gardening, crops are grown for home consumption mainly. Depending on water availability crops are irrigated throughout the year, or irrigation is of supplementary nature during the rainy season. Gardening can be practiced anywhere, near a private borehole or well with a reliable supply of good water. The cultivated area could be as small as 50 m^2 and produce include high-value crops such as (green) maize, sweet potatoes, vegetables and fruit trees. Soil fertility is improved and maintained through manure application and composting.

The major villages have potential for one or two backyard nurseries. Eight of such nurseries already exist in Letlhakane (2), Mosu (3), Rakops (1) and Kedia (1). Depending on demand, farmers could raise seedlings of fruit trees (citrus, papaya, mulberry, mango, morula), decorative trees and shrubs, multi-purpose trees and even vegetables (tomato, cabbage, swiss chard, onion).

If water is available, gardening for home consumption can be practiced successfully in nearly all circumstances. However, little knowledge exists with respect to garden lay-out, soil improvement, crop water demands and crop protection. These and other aspects of gardening are discussed in Chapter 7.

6.4 MOLAPO FARMING

Molapo farming is completely dependant on the flood regime of the Boteti river. Until recently molapo farming was practiced in the channel and floodplain of the river, including Lake Xau. However, molapo farming in Lake Xau came to an end in the early seventies, with the construction of Mopipi Dam and associated waterworks, and elsewhere this form of cultivation has hardly been possible since the early eighties, because of the lack of significant floods (see Section 3.5.1).

The occurrence of floods in the Boteti river depends on many factors, including the rainfall pattern in consecutive years over Angola and over the Okavango delta, the forever changing direction of the streamflows within the delta, and artificial waterworks and water extraction within the catchment of the delta in Angola, Namibia and Botswana. The rainfall and streamflows patterns mentioned above are impossible to predict, but the water offtake in Angola, Namibia and Botswana is likely to increase with increasing population pressure and agricultural developments in the areas concerned. Within the context of the present study the assumption is made that regular and prolonged flow of the Boteti river, as experienced in the seventies, is unlikely to re-occur in the future. If this assumption is correct, molapo farming, as a significant crop production system, has come to an end in LetAD.

Presently, some molapo fields are used for rainfed cropping. Elsewhere in this report the recommendation is made that all suitable molapo fields be used for rainfed cropping and that a formal allocation of land for that purpose is made possible. Flows in the Boteti river can be anticipated months in advance. In case the present conditions change and the river flows again, farmers can still opt for molapo farming. Under very special circumstances it is even possible to do both rainfed cropping and molapo farming in the same season.

6.5 ANIMAL PRODUCTION

6.5.1 Relevant production systems

Animal production systems are defined by main produce (e.g. beef, milk, pork) and system of management. The present study only evaluates the production of beef under four systems of management, as described below. The main differentiating characteristics between the four production system are given in Table 6.5.

- Production system Ab0:

  Production system Ab0 reflects the present situation of extensive grazing of small herds of cattle on communal land. The herd is small and the main aim of the farmer is to increase the size of his/her herd. Off-take is low and inputs are minimal, as described in Section 4.3.5.

- Production system Ab1:

  Production system Ab1 is similar to Ab0, but with somewhat improved management. The main improvement is increased and timely sale of all unproductive animals.

- Production system Ab2:

  Production system Ab2 represents extensive grazing of small herds of cattle on communal land with greatly improved management. The main improvements are increased and timely sale of all unproductive animals and the provision of supplementary feed in times when grazing conditions are exceptionally poor. The supplementary feed may consist of hay and/or crop residues and may be produced on-farm or purchased.

- Production system Ab3:

Production system Ab3 represents a small herd on a small fenced ranch (140 ha) under greatly improved management. The main improvements are increased and timely sale of all unproductive animals, the provision of supplementary feed in times of exceptional poor grazing conditions, and controlled breeding. The supplementary feed may consist of hay and/or crop residues and may be produced on-farm or purchased.

6.5.2 Evaluation procedures

6.5.2.1 Land units

Land units are areas of land which are relatively homogeneous in terms of land resources and are defined for the purpose of land evaluation. Land units for the evaluation for animal production are based on present vegetation, climate, water resources and soils, as defined in Section 3.8.2 and presented on Map 8.

6.5.2.2 Seasonal and periodic variations in climate and vegetation

Most forms of animal production involve grazing and browsing throughout the year, usually for a number of years. Throughout that period the weather and vegetation will experience seasonal and annual variations. Animals can adapt to some of these changes and the farmer can intervene to some extent, but the fact remains that the suitability of the land changes with time. The evaluation for animal production will always be made difficult by these changes as they are impossible to predict.

Seasonal changes have been accounted for by assuming that grazing and browsing animals change from fresh fodder in summer to (standing) hay and dry leaves in winter. Seasonal changes in the digestibility of the main types of fodder are taken into account.

Annual changes have been accounted for by averaging the results of an evaluation over a number of years (see Section 6.5.2.3). The assumption is, that some of the fodder produced in a good year will still be available in a following poor year.

The climate in Botswana is characterized by prolonged periods of relatively low rainfall and relatively high rainfall respectively. Although one or two exceptional years can be "averaged out" (see above), a prolonged dry or wet period will dramatically change the suitability of a land unit. For this reason the average biomass production of a land unit will be given for both relatively wet and dry periods.

Table 6.5 DESCRIPTION OF ANIMAL PRODUCTION SYSTEM

Production System	Herd size (approx no. of animals)	Type of farm	Size of farm	Annual off-take				Supplementary feed	Controlled breeding
				Steers 4 years	Steers 5 years	Steers 6+ years	Cull cows		
Ab0	23	communal, free-range		0%	50%	80%	50%	no	no
Ab1	23	communal, free-range		100%	100%	100%	100%	no	no
Ab2	23	communal, free-range		100%	100%	100%	100%	yes	no
Ab3	23	communal or private, fenced	140 ha	100%	100%	100%	100%	yes	yes (April-July)

6.5.2.3 Application of APSRAMB

The production of livestock is evaluated with the use of a computer programme called the Animal Production and Range Assessment Model for Botswana (APSRAMB). The model has not yet been validated for sandveld areas, such as those of LetAD, and requires detailed input vegetation data, which was not always available. For these reasons, the results of APSRAMB given in the present study have to be considered as a first approximation only.

APSRAMB consists of two modules: a biomass module and a livestock module. Both modules will be briefly discussed below; for more information on APSRAMB reference is made to the APSRAMB User Manual (Powell and Pulles, 1996).

- Biomass module

The biomass module of APSRAMB determines the vegetative dry matter (DM) production of a vegetation type on a specific soil and under a specific climate. The calculated DM is separated according to stem, leave and root and total production for the tree, upper bush and lower bush layers respectively. The total production for the herbaceous (grass) layer is separated for areas under and away from bush/tree canopy respectively. The module is run for a pre-selected range of years, making use of actual (dekadal) rainfall figures, and DM production is calculated for each month of the selected range of years. The annual DM production is analyzed statistically, giving the total DM production over the selected range of years, the average annual DM production as well as quartile distribution figures (DM production at 75%, 50% and 25% probability).

The biomass production of a land unit can be used to make a rough estimate of the carrying capacity of that unit. The carrying capacity (CC) is the minimum number of hectares needed to satisfy the dry matter requirements of one livestock unit (LSU). Potential available biomass for cattle is mainly determined by the aerial biomass (leaves, stems) of the grasses, both under and away from tree/bush canopy. For goats the biomass produced by the leaves of low bushes (up to 1.5m) should also be included. The biomass module can also be used to for the assessment of fuel wood production and a number of other veld products, such as thatching grass and reeds.

In addition to monthly biomass production, the biomass module of APSRAMB calculates a monthly digestibility figure for the herbaceous layer of each vegetation type. The digestibility indicates how easily the available vegetation is taken up by livestock and converted into animal weight gain. The monthly biomass production figures, as well as the monthly digestibility figures are used in the livestock module of APSRAMB.

- Livestock module

This part of APSRAMB uses the biomass production and digestibility figures of the biomass module for the simulation of the performance of defined animal production systems. The module compares monthly digestible biomass production with the intake requirements of the herd. Starting off with a herd of a defined size and composition (sex and age), the programme simulated monthly liveweight gains and losses, conception and calving rates for breeding cows, milk production and mortality rates. The programme keeps track of each individual animal until it is sold at a pre-set age or starves to death. A herd projection is generated for a set period of time under the given management parameters for any given starting herd.

Because the livestock module is stochastic in nature, i.e. it applies the chance effects of barrenness, sex, mortality and conception to individual animals, each simulation will have slightly different results. Therefore, it is necessary to carry out a number of simulations in order to arrive at an average output for the herd productivity.

6.5.3 Potential of land units for various production systems

6.5.3.1 Potential biomass production of various land units

With the use of the biomass module of APSRAMB, the potential biomass production has been calculated for 21 land units. The land units are defined by vegetation, soils and climate, as described in Section 3.8.2 and as shown on Map 8. APSRAMB predicts the potential biomass production by simulating the situation of past periods. In the present study two periods have been simulated: the period from 1968 to 1976 representing a range of years with relatively high rainfall and the period from 1980 to 1990 representing a range of years with relatively low rainfall.

The result of the APSRAMB biomass production simulation is given in Table 6.6. More details are given in Annex 10 (Tables A10.9 and A10.10). The figures given should be interpreted with care. APSRAMB has not yet been validated for relatively dry areas such as LetAD and some of the required input data were not available or only available in a generalized form. One of the important input parameters of which not sufficient information is available is the grass cover percentage of the various land units for the dry period and the wet period respectively. The grass cover percentages used in the present simulation are those observed during fieldwork in April and May 1995, as specified in Tables A10.9 and A10.10.

6.5.3.2 Potential animal production

In the present study, the suitability evaluation for animal production has been limited to the performance of the four production systems, as defined in Section 6.5.1, on one specific land unit (land unit 8, see Map 8)[5] and for one specific simulation period (1980 - 1990). APSRAMB was used to calculate the monthly biomass production over the period 1980 to 1990 for land unit 8 and to simulate the performance of a starting herd of 23 animals. The definition of the starting herd and the initial settings of APSRAMB used for the simulation are given in Annex 10, Tables A10.1 to A10.4.

The performance of the various production systems in terms of sales and herd increases and losses can be read from Tables A10.5 to A10.8 of Annex 10. In case of production systems Ab0 and Ab1 no animals were left at the end of the simulation period. The 1987/88 season was very dry and in the APSRAMB simulation the total herd perished in 1988. Some sales were made in the first eight years of the simulation period. Because of increased off-take, the sales for production system Ab1 compares favourably with that of the baseline scenario (Ab0). In case of production systems Ab2 and Ab3, the herd was kept alive by supplementary feeding and even increased over the total 10-year period. Sales were significantly higher as compared to production systems Ab0 and Ab1.

6.5.4. Gross margin analysis

The value of sales and the increase in value of cattle inventory are the gains over the year. Reduction in herd inventory are losses. The opening inventory valuation in the first year, the closing inventory valuation in the last year and the sales of stock provide the base inputs for the gross margin calculation of all production systems. Not included in the gross margin calculation are the variable costs. These are relatively low for production systems Ab0 and Ab1 and mainly consist of transport costs of sold cattle to BMC Francistown.

The value of the starting herd (in 1980) was assumed to be the same for all three production systems. The value of the herd after ten years (1990) was zero for production systems Ab0 and Ab1. The value of sales of production systems Ab2 and Ab3 is more than double that of the baseline scenario. The summary

[5] Land unit 8 is fairly typical for the whole of LetAD, with the exception of land units 1 (pans) and 2 (halomorphic grasslands) for which the biomass production and potential for beef production is much lower. For a comparison of the potential biomass production of the various land units see Table 6.5

results of the gross margin calculation are given in Table 6.7. Not surprisingly, production systems Ab2 and Ab3 give the highest gross margin. However, if all the supplementary feed has to be purchased, the picture may be different. The cost of supplementary feed may not out-weight the value of the animals being fed and kept alive. Production systems Ab2 and Ab3 are therefore only attractive if hay in sufficient quantity can be produced on-farm or purchased at low cost from a nearby farm.

Table 6.6 AVERAGE ANNUAL POTENTIAL AERIAL BIOMASS PRODUCTION (*) FOR LAND UNITS

LAND UNIT	AVERAGE POTENTIAL DRY MATTER (kg/ha/yr)					
	Period with relatively high rainfall (as in period 1968 - 1976)			period with relatively low rainfall (as in period 1980 to 1990)		
	Grass	Browse	Grass + Browse	Grass	Browse	Grass + Browse
1	0	0	0	0	0	0
2	1947	0	1947	1947	0	1947
3	2674	0	2674	2674	0	2674
4	2390	0	2390	2390	0	2390
5	2311	285	2596	2311	285	2596
6	2355	370	2725	2355	370	2725
7	2698	1081	3779	2698	1081	3779
8	2958	1046	4005	2958	1046	4005
9	2915	1137	4052	2915	1137	4052
10	3277	155	3432	3277	155	3432
11	3707	586	4293	3707	586	4293
12	2536	708	3244	2536	708	3244
13	2875	590	3465	2875	590	3465
14	2401	1450	3851	2401	1450	3851
15	3365	478	3843	3365	478	3843
16	3516	638	4154	3516	638	4154
17	3291	438	3729	3291	438	3729
18	2211	86	2297	2211	86	2297
19	2931	377	3308	2931	377	3308
20	3031	582	3613	3031	582	3613
21	2650	1197	3847	2650	1197	3847

(*) Production of leaves lower bush ("browse") and aerial parts of herbaceous layer ("grass"), not considering losses due to pests, fire, trampling, etc. and not considering palatability and digestibility.

Table 6.7 GROSS MARGIN OF FOUR ANIMAL PRODUCTION SYSTEMS FOR LAND UNIT 8 OVER A PERIOD WITH RELATIVELY LOW RAINFALL (1980-1990)

Land unit 8 Simulation period 1980 - 1990	Production system			
	Ab0 (baseline)	Ab1 (improved)	Ab2 (improved)	Ab3 (improved)
(a) Value herd at start of simulation	13 043	13 043	13 043	13 043
(b) Value herd at end of simulation	0	0	17 812	19 416
(c) Value of sales	8 666	11 921	18 427	20 376
(d) Gross profit/loss (b-a+c)	2 739	5 994	23 196	26 749

Some conclusions which can be drawn from the APSRAMB analysis as presented above are the following:

- All farmers, even those without capital, can almost double farm income by timely sale of unproductive animals.
- Productivity will increase considerably if the herd can be kept alive during periods of exceptionally poor grazing conditions. Farmers are advised to produce hay during years of plenty and feed the whole herd, or the most valuable and vulnerable part, in critical times.
- A comparison of the gross profits of production systems Ab2 and Ab3 (Table 6.7) shows that controlled breeding increases productivity by 15%. Controlled breeding is only possible on fenced farms.

6.6 POULTRY PRODUCTION

Free-range chickens are quite common in traditional households (see Section 4.3.5). Near Letlhakane village a few poultry farms are in operation. In addition to these well-established forms of poultry production, a small-scale, improved system of chicken egg production is proposed below (see also Bekker and Gilika, 1996).

The following example of an improved system of small-scale egg production is based on 10 layers, with a laying capacity each of 255 eggs per year. The animals are sold for meat and replaced by chicks after one year. The value of produce in one year will be Pula 894.25 for the eggs and Pula 125.00 for the chickens. The variable costs consist of Pula 125.00 for the layers and Pula 194.25 for feed (layers mash). The gross margin of this production system is estimated at Pula 700.00 per year. Some farm labour is required for feeding, watering, pen cleaning and marketing. Fixed costs are estimated at Pula 240.00 for fencing, shelter, a water bottle and a food tray. Based on replacement of fixed assets every five years, the net farm income is Pula 652.00 per year.

Although the chickens need daily attention, the total labour input for small-scale poultry is relatively low. It is an ideal activity for households with little labour and for people who can not move away from there residence for prolonged periods (e.g. mothers with school-going children). Improved small-scale egg production is less suitable for the very poor, because of the risks involved (losses from predators and diseases, uncertain market) and the initial capital outlay of a few hundred Pula.

6.7 VELD PRODUCTS

Numerous plants, animals and minerals, occurring naturally in LetAD, are being used by residents for many purposes. Most veld products are for household use only and have little commercial value. Within the present survey, it is not possible to evaluate all or even the majority of veld products. In this section only those veld products which are very important for a majority of households or which have a relatively high monetary value will be discussed.

Significant veld products of LetAD are listed in Table 3.6 (Section 3.6); these are discussed individually below. Important factors to consider are the occurrence of veld products (quantity, location), the sustainability of harvesting, and the value (see also LUPSAD, 1996).

- poles, firewood, timber

Significant number of trees occur near the villages along the Boteti River from Makalamabedi to Mmadikola and Toromoja, and near major villages in the north and north-east of LetAD. Villages without trees in the vicinity include Xhumo and Khwee. A market for firewood and building materials exist in Letlhakane, Orapa, and probably Rakops and Mopipi. The riverine woodlands of the Boteti river and the morukuru woodlands north of Khwee seem to be in decline. These areas still have harvestable trees (both dead and alive), but do not re-generate sufficiently. An alternative source of wood for the villages along the Boteti is the mixed savanna of Gidikwe Ridge and the area further west. The savanna vegetation in the north-east of LetAD (Mosu, Nthane and area east of Sua Pan) seems more vital and may provide wood on a sustainable basis if managed properly. Wood for poles, timber and cooking is mainly collected for home consumption and little is taken out of the area. Large poles for construction are sold locally for P 2.00 to P 5.00 each (Mars, 1996).

- thatch (bojang)

Thatching grass is used for roofing of most private residences throughout LetAD. After seasons with average or more than average rainfall, sufficient grass is available for this purpose. The most abundant thatching grass is tshikitsane (*Stipachrostis uniplumis*), which is of moderate quality. Less common, but of higher quality is motsikiri (*Eragrostis pallens*). Other grasses sometimes used for thatching include seloka (*Aristida congesta*) and rathathe (*Eragrostis rigidior*). The available thatching grasses are a valuable subsistence product for the majority of households, but have limited commercial value. A permit is needed to carry grass across one of the many veterinary cordon fences in the area. The harvesting of grass for thatching is a sustainable practice and does not affect the resource base.

- fruit (maungo), wine (khadi) and morula beer

Berries of various *Grewia spp* are abundant during part of the year and are a valuable subsistence food for anybody living in the lands area or on cattle posts. Other fruits also occur but are less abundant and more localized. Fruits are amongst the few veld products traded within LetAD and its immediate surroundings. Prices for fresh fruit vary widely, as the market is small and easily saturated and the product is perishable. A 250 ml cup of moretlwa sold for P 1.00 in Serowe in December 1995. More profitable is the production and sale of wine (khadi). The price of khadi is P 0.10 per cup. Khadi is also used as payment in kind for labour. The harvesting of wild fruits is a sustainable practice and does not much affect the resource base.

- vegetables (merogo), tubers (kgane), melons and cucumbers

As with wild fruits, vegetables, tubers, melons and cucumbers are a valuable subsistence food for anybody living in the lands area or on cattle posts. Certain edible herbs may even appear right inside intensively used areas, such as villages, cattle posts, cultivated fields, particularly in a wet year. Veld foods such as vegetables, bulbs, roots, tubers, melons and cucumbers are mainly used for home consumption and have a limited market. A 200 ml cup of boiled and dried rothwe sold for P 1.00 in Serowe in December 1995. Under favourable circumstances a woman can gather at least 30 kg of fresh rothwe leaves per year, which

is reduced to approx. 12.5 kg after boiling (Bekker and Gilika, 1996). A very intensive harvesting of roots, tubers and bulbs may have a negative effect on the growth of some species, but usually some plants remain and regenerate quickly under the right circumstances.

- reeds for fencing (lethaka)

The word lethaka (or letlhaka) occurs in the place name Letlhakane and the reeds (Phragmites australis) were once abundant in the floodplain of the Boteti river. The reeds are used for residential enclosures, mats and sometimes roofing. One person can cut around 50 bundles of approx. 10 kg per day with a total market value of Pula 250.00 (Bekker and Gilika, 1996). However, with the prolonged absence of flooding in the Boteti river the significance of this veld product has dramatically declined.

- traditional medicines

The parts of many plants and animals are used in traditional medicine. These products may have little value as a raw products but have a lot of added value once processed and used by a skilled person. The availability of products with medicinal qualities is not known.

- specialized products for export, crafts, etc.

The sand veld area in the western and southern part of LetAD supports some potentially valuable, but relatively rare plants, such as the grapple plant (sengarapile) and the morama bean. Not much is known of the distribution and production characteristics of these plants, but it seems likely that even a veld product specialist would have to travel long distances and spend many days in the bush to collect significant quantities of saleable produce. The marketing and processing of some specialized products is done by Thusano Lefatsheng. Ostrich eggs are another common product of the sand veld, but their value has decreased because of the increasing number of ostrich farms in the country.

There are a number of veld products which are abundant and cheap and derive there value from processing and specialized marketing. One example given by Veld Products Research are dyed leaves, flowers, seeds and branches for floral arrangements for the export market. There is an abundance of aesthetically pleasing plant products in the area, but the marketing aspects may be too difficult for most people.

6.8 BEEKEEPING

Ideal bee habitats contain at least one flowering tree, shrub or herb at any time of the year. Except from irrigated residential gardens, such habitats do not occur in LetAD. Probably the most favourable area for beekeeping is the riverine dense savanna along the Boteti river between Makalamabedi and Rakops (see Map 5). This vegetation unit includes many tree species favoured by bees, such as Acacia erubescens, A. mellifera, A. nigrescens, A. tortilis, Combretum imberbe, Dichrostachys cinerea, Terminalia sericea and Zizyphus mucronata. The river also has many open well and pools from which the bees can derive water. An additional advantage of this area is the presence of the main Orapa - Maun road and many settlements for easy marketing.

Bekker and Gilika (1996) give a simple financial analysis of an operation with two beehives. Under ideal circumstances, each hive, containing one colony, can produce 30 kg of comb honey per harvest. Two harvest per year are possible, in the months April/May and November/December respectively. The total production of two hives is estimated at 120 kg of comb honey with a value of P 1440.00. The only variable cost is five kg of sugar (P 11.50), which is needed as a supplementary feed in winter, and the gross margin for two hives is P 1428.50. Fixed costs total P 390.00 consist of two hives, one bee smoker and one bee veil. If the fixed costs are discounted over five years, the net income from two hives is P 1350.50 per year.

Although the hives need to be checked daily, the total labour input for beekeeping is relatively low. Beekeeping is an ideal activity for households with little labour and for people who cannot move away from there residence for prolonged periods (e.g. mothers with school-going children).

Beekeeping is not suitable for the very poor, because of the risks involved (absconding colonies, pests, poor market) and the initial capital outlay of a few hundred Pula.

6.9 WILDLIFE UTILIZATION AND TOURISM

6.9.1 Production systems

The following production systems or utilization types with a wildlife component, are the most relevant for LetAD:

- Preservation/Maintenance of biodiversity
- Tourist viewing of wildlife, scenery, archaeological sites, rural traditional life, etc. (Eco-tourism)
- Tourist hunting
- Citizen sport hunting
- Game cropping (management and utilization of existing wildlife)
- Game ranching (extensive wildlife production with and without re-stocking)
- Game farming (intensive wildlife production with re-stocking)

A wildlife enterprise will often consist of a combination of two or more production system, e.g. game ranching combined with tourist game viewing. Some wildlife production system can also be combined with forestry or agriculture.

The production systems mentioned above can be owned and operated by the Government (DWNP), by private companies (individuals or companies lease land from Land Board) or by communities (through Community Trust). Management structures can also be complex, for example a Community Trust leases land from the Land Board and sub-leases to a private company. Non-governmental organizations can also play a role.

6.9.2 Relevant land factors

Some important land factors to be considered are listed below. Not every land factor listed is relevant for each production system (see also Rodgers, 1991).

Land Quality	Measurable characteristics
Habitat (for wildlife)	Vegetation structure, availability of grass/browse, biomass production
Access	- Proximity to settlement/major road/airport/accommodation (for tourists) - Proximity to markets, facilities for farmers/managers (for farming and ranching)
Water availability	Type of water source, availability (applies to ranching and farming mainly)
Species diversity	Seasonal abundance of various wildlife species for viewing and hunting
Species abundance	Number of animals per species
Visibility of game	Vegetation structure and density of bush

Scenery (landscape)	Naturalness, disturbance, degree of human presence, uniqueness, grandeur
Present land use	Lack of human activities, livestock, fences, etc. which may interfere with wildlife production system (applies to hunting mainly)

6.9.3 Potential of land units for various production systems

A limited number of production systems have been evaluated systematically for each land unit. The land units used in this case are those defined for animal production, as explained in Section 3.8.2 and shown on Map 8. The suitability assessment is of a qualitative nature and shown in Annex 11. A summary of the results is given below.

- Wildlife viewing, eco-tourism, photo safaris

The number and diversity of wildlife within LetAD is low compared to the main wildlife reserves of Botswana, and not sufficient to attract many tourists. However the area has some unique scenery in the form of the Boteti river and large pans.

The Boteti river between Makalamabedi and Mmadikola (land units 17, 9 and 4 of Map 8) is characterized by steep banks and riverine woodland and supports a rich birdlife and diverse forms of land use (molapo fields, small villages, livestock). Although mostly dry since the early eighties, the river has a few pools with hippopotamus and crocodile and many waterpoints for human use and livestock. Accessibility is good at the moment and will improve greatly with the construction of the improved Rakops - Motopi road. Presently accommodation and other tourist facilities are almost non-existent and very few visitors stay overnight.

LetAD has some large pans in the north (land unit 1) and borders in the north-east on the great salt flats of the Makgadikgadi depression. These areas with their "islands" of grass and trees are popular with some visitors, particularly with enthusiasts of terrain vehicles and campers. Lekhubu Island (also called "Kubu"), 30 km north of Mmatshumo, attracts a small but steady flow of visitors, particularly during full moon.

Both the Boteti river and the Makgadikgadi Pans provide opportunities for individuals and communities to profit from tourism. Visitors to the nearby Central Kalahari Game Reserve and the Makgadikgadi Pans National Park could also provide business.

- Tourist trophy hunting

Most of LetAD used to be suitable for trophy hunting, with plenty lions and other prized trophy animals. However, wildlife populations have declined rapidly over the last few decades. Low wildlife populations and the presence of many livestock severely limit the suitability of the area for extensive forms of trophy hunting. The most suitable area for trophy hunting is probably the north-western corner of LetAD (land units 11 and 16 of Map 8). The area has a relatively high wildlife population and can be serviced from Maun. Hunting on fenced game ranches, stocked and managed for this purpose, may be possible in remote corners of LetAD, away from concentrations of people and livestock. Such an enterprise would require a lot of capital and specialized skills.

- Citizen subsistence and recreational hunting

Hunting for subsistence and recreation, with or without a license is widely practiced in LetAD. For the government the income from hunting is very low, as shown in Section 4.3.6. The returns for individual hunters are difficult to establish, as few records are kept on licensed hunting and none on poaching. People who are likely to benefit most are residents and outsiders with terrain vehicles and firearms. Main large wildlife species include zebra, wildebeest, springbok, eland, duiker, gemsbok, steenbok, hartebeest, impala and kudu. Huntable bird species, such as guinea fowl, francolins and sandgrouse, occur in the woodlands

along the Boteti river and other areas with dense woody vegetation. Ostrich is common in the open plains, but is largely left alone, probably for traditional reasons.

Under good management, most of LetAD would be suitable for extensive forms of subsistence and recreational hunting. The main difficulties with this type of land use lie with the enforcement of control measures and the distribution of benefits to local residents.

- Game ranching and farming (with or without livestock)

Ostriches are amongst the most ubiquitous forms of wildlife still present in LetAD, and ostrich farming is one of the most promising forms of wildlife utilization in the area. An ostrich farm is in operation just outside LetAD, south-east of Makoba. Ostriches are not subject to Foot and Mouth disease and do not need stringent veterinary checks. Various intensities of ostrich farming are possible, from stall-fed animals to free-range, wild birds in large ranches in combination with cattle. The most suitable natural habitat for ostrich ranching are open wooded grasslands with good grass cover, such as the low shrub savannas in the south-east of LetAD (land unit 8 of Map 8).

Other game animals which can be kept in combination with cattle include zebra, gemsbok, hartebeest and kudu. These animals do not require a special game fence and have a moderate to high value (Rodgers, 1991). However, all these animals need specialized management and marketing and very few of the present livestock farmers in LetAD will have the skill, resources and motivation to embark on a such an enterprise.

- Preservation of biodiversity

The lowest parts of large pans with saline water in summer attract a variety of birds, including pelicans, flamingos, waterfowl and waders (MCI, 1995). One such area is the southern part of Sua Pan, north of Mosu. Other areas of great biodiversity are the Boteti river and its riverine woodlands and the Mosu-Nthane sandstone escarpment with its springs and archaeological sites. Lake Xau, north of Kedia, must have supported an unique ecosystem before it dried up in the early eighties. The area may still have potential as a nature reserve.

LetAD borders on the Makgadikgadi Pans National Park and the Central Kalahari Game Reserve which are large areas set aside for the preservation of biodiversity. The establishment of more reserves in the area is unlikely to be popular with the resident population, unless it can profit economically.

6.10 RESIDENTIAL AREAS

The present study does not include detailed village plans, with areas zoned for housing, roads and other infrastructure. Two such village plans have been prepared by DTRP, for Letlhakane and Rakops respectively. This section lists some environmental factors, to be considered in connection with land allocation for housing and other infrastructure.

- flooding

  Floods or waterlogging may occur in the rivers, valleys, depressions and pans, as indicated on Maps 6 and 11 of this report.

- shallow groundwater and wells

  In the north of LetAD, water for human and animal consumption is drawn from wells, tapping shallow groundwater which is easily polluted. Waterpoints should be protected from human and

animal waste. The distribution of wells and boreholes is shown on Map 4.

- wind erosion (dust)

The lacustrine deposits of the Makgadikgadi depression have a high content of coarse silt and fine sand and disturbed soils without protective cover may produce a lot of dust. The extend of the lacustrine deposits is shown on Map 2 (unit L1 and AL2).

- fragile and valuable vegetation

Some of the scarce and valuable woodlands in LetAD are remnants of periods with higher rainfall or higher groundwater tables than the present. Such woodlands do not re-generate easily, if at all. Such fragile types of vegetation include the riverine dense savanna along the Boteti river and the morukuru woodland north of Khwee (see Map 5).

CHAPTER 7

AGRICULTURAL LAND USE PLAN

The Agricultural Land Use Plan (ALUP) consists of recommendations with respect to specific problems, opportunities for change, extension messages and a map showing recommended land use (Map 11). Since the ALUP is aimed at specialists and decision makers at various levels and with various background, the conclusion and recommendations will be formulated from more than one perspective. For example, the general conclusion that rainfed cropping has little potential may be of interest to national planners but is irrelevant to Agricultural Demonstrators who advise subsistence farmers who have been cultivating for generations and will continue to do so. The latter will be more interested in recommendations which will lead to more and better crops, produced with less risk and less effort.

7.1 RECOMMENDED LAND USE

7.1.1 Over-all land suitability

Taking LetAD as a whole, the most suitable land use is extensive grazing. Rainfall is low and variable, but sufficient to support a savanna vegetation which can feed a low livestock population. Water for livestock is available in most areas, although expensive in most cases and not always of good quality. The sustainability of animal production largely depends on the availability of external markets for beef, the control of epidemic diseases and continuing water availability.

Although there are some possibilities for game ranching and extensive forms of wildlife use, the area has lost its over-all potential for wildlife production and tourism. The main reasons are the existence of veterinary cordon fences which cut across migratory routes and the lack of surface water in the Boteti River and Lake Xau since the mid eighties.

Although good yields can be achieved in years of exceptionally favourable rainfall, the area is only marginally suitable for the rainfed production of traditional crops and occasional crop failures can be expected under any type of management.

The Boteti River has experienced only two significant flows since 1980 and molapo farming has hardly been possible since then. Because of irregular flows in the Boteti river, molapo farming cannot be planned properly.

The potential for irrigated cropping is very limited mainly because of lack of water, poor soils and a small local market.

The potential of LetAD for forestry has always been low. There are no forests in the area and the production of plantations will always be low due to the short growing season. However, existing dense savanna along the Boteti River and in the north and north-east are valuable sources of timber and firewood and need protection and proper management.

7.1.2 Recommended land use; production zones (Map 11)

Map 11 gives the recommended land use in the form of broad production zones. The zonation is based on present land use, present plans and designations and identified land use opportunities. The zones indicate primary use only, although most land is used for many purposes simultaneously. The zones are briefly described in Table 7.1. The meaning of "improved rainfed cropping" and "improved extensive grazing" are described in Sections 7.2.2 and 7.2.3 respectively.

7.2 SOLUTIONS TO LAND USE PROBLEMS AND OPPORTUNITIES FOR CHANGE

7.2.1 Introduction

The main asset of LetAD is mineral wealth in the form of diamonds. Otherwise the area has few productive land resources. The rainfall is low and variable, the soils are poor in nutrients, the water resources are underground and probably not being replenished, the vegetation mainly consists of shrubs and grasses with only seasonal growth and the once thriving wildlife population has all but disappeared. Other than diamond mining, the area has little potential for industrial growth because of its remote location, low population density and largely unskilled labour force.

The poor land resources are reflected in low population density, which is 1.5 person/km^2 (including the population of Orapa). The total number of households (HH) in LetAD is around 9000. Assuming that a third of these HH are directly dependant on the mining industry or on government employment, not more than 6000 HH are directly or in-directly dependant on the fruits of the land (agriculture, forestry, wildlife, veld products). Theoretically speaking it should not be difficult to improve the income and living conditions of 6000 HH through education, well-targeted extension messages, incentives and subsidies. However, some obstacles which stand in the way of a productive and sustainable use of the large area of land by the limited number of resident households. These obstacles include the following:

- increasing individualism and loss of community sense in an area where nearly all the land is communally owned
- unequal access to water resources (for grazing) and land (molapo)
- illiteracy or low level of education
- unequal access to information e.g. with respect to available subsidies, markets, opportunities
- legal use (cattle posts, hunting) and illegal use (poaching) of land resources by people from outside the area
- ineffective enforcement of legislation related to land use e.g. Agricultural Resources Conservation Act and Herbage Preservation Act

Some of the obstacles mentioned above are discussed in more detail in Chapter 5 and elsewhere in this report. Other issues are outside the scope of an ALUP, but are not less relevant to improved and sustainable land use and improved living conditions of the resident population.

Table 7.1 PRODUCTION ZONES AND RECOMMENDED LAND USE

ZONE	AREA*		PRESENT USE (see also Map 6)	RECOMMENDED USE (primary uses only)
	km²	%		
				Crop production
1	269	0.9	Lands areas with perimeter fence	Improved rainfed cropping on suitable (deep) soils only.
2	79	0.3	Area with scattered cultivation	Improved rainfed cropping on deep soils only.
3	513	1.8	Area with scattered rainfed cultivation near the Boteti river	Improved rainfed cropping. Cultivation in small fields (5 ha or less), in depressions or other suitable sites at least 100m away from the river bank.
4	44	0.2	Channel and floodplain of the Boteti river used for molapo farming and water extraction	Improved rainfed cropping on existing molapo fields, with molapo farming in exceptional years of flooding. Protected open wells for human and animal consumption. Collection of veld products and beekeeping.
				Animal production
5	3600	12.3	Extensive grazing	Improved extensive grazing (cattle posts and communal). Stocking control needed. Controlled hunting (part of CT8).
5p	121	0.4	Pan areas, associated with unit 5.	
6	1034	3.5	Boteti State Land used for extensive grazing	Improved extensive grazing (cattle posts). Area to be tribalized. Stocking control needed. Hunting suspended.
6p	213	0.7	South-western tip Ntwetwe Pan and other pan areas, associated with unit 6	
7	387	1.3	Extensive grazing with freeze on borehole allocation	Hima area. Land to be reserved for use by Remote Area Dwellers from Kedia. Improved extensive grazing and/or community controlled wildlife utilization (part of CT20).
				Animal production (cont.)
8	2985	10.2	Extensive grazing	Improved extensive grazing: either cattle posts, or fenced ranches. Area suitable for community controlled wildlife utilization (part of CT20).
9	3640	12.5	Extensive grazing; area designated for fenced ranches (Kaka)	Improved extensive grazing in fenced ranches. Controlled hunting (part of CT21).
10	6115	21.0	Extensive grazing	Improved extensive grazing. Area may have potential for fenced ranches (further study needed). Controlled hunting (part of CT21).
11	927	3.2	Extensive grazing	Improved extensive grazing (cattle posts). Hunting suspended (CT19).
11p	131	0.5	Rysana Pan and other pan areas, associated with unit 11	
12	3953	13.6	Extensive grazing	Improved extensive grazing (cattle posts and communal). Controlled hunting (part of CT21).
12p	265	0.9	Pan areas, associated with unit 12	
13	192	0.7	Extensive grazing	Improved extensive grazing (cattle posts). Controlled hunting (part of CT13).
13p	541	1.9	South-eastern part Sua Pan, associated with unit 13	

* Total area is 29 170 km² (= 2 917 000 ha)

cont.....

Table 7.1 RECOMMENDED PRODUCTION ZONES AND LAND USE (cont.)

ZONE	AREA*		PRESENT USE (see also Map 6)	RECOMMENDED USE (primary uses only)
	km²	%		
14	366	1.3	Quarantine camps	Quarantine camps
15	48	0.2	Extensive grazing	Extension of Setata Quarantine Camp
				Wildlife conservation and tourism
16	693	2.4	Boteti State Land used by wildlife and livestock	Wildlife Management Area. In consultation with DWNP, grazing of livestock and veld product collection could be allowed, but no settlement.
17	16	0.1	Extensive grazing	Wildlife conservation and tourism controlled by Khumaga community. With private lodge and community controlled camp site (17x).
18p	81	0.3	Lake Xau: pan area with sparse grazing and cultivation	Area may have potential for bird sanctuary. Use of former molapo fields in and around the pan to be investigated. Detailed study required.
				Natural woodland management
19	140	0.5	Banks Boteti river with many uses. Riverine dense savanna degrading.	Management of natural riverine dense savanna for sustainable wood production, conservation of bio-diversity, veld products, beekeeping and tourism.
20	61	0.2	Extensive grazing (morukuru woodland)	Management of natural woodland by Khwee residents for sustainable wood production (crafts, timber).
21	369	1.3	Extensive grazing (mopane mixed dense savanna)	Management of natural mixed savanna with mopane for sustainable wood production (firewood, poles, timber). Controlled hunting (part of CT21).
22	30	0.1	Extensive grazing (mopane dense savanna)	Management of natural vegetation for sustainable wood production (firewood, poles, timber). Controlled hunting (part of CT13).
23	1890	6.5	Extensive grazing (mixed savanna)	Management of natural vegetation for sustainable wood production (firewood, poles, timber). Improved extensive grazing. Controlled hunting (part of CT8).
				Residential
24	40	0.1	Major villages	Development of Letlhakane and Rakops according to Village Development Plans. Protection of remaining indigenous trees within the villages. Hedge and tree planting around public places and private compounds. Gardening and backyard cultivation to be promoted.
			Areas under control of Debswana Diamond Company	
25	40	0.1	Mine and mine town (Orapa and Letlhakane Mine)	
26	368	1.3	Precious stones protection area (Orapa and Letlhakane Mine)	
27p	19	0.1	Mopipi dam	

* Total area is 29 170 km² (= 2 917 000 ha)

7.2.2 Improved crop production

7.2.2.1 General extension messages

Many interventions will only be effective if practiced in combination. For example, fertilizer application will not result in a higher yield if not combined with early ploughing, timely weeding and pest control. Combinations of interventions relevant for various farmer groups are discussed in Section 7.2.2.2.

- Size of field

1. Size of ploughed and planted area should be manageable by farmer, including weeding and bird scaring. Properly managed small area is more productive than poorly managed large area.

2. Cropping and inputs to be concentrated on part of holding with best soils (deep, loamy) and topography (depressions)

- Ploughing

3. Use mouldboard plough only when land is full of weeds or when manure or crop residues have to be turned into the soil. Otherwise use cultivator in compact and/or hard soil or plant directly in loose, sandy soil without weeds.

4. In case the land is sloping, plough across the slope to conserve soil and moisture.

- Time of planting (rainfed cropping only)

5. Plant early, with first significant rains from early November onwards

6. In case of failure of early planted crop, replant before end of January with early maturing variety. Direct planting (without ploughing) if possible.

- Planting density, rowplanting

7. The optimum planting density in an average year is 15 000 pl/ha for sorghum, maize, millet, cowpea and groundnuts. Planting densities should be somewhat higher in wet years and lower in dry years. Overall thinning could be carried out at time of weeding when season does not look promising.

8. Plants should be evenly spaced: clusters of plants to be thinned at time of weeding, gaps to be filled in.

9. Rowplanting to be practiced if weeding is to be carried out mechanically, otherwise not much advantage. Rowplanting with Sebele plough-planter or by hand (seeds dropped in open plough furrow).

- Weeding

10. Weeding (and thinning) to be carried out approximately 30 days after emergence.

Effective weeding at an early stage will reduce weed population in the next year.

- Soil fertility maintenance

11. If available, old kraal manure to be applied in winter. Either broadcasted over part of field to be used for maize or sorghum, or applied to permanent planting rows.

12. Apply modest amounts of fertilizer: approximately 100 kg of single superphosphate every two or three years and spot application of urea in wet years with well established crop.

13. Crop rotation to be practiced: sorghum or maize to be rotated with legume (cowpea, jugo bean)

- Draught power

14. Unless provided free by government or other source, mechanized traction is not profitable, even on large farms.

15. Stalks and other crop residue to stored for consumption by draught animals early November.

- Most commercial crop

16. LetAD is not very suitable for commercial crop production, but in relative terms and with 1995 producer prices, the most profitable grain crop to grow in most of the District is maize. Exceptions are Rakops, Mmadikola, Xhumo and Kedia AEAs where sorghum is expected to be marginally more profitable in the long run.

7.2.2.2 Specific recommendations for various farmer groups

In this section specific recommendations are given for each of the farmer groups as defined in Section 4.3.3.

- Farmer group I

Farmers of group I have little labour, no cattle and few other resources and would not be able to farm at all without ploughing subsidies and/or assistance from relatives or neighbouring farmers with more resources. Many de facto female headed HH, with small children only, belong to this group. Farming is only a part-time occupation. Less than 10% of the farmers belong to group I.

If assistance with ploughing is available, either from government or from other farmers, traditional forms of cropping can be practiced with more attention to weeding, thinning and crop rotation. Bird resistant sorghum varieties may be preferred. If assistance with ploughing is not available, the farmer could concentrate on gardening rather than traditional cropping. Gardening involves the intensive cultivation of very small plots near the (permanent) homestead. Agro-forestry practices are combined with soil fertility improvement and water conservation techniques to produce fruits, vegetables, legumes and cereals mainly for home consumption. The garden will be both rainfed and irrigated, the proportion to be irrigated depending on water availability and farmer's preferences. Gardening can be combined with small-scale poultry production and/or beekeeping. Appropriate gardening techniques, with or without government

support packages, will have to be developed (see Section 7.3.3).

- Farmer group II

Farmers of group II have few assets, except a few donkeys, some goats and possibly a few head of cattle. However, there is enough labour in the HH to cultivate a few hectares of land and sufficient draught power. In most cases farm implements have to be borrowed or shared. Approximately one-third of the farmers belong to group II.

The main message for farmers of group II is to intensify cropping, which is to produce more on less land, and to spread farming activities. Since they have little livestock, they can concentrate on arable farming.

1. Select the best part of available land (deep soils, depressions, lower slopes).
2. Apply old manure in winter in rows 90 to 150cm apart on part of the field.
3. Plant early, in the fertilized rows, with first rains from early November onwards. In the absence of planters, seeds can be placed by hand in plough furrows during ploughing.
4. Practice crop rotation with maize or sorghum as first crop on the fertilized part and a legume as the second crop.
5. Weed 30 days after emergence and thin and/or replant if necessary to obtain an even crop stand
6. Protect mature crops from birds and ask advice from AD in case of serious pest problems

- Farmer group III

Farmers of group III have a small herd of cattle and/or have small but regular income from employment, remittances, pensions or other sources. They have sufficient draught power or can afford to hire it. Approximately one-third of the farmers belong to group III.

The messages for group III are similar to those of group II, except that the farmers will have enough capital to make the downpayment for ALDEP packages and to buy small quantities of fertilizer. The most relevant ALDEP packages are those for implements (ploughs and planters) and fencing. Well-targeted application of small amounts of single superphosphate, with or without urea, as explained in Section 7.2.2.1 is most cost-effective. Fertilizer can be applied with or without manure.

Group III farmers have less than 20 head of cattle and, unless these animals are part of a larger herd, the main priority of the farmer will be an increase in the number of cows to make the herd more viable. Crop residues and or hay should be stocked to keep cow-calves and cows alive during periods with little grazing. Steers over four years old and unproductive cows should be sold in time.

- Farmer group IV

Farmers of group IV have a sizeable herd of cattle and other livestock and may have additional income from other sources. They are actively engaged in both livestock and crop production and can afford the necessary inputs for both. A few farmers of this group own a tractor which is also hired out. About 20% of the farmers belong to group IV.

All general extension messages of Section 7.2.2.1 apply. Unless heavily subsidized, the use of tractors for ploughing will not be encouraged, as it is not cost-effective. Farmers of group IV may have sufficient resources to experiment with cashcrops, such as sunflower, groundnuts and jugo bean. Farmers of this group are also encouraged to grow fodder crops, either as part of a rotation or as a sequential after an early harvest or a crop failure.

With respect to livestock, all general extension messages of Section 7.2.3.1 apply

- Farmer group V

Farmers of group V are mainly concerned with animal production and have a herd of at least 50 cattle. They usually have other sources of income and leave day-to-day management to herdboys. Only a few percent of the farmers belong to group V.

All general extension messages apply, as described in Section 7.2.3.1. Farmers of group V are mostly out of the reach of Agricultural Demonstrators and should be targeted through the various Divisions of DAHP (Livestock Advisory Centre, Veterinary Services and Animal Production).

7.2.2.3 The use of existing molapo fields for rainfed cropping

The soils and the slopes in the Boteti river are very variable: there are shallow and deep soils, steep valleysides and flat valleybottoms, some sites are waterlogged for most of the year. It is estimated that about 30% of the soils in the riverbed are suitable for cropping. This 30% includes some of the best soils of the whole of Boteti sub-District. Most of the suitable sites have been used in the past for molapo farming. However, the river has not flooded for many years and some sites have been used for dryland farming. Farmers have customary rights to their molapo fields. The Land Board does not allocate land in the river and for that reason molapo farmers cannot benefit from certain subsidies (e.g. for fencing). The Boteti river downstream of Makalamabedi has not experienced significant floods since 1980 (minor floods occurred in 1983/84 and 1988/89). Because of increased water consumption in the catchment area of the river (Angola, Namibia, Ngamiland), it is unlikely that a long period with reliable floods (as in the seventies) will re-occur. Therefore, molapo farming is not a sustainable form of crop production.

Under the present circumstances the molapo fields in the Boteti river are an under-utilized resource. However, the same fields could be used for rainfed cropping in the rainy season. In the unlikely case that the river flows again, the fields can still be used for molapo farming. The likelihood of a flood in the Boteti downstream of Makalamabedi can be predicted months in advance and farmers should be advised accordingly.

To encourage the use of molapo fields for rainfed cropping the following action has to be undertaken:

1. The Land Board has to change its policy on land allocation in the Boteti river. The cultivation of suitable sites should be allowed. Individual farmers should not be allocated more than 3 ha, to encourage an equal access to land.
2. The DAO has to encourage the use of molapo fields for rainfed cropping by means of on-site demonstrations
3. The boundary between communal land and the National Park along the Boteti river between Moreomaoto and Sukwane has to be negotiated
4. The western boundary of the Makgadikgadi Pans National Park has to be fenced to protect the fields in the river from damage by wildlife (see also Section 7.2.4.2).

Since various institutions will be involved in the promotion of a more intensive use of existing molapo fields, a project may be needed. Such a project is formulated in Section 7.3.1.

7.2.2.4 Re-organization of existing lands areas

Large lands areas, surrounded by a perimeter fence, occur near Mosu (Nthane), Letlhakane, Mmatshumo, Mokobaxane (2) and Moreomaoto (see Map 6). The practice of concentrating fields in one area has many advantages, such as better protection from livestock, more efficient extension service, and more effective pest control. It seems that the lands areas of LetAD are not functioning properly as they cover large areas with relatively few fields. The existing perimeter fences are very long, often poorly maintained and have many poorly controlled gates. Many farmers keep smallstock, lactating cows, calves and draught animals at the lands during the growing season and some lands areas may even include one or more cattle posts. In addition to the perimeter fence, many farmers have constructed a wire fence around their individual fields. This practice is encouraged by ALDEP subsidies.

A re-organization of existing lands areas could make rainfed cropping more productive, by reducing constraints such as damage by livestock, damage by pests, and long distances to arable land and water. The re-organization requires a detailed land use plans for selected lands areas, made in close co-operation with the affected farmers.

A proposal for detailed land use plans for existing major lands areas is formulated as a project in Section 7.3.6

7.2.2.5 Protection from wildlife (Boteti river)

The western boundary of the Makgadikgadi Pans National Park runs along the channel of the Boteti river from Moreomaoto to Sukwane. The river is used for livestock and cropping by communities living on the east bank and by wildlife for water and forage. Crop damage by wildlife is common and some animals pose a threat to both humans and livestock. Large numbers of livestock stray into to National Park or are deliberately taken there to graze.

The Makgadikgadi/Nxai Pans Management Plan (MCI, 1995) proposes to fence at least part of the western boundary of the National Park. Before such a fence is erected, the exact boundary between the NP and the communal land has to be negotiated. To satisfy the needs of both the residents of the mid-Boteti area and the DWNP, such a fence could cross the river at several points, leaving some sections of the river (e.g. hippo pools) to the National Park and other section (e.g. cultivable land) to the villages.

The study of a so-called "give and take" fence along the western boundary of the Makgadikgadi Pans National Park is part of a proposed project, formulated in Section 7.3.1.

7.2.2.6 Gardening

For many households with access to a small and cheap supply of water, gardening may be a more productive form of arable farming than traditional rainfed cropping. Rather than attempting to cultivate large fields in distant lands areas, these households could cultivate small plots in an intensive manner near their homestead.

The most productive form of gardening combines agro-forestry practices with soil fertility improvement and water conservation techniques to produce fruits, vegetables, legumes and cereals mainly for home consumption. The garden would be primarily rainfed, with most activities limited to the rainy season. Supplementary irrigation will be needed to raise seedlings and to support small areas of drought-sensitive

crops during dry spells. The amount of irrigation will vary according to water availability. Small-scale poultry production and/or beekeeping could also be considered.

Gardening is also considered as an alternative income generating activity for households with little labour and other resources (see Section 7.2.6).

Many details with respect to gardening need further investigation. For this reason a project has been formulated which deals with both "backyard" and "communal" gardening (Section 7.3.3).

7.2.3 Improved animal production

7.2.3.1 General extension messages

Messages for all livestock farmers (communal, cattle posts, ranches):

- Marketing

1. Timely sale (or slaughter) of non-productive animals, such as all cull cows (cows more than 144 months old), steers (over 48 months), barren cows, sick or injured animals and excessive donkeys.

- Rotational grazing

2. Rotate grazing either through system of paddocking or intensive herding (will allow vegetation to re-generate through seeding).

- Controlled stocking rate

3. Prevent rangeland degradation caused by overstocking

- Disease control

4. Timely vaccination, regular dipping, and other disease control measures

- Supplementary feeding

5. Provide supplementary feeds in the form of rumevite blocks (improves digestibility of available food in winter), dicalcium phosphate and cattle maintenance licks.

6. Provide supplementary fodder in the form of hay or crop residues in times of exceptionally poor grazing. If possible, the fodder should be produced on-farm and stored in such a way that it can be preserved for a long time. Depending on the availability of fodder, supplementary feed could be given to the whole herd or to the most valuable and vulnarable animals only.

Messages for high-input production systems (including fenced ranches):

- Fodder crop production

7. In addition to fodder production from natural vegetation and crop residues (see above), fodder crops can be produced in years with good rainfall. Recommended fodder species are siratro

(*Macroptilium atropupureum*) and lucerne (*Stylosanthes humilis*).

- Range improvement

8. Under certain circumstances the range could be improved by bush clearance and seeding. A good grass to plant in bare patches during a good rainy season would be buffel grass (*Cenchrus ciliaris*).

- Controlled reproduction and breeding

9. Introduction of improved breeds and timed insemination to synchronize calving and weaning within herd.

- Timely weaning

10. Timely weaning of calves improves the overall productivity of cows

7.2.3.2 Ranching

The National Agricultural Development Policy (NADP) was approved by the National Assembly on the 15th of February 1991. Where feasible, farmers will be allowed to fence land for animal production. They can do this as individuals, groups or communities. The aim is to improve the productivity of the livestock subsector and ensure sustainable use of range resources.

The main advantage of ranching is the possibility of controlling livestock numbers, livestock movements and breeding. Many aspects of good management become easier in a controlled environment as compared to free and communal range. Disadvantages include the displacement of Remote Area Dwellers and the increasing control over land by a minority. The economic feasibility of ranching is debatable. In general, the gross margin of leasehold farms is higher than that of communal farms (ASPIC, 1996). However, a full financial analysis may give a different picture.

Kaka area in LetAD (see Maps 6 and 11) has already been designated for ranch development. It seems prudent to evaluate the result of this development in economic, social and environmental terms before ranching is promoted in other parts of LetAD.

As for Kaka area itself, it seems fair to reserve land for displaced Remote Area Dwellers as proposed by ASPIC (1996).

For Kaka and any other area with a (future) concentration of ranches to be economically viable good management is essential. Since very few farmers want to live permanently in remote areas, it seems advisable that a number of ranches in the same area jointly employ a qualified manager. The layout of ranches and infra-structure could take the form of "clusters" of ranches around a central service area with housing and other facilities.

7.2.3.3 The status and use of Boteti State Land

South of Makgadikgadi Pans National Park and north of Toromoja there is a strip of land which is part of Boteti State Lands (see Map 6 or 11). The eastern part of this area has many cattleposts around open

wells (see Map 4). The western part has no wells but is also used for grazing. The whole area is marginally suitable for livestock production because of limited carrying capacity (high proportion of pans and halomorphic grassland) and the occurrence of saline groundwater. The DWNP has designated the area as Wildlife Management Area (WMA). However, tribalization of the most intensively used part should be considered.

The land tenure and use of Boteti State Land south of Makgadikgadi Pans National Park concerns many "stake holders", including resident farmers, DWNP, MoA, Land Board and the Lands Department. A project has been formulated to address this land issue (Section 7.3.2).

7.2.4 Farmers and wildlife conservation

7.2.4.1 Community benefits from wildlife

DWNP is in the process of improving its capability of communicating with residents of areas near nature reserves. New and enlarged operating procedures will be established. This includes the supervision of problem animal control and community liaison functions, which will be the responsibilities of the Community Liaison Officer. High priority will be given to the development of joint venture tourism, both within and outside the National Park boundaries. Neighbouring communities will be favoured as participants in tourism and recipients of revenue. Formation of Local Advisory Committees is envisaged, involving a number of stakeholders and government officials to address various issues.

Possible joint ventures and other community benefits from wildlife and tourism include the following:

Employment:
- by DWNP (tour guides, wardens, gate keepers)
- by private companies

Joint ventures:
- Bird hunting safaris
- Photo safaris
- Camp sites, lodges
- Tanneries

Other:
- Veld products utilization
- Sale of souvenirs, crafts
- Sale of general provisions, fuel etc

More than one private company has already shown interest in the establishment of a lodge near the Boteti river near the western edge of Makgadikgadi Pans National Park. The community should offer short-term leases to these companies if they do not want to go into joint ventures. A community campsite is proposed near Khumaga.

7.2.4.2 Fencing the western boundary of the Makgadikgadi Pans National Park

The western boundary of the Makgadikgadi Pans National Park runs along the channel of the Boteti river from Moreomaoto to Sukwane. The river is used for livestock and cropping by communities living on the west bank and by wildlife for water and forage. Crop damage by wildlife is common and some animals pose a threat to both humans and livestock. Large numbers of livestock stray into to National Park or are deliberately taken there to graze.

The Makgadikgadi/Nxai Pans Management Plan proposes to fence at least part of the western boundary of the National Park. Before such a fence is erected, the boundary between the National Park and communal land has to be negotiated. There are several options, such as a fence on the east bank or on the west bank, or a fence crossing the river at one or more sites. The latter option is called the "give and take fence" and could satisfy both the needs of the community and the DWNP. For a correct alignment of the fence the Boteti river has to be surveyed, including soils, land suitability for molapo farming, and present land use. Such a survey is part of the proposed Boteti river project (Section 7.3.1). The survey could result in various detailed proposals for fence alignment which could then be discussed with the communities concerned and the DWNP.

7.2.5 Improved conditions for Remote Area Dwellers

From a Participatory Rural Appraisal in Kedia in 1996 (BOC, 1996) it appeared that RADs from that village were most interested in animal production and on-site job creation. The villagers had good memories of the Kedia Game Harvesting Project of the late eighties, which came to a premature end because of poor management and a depleted resource base. RADs are very wary of reserved areas, fearing to be left alone in remote areas without water and means of living.

The conditions of the RADs cannot be improved without some affirmative action and assistance. Present assistance provided by the government through the Accelerated Remote Area Development Programme and by NGOs should be continued and fine-tuned in close collaboration with the beneficiaries. Some forms of assistance most relevant for the RADs of LetAD are listed below. Specific suggestions for RADs from Kedia are given in the Kedia Baseline Survey (Van der Maas ed., 1995b) and the Kedia Village Development Plan (BOC, 1996).

- Reserve grazing areas for exclusive use by RADs and assist with water development, the formation of farmer associations and management. The grazing areas could be used for livestock production or game ranching, or a combination of the two.

- Assist RADs with taking advantage of employment opportunities, such as drought relief projects, rural road projects and other labour intensive projects.

- Assist RADs in taking advantage of subsidy schemes, such as ALDEP, AE10, etc.

- Assist RADs with village and compound improvement, such as house construction, backyard gardening, water harvesting and small-scale poultry. Certain forms of compound improvement were successfully implemented in Khwee in 1996. (see also Section 7.2.6).

- Train RADs in livestock management and negotiate working and living conditions

7.2.6 Gardening and income opportunities for households with little labour

Several forms of supplementary income generation and/or subsistence have been identified. These include backyard gardening, backyard nurseries, beekeeping and small-scale poultry. None of these activities will keep a family alive, but will supplement income derived from remittances, social welfare, home industries (food processing, beer brewing, handicrafts) and other sources.

Provided a small but cheap source of water is at hand, year-round or seasonal gardening is recommended

for all households. Intensive gardening of very small plots (less than 100 m^2) is recommended with or without poultry and beekeeping. Simple and locally applicable guidelines are needed for this activity. The design and promotion of appropriate gardening techniques is part of a proposed project (Section 7.3.3). Communal gardening around a centrally located waterpoint is another option, but experiences with community projects in Boteti District are not very good (Boteti sub-DLUPU, 1996).

In contrast to beekeeping, the Ministry of Agriculture does not give much attention to backyard gardening. However, in places where a modest but cheap source of water is available, small-scale gardening can be more profitable than rainfed cropping and may be more suited to households with few resources.

Beekeeping and small-scale poultry can be a profitable activity, provided supervision is on a daily basis and continuous. These activities are ideal for people tied to their home, such as single woman with children and the elderly.

7.2.7 Measures to combat the degradation of natural resources

7.2.7.1 Natural woodland management

The vegetation of Letlhakane Agricultural District is characterized by grasslands, shrub savanna and savanna. Forests and real woodlands[6] do not occur. The most valuable forest resources occur in the following areas:

- Gidikwe mixed savanna: Gidikwe ridge west of the Boteti river (total area 432 500 ha)
- Mosu mixed savanna: around Mosu and Nthane (total area 47 800 ha)
- Sua east mopane dense savanna: east of Sua Pan (total area 73 200 ha)
- Khwee morukuru woodland: north of Khwee (total area 6 000 ha)
- Boteti riverine dense savanna: banks of the Boteti river between Makalamabedi and Mmadikola (total area 18 700 ha)

The forestry resources are in decline because of various reasons, including absence of flooding and groundwater recharge (Boteti river), increased grazing and increased exploitation. The population of Letlhakane Agricultural District and the demand for wood and timber will continue to grow for the foreseeable future.

Communities with an interest to secure their long-term supply of wood and timber should reserve suitable areas[7] for forestry. Such areas should be managed and protected by the community with assistance from the Forestry and Range Ecology Division (MoA) and/or NGOs. Where possible, forestry production should be combined with crafts, beekeeping, gathering (veld products), fodder production ("cut and carry"), wildlife utilization, tourism and soil and water conservation.

Natural woodland management is a relatively new concept in Botswana, particularly in the context of communally owned land and needs further study. Proposals to reserve the morukuru woodland north of

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[6] For the purpose of vegetation mapping a woodland is defined as an area with a tree canopy cover of more than 60%. However, the term woodland is also used loosely for any area with a relatively high concentration of trees, such as in expressions like "riverine woodland", "morukuru woodland" and "woodland management"

[7] The size of a managed woodland may vary considerably from place to place but should at least measure several hundred to several thousand hectares to make it productive

Khwee for sustainable use by Khwee residents are in an advanced stage. This project is in the hands of the Boteti sub-DLUPU and has the support of the rural administration and the MoA. Another suitable area for woodland management is Mosu AEA where two villages (Mosu and Nthane) are surrounded by dense savanna. A project concerning natural woodland management in Mosu AEA is formulated in Section 7.3.7.

7.2.7.2 Improved village environment

The northern and north-eastern part of Letlhakane Agricultural District is part of the Makgadikgadi Basin, characterized by the occurrence of salt flats (pans) and soils with a high content of silt and fine sand. The sparse vegetation in and around pans and the nature of the soils give rise to dusty conditions on windy days in dry periods. Wind erosion and dust formation of this nature are exacerbated by trampling of vegetation and soils by livestock. Dusty winds make living conditions uncomfortable for all residents and may cause ill health for some. Although dust formation on a large scale is part of the natural environment, protective measures can be taken in and around settlement to improve outdoor living conditions.

Several programmes are already in place which promote the improvement of village environment. They include the National Tree Planting Day and the tree planting activities of the Forestry Association of Botswana. However, villages such as Rakops, Xhumo, Mopipi, Toromoja and Mosu need a more systematic approach, including the plantation of hedges, the protection and stimulation of natural groundcover (harmless shrubs, grasses and weeds) and the construction of reed fences, grass fences and low mud walls around homesteads across the prevalent wind direction. Stimulation of vegetative growth to combat dust can be combined with the production of fodder and the growth of fruit trees and shade trees around the homestead and around public places (schools, hospitals, offices, kgotla).

For an effective improvement of village environment, support is needed from the whole community and full co-operation between local leaders, District Council, MoA (Forestry), MLGLH and NGOs. A project concerning village environment improvement is formulated in Section 7.3.4.

7.3 PROJECTS

In this Section a number of projects are proposed which are expected to provide some of the solutions to identified land use problems. Projects are needed when required change cannot easily be realized by existing institutions because of lack of funds or expertise or by their limited scope and mandate.

7.3.1 Project A: Boteti river: Natural resource management and arable farming

Even though no floods have occurred in recent years, the Boteti River and its banks are one of the most valuable land resources of LetAD and a relatively large number of people depend on it for an important part of their livelihood. The area has many land uses, including rainfed cropping, molapo farming, grazing, wildlife, veld products and has potential for more, such as tourism and beekeeping. The ecological and economic importance of the area has resulted in land use conflicts and the forest resources and ecological diversity are threatened by exploitation and neglect.

Objectives:

- To improve the productivity of cropping on suitable land in the river
- To promote sustainable use of riverine vegetation for wood and other veld products
- To preserve the biodiversity of the Boteti river ecosystem
- To solve conflict between farmers and DWNP along the western boundary of Makgadikgadi Pans National Park and increase ecological diversification within the Park
- To arrest erosion of the river banks
- To create additional income generating opportunities from tourism, handicraft and beekeeping

Activities:

- To map, at scale 1:5000, the soils, vegetation, waterpoints and present land use of the Boteti River and its banks between Makalamabedi and Mopipi
- To determine the formal or traditional ownership of existing fields and waterpoints
- To determine the land suitability of existing fields for rainfed cropping and molapo farming
- To zone the land for cropping, wildlife (National Park), forestry (management and sustainable use of riverine vegetation), livestock (access to waterpoints and grazing), tourism and settlement
- To construct a wildlife fence, separating communal land and the Makgadikgadi Pans National Park between Khumaga and Sukwane
- To construct drift fences to protect blocks of arable land from livestock and to provide access for livestock to waterpoints
- To design a management system for rainfed cropping and/or molapo farming on suitable arable land
- To re-distribute and formally allocate small fields in the river to interested households
- To regulate the use of existing vegetation and dead wood, and create conditions for regrowth and renewal of the riverine vegetation
- To identify income generating opportunities related to tourism, the production of handicraft, the sale of veld products and beekeeping

Main people and institutions involved:

The project would need the co-operation of the majority of present land users and a close collaboration between the Ministry of Agriculture (DCPF), the Ministry of Commerce and Industry (DWNP, Tourism Div.) and the Ministry of Local Government, Lands and Housing (Land Board, District Administration). The IUCN could also be involved because of their knowledge of the area.

Main inputs:

- Aerial photography at scale 1:10 000 of an area 100 km long and 5 km wide
- Wildlife fence of a length of 50 to 75 km
- Personnel, transport and institutional support

Expected bottlenecks:

- Existing Land Board policy not to allocate land in the Boteti river
- Opposition to removal of livestock from Makgadikgadi Pans National Park from owners, and possible compensation claims
- Opposition to re-distribution of molapo fields from farmers with traditional claims to large fields
- High cost of wildlife fence
- Maintenance and repair of both wildlife and drift fences in the river in case of severe flooding

7.3.2 Project B: Boteti State Land: Tribalization and wildlife management

South and south-east of Makgadikgadi Pan National Park is an area which is part of Boteti State Land (see Map 6, Present Land Use). The area covers 194 000 ha, a substantial part of which is occupied by pans without vegetation. The area is illegally used for livestock production and as such provides a livelihood for approx. 1000 residents at 25 cattleposts and an unknown number of non-residents (see Map 4, Waterpoints). The livestock is not easily translocated, as adjoining communal land in the south already has a very high stocking density. The Makgadikgadi Pans Management Plan (MCI, 1995) includes a proposal to tribalize part of the State Land. The eastern part of the area is enclosed by the Boteti river in the south and a recently erected veterinary cordon fence in the east, north (Tjai) and west. The ecological impact of this fence may be considerable (MCI, 1995). Meanwhile the DWNP has designated the area immediately south of Makgadikgadi Pans National park as WMA, giving priority to use by wildlife.

Objectives:

- To solve the conflict between livestock owners and DWNP and to legalize the position of livestock owners
- To create effective bufferzone, in the form of a WMA or otherwise, between Makgadikgadi Pan National Park and communal land

Activities:

- To make an inventory of population, livestock, waterpoints, cattleposts, veterinary fences and ecologically sensitive sites of the area and its surroundings
- To consult residents and authorities concerned and make a land use plan which may include proposals for the tribalization of State Land and realignment of the veterinary cordon fence

Main people and institutions involved:

The project would need the co-operation of the majority of present land users and a close collaboration between the Ministry of Agriculture (DAHP), the Ministry of Commerce and Industry (DWNP) and the Ministry of Local Government, Lands and Housing (Land Board, District Administration)

Main inputs:

- Personnel, transport and institutional support

Expected bottlenecks:

- Existing legislation concerning State Land boundaries and the use of State Land
- Opposition to change from livestock owners within Boteti State Land

7.3.3 Project C: Gardening: appropriate cultivation practices for resource-poor households

More than 10% of the rural households in Letlhakane Agricultural District do not have sufficient resources in terms of capital, draught power and labour to practice conventional forms of cultivation. For the same reason they cannot make fully use of existing government programmes and subsidies, such as ALDEP and Drought Relief. These households mostly consist of a mother or grandmother with small children. Rather than attempting to cultivate large fields in distant lands areas, it would be more appropriate for these farmers to cultivate small plots in an intensive manner near their homestead. This type of gardening would combine agro-forestry practices with soil fertility improvement and water conservation techniques to produce fruits, vegetables, legumes and cereals mainly for home consumption. The garden would be a combination of rainfed and irrigated crop production, depending on availability of water and land and other factors. This type of gardening could be combined with small-scale poultry production and/or beekeeping. The gardens could be situated near individual homesteads (backyard gardening) or developed as a block of several individual gardens at a suitable site near the village (communal gardening). In the latter case assistance can be obtained from the MoA (AE10 projects). Existing government support programmes should be adjusted to accommodate and encourage this form of gardening.

Objectives:

- To assist resource-poor farmers to produce nutritious fruits, vegetables and other crops for home consumption and minor sales

Activities:

- To design and promote forms of both rainfed and irrigated gardening, appropriate for resource-poor farmers
- To adjust government support programmes for the benefit of resource-poor farmers

Main people and institutions involved:

The co-operation of a substantial number of resource-poor farmers is required, otherwise the project is mainly in the hands of the Ministry of Agriculture (DCPF). The Permaculture Trust of Botswana may play an advisory role.

Main inputs:

- Personnel, transport and institutional support

Expected bottlenecks:

- Regulations concerning the use and cost of water provided by the District Council or the Department of Water Affairs

7.3.4 Project D: Improvement of village environment

The northern and north-eastern part of Letlhakane Agricultural District is part of the Makgadikgadi Basin, characterized by the occurrence of salt flats (pans) and soils with a high content of silt and fine sand. The sparse vegetation in and around pans and the nature of the soils give rise to dusty conditions on windy days in dry periods. Wind erosion and dust formation of this nature are exacerbated by trampling of vegetation and soils by livestock. Dusty winds make living conditions uncomfortable for all residents and may cause ill health for some. Although dust formation on a large scale is part of the natural environment, protective measures can be taken in and around settlement to improve outdoor living conditions. Protective measures include the cultivation of hedges, protection and stimulation of natural groundcover (harmless shrubs, grasses and weeds) and the construction of reed fences, grass fences and low mud walls around homesteads across the prevalent wind direction. Villages particularly vulnerable to dusty winds include Rakops, Xhumo, Mopipi, Toromoja and Mosu. Stimulation of vegetative growth to combat dust can be combined with the production of fodder and the growth of fruit trees and shade trees around the homestead and around public places (schools, hospitals, offices, kgotla).

Objectives:

- To improve outdoor living conditions and health of residents

Activities:

- To select and provide suitable plant species for windbreaks and other use
- To design and promote appropriate methods of yard maintenance, including cleaning, hedge and tree plantation, and fence or wall construction

Main people and institutions involved:

Co-operation of local residents and village committees is essential. The Forestry Division of DCPF (MoA) and the District Administration would be involved, together with NGOs such as the Permaculture Trust of Botswana and the Forestry Association of Botswana.

Main inputs:

- Personnel, transport and institutional support

Expected bottlenecks:

- Negative attitude of residents towards vegetation and hedges in and around the compound

7.3.5 Project E: Water harvesting for livestock production and wildlife

Water for livestock is mainly derived from open wells and boreholes. Open wells, common in the northern and north-eastern part of LetAD, tap perched groundwater tables which are recharged during periods of heavy rainfall. Boreholes, common in the west and south of LetAD, mainly tap deep groundwater which is probably not being recharged and therefore may dry up in the future. The combination of permeable, sandy soils and almost flat topography in the west and south prevents runoff and the development of rivers and other forms of surface water. In areas without surface water and without shallow groundwater of good quality, rainwater harvesting techniques may be appropriate to maintain small numbers of livestock or wildlife. Such techniques can be applied in areas with gentle slopes (e.g. fossil dune formations and fossil valleys). The catchment would be a protected upper slope with an artificially sealed surface. The collection point would be situated at the foot of the slope and consist of a sealed trough, filled with sand. Water can be extracted from the sand with a hand pump or windmill.

Objectives:

- To provide sustainable water supply for small herds of livestock or wildlife

Activities:

- Literature study and consultation of experts in the field of water harvesting techniques
- Field trials of water harvesting techniques
- Construction of a few water harvesting sites and monitoring

Main people and institutions involved:

- Ministry of Agriculture: Water Development Section

Main inputs:

- (Government) Personnel, transport and institutional support
- Consultancy water harvesting
- Materials and equipment for trial sites

Expected bottlenecks:

- Water harvesting as proposed involves interference with the soil and vegetation and will cause environmental change over an area of a few hectares per site
- Water harvesting as proposed may turn out to be too costly or unreliable to be practicable.
- As dams and wells, water harvesting sites have to be continuously maintained and protected

7.3.6 Project F: Detailed land use plans for existing major lands areas

Large lands areas, surrounded by a perimeter fence, occur near Mosu (Nthane), Letlhakane, Mmatshumo, Mokobaxane (2) and Moreomaoto. The practice of concentrating fields in one area has many advantages, such as better protection from livestock, more efficient extension service, and more effective pest control. The lands areas of LetAD are not functioning properly as they cover large areas with relatively few fields. The existing perimeter fences are very long, often poorly maintained and have many poorly controlled gates. Many farmers keep smallstock, lactating cows, calves and draught animals at the lands during the growing season and some lands areas may even include one or more cattle posts. In addition to the perimeter fence, many farmers, encouraged by ALDEP subsidies, have constructed a wire fence around their individual field.

The ideal lay-out of a lands area depends on many factors and will differ from place to place. Some important elements of a detailed land use plan for a lands area are:

- A choice by the farmers for individual fencing or collective (perimeter) fencing
- A (further) concentration of fields on the most suitable sites
- An effective system of roads with few gates (in case of a perimeter fence)
- Easy access to existing water points

Objectives:

- To improve the efficiency and productivity of lands area
- To guide farmers and Land Board with future land allocations
- To make efficient use of existing fencing subsidies

Activities:

- The formation or revival of farmer groups (drift fence groups)
- Soil survey and land suitability assessment of present lands area and immediate surroundings
- An inventory of present land use (fields, compounds, waterpoints, livestock)
- A survey of present perimeter fence and gates (location, condition)
- The preparation of a land use plan with farmers/farmer group

Main people and institutions involved:

- Farmers
- Regional Agricultural Office: Soil Surveyor, Land Use Officer, Agricultural Land Use Planner
- District Agricultural Office (subsidies for fencing, etc).
- Land Board, District Council (roads, waterpoints)

Main inputs:

- Personnel, transport and institutional support
- Existing subsidies

Expected bottlenecks:

- In exceptional cases some fields may have to be re-allocated or some farmers left out of a re-designed lands area.

7.3.7 Project G: Natural woodland management in Mosu Agricultural Extension Area

The north and north-east of Mosu AEA is characterized by a dense savanna vegetation with sizable trees (notably mopane). If properly managed, selected areas could provide timber, poles and firewood on a sustainable basis.

Objectives:

- To provide forestry products to local community on a sustainable basis

Activities:

- To make inventory of forest resources in Mosu Agricultural Extension Area
- To investigate present use and customary rights of land involved
- To form a local forest management group
- To prepare a management plan with the forest management group

Main people and institutions involved:

- Local residents
- Regional Agricultural Office: Forestry Section
- NGOs (FAB, other)

Main inputs:

- Personnel, transport and institutional support (government, NGOs)

Expected bottlenecks:

- Exploitation of woodlands in remote areas may be difficult to control
- The "ownership" of the woodlands and the distribution of benefits to the whole community may be an issue

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ANNEXES

ANNEX 1 DETAILS OF TOPOGRAPHIC MAPS, SOIL MAP, AERIAL PHOTOGRAPHY AND SATELLITE IMAGERY COVERING LETLHAKANE AGRICULTURAL DISTRICT

1. AVAILABLE SHEETS TOPOGRAPHICAL MAPS, 1:50 000 SERIES

NB Coverage not complete (missing sheets not yet published)

sheet no.		type (*)	sheet no.		type	sheet no.		type
2023	B4	p77	2025	C1	p82	2125	A1	p73
2024	A1	p77		C3	p82		A2	p73
	A3	p77		C4	p82		A3	p73
	A4	p78	2124	A2	p78		A4	p
2024	B3	p77		A4	p	2125	B1	p73
2024	C2	p78	2124	B1	p73		B2	c77
	C4	p78		B2	p73		B3	p73
2024	D1	p78		B3	p73		B4	c77
	D3	p78		B4	p73	2126	A1	c77
	D4	p					A3	c77
						2126	C1	c79

(*) p73 = photomaps from 1971 photography + additions (1972), published 1973
p77 = photomaps from 1973 photography + additions (1976), published 1977
p78 = photomaps from 1973 photography + additions (1976 or 1978), published 1978
p82 = photomaps from 1978 photography + additions (1980), published 1982
c77 = conventional map from 1971 photography + additions (1974), published 1977
c79 = conventional map from 1974 photography + additions (1976), published 1979

2. AVAILABLE SHEETS TOPOGRAPHICAL MAPS, 1:250 000 SERIES

sheet no.	name	type	year
10 (SF.34.4)	Toteng	monochrome	?
11	Bushman Pits (Gweta)	conventional	1990
12	Nata	conventional	1983
16 (SF.35.5)	Lake Xau (Orapa)	monochrome	1981
17	Matsitama (Letlhakane)	conventional	1987
22	Mazeamanong	monochrome	1985

3. MOST RECENT AERIAL PHOTOGRAPHY

year	contract name	scale
1985	Eastern Kalahari Area A	1:50,000
1986	Eastern Kalahari	1:50,000
1987	Gweta - Nata	1:50,000
1991	Okavango Delta(*)	1:50,000

(*) overlaps with western part of Gweta-Nata

4. SATELLITE IMAGERY (AVAILABLE PRINTS)

Landsat 3 (?) (in Serowe office)

Makgad./Maitengwe	185-074	4/11/81	bands 457 (poor)
Makgad./Maitengwe	185-074	8/5/81	bands 457, medium quality
Maun/Makgadikgadi	186-074	5/11/81	bands 457 (poor) 2 copies
Deception/Orapa	186-075	5/11/81	bands 457, medium quality

Landsat 5 (borrowed from Cartography Section, Land Utilization Division)

Orapa	173-075	7 June 1994	bands 432, good quality
Mmashoro	172-075	(not available)	
Makgadikgadi	173-074	(not available)	
Maun	174-074	(not available)	

5. AVAILABLE SHEETS SOIL MAP, 1:250 000 SERIES

sheet no.	name	year
10	Toteng	1988
11	Gweta (Bushman Pits)	1990
12	Nata	1984
15	Letiahau	1990
16	Orapa (Lake Nxau)	1989
17	Letlhakane (Matsitama)	1989

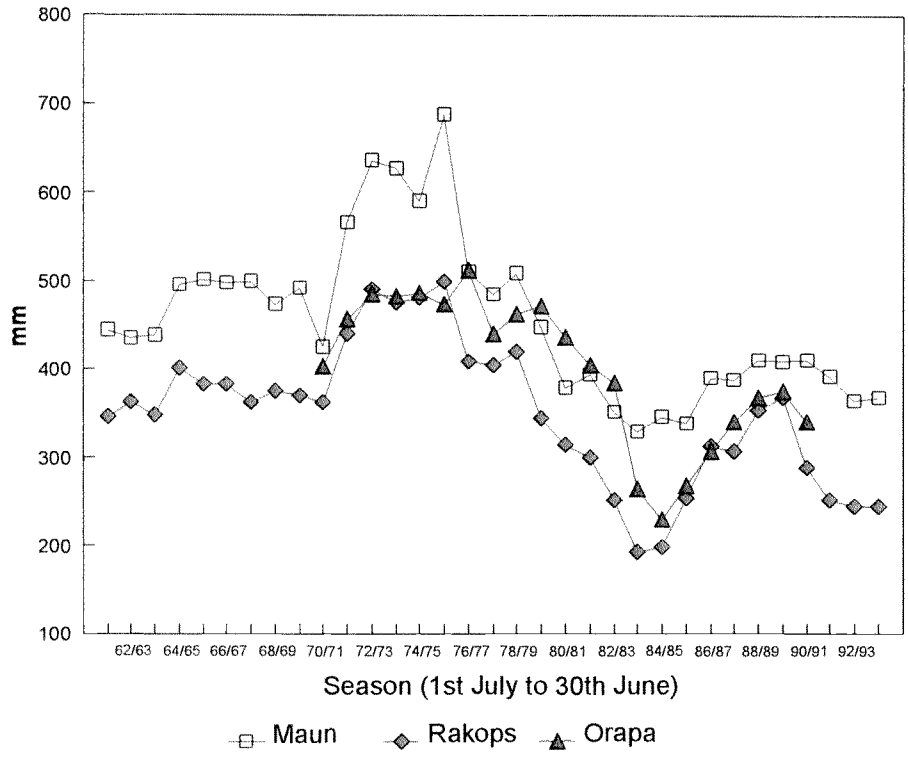
6. COORDINATES/GRID REFERENCE OF RECTANGLE COMPRISING STUDY AREA

Coordinates	upper/right corner	S 20° 12′ E 26° 16′
	lower/left corner	S 22° 25′ E 23° 53′
UTM grid	upper/right corner	S 7 765 000 E 425 000
	lower/left corner	S 7 519 000 E 173 750

dimensions: North: 246 km, East: 251 km = 98.4 cm x 100.4 cm (at scale 1:250,000)

ANNEX 2 ADDITIONAL RAINFALL DATA

Figure A2.1 MOVING AVERAGES OF SEASONAL RAINFALL



The moving average of one season is the average of the rainfall of that seaon and the rainfall of the two preceding and two following seasons. For example, the moving average for the season 71/72 is the sum of the seasonal rainfall of the five seasons from 69/70 to 73/74, divided by five.

Table A2.1 MONTHLY AND SEASONAL* RAINFALL (mm): MAUN (59/60 – 95/96)

STATION: MAUN Height: 945 m asl Latitude: 1959 S
STATION NO.: 130 Longitude: 2325 E

YEAR	J	A	S	O	N	D	J	F	M	A	M	J	SEASON TOTAL
59/60	0.0	0.0	0.1	2.1	18.3	80.2	30.5	73.4	21.0	71.0	16.2	3.3	316.1
60/61	0.0	0.0	0.0	2.7	54.2	49.3	111.8	133.2	145.3	12.2	24.4	0.0	533.1
61/62	5.4	0.0	0.0	3.8	30.0	35.2	155.1	35.5	8.3	41.2	0.0	0.0	314.5
62/63	0.0	3.9	0.0	4.4	79.9	113.6	208.7	58.0	66.6	12.8	4.8	0.3	553.0
63/64	0.0	0.0	0.0	29.8	98.9	208.7	79.2	70.1	17.6	0.0	0.0	0.0	504.3
64/65	0.0	0.0	0.2	16.1	50.0	49.8	33.2	54.0	6.4	58.0	0.0	0.0	267.7
65/66	0.0	0.0	2.3	0.2	35.6	52.5	101.1	160.0	123.6	59.7	0.2	17.1	552.3
66/67	0.0	0.0	29.2	0.0	2.7	108.3	137.6	186.1	20.8	120.4	0.0	0.0	605.1
67/68	0.0	0.0	0.0	8.8	111.9	64.1	109.9	104.2	81.3	65.5	33.8	0.0	579.5
68/69	0.0	0.0	0.0	2.1	70.2	59.9	50.2	245.3	36.9	15.4	0.1	0.0	480.1
69/70	0.0	9.6	21.0	10.1	67.6	13.0	123.6	21.2	9.2	1.4	0.0	0.0	276.7
70/71	0.0	0.0	8.6	0.0	58.7	159.7	108.4	12.4	34.4	44.6	0.0	0.0	426.8
71/72	0.0	0.0	1.6	9.7	66.8	94.4	260.3	51.5	192.9	19.8	0.0	0.0	697.0
72/73	0.0	0.0	0.0	10.5	2.0	45.2	80.8	67.5	21.9	14.8	0.0	0.0	242.7
73/74	0.0	0.0	0.0	100.8	43.9	262.2	347.0	365.7	17.9	50.1	0.0	0.0	1187.6
74/75	0.0	0.0	11.1	6.5	98.7	27.8	161.1	60.8	191.4	71.3	3.5	0.0	632.2
75/76	0.0	0.0	0.0	1.2	10.5	71.2	113.6	68.1	108.3	3.7	2.7	0.0	379.3
76/77	0.0	0.0	12.0	25.3	74.2	37.7	114.8	98.4	126.5	19.2	4.0	0.0	512.1
77/78	0.0	1.2	31.9	3.1	77.1	226.7	91.9	226.2	37.4	12.1	14.4	12.0	734.0
78/79	0.0	0.0	0.2	11.2	19.0	73.2	124.8	30.2	25.8	7.3	0.0	0.0	291.7
79/80	0.0	0.1	0.0	26.8	20.1	36.5	91.0	290.5	42.5	1.2	0.0	0.0	508.7
80/81	0.0	0.0	1.9	3.0	74.0	27.7	126.3	160.6	92.9	5.2	4.5	0.0	496.1
81/82	0.0	0.0	0.0	8.2	74.7	58.6	24.5	17.0	11.3	14.9	0.0	0.0	209.2
82/83	0.0	0.0	0.0	101.1	84.2	34.6	98.6	11.4	25.1	19.5	15.8	1.0	391.3
83/84	0.0	0.0	0.0	20.0	53.5	153.4	20.0	17.9	81.8	8.3	0.9	0.0	355.8
84/85	0.0	0.3	0.5	20.2	92.5	12.6	76.8	41.8	55.1	2.4	0.0	0.0	302.2
85/86	0.0	0.0	0.0	21.6	7.8	134.7	53.8	70.0	34.6	52.4	10.7	0.0	385.6
86/87	0.0	0.0	19.2	49.6	49.3	57.1	32.2	60.3	27.3	0.0	0.0	0.0	295.0
87/88	0.0	0.0	3.9	8.5	6.1	92.3	38.2	104.0	79.4	19.2	0.0	0.0	351.6
88/89	0.0	0.0	7.6	12.9	14.5	46.0	215.5	180.2	44.3	96.3	0.0	0.0	617.3
89/90	0.0	0.0	0.0	0.0	7.2	40.1	87.1	110.1	33.3	17.3	0.0	0.0	295.1
90/91	0.0	0.0	0.0	17.4	5.5	41.5	177.6	133.9	121.6	0.0	0.0	0.0	497.5
91/92	0.0	0.0	5.0	28.5	12.3	78.4	50.1	7.4	87.3	5.0	5.0	5.0	284.0
92/93	0.0	0.0	1.4	6.7	40.7	55.1	66.5	122.0	15.4	47.4	0.0	0.0	355.2
93/94	0.7	0.0	8.2	14.3	23.9	154.8	275.0	50.0	6.2	0.0	0.0	0.0	533.1
94/95	0.0	0.0	0.0	0.0	44.0	15.2	27.0	14.4	48.3	0.0	2.0	0.0	150.9
95/96	0.0	0.0	21.6	11.2	16.6	54.1	139.1	260.6	9.0	NA	NA	NA	512.2
MEAN	0.2	0.4	4.5	15.9	45.4	77.6	108.2	95.0	56.8	27.5	4.0	1.1	435.5
SD %					69.9	77.7	68.6	87.4	88.4				43.5

Table A2.2 MEAN (mm) AND STANDARD DEVIATION MONTHLY AND SEASONAL* RAINFALL MAUN (68/69 – 89/90)

STATION: MAUN Height: 945 m asl Latitude: 1959 S
STATION NO.: 130 Longitude: 2325 E

	J	A	S	O	N	D	J	F	M	A	M	J	SEASON TOTAL
MEAN	0.0	0.5	5.4	20.6	48.8	80.2	110.9	105.1	60.5	22.6	2.6	0.6	457.6
SD %					64.1	82.1	69.3	92.0	85.6				46.9

* SEASON = Period from the 1st of July one year to the 30th of June the next year
SD % = Standard Deviation in percentage NA = Not Available

Table A2.3 MONTHLY AND SEASONAL RAINFALL (mm): ORAPA (68/69 – 94/95)

STATION: ORAPA Height: 748 m asl Latitude: 2115 S
STATION NO: 179 Longitude: 2523 E

YEAR	J	A	S	O	N	D	J	F	M	A	M	J	SEASON TOTAL
68/69	NA	NA	NA	NA	22.6	44.5	31.6	183.0	107.6	12.8	0.9	0.0	403.0
69/70	0.0	2.1	0.0	15.9	104.5	49.9	24.8	48.8	10.4	0.0	0.0	5.5	261.9
70/71	0.0	0.0	5.3	0.0	15.8	157.8	NA	NA	NA	NA	NA	NA	NA
71/72	NA	NA	40.6	34.8	48.3	51.3	206.3	28.7	106.7	25.6	4.2	0.0	546.5
72/73	0.0	0.0	8.5	0.0	28.0	34.3	83.3	76.8	52.0	11.7	0.0	0.0	294.6
73/74	0.0	0.0	1.5	76.9	20.4	98.3	280.7	81.2	34.7	74.9	5.0	0.0	673.6
74/75	0.0	0.0	13.1	0.0	59.5	74.2	99.9	32.9	63.7	45.2	4.9	0.2	393.6
75/76	0.0	0.0	4.5	4.0	11.1	134.5	168.0	44.9	130.3	2.1	26.6	0.0	526.0
76/77	0.0	0.0	28.7	52.0	NA	NA	92.9	41.8	144.1	0.0	3.0	0.0	NA
77/78	0.0	4.0	17.7	4.0	75.0	106.0	94.0	134.5	51.0	0.0	0.0	0.0	486.2
78/79	0.0	0.0	0.2	5.6	19.9	117.5	71.7	32.5	63.8	NA	NA	NA	311.2
79/80	NA	NA	NA	NA	NA	NA	100.5	124.0	2.5	NA	NA	NA	NA
80/81	NA	NA	3.0	2.0	140.0	27.3	245.5	99.5	53.0	0.5	0.0	0.0	570.8
81/82	0.0	0.0	0.0	4.5	34.5	57.8	88.8	48.3	47.5	27.6	0.0	0.0	309.0
82/83	0.0	0.0	0.0	127.3	43.0	67.5	17.5	28.0	10.9	7.0	17.5	4.5	323.2
83/84	0.0	0.0	0.0	14.0	32.1	46.0	24.0	45.3	48.5	3.3	0.0	0.0	213.2
84/85	2.0	0.0	11.1	11.0	64.0	11.3	35.8	37.6	49.0	0.0	0.0	0.0	221.8
85/86	0.0	0.0	0.0	24.3	0.5	35.9	95.6	34.2	35.3	36.0	0.0	0.0	261.8
86/87	0.0	0.8	7.0	27.8	42.5	18.5	3.0	11.0	14.5	0.0	0.0	0.0	125.1
87/88	0.0	0.0	0.0	0.0	54.2	93.6	70.5	153.8	104.2	37.8	0.0	0.0	514.1
88/89	0.0	0.0	3.6	88.7	0.0	86.9	41.3	117.0	12.2	58.3	0.0	0.0	408.0
89/90	0.0	0.0	0.0	28.8	32.2	30.2	135.2	54.6	54.5	7.5	46.0	0.0	389.0
90/91	0.0	0.0	0.0	12.2	24.5	46.0	153.0	115.0	47.0	0.0	0.0	0.0	397.7
91/92	0.0	0.0	0.0	0.0	7.0	28.0	37.0	42.0	12.5	41.0	4.7	0.0	172.2
92/93	4.7	0.0	0.0	3.5	50.5	40.5	101.5	128.5	7.5	1.0	0.0	0.0	337.7
93/94	2.0	0.0	19.0	15.0	NA	NA	109.5	62.5	4.5	0.0	0.0	0.0	NA
94/95	0.0	0.0	0.0	1.5	74.0	28.0	NA	NA	NA	NA	NA	NA	NA
MEAN	0.4	0.3	6.6	22.2	41.8	61.9	96.5	72.3	50.7	17.1	4.9	0.4	370.0
SD %					79.4	65.8	73.8	65.9	79.4				51.2

Table A2.4 MEAN (mm) AND STANDARD DEVIATION MONTHLY AND SEASONAL RAINFALL ORAPA (68/69 – 89/90)

STATION: ORAPA Height: 748 m asl Latitude: 2115 S
STATION NO: 179 Longitude: 2523 E

	J	A	S	O	N	D	J	F	M	A	M	J	SEASON TOTAL
MEAN	0.1	0.4	7.2	26.1	42.4	67.2	95.8	69.4	57.0	18.4	5.7	0.5	380.7
SD %					80.7	62.8	77.6	68.7	70.7				48.3

* SEASON = Period from the 1st of July one year to the 30th of June the next year
SD % = Standard Deviation in percentage NA = Not Available

Table A2.5 MONTHLY AND SEASONAL* RAINFALL (mm): RAKOPS (59/60 – 95/96)

STATION: RAKOPS Height: 914 m asl Latitude: 2103.S
STATION NO: 195 Longitude: 2424 E

YEAR	J	A	S	O	N	D	J	F	M	A	M	J	SEASON TOTAL
59/60	0.0	0.0	0.0	0.0	4.6	56.0	28.2	40.4	31.0	29.5	7.5	0.0	197.2
60/61	0.0	0.0	0.0	0.0	77.5	51.0	35.0	54.5	231.0	41.0	22.1	0.0	512.1
61/62	5.8	0.0	0.0	2.0	24.6	37.0	50.1	32.4	33.3	38.2	0.0	0.0	223.4
62/63	0.0	0.0	0.0	9.0	113.5	162.0	104.0	0.0	47.0	26.0	0.0	5.5	467.0
63/64	0.0	0.0	0.0	35.7	27.0	198.0	13.5	33.0	18.0	0.0	0.0	0.0	325.2
64/65	0.0	0.0	0.0	20.5	38.5	150.0	36.0	9.0	1.0	26.0	0.0	0.0	281.0
65/66	0.0	0.0	2.5	0.0	9.5	19.9	126.4	184.0	9.5	33.4	2.0	57.0	444.2
66/67	0.0	0.0	20.5	5.0	24.0	89.0	229.0	42.4	0.0	75.5	1.5	0.0	486.9
67/68	0.0	6.5	0.0	2.5	18.2	32.5	28.3	43.0	136.4	50.5	56.0	0.0	373.9
68/69	0.0	0.0	0.0	1.0	24.5	48.0	45.0	60.5	126.5	23.3	0.0	0.0	328.8
69/70	0.0	0.0	24.5	37.5	16.5	8.5	17.7	41.5	35.0	0.0	0.0	0.0	181.2
70/71	0.0	0.0	0.0	0.0	95.5	71.5	263.6	0.0	77.3	0.0	0.0	0.0	507.9
71/72	0.0	20.7	0.0	0.0	95.0	49.0	192.8	14.0	59.3	25.0	0.0	0.0	455.8
72/73	0.0	0.0	0.0	1.7	5.0	27.4	58.5	205.5	36.0	0.0	0.0	0.0	334.1
73/74	0.0	0.0	0.0	107.5	57.0	136.5	213.5	125.5	22.0	50.0	7.0	0.0	719.0
74/75	0.0	0.0	5.0	0.0	90.4	37.5	121.0	64.0	79.5	38.0	0.0	0.0	435.4
75/76	0.0	0.0	0.0	0.0	0.0	158.0	151.0	54.5	71.0	0.0	0.0	0.0	434.5
76/77	0.0	0.0	16.1	31.1	59.5	35.2	113.5	76.5	15.0	134.5	0.0	0.0	481.4
77/78	0.0	0.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
78/79	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
79/80	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2.0	NA
80/81	0.0	1.0	19.0	3.0	55.5	46.0	226.4	65.0	85.0	0.0	0.0	0.0	500.9
81/82	0.0	0.0	2.0	0.0	47.6	22.4	18.0	9.0	6.0	0.0	0.0	0.0	105.0
82/83	0.0	0.0	0.0	66.0	76.0	65.0	25.0	30.0	0.0	20.0	18.1	3.0	303.1
83/84	0.0	0.0	0.0	6.0	28.0	16.3	0.0	32.4	69.7	5.2	0.0	0.0	157.6
84/85	0.0	0.0	2.0	0.0	100.2	16.0	33.0	8.0	31.1	0.0	0.0	0.0	190.3
85/86	0.0	0.0	0.0	11.4	9.0	62.0	43.0	23.8	5.2	46.4	0.0	0.0	200.8
86/87	0.0	0.0	5.0	32.9	43.3	13.0	20.0	14.8	11.0	0.0	0.0	0.0	140.0
87/88	0.0	0.0	0.0	14.0	41.3	119.9	18.0	228.0	124.2	30.0	0.0	0.0	575.4
88/89	0.0	0.0	5.0	49.2	0.0	39.4	238.7	57.5	12.0	58.0	0.0	0.0	459.8
89/90	0.0	0.0	0.0	25.0	25.0	3.0	52.0	22.0	7.0	23.0	0.0	0.0	157.0
90/91	0.0	0.0	0.0	0.0	0.0	0.0	224.0	197.5	8.1	0.0	0.0	0.0	429.6
91/92	0.0	0.0	6.0	85.0	3.0	75.0	39.0	10.0	0.0	0.0	0.0	0.0	218.0
92/93	0.0	0.0	0.0	3.0	65.0	26.0	14.0	61.0	0.0	11.0	0.0	0.0	180.0
93/94	0.0	0.0	0.0	35.0	0.0	13.0	220.0	0.0	0.0	0.0	0.0	0.0	268.0
94/95	0.0	0.0	0.0	9.0	40.0	16.0	8.0	0.0	50.5	0.0	0.0	0.0	123.5
95/96	0.0	0.0	0.0	14.5	41.0	36.0	122.0	215.0	NA	NA	NA	NA	428.5
MEAN	0.2	0.8	3.2	17.4	38.7	55.9	88.4	54.1	43.6	23.8	3.5	2.0	329.4
SD %					87.0	92.0	96.0	112.1	115.2				54.2

Table A2.6 MEAN (mm) AND STANDARD DEVIATION MONTHLY AND SEASONAL* RAINFALL: RAKOPS (68/69 – 89/90)

STATION: RAKOPS Height: 914 m asl Latitude: 2103.S
STATION NO: 195 Longitude: 2424 E

	J	A	S	O	N	D	J	F	M	A	M	J	SEASON TOTAL
MEAN	0.0	1.1	4.1	20.3	45.8	51.3	97.4	59.6	45.9	23.9	1.3	0.3	350.9
SD %					75.0	84.2	89.8	101.8	86.0				56.5

* SEASON = Period from 1st of July one year to 30th of June the next year
SD % = Standard Deviation in percentage NA = Not Available

ANNEX 3 ADDITIONAL POPULATION DATA

Table A3.1 POPULATION BOTETI SUB-DISTRICT (1991) BY AGE GROUP AND SEX

	AGE														
	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65+	TOTAL
MALE	2968	2834	2418	1667	1034	1057	915	736	614	436	457	309	291	1096	16834
FEMALE	2888	2825	2469	1946	1447	1447	994	852	664	579	536	422	328	1228	18625
TOTAL	5856	5659	4887	3613	2481	2504	1909	1588	1278	1015	993	731	619	2324	35459

Figure A3.1 POPULATION BOTETI SUB-DISTRICT (1991) BY AGE GROUP AND SEX

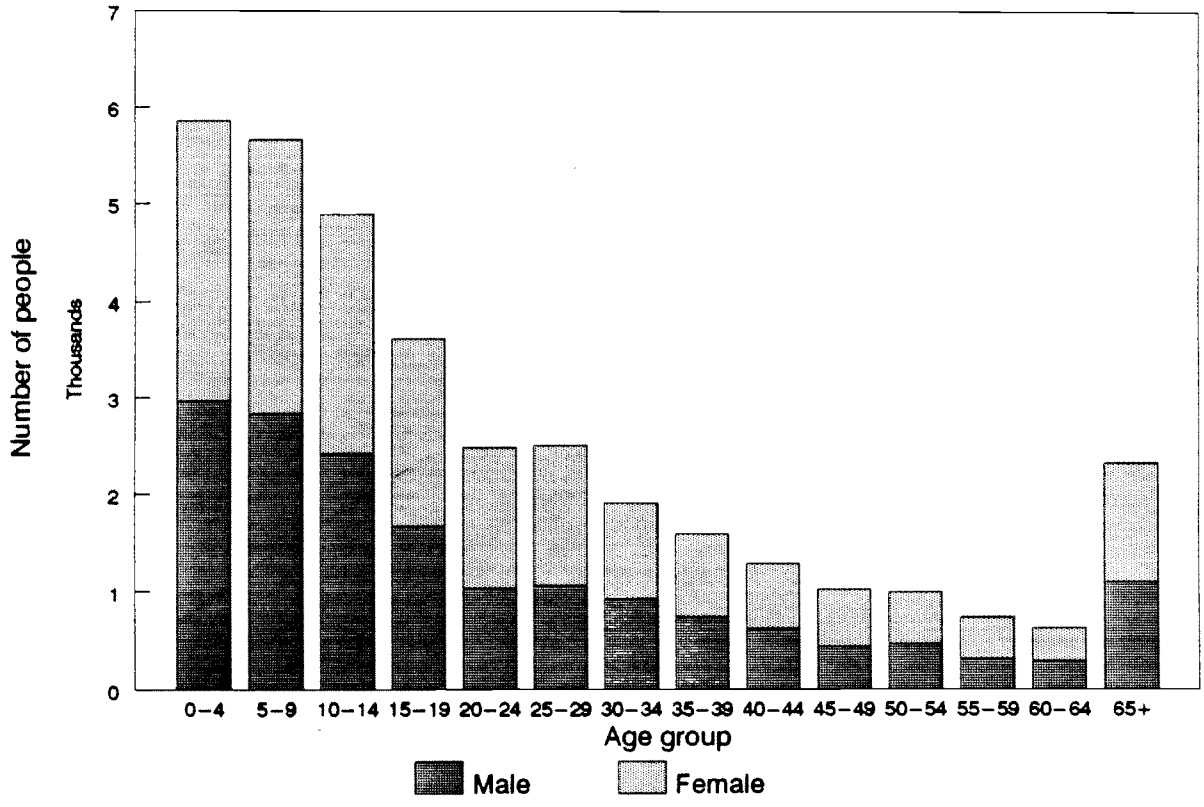


Table A3.2 POPULATION MMADIKOLA VILLAGE (1991) BY AGE GROUP AND SEX

	AGE														
	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65+	TOTAL
MALE	60	69	48	35	13	11	8	3	6	2	5	7	10	10	287
FEMALE	52	55	48	32	34	21	13	18	19	13	17	7	5	27	359
TOTAL	112	124	96	67	47	32	21	19	25	15	22	14	15	37	646

Figure A3.2 POPULATION MMADIKOLA VILLAGE (1991) BY AGE GROUP AND SEX

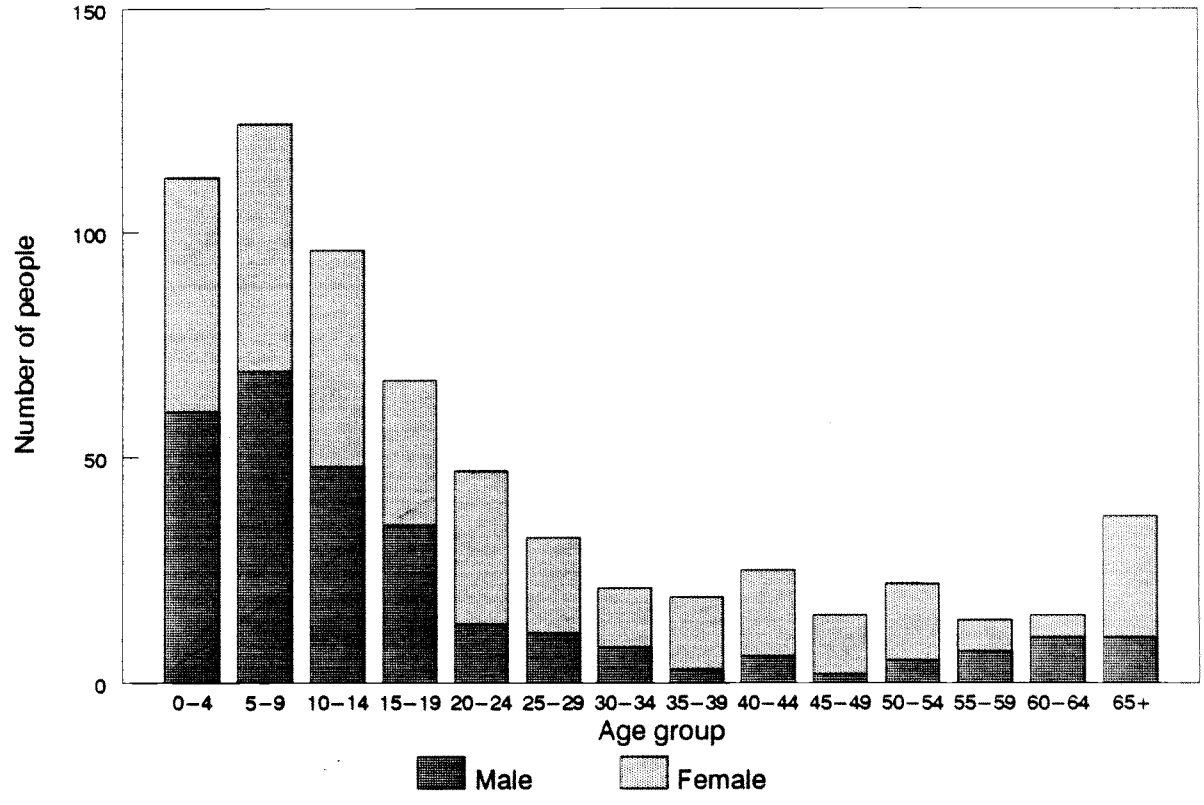
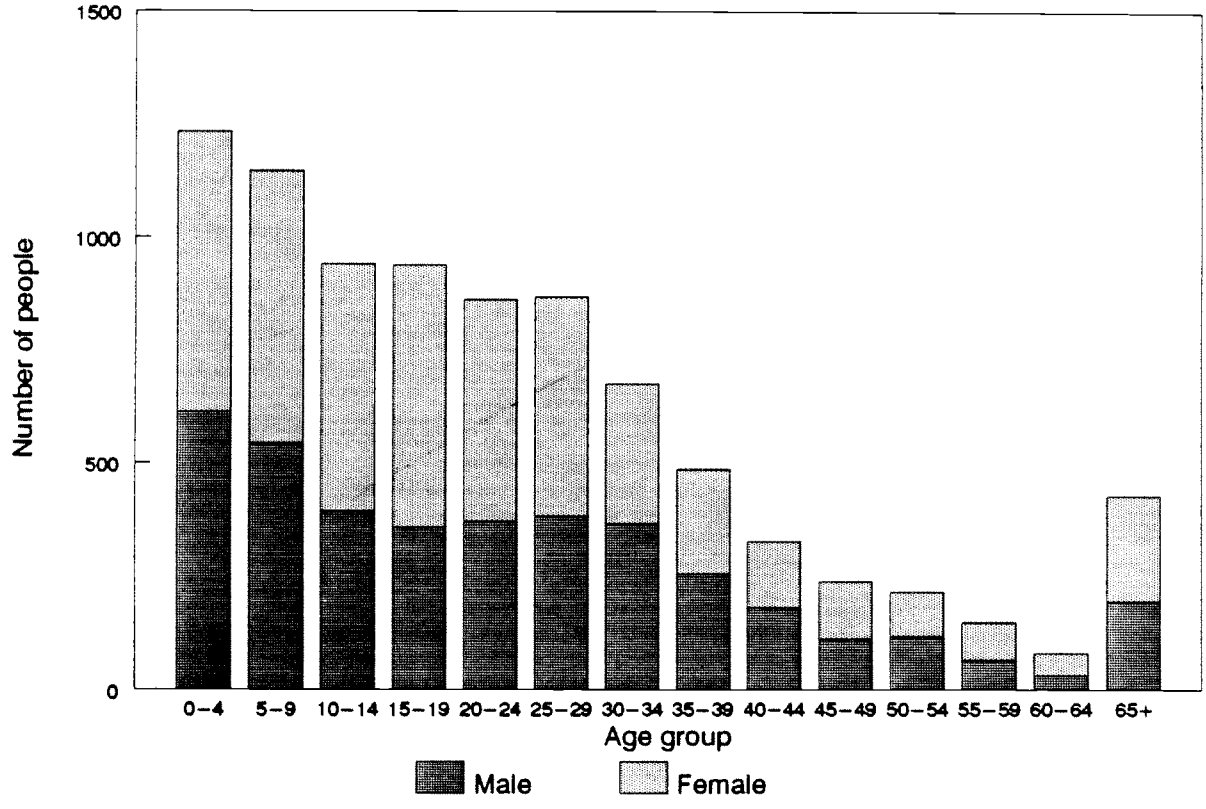


Table A3.3 POPULATION LETLHAKANE VILLAGE (1991) BY AGE GROUP AND SEX

	AGE														
	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65+	TOTAL
MALE	612	543	394	356	369	381	365	254	180	111	116	65	32	194	3972
FEMALE	619	602	548	583	494	488	310	232	145	126	98	83	49	234	4611
TOTAL	1231	1145	942	939	863	869	675	486	325	237	214	148	81	428	8583

Figure A3.3 POPULATION LETLHAKANE VILLAGE (1991) BY AGE GROUP AND SEX



ANNEX 4 DROUGHT RELIEF DATA FROM LETLHAKANE AGRICULTURAL DISTRICT

Table A4.1 RECIPIENTS OF PLOUGHING SUBSIDIES FOR AGRICULTURAL EXTENSION AREAS 1994/95 (source: DAO)

AEA	No. of farmers	Total area (ha)	Farm size (ha)	Means of traction			
				Donkeys	Oxen	Tractor	Hoe
Makalamabedi	193 (240)(*)	557	> 0.25	171	17	5	-
Motopi	150	331	0.36-5.0	107	39	4	-
Moreomaoto	86	218	0.40-6.2	5	81	-	-
Khumaga	279	764	0.37-5.0	119	160	-	-
Rakops	329	572	0.11-8.4	278	11	40	-
Mmadikola	162	254	> 0.09	45	110	3	4
Toromoja	67	66	> 0.13	50	17	-	-
Xhumo	181 (325)	316	> 0.38	140	40	1	-
Kedia	116 (231)	159	?	58	53	1	-
Mopipi	528 (800)	1 103	0.15-5.0	420	55	51	2
Letlhakane/Khwee	394 (420)	1 196	> 0.36	141	3	250	-
Mmatshumo	125	221	> 0.36	68	4	41	2
Mosu	264	710	0.34-5.0	152	33	79	-
TOTAL	2 874	6 467					

(*) Between ( ) the estimated total number of farmers in the AEA

Table A4.2 DROUGHT RELIEF SUBISIDIES (1995/96)

ITEM	UNIT	GROSS SUBSIDY (Pula)	FARMER'S CONTRIBUTION (Pula)	NET SUBSIDY (Pula)
Ploughing *	ha	132.00	12.00	120.00
Row planting *	ha	55.00	5.00	50.00
Seed (sorghum, maize or millet) **	10 kg	7.00	-	7.00

* Maximum of 5 ha ** Maximum of 50 kg in kind (approx. value P 7.00/10 kg)

ANNEX 5 LIVESTOCK NUMBERS AND STOCKING DENSITIES BOTETI SUB-DISTRICT 1995

Table A5.1 NUMBER OF LIVESTOCK FOR VETERINARY EXTENSION AREAS
(Source of livestock numbers: Animal stock census, 1995)

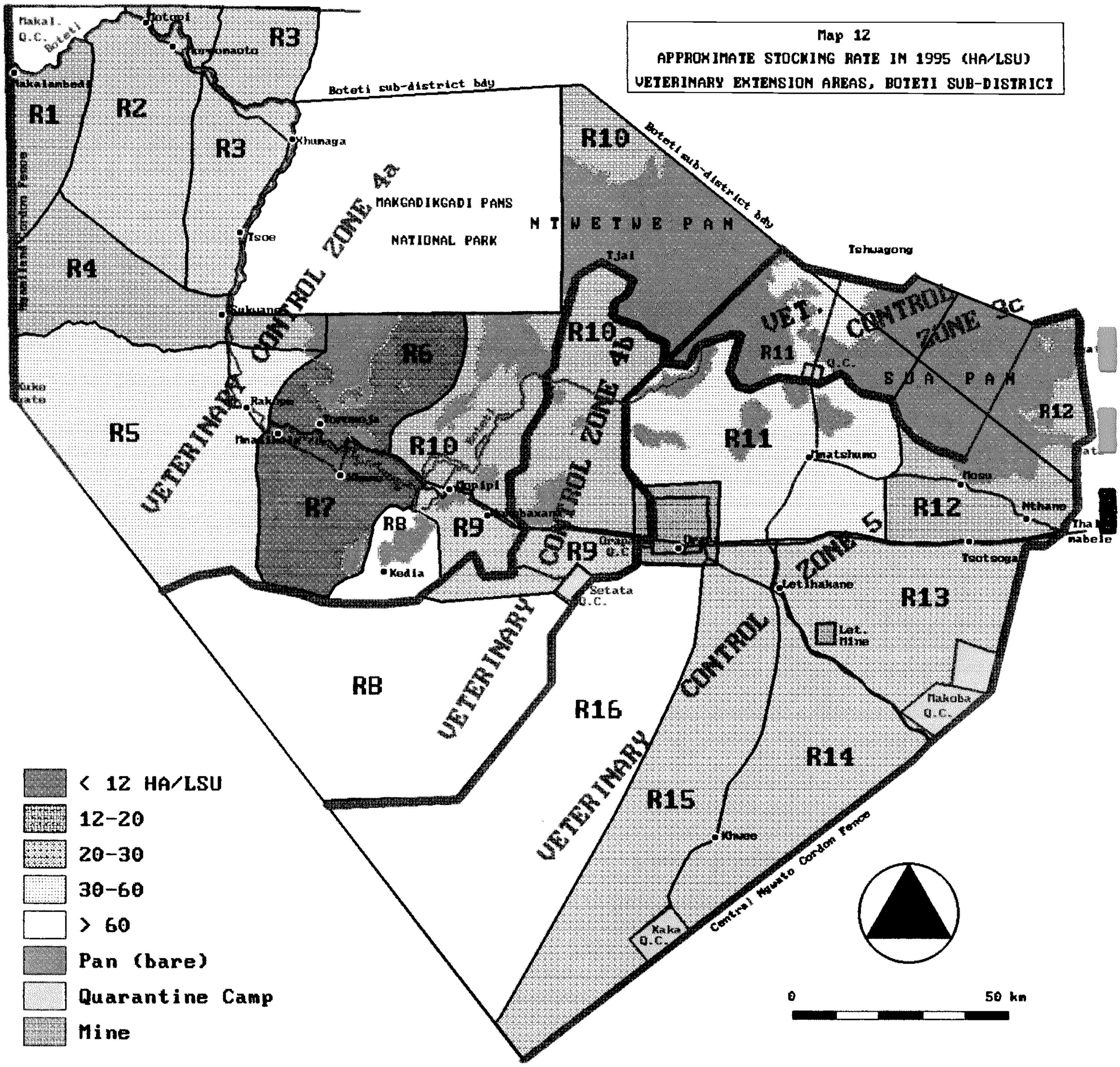
EXTENSION AREA	BU Local	BU improved	COWS	HEIFERS	OXEN	TOL-LIES	CALVES Bull	CALVES Heifer	TOTAL CATTLE	SHEEP	GOATS	HOR-SES	DON-KEYS	TOTAL LSU (*)
R1 Makalamabedi	17	47	1715	382	365	300	499	441	3766	28	1807	64	291	3351.4
R2 Motopi	74	45	2591	1065	531	892	540	529	6270	120	3101	111	548	5685.9
R3 Khumaga	69	31	2273	971	641	796	406	498	5685	129	3602	114	559	5393.4
R4 Rakops west (Sukwane)	51	67	2876	1000	701	897	453	624	6669	409	3941	203	515	6360.7
R5 Rakops east	91	63	2134	764	394	619	603	672	5340	730	2285	91	85	4495
R6 Toromoja	80	82	3445	1276	783	951	316	499	7432	418	3428	132	483	7039.4
R7 Xhumo	502	20	4255	1741	992	1214	463	431	9618	1356	5387	338	332	9517.8
R8 Mopipi west (Kedia)	136	38	1342	412	344	207	289	302	3070	238	2862	103	225	3151.4
R9 Mopipi	71	21	1637	453	307	367	557	553	3966	258	3486	80	266	3655.8
R10 Mokobaxane	205	58	4184	1388	1054	1144	914	1066	10013	535	7196	380	889	9746.3
R11 Mmatshumo	71	30	2865	1001	356	728	490	496	6037	333	4041	192	419	5761.2
R12 Mosu	47	54	2059	850	150	797	507	783	5247	210	4835	76	513	4796.5
R13 Tsotsoga	40	118	3627	1097	435	786	608	714	7425	214	2847	85	181	6408.2
R14 Makoba + R15 Letlhakane (+ R17 Khwee)	80	287	8755	3542	1036	2324	1839	2465	20328	1230	12461	287	746	17719
R16 Setata	5	90	1898	637	271	546	577	609	4633	219	2580	44	177	3886.5
TOTAL (without Orapa)	1539	1054	45656	16579	8360	12568	9061	10682	105499	6427	63859	2300	6229	96968

(*) Bull=1.2 LSU, Cow=1.0 LSU, Heifer=0.6 LSU, Ox=1.1 LSU, Tolly=0.6 LSU, Calf=0.25 LSU, Sheep/Goat=0.15 LSU, Horse=1.0 LSU, Donkey=0.6 LSU

Table A5.2 APPROXIMATE STOCKING RATES FOR VETERINARY EXTENSION AREAS 1995

EXTENSION AREA	TOTAL AREA (1) (ha) (A)	PANS (2) (ha) (B)	HALOMORPHIC GRASSLAND (3) (ha) (C)	AVAILABLE GRAZING (ha) (D=A-B-0.5C)	TOTAL LSU (E)	APPROXIMATE STOCKING RATE (ha/LSU) (D/E)
R1 Makalamabedi	58720	0	0	58720	3351	17.5
R2 Motopi	151100	0	0	151100	5686	26.6
R3 Khumaga	134300	0	0	134300	5393	24.9
R4 Rakops west (Sukwane)	121600	3268	2332	117166	6361	18.4
R5 Rakops east	260800	2135	2330	257500	4495	57.3
R6 Toromoja	100100	23734	38864	56934	7039	8.1
R7 Xhumo	105100	4000	1585	100307.5	9518	10.5
R8 Mopipi west (Kedia)	355200	9060	1885	345197.5	3151	109.6
R9 Mopipi	78520	2380	0	76140	3656	20.8
R10 Mokobaxane	395200	173903	95467	173563.5	9746	17.8
R11 Mmatshumo	361500	120235	56327	213101.5	5761	37.0
R12 Mosu	219500	124896	9625	89791.5	4796	18.7
R13 Tsotsoga	164100	0	0	164100	6408	25.6
R14 Makoba + R15 Letlhakane (+ R17 Khwee)	422600	0	0	422600	17719	23.9
R16 Setata	364400	0	0	364400	3886	93.8
TOTAL	3292740	463611	208415	2724921.5	96966	28.1

(1) Quarantine camps and mines not included
(2) Bare pan surfaces are assumed to be not available for grazing
(3) Of the halomorphic grasslands, surrounding the pans, only 50% was assumed to be available for grazing


Map 12
APPROXIMATE STOCKING RATE IN 1995 (HA/LSU)
VETERINARY EXTENSION AREAS, BOTETI SUB-DISTRICT
R1
R2
R3
R4
R5
R6
R7
R8
R9
R10
R11
R12
R13
R14
R15
R16
Boteti sub-district bdy
MAKGADIKGADI PANS
NATIONAL PARK
N T W E T W E P A N
S U A P A N
VETERINARY CONTROL ZONE 4a
CONTROL ZONE 4b
VET. CONTROL ZONE 9c
ZONE 5
VETERINARY CONTROL
VETERINARY
Khumaga
Tsoe
Tjai
Tshwagong
Mmatshumo
Mosu
Nthane
Tsotsoga
Letlhakane
Let. Mine
Makoba Q.C.
Kedia
Mopipi
Setata Q.C.
Kaka Q.C.
Central Ngwato Cordon Fence
< 12 HA/LSU
12-20
20-30
30-60
> 60
Pan (bare)
Quarantine Camp
Mine
0
50 km

ANNEX 6 VELD FOODS AND MEDICINAL PLANTS IDENTIFIED IN AND AROUND LETLHAKANE AGRICULTURAL DISTRICT

S = Western Sandveld (south-east of Letlhakane Agric. District) (Campbell, Main and Associates, 1991)
K = Khwee (PTB, 1994) and Kedia (Van der Maas, 1995b)
M = Mokobaxane (Mars, 1996) B = mid-Boteti river area (MoA/UB, 1994)

Tubers	digwere	
Ceropegia brachystelina	serua, serowa	SKM
Coccinia sessifolia	legabala,	S
	kgabala	S
?	mahubala	KM
Coccinia rehmanii	legapa	S
Cucumis kalahariensis	mots(h)ia	SK
Ipomoea spp	kgana, kgane	S
Raphionacme burkei	leditsa	S
Brachystelma barberiae	kwele	S
Ledebouria spp	leruswa	SKM
??	mokgothwane	KM
??	sexhudumu	M
??	xhukhumu	M
??	xwhee	K
??	kgaba	K

Bulbs	neku	
Babiana hypogenea	tshuge	S
Walleria nutans	tshe, nxu	S
Eulophia spp	lekwesa	S
Scilla spp	moro	S

Roots	medi	
taproots ??	mokoto	S
Vigna dinteri	tshada	S
???	thobokwe	K

Succulents		
Aloe zebrina	kgopane	S
Caralluma spp	mangoleadikhudu	S
Sansevieria spp	mosokelatsebeng	S
Portulaca spp	serepe	S

Nuts, beans		
Tylosema esculentum	morama	SK
Bauhinia petersiana	motshanja,	S
	motsantsa	K
Vigna unguiculata	dinawa tsanaga	S

Fruits	maungo	
Boscia albitrunca	mot(l)opi	SK
Boscia foetida	mopipi	B
Diospyros lycioides	letlhajwa	S
Ehutia rigida	morobe	S
Ficus sycomorus	motshaba	B
Grewia flava	moret(l)wa	SKMB
Grewia avellana	moragoamohumugadi	S M
Grewia bicolor	mogwana	SKMB
Grewia flavescens	mokgomphata	S M
Grewia retinervis	motsotsojane	SKMB
Grewia spp	moseme	KM
Ochna pulchra	monyelenyele	S
Sclerocarya birrea	morula	M
Strychnos cocculoides	mogorogorwana	SK
Strychnos pungens	mogwagwa	S
Vangueria infausta	mmilo	S
Ximenia spp	moretologa	SKMB
Ziziphus mucronata	mokgalo	SKMB

Leaves	merogo	
Amaranthus spp	thepe	SK
Cleome gynandra	bengwa, rothwe	K
Cucumis myriocarpus	monyaku	S

	matlhare	
Combretum imberbe	motswere	S
Gynandropsis spp	lerotho	S
Lippia scaberina	mosukudu	S
Oxygonum alatum	letswai la khudu	K
Pentarrhinum spp	leshwe	S
Terminalia sericea	mogonono	S

Cucumbers, melons		
Citrullus lanatus	kgengwe	S
	mokate	K
	mokatane	K
Citrullus naudinianus	mokapane,	SK
	motsi,	S
	mokawa	S
Coccinia sessilifolia	legabala	S
	mogabala,	S
??	mokgame	K

Fungi	mabowa	
Amanita edulis	mabowa	S
Termitomyces titanicus	mabowa	S
Terfezia spp	magopo	S

Edible gums	boreku, boroku		
Acacia spp		S	
Burkea africana	monato	S	
Combretum imberbe	motswere	S	
Commiphora spp		S	
Dichrostachys cinerea	moselesele	S	
Terminalia sericea	mogonono	S	

Medicinal plants			
Harpagophytum procumbens	sengaparile	S	
	mokurukwane	S	
	moswaapheba	S	
Jatropha erythropoda (root)	thotamadi		M
Otoptera burchelli (root)	mosifawapoo	S	M
Ximenia spp (root)	moretologa		M
???	kakwe		M
???	melomoya		M
???	sehuba		M
Grewia flavescens (fruit)	mokgomphata		M
Combretum hereroense (bark)	mokabi		M
Viscum spp (fruit)	palamela		M
Cassia abbreviata	monepenepe		M
Acacia tortilis (leaves)	mosu		M
Combretum imberbe (roots)	motswere		M
???	moganetsane		M
???	ketlatlakentse		M
???	areyegae		M
???	magorometsa		M

not identified:	motsega (motsegu?)	S
	mokoshwa	S
	sekope, sek(g)opane	SK
	tsheme	S
	mhukuto	S
	mokeno	S

only products sold:

Grewia spp	moretlwa,	SK
	mokgomphata,	S
	motsotsojane	S
	mogwana	K
	moseme	K
Strychnos cocculoides	mogorogorwana	S
Tylosema esculentum	morama	S
Ximenia spp	moretologa	K

ANNEX 7 CYSLAMB EVALUATION RESULTS

Table A7.1 DEPENDABLE CYSLAMB YIELD OF MAIZE BY LAND UNIT (kg/(ha holding)/year)

Management system [1]				Cr0		Cr3			Cr00
Planting date (from)		DEC1	DEC1	DEC1	NOV1	NOV3	DEC1	DEC1	JAN1
Planting occasions (no)		3	3	3	1	1	1	1	1
Planting density (pl/ha)		15000	15000	15000	15000	15000	15000	25000	15000
Weeding (days after planting)		-	50	30	30	30	30	30	30
Phosphorus level topsoil (ppm)		3	3	3	3	3	3	3	3
LAND UNIT	B	40	220	220	500	460	380	300	210
	C	0	60	60	350	180	180	80	0
	D	40	320	320	900	830	740	710	180
	E	40	320	320	740	740	730	690	180
	F	0	300	310	790	590	550	490	290
	G	60	240	240	650	620	590	540	250
	H	60	240	240	680	680	660	620	250
	J	0	380	380	850	680	610	500	350
	K	0	30	30	150	90	90	0	0
	L	20	260	260	730	670	600	540	120
	M	40	320	320	760	760	740	710	180
	N	40	300	300	740	740	740	710	180

Management system [1]			Cr2			Cr1 Cr4			
Planting date (from)		NOV1	NOV3	DEC1	NOV1	NOV3	DEC1	DEC1	DEC1
Planting occasions (no)		2	2	1	1	1	1	1	1
Planting density (pl/ha)		15000	15000	15000	15000	15000	15000	25000	15000
Weeding (days after planting)		30	30	-	30	30	30	30	30
Phosphorus level topsoil (ppm)		3	3	6	6	6	6	6	10
LAND UNIT	B	340	320	230	720	660	580	530	790
	C	180	90	0	530	320	320	230	410
	D	500	500	240	1220	1140	1030	1030	1230
	E	500	500	240	1030	1030	1010	1010	1200
	F	600	540	20	1080	820	790	760	950
	G	560	560	320	910	890	830	820	1010
	H	590	590	320	950	950	920	910	1120
	J	700	600	60	1170	950	880	850	1040
	K	80	40	0	270	200	200	90	270
	L	400	400	160	1020	930	840	830	1020
	M	500	500	240	1050	1050	1030	1030	1230
	N	500	500	240	1030	1030	1030	1030	1230

[1] Management systems are defined and described in more detail in Section 6.2.1 of this report

Table A7.2 DEPENDABLE CYSLAMB YIELD OF SORGHUM BY LAND UNIT (kg/(ha holding)/year)

Management system [1]				Cr0		Cr3			Cr00
Planting date (from)		DEC1	DEC1	DEC1	NOV1	NOV3	DEC1	DEC1	JAN1
Planting occasions (no)		3	3	3	1	1	1	1	1
Planting density (pl/ha)		15000	15000	15000	15000	15000	15000	25000	15000
Weeding (days after planting)		-	50	30	30	30	30	30	30
Phosphorus level topsoil (ppm)		3	3	3	3	3	3	3	3
LAND UNIT	B	210	200	270	630	630	570	570	210
	C	100	80	160	550	480	480	460	0
	D	210	190	310	820	800	770	810	180
	E	210	190	310	770	770	760	800	180
	F	270	210	400	780	680	660	700	290
	G	220	200	320	720	690	680	720	250
	H	220	200	330	740	740	720	740	250
	J	300	240	450	820	740	680	710	350
	K	100	80	150	500	450	450	450	0
	L	210	190	310	850	800	760	800	120
	M	210	190	310	750	750	750	790	180
	N	210	190	320	770	770	760	800	180

Management system [1]			Cr2			Cr1 Cr4			
Planting date (from)		NOV1	NOV3	DEC1	NOV1	NOV3	DEC1	DEC1	DEC1
Planting occasions (no)		2	2	1	1	1	1	1	1
Planting density (pl/ha)		15000	15000	15000	15000	15000	15000	25000	15000
Weeding (days after planting)		30	30	-	30	30	30	30	30
Phosphorus level topsoil (ppm)		3	3	6	6	6	6	6	10
LAND UNIT	B	400	400	610	860	850	770	810	920
	C	280	240	450	750	650	650	690	780
	D	460	460	240	1100	1090	1050	1110	1210
	E	460	460	640	1050	1050	1030	1090	1190
	F	690	660	640	1060	930	900	950	1070
	G	480	480	510	950	930	930	980	1100
	H	500	500	660	980	980	950	1040	1140
	J	760	700	660	1100	970	920	970	1100
	K	250	220	510	680	630	630	640	750
	L	460	460	450	1120	1090	1030	1090	1190
	M	460	460	640	990	990	990	1080	1180
	N	480	460	640	1050	1050	1030	1090	1190

[1] Management systems are defined and described in more detail in Section 6.2.1 of this report

Table A7.3 DEPENDABLE CYSLAMB YIELD OF MILLET BY LAND UNIT (kg/(ha holding)/year)

Management system [1]				Cr0		Cr3			Cr00
Planting date (from)		DEC1	DEC1	DEC1	NOV1	NOV3	DEC1	DEC1	JAN1
Planting occasions (no)		3	3	3	1	1	1	1	1
Planting density (pl/ha)		15000	15000	15000	15000	15000	15000	25000	15000
Weeding (days after planting)		-	50	30	30	30	30	30	30
Phosphorus level topsoil (ppm)		3	3	3	3	3	3	3	3
LAND UNIT	B	150	140	210	440	440	430	420	300
	C	40	30	110	360	320	320	290	0
	D	150	120	250	640	660	640	650	350
	E	150	120	250	560	560	560	570	350
	F	190	140	310	660	660	480	470	400
	G	160	130	260	560	560	560	570	380
	H	160	130	260	590	600	590	600	380
	J	190	150	340	680	680	510	520	440
	K	40	30	90	340	280	280	240	0
	L	140	120	240	610	650	640	650	350
	M	140	120	240	560	560	560	570	350
	N	150	120	240	560	560	560	570	350

Management system [1]			Cr2			Cr1 Cr4			
Planting date (from)		NOV1	NOV3	DEC1	NOV1	NOV3	DEC1	DEC1	DEC1
Planting occasions (no)		2	2	1	1	1	1	1	1
Planting density (pl/ha)		15000	15000	15000	15000	15000	15000	25000	15000
Weeding (days a. pl)		30	30	-	30	30	30	30	30
Phosphorus level topsoil (ppm)		3	3	6	6	6	6	6	10
LAND UNIT	B	330	330	430	590	590	590	600	710
	C	180	160	190	510	460	460	460	560
	D	370	370	430	850	900	840	920	1000
	E	370	370	430	770	770	770	810	910
	F	520	520	360	890	760	660	670	780
	G	390	390	460	770	770	760	810	910
	H	400	400	460	800	810	810	860	960
	J	550	550	390	930	810	700	740	840
	K	170	140	210	480	400	400	380	500
	L	360	360	430	830	890	840	920	1000
	M	360	360	430	770	770	770	810	910
	N	360	360	430	770	770	770	810	910

[1] Management systems are defined and described in more detail in Section 6.2.1 of this report

Table A7.4 DEPENDABLE CYSLAMB YIELD OF COWPEA BY LAND UNIT (kg/(ha holding)/year)

Management system [1]				Cr0		Cr3			Cr00
Planting date (from)		DEC1		DEC1	NOV1	NOV3	DEC1		JAN1
Planting occasions (no)		3		3	1	1	1		1
Planting density [2]		20000		20000	20000	20000	20000		20000
Weeding (days after planting)		-		30	30	30	30		30
Phosphorus level topsoil (ppm)		3		3	3	3	3		3
LAND UNIT	B	70		80	190	200	200		180
	C	30		50	180	160	160		0
	D	60		100	230	230	230		170
	E	60		100	190	220	210		150
	F	90		130	230	240	210		200
	G	70		90	220	230	230		180
	H	70		100	220	220	230		170
	J	90		130	220	230	200		200
	K	20		30	110	100	100		0
	L	40		60	150	160	160		110
	M	60		90	190	230	220		150
	N	60		90	190	190	190		140

Management system [1]			Cr2			Cr1 Cr4			
Planting date (from)		NOV1	NOV3	DEC1		NOV3	DEC1		DEC1
Planting occasions (no)		2	2	1		1	1		1
Planting density [2]		20000	20000	20000		20000	20000		20000
Weeding (days after planting)		30	30	-		30	30		30
Phosphorus level topsoil (ppm)		3	3	6		6	6		10
LAND UNIT	B	120	120	180		250	250		290
	C	90	80	120		210	210		250
	D	140	140	180		230	230		340
	E	140	140	180		290	270		310
	F	220	220	180		310	270		310
	G	140	140	190		300	300		350
	H	150	150	200		290	300		350
	J	220	220	180		280	260		300
	K	60	50	80		60	120		150
	L	100	100	120		120	200		230
	M	140	140	180		180	280		320
	N	140	140	170		180	250		280

[1] Management systems are defined and described in more detail in Section 6.2.1 of this report

[2] CYSLAMB does not differentiate for planting density of cowpea

Table A7.5 DEPENDABLE CYSLAMB YIELD OF GROUNDNUT BY LAND UNIT (kg/(ha holding)/year)

Management system [1]				Cr0		Cr3			Cr00
Planting date (from)		DEC1		DEC1	NOV1	NOV3	DEC1		JAN1
Planting occasions (no)		3		3	1	1	1		1
Planting density [2]		20000		20000	20000	20000	20000		20000
Weeding (days after planting)		-		30	30	30	30		30
Phosphorus level topsoil (ppm)		3		3	3	3	3		3
LAND UNIT	B	220		240	640	640	610		580
	C	170		190	610	580	580		0
	D	210		260	700	700	640		520
	E	210		260	620	600	520		460
	F	360		430	690	670	660		590
	G	220		270	670	660	660		600
	H	220		270	670	670	620		540
	J	370		430	630	630	620		600
	K	120		150	440	440	440		0
	L	160		200	530	530	510		420
	M	210		260	620	620	530		470
	N	210		250	610	580	510		370

Management system [1]			Cr2			Cr1 Cr4			
Planting date (from)		NOV1	NOV3	DEC1		NOV3	DEC1		DEC1
Planting occasions (no)		2	2	1		1	1		1
Planting density [2]		20000	20000	20000		20000	20000		20000
Weeding (days after planting)		30	30	-		30	30		30
Phosphorus level topsoil (ppm)		3	3	6		6	6		10
LAND UNIT	B	360	360	700		820	780		900
	C	360	290	650		750	750		860
	D	390	390	680		900	820		950
	E	380	380	680		770	670		770
	F	660	640	680		850	840		980
	G	400	400	720		850	850		980
	H	410	410	720		860	800		920
	J	610	610	680		810	790		910
	K	220	220	480		560	560		650
	L	300	300	530		680	650		750
	M	390	390	680		800	680		780
	N	370	370	670		750	650		750

[1] Management systems are defined and described in more detail in Section 6.2.1 of this report

[2] CYSLAMB does not differentiate for planting density of groundnut

ANNEX 8 OPERATING COSTS AND PRODUCER PRICES 1995/96

Table A8.1 OPERATING EXPENDITURE AND INVESTMENT COSTS FOR VARIOUS PRODUCTION SYSTEMS

	TYPE	ITEM	UNIT	PRICE (Pula)	SOURCE
ANNUAL FARMER OPERATING EXPENDITURE	SEEDS	Maize, Kalahari Early Pearl	10kg	3.36	BAMB
		Sorghum, Segaolane	10kg	3.36	BAMB
		Groundnuts	10kg	5.62	BAMB
		Cowpea, Tswana/Blackeye	10kg	5.62	BAMB
	FERTILIZERS	Superphosphate	50kg	39.40	BAMB##
		2:3:2	50kg	45.85	BAMB##
		LAN	50kg	45.70	BAMB##
		Urea	50kg	72.00	BAMB##
	CATTLE HEALTH	Vaccines**	dose/LSU*	1.10	LAC
		Medicines***	dose/LSU*	2.80	LAC
		Dip	dose/LSU*	0.50	LAC
		Supplementary minerals****	dose/LSU*	12.00	LAC
	CATTLE	Transport to abattoir	animal	40–50	Estimate
	POULTRY	Layers	animal	12.50	Bekker, 1996
		Layers mash	kg	1.11	Bekker, 1996
	BEEKEEPING	Sugar	kg	2.30	
FARMER INVESTMENT COSTS	CROPPING	VS10 plough (single furrow)	unit	125.00	Market. Coop#
		Planter (Sebele)	unit		Market. Coop#
		Zigzag harrow (single)	unit	208.75	Market. Coop#
		Cultivator	unit		Market. Coop#
		Hand hoe	unit	9.25	Market. Coop#
		Scotch cart	unit	2468.75	Market. Coop#
	LIVESTOCK	Knapsack sprayer	unit	185.90	LAC
		Dehorning iron	unit	17.80	LAC
		Burdizzo	unit	156.00	LAC
		Syringe	set	3.15	LAC
	BEEKEEPING	Hive	unit	125.00	Bekker, 1996
		Smoker	unit	90.00	Bekker, 1996
		Veil	unit	50.00	Bekker, 1996
	POULTRY	Perimeter fence	m	3.75	Bekker, 1996
		Shelter	unit	50.00	Bekker, 1996
		Water bottle	unit	10.00	Bekker, 1996
		Food tray	unit	10.00	Bekker, 1996

* Calculated from commercially sold bottles/packs/rolls; Livestock Specialist assessment
** Vaccines against Enterotoxaemia, Pasteurella, Lumpy skin and Calf paratyphoid (immature stock only)
*** Terramycin and Sulphamezathin
**** Cattle maintenance lick, salt and bonemeal
BAMB Serowe
Serowe Marketing Cooperative

Table A8.2 VARIOUS PRODUCER PRICES (1995/96)

TYPE	PRODUCT	UNIT	GRADE	PRICE (Pula)	SOURCE
CROPS	Sorghum, Segaolane	kg	Grade 1	0.42	BAMB
		kg	Grade 2	0.39	BAMB
		kg	Grade 3	0.36	BAMB
	Maize (white) KEP ?	kg	Grade 1	0.51	BAMB
		kg	Grade 2	0.49	BAMB
		kg	Grade 3	0.44	BAMB
	Millet	kg	–	0.36	BAMB
	Cowpea (purple)	kg	–	0.61	BAMB
	Cowpea (blackeye)	kg	–	0.96	BAMB
	China pea	kg	–	0.72	BAMB
	Jugo bean	kg	–	0.73	BAMB
	Tepary bean	kg	–	0.51	BAMB
	Groundnut (shelled)	kg	Grade 1	1.32	BAMB
	Groundnut (shelled)	kg	Grade 2	1.26	BAMB
	Groundnut (shelled)	kg	Grade 3	1.06	BAMB
	Sunflower	kg	Grade 1	0.58	BAMB
LIVESTOCK	Cattle (F'town abattoir)	100 kg	Grade SS	488.00	BMC
	(April–July 1995)	100 kg	Grade 1	444.00	BMC
		100 kg	Grade 2	403.00	BMC
		100 kg	Grade 3	372.00	BMC
		100 kg	Grade 4	340.00	BMC
ANIMAL PRODUCTS	Eggs	unit		0.35	Bekker, 1996
	Layers (18 months)	unit		12.50	Bekker, 1996
	Comb honey (farmer's)	kg		12.00	Serowe, RAO
	Comb honey (MoA)	kg		6.50	Serowe, RAO
VELD PRODUCTS	Rothwe (vegetable)	cup		1.00	Serowe market
	Lethaka (reeds)	bundle 10 kg		5.00	Bekker, 1996
	Morethwa (fruits)	cup		1.00	Serowe market
	Khadi (wine/beer)	cup		0.10	Mars, 1996

ANNEX 9 GROSS MARGINS OF SELECTED PRODUCTION SYSTEMS (RAINFED CROPPING) BY LAND UNIT

(For explanation see Section 6.2.4 of this report)

Land Unit B

(1)	(2)	(3)	(4)	(5)			(6)	(7)	(8)
Production System		Potential Dependable Yield (kg/ha)	Production Value (a) (P/ha)	Variable Production Costs (P/ha) seed (b)	fertilizer (c)	fuel (d)	Potential Gross Margin (P/ha)	Area farmed (ha)	Potential Gr.Mar. Total (P)
Sorghum	Cr00	210.00	88.20	7.50	0.00	0.00	80.70	1.50	121.05
	Cr0	270.00	113.40	7.50	0.00	0.00	105.90	4.00	423.60
	Cr1 (e, f)	860.00	361.20	4.00	0.00	0.00	357.20	1.50	535.80
	Cr2	400.00	168.00	7.50	0.00	0.00	160.50	4.00	642.00
	Cr3	630.00	264.60	7.50	0.00	81.00	176.10	10.00	1761.00
	Cr4 (e)	860.00	361.20	7.50	20.00	81.00	252.70	10.00	2527.00
Millet	Cr00	300.00	108.00	7.50	0.00	0.00	100.50	1.50	150.75
	Cr0	210.00	75.60	7.50	0.00	0.00	68.10	4.00	272.40
	Cr1 (e, f)	590.00	212.40	4.00	0.00	0.00	208.40	1.50	312.60
	Cr2	330.00	118.80	7.50	0.00	0.00	111.30	4.00	445.20
	Cr3	440.00	158.40	7.50	0.00	81.00	69.90	10.00	699.00
	Cr4 (e)	590.00	212.40	7.50	20.00	81.00	103.90	10.00	1039.00
Maize	Cr00	210.00	107.10	7.50	0.00	0.00	99.60	1.50	149.40
	Cr0	220.00	112.20	7.50	0.00	0.00	104.70	4.00	418.80
	Cr1 (e, f)	720.00	367.20	4.00	0.00	0.00	363.20	1.50	544.80
	Cr2	340.00	173.40	7.50	0.00	0.00	165.90	4.00	663.60
	Cr3	500.00	255.00	7.50	0.00	81.00	166.50	10.00	1665.00
	Cr4 (e)	720.00	367.20	7.50	20.00	81.00	258.70	10.00	2587.00

(a) Grade 1 for sorghum and maize

(b) 3 kg/ha for planting density of 15 000 pl/ha; 1.5 kg/ha for production system Cr1

(c) Cost of fertilizer spread over three years

(d) 3 operations, 2.5 hours/ha, 10 l/hour, 1.08 P/l

(e) Extra labour for fertilizer and/or manure application and weeding

(f) Extra labour for row-planting by hand

Note: Although some production systems allow for mixed cropping (Cr00, Cr0, Cr2) or inter-cropping (Cr1), all figures are for single crop stands

Land Units C and K

Production System		Potential Dependable Yield (kg/ha)	Production Value (a) (P/ha)	Variable Production Costs (P/ha) seed (b)	fertilizer (c)	fuel (d)	Potential Gross Margin (P/ha)	Area farmed (ha)	Potential Gr.Mar. Total (P)
Sorghum	Cr00	0.00	0.00	7.50	0.00	0.00	−7.50	1.50	−11.25
	Cr0	160.00	67.20	7.50	0.00	0.00	59.70	4.00	238.80
	Cr1 (e, f)	750.00	315.00	4.00	0.00	0.00	311.00	1.50	466.50
	Cr2	280.00	117.60	7.50	0.00	0.00	110.10	4.00	440.40
	Cr3	550.00	231.00	7.50	0.00	81.00	142.50	10.00	1425.00
	Cr4 (e)	750.00	315.00	7.50	20.00	81.00	206.50	10.00	2065.00
Millet	Cr00	0.00	0.00	7.50	0.00	0.00	−7.50	1.50	−11.25
	Cr0	110.00	39.60	7.50	0.00	0.00	32.10	4.00	128.40
	Cr1 (e, f)	510.00	183.60	4.00	0.00	0.00	179.60	1.50	269.40
	Cr2	180.00	64.80	7.50	0.00	0.00	57.30	4.00	229.20
	Cr3	360.00	129.60	7.50	0.00	81.00	41.10	10.00	411.00
	Cr4 (e)	510.00	183.60	7.50	20.00	81.00	75.10	10.00	751.00
Maize	Cr00	0.00	0.00	7.50	0.00	0.00	−7.50	1.50	−11.25
	Cr0	60.00	30.60	7.50	0.00	0.00	23.10	4.00	92.40
	Cr1 (e, f)	530.00	270.30	4.00	0.00	0.00	266.30	1.50	399.45
	Cr2	180.00	91.80	7.50	0.00	0.00	84.30	4.00	337.20
	Cr3	350.00	178.50	7.50	0.00	81.00	90.00	10.00	900.00
	Cr4 (e)	530.00	270.30	7.50	20.00	81.00	161.80	10.00	1618.00

Land Unit D

Production System		Potential Dependable Yield (kg/ha)	Production Value (a) (P/ha)	Variable Production Costs (P/ha) seed (b)	fertilizer (c)	fuel (d)	Potential Gross Margin (P/ha)	Area farmed (ha)	Potential Gr.Mar. Total (P)
Sorghum	Cr00	180.00	75.60	7.50	0.00	0.00	68.10	1.50	102.15
	Cr0	310.00	130.20	7.50	0.00	0.00	122.70	4.00	490.80
	Cr1 (e, f)	1100.00	462.00	4.00	0.00	0.00	458.00	1.50	687.00
	Cr2	460.00	193.20	7.50	0.00	0.00	185.70	4.00	742.80
	Cr3	820.00	344.40	7.50	0.00	81.00	255.90	10.00	2559.00
	Cr4 (e)	1100.00	462.00	7.50	20.00	81.00	353.50	10.00	3535.00
Millet	Cr00	350.00	126.00	7.50	0.00	0.00	118.50	1.50	177.75
	Cr0	250.00	90.00	7.50	0.00	0.00	82.50	4.00	330.00
	Cr1 (e, f)	850.00	306.00	4.00	0.00	0.00	302.00	1.50	453.00
	Cr2	370.00	133.20	7.50	0.00	0.00	125.70	4.00	502.80
	Cr3	640.00	230.40	7.50	0.00	81.00	141.90	10.00	1419.00
	Cr4 (e)	850.00	306.00	7.50	20.00	81.00	197.50	10.00	1975.00
Maize	Cr00	180.00	91.80	7.50	0.00	0.00	84.30	1.50	126.45
	Cr0	320.00	163.20	7.50	0.00	0.00	155.70	4.00	622.80
	Cr1 (e, f)	1220.00	622.20	4.00	0.00	0.00	618.20	1.50	927.30
	Cr2	500.00	255.00	7.50	0.00	0.00	247.50	4.00	990.00
	Cr3	900.00	459.00	7.50	0.00	81.00	370.50	10.00	3705.00
	Cr4 (e)	1220.00	622.20	7.50	20.00	81.00	513.70	10.00	5137.00

Land Unit F

Production System		Potential Dependable Yield (kg/ha)	Production Value (a) (P/ha)	Variable Production Costs (P/ha) seed (b)	fertilizer (c)	fuel (d)	Potential Gross Margin (P/ha)	Area farmed (ha)	Potential Gr Mar Total (P)
Sorghum	Cr00	290.00	121.80	7.50	0.00	0.00	114.30	1.50	171.45
	Cr0	400.00	168.00	7.50	0.00	0.00	160.50	4.00	642.00
	Cr1 (e, f)	1060.00	445.20	4.00	0.00	0.00	441.20	1.50	661.80
	Cr2	690.00	289.80	7.50	0.00	0.00	282.30	4.00	1129.20
	Cr3	780.00	327.60	7.50	0.00	81.00	239.10	10.00	2391.00
	Cr4 (e)	1060.00	445.20	7.50	20.00	81.00	336.70	10.00	3367.00
Millet	Cr00	400.00	144.00	7.50	0.00	0.00	136.50	1.50	204.75
	Cr0	310.00	111.60	7.50	0.00	0.00	104.10	4.00	416.40
	Cr1 (e, f)	890.00	320.40	4.00	0.00	0.00	316.40	1.50	474.60
	Cr2	520.00	187.20	7.50	0.00	0.00	179.70	4.00	718.80
	Cr3	660.00	237.60	7.50	0.00	81.00	149.10	10.00	1491.00
	Cr4 (e)	890.00	320.40	7.50	20.00	81.00	211.90	10.00	2119.00
Maize	Cr00	290.00	147.90	7.50	0.00	0.00	140.40	1.50	210.60
	Cr0	310.00	158.10	7.50	0.00	0.00	150.60	4.00	602.40
	Cr1 (e, f)	1080.00	550.80	4.00	0.00	0.00	546.80	1.50	820.20
	Cr2	600.00	306.00	7.50	0.00	0.00	298.50	4.00	1194.00
	Cr3	790.00	402.90	7.50	0.00	81.00	314.40	10.00	3144.00
	Cr4 (e)	1080.00	550.80	7.50	20.00	81.00	442.30	10.00	4423.00

Land Units

G, E, H, M

Production System		Potential Dependable Yield (kg/ha)	Production Value (a) (P/ha)	Variable Production Costs (P/ha) seed (b)	fertilizer (c)	fuel (d)	Potential Gross Margin (P/ha)	Area farmed (ha)	Potential Gr.Mar. Total (P)
Sorghum	Cr00	250.00	105.00	7.50	0.00	0.00	97.50	1.50	146.25
	Cr0	320.00	134.40	7.50	0.00	0.00	126.90	4.00	507.60
	Cr1 (e, f)	950.00	399.00	4.00	0.00	0.00	395.00	1.50	592.50
	Cr2	480.00	201.60	7.50	0.00	0.00	194.10	4.00	776.40
	Cr3	720.00	302.40	7.50	0.00	81.00	213.90	10.00	2139.00
	Cr4 (e)	950.00	399.00	7.50	20.00	81.00	290.50	10.00	2905.00
Millet	Cr00	380.00	136.80	7.50	0.00	0.00	129.30	1.50	193.95
	Cr0	260.00	93.60	7.50	0.00	0.00	86.10	4.00	344.40
	Cr1 (e, f)	770.00	277.20	4.00	0.00	0.00	273.20	1.50	409.80
	Cr2	390.00	140.40	7.50	0.00	0.00	132.90	4.00	531.60
	Cr3	560.00	201.60	7.50	0.00	81.00	113.10	10.00	1131.00
	Cr4 (e)	770.00	277.20	7.50	20.00	81.00	168.70	10.00	1687.00
Maize	Cr00	250.00	127.50	7.50	0.00	0.00	120.00	1.50	180.00
	Cr0	240.00	122.40	7.50	0.00	0.00	114.90	4.00	459.60
	Cr1 (e, f)	910.00	464.10	4.00	0.00	0.00	460.10	1.50	690.15
	Cr2	560.00	285.60	7.50	0.00	0.00	278.10	4.00	1112.40
	Cr3	650.00	331.50	7.50	0.00	81.00	243.00	10.00	2430.00
	Cr4 (e)	910.00	464.10	7.50	20.00	81.00	355.60	10.00	3556.00

Land Unit J

Production System		Potential Dependable Yield (kg/ha)	Production Value (a) (P/ha)	Variable Production Costs (P/ha) seed (b)	fertilizer (c)	fuel (d)	Potential Gross Margin (P/ha)	Area farmed (ha)	Potential Gr.Mar. Total (P)
Sorghum	Cr00	350.00	147.00	7.50	0.00	0.00	139.50	1.50	209.25
	Cr0	450.00	189.00	7.50	0.00	0.00	181.50	4.00	726.00
	Cr1 (e,f)	1100.00	462.00	4.00	0.00	0.00	458.00	1.50	687.00
	Cr2	760.00	319.20	7.50	0.00	0.00	311.70	4.00	1246.80
	Cr3	820.00	344.40	7.50	0.00	81.00	255.90	10.00	2559.00
	Cr4 (e)	1100.00	462.00	7.50	20.00	81.00	353.50	10.00	3535.00
Millet	Cr00	440.00	158.40	7.50	0.00	0.00	150.90	1.50	226.35
	Cr0	340.00	122.40	7.50	0.00	0.00	114.90	4.00	459.60
	Cr1 (e,f)	930.00	334.80	4.00	0.00	0.00	330.80	1.50	496.20
	Cr2	550.00	198.00	7.50	0.00	0.00	190.50	4.00	762.00
	Cr3	680.00	244.80	7.50	0.00	81.00	156.30	10.00	1563.00
	Cr4 (e)	930.00	334.80	7.50	20.00	81.00	226.30	10.00	2263.00
Maize	Cr00	350.00	178.50	7.50	0.00	0.00	171.00	1.50	256.50
	Cr0	380.00	193.80	7.50	0.00	0.00	186.30	4.00	745.20
	Cr1 (e,f)	1170.00	596.70	4.00	0.00	0.00	592.70	1.50	889.05
	Cr2	700.00	357.00	7.50	0.00	0.00	349.50	4.00	1398.00
	Cr3	850.00	433.50	7.50	0.00	81.00	345.00	10.00	3450.00
	Cr4 (e)	1170.00	596.70	7.50	20.00	81.00	488.20	10.00	4882.00

Land Unit L

Production System		Potential Dependable Yield (kg/ha)	Production Value (a) (P/ha)	Variable Production Costs (P/ha) seed (b)	fertilizer (c)	fuel (d)	Potential Gross Margin (P/ha)	Area farmed (ha)	Potential Gr.Mar. Total (P)
Sorghum	Cr00	120.00	50.40	7.50	0.00	0.00	42.90	1.50	64.35
	Cr0	310.00	130.20	7.50	0.00	0.00	122.70	4.00	490.80
	Cr1 (e,f)	1120.00	470.40	4.00	0.00	0.00	466.40	1.50	699.60
	Cr2	460.00	193.20	7.50	0.00	0.00	185.70	4.00	742.80
	Cr3	850.00	357.00	7.50	0.00	81.00	268.50	10.00	2685.00
	Cr4 (e)	1120.00	470.40	7.50	20.00	81.00	361.90	10.00	3619.00
Millet	Cr00	350.00	126.00	7.50	0.00	0.00	118.50	1.50	177.75
	Cr0	240.00	86.40	7.50	0.00	0.00	78.90	4.00	315.60
	Cr1 (e,f)	830.00	298.80	4.00	0.00	0.00	294.80	1.50	442.20
	Cr2	360.00	129.60	7.50	0.00	0.00	122.10	4.00	488.40
	Cr3	610.00	219.60	7.50	0.00	81.00	131.10	10.00	1311.00
	Cr4 (e)	830.00	298.80	7.50	20.00	81.00	190.30	10.00	1903.00
Maize	Cr00	120.00	61.20	7.50	0.00	0.00	53.70	1.50	80.55
	Cr0	260.00	132.60	7.50	0.00	0.00	125.10	4.00	500.40
	Cr1 (e,f)	1020.00	520.20	4.00	0.00	0.00	516.20	1.50	774.30
	Cr2	400.00	204.00	7.50	0.00	0.00	196.50	4.00	786.00
	Cr3	730.00	372.30	7.50	0.00	81.00	283.80	10.00	2838.00
	Cr4 (e)	1020.00	520.20	7.50	20.00	81.00	411.70	10.00	4117.00

ANNEX 10 APSRAMB INITIAL SETTINGS, DEFINITIONS AND RESULTS

Table A10.1 INITIAL SETTINGS

FILE	SECTION	KEY	VALUE
Biomass.ini	General	Constant	2
		Begindekad	25
	Herbs	Losses	0
Livestoc.ini	Biomass	Constant	2
		Degrade	14
		Initial	1000

Table A10.2 DEFINITION OF "MANAGEMENT" FOR VARIOUS PRODUCTION SYSTEMS

		PRODUCTION SYSTEM	
		Ab0 (Communal, baseline)	Ab1, Ab2 and Ab3 (Communal, improved)
LAND	Area	140	140
	Walk dist.	8,10,10,10,12,12,12,12,12,12,12,10	8,10,10,10,12,12,12,12,12,12,12,10
SALES	Cull cows	-50,144,0,4,4	0,144,0,4,4
	Steer 4yr	-100,48,0,4,4	0,48,0,4,4
	Steer 5yr	-50,60,0,4,4	0,60,0,4,4
	Steer 6+yr	-20,72,0,4,4	0,72,0,4,4
BREEDING	Months	1,2,3,4,5,6,7,8,9,10,11,12	1,2,3,4,5,6,7,8,9,10,11,12

Table A10.3 DEFINITION OF "SUPPLEMENT" FOR PRODUCTION SYSTEM Ab2 and Ab3

PRODUCTION SYSTEM	YEAR	MONTH	AMOUNT	DIG
Ab2, Ab3	1987	3	56 000	0.5

Table A10.4 DEFINITION OF STARTING "HERD" FOR VARIOUS PRODUCTION SYSTEMS

CATEGORY	PRODUCTION SYSTEMS Ab0, Ab1, Ab2 and Ab3				
	Number (*)	Age (months)	Age calf (months)	Sex calf	Months pregnant
Bull calf	3	10			
Steer 1yr	2	13			
Steer 2yr	2	26			
Steer 3yr	1	38			
Steer 4yr	1	49			
Steer 5yr	0				
Steer 6+yr	1	74			
Heifer calf	3	10			
Heifer 1yr	2	13			
Heifer 2yr	2	25			
Cow 3yr	1	36	5	M	6
Cow 4yr	1	48			
Cow 5yr	1	60	-9	-9	
Cow 6yr	0				
Cow 7yr	1	84	-9	-9	6
Cow 8yr	0				
Cow 9yr	1	108	-9	-9	
Cow 10yr	0				
Cow 11yr	1	132	-9	-9	6
Cull cow	0				
(Total no. of animals)	(23)				
(ha/LSU)	(8.8)				

(*) herd for 140 ha

Table A10.5 VALUE OF SALES OF VARIOUS PRODUCTIONS SYSTEMS

Production system	Category	Average (*) number of animals sold	Approx. weight per category (kg)	Approx. Cold Dressing Weight per category (kg)	Average grade (estimated)	Unit price (**) (P/kg)	Total value per category (P)
Ab0	Steer 4yr	0	380	190	1	4.44	0
	Steer 5yr	3.6	395	198	2	4.03	2 873
	Steer 6+yr	6.2	427	214	2	4.03	5 347
	Cull cow	0.8	300	150	3	3.72	446
	Total value of sales						**8 666**
Ab1	Steer 4yr	11.2	380	190	1	4.44	9 448
	Steer 5yr	0.2	395	198	2	4.03	160
	Steer 6+yr	1.0	427	214	2	4.03	862
	Cull cow	2.6	300	150	3	3.72	1451
	Total value of sales						**11 921**
Ab2	Steer 4yr	17.4	380	190	1	4.44	14 679
	Steer 5yr	0.4	395	198	2	4.03	319
	Steer 6+yr	1.0	427	214	2	4.03	862
	Cull cow	4.6	300	150	3	3.72	2 567
	Total value of sales						**18 427**
Ab3	Steer 4yr	17.8	380	190	1	4.44	15 016
	Steer 5yr	2	395	198	2	4.03	1 596
	Steer 6+yr	1	427	214	2	4.03	862
	Cull cow	5.2	300	150	3	3.72	2 902
	Total value of sales						**20 376**

(*) Average over five replications
(**) Francistown abattoir, April-June 1995

Table A10.6 VALUE OF STARTING HERD PRODUCTION SYSTEMS Ab0, Ab1, Ab2, Ab3

Category	Number of animals	Approx. weight per category (kg)	Approx.CDW per category (kg)	Average grade	Unit price (P/kg)	Total value per category (P)
Calves	6	110	55	SS	4.88	1 610
Steer 1-2yr	4	270	135	1	4.44	2 398
Heifer 1-2yr	4	270	135	1	4.44	2 398
Steer 3yr	1	320	160	1	4.44	710
Steer 4yr	1	380	190	1	4.44	844
Steer 5yr	0	400	198	2	4.03	0
Steer 6+yr	1	425	214	2	4.03	862
Cow 3yr	1	310	155	1	4.44	688
Cow 4yr	1	330	115	1	4.44	511
Cow 5yr	1	360	180	2	4.03	725
Cow 6-12yr	3	380	190	2	4.03	2 297
Cull cow	0	300	150	3	3.72	0
Total value						**13 043**

Table A10.7 VALUE OF HERD AFTER 10 YEARS (PRODUCTION SYSTEM Ab2)

Category	Average (*) number of animals	Approx. weight per category (kg)	Approx. CDW per category (kg)	Average grade	Unit price (P/kg)	Total value per category (P)
Calves	4.2	110	55	SS	4.88	1 127
Steer 1-2yr	3.6	270	135	1	4.44	2 158
Heifer 1-2yr	5.8	270	135	1	4.44	3 477
Steer 3yr	2.4	320	160	1	4.44	1 705
Steer 4yr	0.4	380	190	1	4.44	337
Steer 5yr	0	400	198	2	4.03	0
Steer 6+yr	0	425	214	2	4.03	0
Cow 3yr	3.1	310	155	1	4.44	2 133
Cow 4yr	3.1	330	115	1	4.44	1 583
Cow 5yr	3.1	360	180	2	4.03	2 249
Cow 6-12yr	3.1	380	190	2	4.03	2 374
Cull cow	1.2	300	150	3	3.72	670
Total value of sales						**17 812**

(*) Average over five replications

Table A10.8 VALUE OF HERD AFTER 10 YEARS (PRODUCTION SYSTEM Ab3)

Category	Average (*) number of animals	Approx. weight per category (kg)	Approx. CDW per category (kg)	Average grade	Unit price (P/kg)	Total value per category (P)
Calves	4.4	110	55	SS	4.88	1 181
Steer 1-2yr	4.4	270	135	1	4.44	2 637
Heifer 1-2yr	5.6	270	135	1	4.44	3 357
Steer 3yr	2	320	160	1	4.44	1 421
Steer 4yr	0.8	380	190	1	4.44	675
Steer 5yr	0	400	198	2	4.03	0
Steer 6+yr	0	425	214	2	4.03	0
Cow 3yr	2	310	155	1	4.44	1 376
Cow 4yr	2.2	330	115	1	4.44	1 123
Cow 5yr	2.4	360	180	2	4.03	1 741
Cow 6-12yr	6.4	380	190	2	4.03	4 900
Cull cow	1.8	300	150	3	3.72	1 004
Total value of sales						**19 416**

(*) Average over five replications

Table A10.9 AVERAGE POTENTIAL AERIAL BIOMASS PRODUCTION (*) FOR PERIOD WITH RELATIVELY HIGH RAINFALL (1968 – 1976) BY LAND UNIT

LAND UNIT (Map 8)	VEGETATION UNIT (Map 4)	GRASS COVER (%)	SOIL UNIT (Map 3)		AVERAGE POTENTIAL DRY MATTER (kg/ha/yr)					
					Per Soil Unit			Aggregate		
			Unit	Weight %	Grazing	Browse	Gr + Br	Grazing	Browse	Gr + Br
1	1	0	15	100	0	0	0	**0**	0	0
2	2	25	15	100	1947	0	1947	**1947**	0	1947
3	3	40	3	100	2674	0	2674	**2674**	0	2674
4	3	40	3	40	2674	0	2674	**2390**	0	2390
			9 (8)	40	2458	0	2458			
			1	20	1684	0	1684			
5	4	40	1	40	1779	129	1908	**2311**	285	2596
			3	30	2630	412	3042			
			5	30	2701	367	3068			
6	4	40	5 (6)	100	2355	370	2725	**2355**	370	2725
7	6	50	7	60	2653	1196	3849	**2698**	1081	3779
			9 (8)	20	2650	1197	3847			
			3	20	2879	621	3500			
8	6	50	9	80	2914	1137	4051	**2958**	1046	4005
			3	20	3136	684	3820			
9	6	50	7	70	2915	1137	4052	**2915**	1137	4052
			9	30	2914	1137	4051			
10	7	50	3	50	3262	143	3405	**3277**	155	3432
			15 (14,16,18,19)	50	3292	167	3459			
11	9	60	7	80	3707	586	4293	**3707**	586	4293
			9 (8)	20	3706	586	4292			
12	8	40	11	100	2536	708	3244	**2536**	708	3244
13	10	50	3	50	2866	577	3443	**2875**	590	3465
			5 (6)	40	2935	514	3449			
			7	10	2683	958	3641			
14	11	50	9 (10)	60	2436	1814	4250	**2401**	1450	3851
			3 (4)	30	2579	1092	3671			
			1	10	1656	342	1998			
15	13	60	3	60	3474	349	3823	**3365**	478	3843
			7	40	3201	672	3873			
16	13	60	7	100	3516	638	4154	**3516**	638	4154
17	14	50	7	60	3291	436	3727	**3291**	438	3729
			9 (8,10)	40	3290	442	3732			
18	14	50	1	100	2211	86	2297	**2211**	86	2297
19	15	50	3 (2)	50	2866	377	3243	**2931**	377	3308
			11	25	2943	340	3283			
			15 (17)	25	3049	415	3464			
20	16	50	11 (12)	100	3031	582	3613	**3031**	582	3613
21	17	40	9	100	2650	1197	3847	**2650**	1197	3847

(*) Production of leaves lower bush ("browse") and aerial parts of herbaceous layer ("grazing"), not considering losses due to pests, fire, trampling etc. and not considering palatability and digestibility

Table A10.10 AVERAGE POTENTIAL AERIAL BIOMASS PRODUCTION (*) FOR PERIOD WITH RELATIVELY LOW RAINFALL (1980 – 1990) BY LAND UNIT

LAND UNIT (Map 8)	VEGETATION UNIT (Map 4)	GRASS COVER (%)	SOIL UNIT (Map 3)		AVERAGE POTENTIAL DRY MATTER (kg/ha/yr)					
					Per Soil Unit			Aggregate		
			Unit	Weight %	Grazing	Browse	Gr + Br	Grazing	Browse	Gr + Br
1	1	0	15	100	0	0	0	**0**	0	0
2	2	25	15	100	1388	0	1388	**1388**	0	1388
3	3	40	3	100	1676	0	1676	**1676**	0	1676
4	3	40	3	40	1676	0	1676	**1547**	0	1547
			9 (8)	40	1567	0	1567			
			1	20	1248	0	1248			
5	4	40	1	40	1888	108	1996	**2277**	187	2464
			3	30	2702	221	2923			
			5	30	2369	259	2628			
6	4	40	5 (6)	100	1649	173	1822	**1649**	173	1822
7	6	50	7	60	1384	563	1947	**1400**	507	1907
			9 (8)	20	1384	563	1947			
			3	20	1465	282	1747			
8	6	50	9	80	1944	525	2469	**1965**	493	2459
			3	20	2050	367	2417			
9	6	50	7	70	1944	525	2469	**1944**	525	2469
			9	30	1944	525	2469			
10	7	50	3	50	2459	65	2524	**2355**	83	2438
			15	50	2251	101	2352			
			(14,16,18,19)							
11	9	60	7	80	2594	271	2865	**2594**	271	2865
			9 (8)	20	2594	271	2865			
12	8	40	11	100	2211	401	2612	**2211**	401	2612
13	10	50	3	50	2316	310	2626	**2196**	344	2540
			5 (6)	40	2041	362	2403			
			7	10	2213	443	2656			
14	11	50	9 (10)	60	2376	838	3214	**2336**	707	3043
			3 (4)	30	2465	586	3051			
			1	10	1706	286	1992			
15	13	60	3	60	1839	159	1998	**1799**	222	2020
			7	40	1738	316	2054			
16	13	60	7	100	2443	295	2738	**2443**	295	2738
17	14	50	7	60	2562	263	2825	**2562**	263	2825
			9 (8,10)	40	2562	264	2826			
18	14	50	1	100	1877	72	1949	**1877**	72	1949
19	15	50	3 (2)	50	2316	182	2498	**2203**	200	2403
			11	25	2041	213	2254			
			15 (17)	25	2138	223	2361			
20	16	50	11 (12)	100	2107	329	2436	**2107**	329	2436
21	17	40	9	100	1384	563	1947	**1384**	563	1947

(*) Production of leaves lower bush ("browse") and aerial parts of herbaceous layer ("grazing"), not considering losses due to pests, fire, trampling etc. and not considering palatability and digestibility

ANNEX 11 LAND SUITABILITY FOR SELECTED WILDLIFE PRODUCTION SYSTEMS

Table A11 RATING[1] OF LAND UNITS FOR THREE WILDLIFE PRODUCTION SYSTEMS

LAND UNIT (see Map 8)	PRODUCTION SYSTEMS[2] AND LAND QUALITIES[3]													
	ECO-TOURISM						TROPHY HUNTING (TOURISM)					OSTRICH RANCHING		
	Access	Scenery	Sp Diversity	Sp Abundance	Visibility	TOTAL (4)	Access	Sp Diversity	Sp Abundance	Present use	TOTAL (4)	Access	Habitat	TOTAL (4)
1	-	++	-	±	++	±	-	-	-	++	-	-	-	-
2	-	++	+	+	++	+	-	+	+	-	-	-	±	-
3	-	-	+	+	++	+	-	+	+	-	-	+	+	+
4	++	++	+	+	++	++	+	+	+	-	-	+	+	+
5	±	-	-	-	-	-	+	-	-	-	-	++	±	±
6	-	+	+	+	+	+	-	+	+	-	-	-	±	-
7	-	-	++	++	+	+	-	++	++	+	+	-	++	+
8	±	-	-	+	+	-	±	-	+	+	-	±	++	++
9	++	++	++	++	+	++	+	++	++	-	+	+	+	+
10	++	++	+	-	++	++	+	+	-	-	-	+	+	+
11	-	-	++	++	+	+	+	++	++	+	++	±	+	±
12	-	+	+	±	+	+	-	+	±	++	+	-	+	-
13	++	-	+	+	-	+	+	+	+	+	+	+	-	-
14	±	±	+	+	-	±	±	+	+	±	+	±	-	-
15	-	+	++	++	-	+	-	++	++	+	+	-	-	-
16	-	±	++	++	-	+	+	++	++	+	++	-	-	-
17	++	++	++	++	+	++	++	++	++	-	++	++	±	+
18	-	-	+	+	-	-	-	+	+	+	-	-	+	-
19	++	+	+	-	-	+	+	+	-	-	-	+	-	-
20	-	+	+	+	-	-	-	+	+	++	+	-	-	-
21	-	+	+	+	-	-	-	+	+	++	+	-	-	-

(1) ratings are in qualitative terms: - (low), + (moderate), ++ (high) and ± (variable)
(2) production systems are described in Section 6.9.1 (3) land qualities are described in Section 6.9.2
(4) TOTAL = final rating, indicting relative suitability of land unit for specific production system

FIELD DOCUMENTS

produced by FAO/UNDP/GOB project BOT/91/001
Land Use Planning for Sustainable Agricultural Development

1. Some notes on the identification and socio-economic analysis of different farmer classes, 1993.
2. Agricultural Land Use Plan for Former Freehold Farms 25/77 and 27/77 NQ (North-East District), 1994.
3. Agricultural Land Use Plan for Ratholo Agricultural Extension Area (Central Region), 1995.
4. Guidelines for the Use of CYSLAMB. Applications for Agricultural Land Use Planning and Extension in Botswana, 1994.
5. Guidelines for the Use of ILWIS, 1994.
6. Agricultural Land Use Plan for Lesoma Village Area (Chobe District), 1995.
7. Flood recession farming (molapo farming) in the Chobe Enclave (Chobe District), 1995.
8. On-farm Crop Trials Cropping Season 1994/95. Results and Evaluation, 1995.
9. Agricultural Land use Plan for Moroka Agricultural Extension Area (North-East District), 1995.
10. Guidelines for Agricultural Land Use Planning in Botswana, 1996.
11. Agricultural Land Use Plan for Moshupa-South Agricultural Extension Area (Southern Region), 1995.
12. Agricultural Land Use Plan for Chanoga Agricultural Extension Area (Maun Region), 1996.
13. Guidelines for Land Allocation along the River Banks in the Maun Area, 1995.
15. Agricultural Land Use Plan for Letlhakane Agricultural District (Central Region), 1996.
17. The Animal Production and Range Assessment Model for Botswana (APSRAMB) Part I, Theory and Validation, 1996.
18. The Animal Production and Range Assessment Model for Botswana (APSRAMB) Part II, User Manual and Applications, 1996.
19. The Animal Production and Range Assessment Model for Botswana (APSRAMB) Part III, Technical Manual, 1996.
20. Land evaluation of a portion of the freehold farm known as Crocodile Pools, South East District, 1996.

Copies of these documents can be obtained from the Department of Crop Production & Forestry, Division of Land Utilization, Ministry of Agriculture, Private Bag 003 Gaborone.