

BOT/91/001  
Field Document 3

Land use planning for Sustainable Agricultural Development

BOTSWANA

**PROPOSED**  
**AGRICULTURAL LAND USE PLAN**  
FOR  
**RATHOLO AGRICULTURAL EXTENSION AREA**  
**CENTRAL REGION**

Food & Agriculture  
Organization of  
the United Nations

Republic of  
Botswana

United Nations  
Development  
Programme

APRIL 1995

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RATHOLO AGRICULTURAL EXTENSION AREA

CENTRAL REGION

by

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## LIST OF ABBREVIATIONS AND ACRONYMS

AD	Agricultural Demonstrator
AEA	Agricultural Extension Area
ALDEP	Arable Land Development Programme
ALUP	Agricultural Land Use Planner (MoA)
AP	Aerial Photograph
approx.	approximately
APRRU	Animal Production and Range Research Unit
APSRAMB	Animal Production System and Resource Assessment Model for Botswana
ARAP	Accelerated Rainfed Arable Programme
asl	above sea level (altitude)
BAMB	Botswana Agricultural Marketing Board
BCU	Botswana Co-operative Union
BDC	Botswana Development Corporation
BMC	Botswana Meat Commission
CYSLAMB	Crop Yield Simulation and Land Assessment Model for Botswana
DAHP	Department of Animal Health and Production
DAO	District Agricultural Office(r)
DCPF	Department of Crop Production and Forestry
DDC	District Development Committee
DLUPU	District Land Use Planning Unit
DO(D)	District Officer (Development)
DO(L)	District Officer (Lands)
DLRFS	Dryland Farming Research Scheme
DRP	Drought Relief Programme
EFSAIP	Evaluation of Farming Systems and Agricultural Implements Project
FAO	Food and Agricultural Organization of the United Nations
FAB	Forestry Association Botswana
FAP	Financial Assistance Policy
GIS	Geographical Information System
LAC	Livestock Advisory Centre
LGP	Length of Growing Period
LSU	Livestock Unit
LU	Land Unit
LUO	Land Use Officer (MoA)
LUPSAD	Land Use Planning for Sustainable Agricultural Development
MoA	Ministry of Agriculture
OSSCA	One Stop Service Centre for Agriculture
PDT	Palapye Development Trust
PET	Potential Evapo-transpiration
pH	An indication of (soil) acidity
pl/ha	plants per hectare
ppm	parts per million
PPO	Plant Protection Office(r)
PRICE	Pioneer Rural Industries Centre
RAO	Regional Agricultural Office(r)
SI	Stock Inspector
SMCS	Serowe Marketing Cooperative Society (Ltd)
sp	species
VA	Veterinary Assistant
VDC	Village Development Committee

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## EXECUTIVE SUMMARY

### Location, population

1. Ratholo Agricultural Extension Area (AEA) covers an area of approximately 27,000 ha in eastern Central District half-way between Palapye and Martins Drift. The area includes the villages of Ratholo and Majwaneng, and Moeng College. The total population of the area is 5,031 or 840 families. An estimated 80 % of households is involved in agricultural activities. Most of the resident adults are female and day-to-day life in most farm households is run by a woman. The average age of the farmer is around 50. Land is communally owned and used by local communities for livestock grazing, arable farming and collection of veld products.

### Land resources, land suitability

2. The mean annual rainfall in the AEA is 400 mm, with a standard deviation of 148 mm. Most of the rain falls in isolated storms scattered over a long season. Dry spells of several weeks occur within the growing season. The semi-arid climate poses severe restrictions to arable farming and causes shortages of drinking water and highly variable range conditions for livestock.

3. The main landforms of the AEA are the Tswapong Hills and their footslopes at an altitude of 1000 to 1160 m in the north, and the almost flat Molapo plain at an altitude of approximately 900 m in the south. All soils are deficient in major plant nutrients and thus have inherent restrictions for farming. The best soils are deep, freely drained and medium textured Luvisols of the footslope zone and the higher reaches of the Molapo plain. Most soils in the lower and most southern part of the plain have a gravelly layer in the subsoil, posing an impediment to root development. Minor parts of the plain and footslope area occasionally suffer from flooding after rainstorms. Soils in the hills are shallow and stony, with frequent rock outcrops.

4. Moderate to severe sheet and rill erosion has affected 4,200 ha mainly in the footslope zone, and has done irreversible damage in some localised areas. Topsoil deterioration and crusting of topsoils are widespread both in farmer's fields and in rangelands. Soil degradation is expected to spread and intensify in the future if no appropriate action is taken.

5. Most of the AEA is covered with degraded tree and shrub savanna. Degradation of the herbaceous layer (grasses and forbs) is widespread. The grass density is low and species which have little value for grazing dominate. The woody vegetation of the plain is dominated by mopane (*Colophospermum mopane*). This tree is the host of the Mopane moth (*Gonimbrasia belina*) (see Paragraph 10).

6. Nine Land Units (LUs) have been identified and mapped on the basis of variations in landform and soil. Almost half of the AEA is suitable for arable farming (LUs 2, 7 and 8). Another 9 % is marginally suitable due to limited soil depth (LU 9). Arable farming is presently confined to LUs 7, 8 and 9. The remaining part of the AEA is unsuitable for cultivation due to flood risk (LU 6), present erosion and erosion hazard (LUs 3, 4 and 5), and a combination of steep slope and shallow soil (LU 1). Land not used for arable farming is used for grazing and the collection of veld products.

## Present land use

7. The present study subdivides the farmers of the AEA into four groups, defined on the basis of farm size and number of livestock owned. Farmers in *Group 1*, comprising 20 % of farmers, cultivate an average of 3 ha and own only small stock. They have to hire or borrow animals for ploughing. Farmers in *Group 2*, comprising 40 % of farmers, cultivate an average of 5 ha. They own some cattle or donkeys, but to form a span to plough their fields they have to hire or borrow additional animals. Farmers in *Group 3*, comprising 32 % of farmers, cultivate an average of 8 ha. They own their own animals for traction. Farmers in *Group 4*, comprising 8 % of farmers, cultivate more than 8 ha and own more than 20 head of cattle.

8. During the 1992/93 season an area of less than 4,000 ha was cultivated. Farmers grow a mixture of crops, dominated by sorghum (approx. 90 %), with maize, beans and melons. Farming is for subsistence mainly and yields are very low. The average farm size is 5.8 ha. Nearly all farmers broadcast the seeds and plough them under. Traditionally ploughing is carried out with a span of four to six donkeys or oxen but, since the introduction of drought relief, ploughing is frequently carried out by contractors using tractors. Ploughing and planting are often performed relatively late in the season because of lack of labour, lack of draught power, lack of input and general unpreparedness. Very few farmers apply fertilizer or use pesticides.

9. The area is grazed and browsed by an estimated 2,000 cattle, 4,300 goats and 1,300 donkeys. Stock is kept through a system of extensive grazing in which the fodder base consists of untended natural grasslands and shrubs, and crop residues. Livestock is mainly kept for meat production, and draught power, and also contributes to status. Small quantities of milk are also produced. Livestock suffers from shortage of feed and drinking water during the dry season, and from diseases. Income derived from livestock constitutes the major share of total income for large farmers but is insignificant for small farmers.

10. Collection of veld products and fuel wood are important activities. Phane (mopane worm), a caterpillar which feeds on the leaves of *Colophospermum mopane*, is the most important and most profitable veld product. It constitutes an important source of income, especially for small farmers. Production is limited by labour availability during short periods of the rainy season.

11. Agricultural productivity is low because of a complex of constraints related to the natural environment, the socio-economic environment and farm management. Main limitations include adverse natural conditions, a fragile environment, low farmers' motivation, insufficient extension, and poor management of communally owned grazing areas and water resources.

## Crops

12. Crops best suited to the natural conditions of the AEA include, apart from sorghum and millet, many types of beans and peas, groundnuts, sunflower and sunhemp.

13. Present sorghum yields are low and production is insufficient on most farms in most years to meet subsistence requirements of the household. Only on the largest farms can requirements be regularly met. Many farmers survive on income derived from activities other than farming or the collection of veld products and from remittances from family members residing outside the AEA.

14. Simulation of potential rainfed sorghum yield using the CYSLAMB land evaluation model indicates that the *dependable* yield (calculated as the yield exceeded in 75 % of years), under an assumed improved traditional management system, is between three to seven bags (200 to 500 kg) per hectare, which is adequate to cover subsistence household food requirements of Group 2 farms

(typically 5 ha) and Group 3 farms (typically 8 ha). On small farms (typically 3 ha) staple requirements are usually not met. Farmers with sufficient resources are recommended to adopt a set of farm practices to achieve higher yields, which include the use of early planting opportunities, rowplanting and row weeding, timely weeding, the use of fertilizer, improvement of topsoil, spraying against pests and diseases, and improved bird scaring. The first four recommendations are also assumptions which underlie yield simulations using CYSLAMB.

15. Simulation of potential rainfed groundnut yield using CYSLAMB indicates that the *dependable* yield is about 530 kg/ha (unshelled), assuming the adoption of improved farm practices, which are listed in Paragraph 14 above, and assuming that the farmer ploughs and plants his entire field at the first planting opportunity in the period November 1st to February 20th. Production of groundnuts, at a market price (1993/94 season) of Pula 120 per 100 kg (shelled, grade 2), could increase the cash income of the average farmer considerably.

#### Improved farming practices

16. The present land use plan aims to increase the market orientation of the farmer. A proposal is made to split up farms into three sub-units: two ha planted to single-row sorghum (for home consumption), 0.25 ha planted to broadcasted mixed crops (also for home consumption), and the remainder of the farm (the size of which varies) planted to a cash crop (groundnuts or other).

17. If the farmer mainly practices mono-cropping as suggested in Paragraph 16, crop rotation is recommended, whereby sorghum is rotated with groundnuts or another legume. Alternatively intercropping is practiced, whereby in the same field every second or third row of sorghum is replaced by a row of groundnuts or another legume.

18. In general, best yields are obtained if farmers plant with the first planting opportunity which occurs after the first of November. A planting opportunity can be defined as the first two or three days immediately after rainfall of more than 30 mm. Planting of rainfed crops in October is not recommended.

#### Livestock

19. Estimation of the grazing carrying capacity indicates, that grazing demands posed by cattle, donkeys and goats can be met in good rainfall years. In poor rainfall years grazers are forced to turn to browse quite early in the dry season thus straining their health. The present cull and milk production are modest.

20. Adoption of improved herd management would enhance production by an estimated 100 % in culls, and by 60 % in milk production. Even with the improvements, the herd take-off rates are only a modest 11 % as compared to 7 % without improvements. Livestock owners are recommended to improve veterinary care, and to provide supplementary feed to all cattle. In such a scenario controlled stocking is essential. The total number of grazing animals should not be allowed to grow, and individual herd sizes should be controlled. Generally, a flexible system is required in which animals are sold or moved in response to grazing conditions.

#### Financial analyses of various production systems

21. Financial analysis indicates that the present net benefit, without drought relief, for a farm typical of Group 1 farmers (see Paragraph 7) is Pula 330 per year, and for farms typical of Group 2 and 3 farmers Pula 555 and Pula 985 per year respectively. Income is obtained from all three major farming system components: livestock grazing, arable farming and collection of veld products. The figures

above show a low income from farming and the collection of veld products and confirm the assumption that many farmers depend on additional sources of income (see also Paragraph 13).

22. Financial analysis indicates that adoption of improved farm practices leads to an estimated potential net benefit for typical Group 2 and Group 3 farms of Pula 770 and Pula 2,713 per year respectively. These benefits are considerably higher than at present, representing an increase of 39 % for Group 2 farms and 175 % for Group 3 farms. The largest share of the increased benefit is derived from groundnut farming, which would thus outperform livestock.

23. Adoption of improved farm practices does not make sense in the case of the resource-poor small farmer (Group 1). The potential net benefit is estimated to be negative, because of high cost for hired draughtpower and implements. Introduction of improved management is clearly pointless on small farms which are without means of traction. The high production costs could be mitigated by a Government subsidy directed to small farmers. A programme assisting small farmers in obtaining donkeys or oxen should be designed in such a way so as not to overburden the already stressed grazing resources.

24. Financial analysis indicates that drought relief in its present form reduces operating expenditures to close to zero on farms without means of traction and to negative for larger farms which do have means of traction. Larger farms benefit more than smaller farms from drought relief.

#### Labour

25. Labour availability is a crucial determining factor in the adoption of improved management practices. At present, a labour shortage exists on larger farms (Group 3) and excess labour may be available on some small farms (Group 1). It is estimated that the change to rowplanting and related operations would increase overall labour demand by 25 % during the cropping season. In addition, the production of groundnuts is assumed to increase labour demand during the growing season with another 25 % as compared to sorghum. Labour availability within the area seems adequate to meet this demand.

#### Land allocation

26. It is recommended that the present pattern of arable fields be maintained, and not to attempt to modify it either by consolidation of farms or relocation of farms on better soils. It is considered that the social and infrastructural disruption, which the re-location of farms might provoke, are not counter balanced by sufficient benefits. However, future land allocation should concentrate on the deep soils south of the drift fence (unit 7b on Map 7).

#### Soil conservation

27. Soil conservation both in farmers' fields and in rangelands will be required to prevent further deterioration of topsoils and vegetation. Fertility maintenance of arable soils should be promoted by the use of kraal manure, ploughing in of crop residues and/or green manure, crop rotation, and the use of chemical fertilizer. The installation of a system of paddocks to control grazing, is required. This subject should be further discussed with the whole community.

#### Settlements, tree planting

28. The villages of Ratholo and Majwaneng are threatened by erosion caused by run-off from the Tswapong footslopes. Future expansion of the villages should be in southerly direction and not further upslope. The footslopes north of the villages should be protected and provide good sites for woodlots.

Tree planting within the compounds should be encouraged. Some physical structures will be needed to control gully erosion in the villages.

#### Dams, springs, irrigation

29. No suitable dam sites have been identified in the area below the Tswapong Hills. Present dams are shallow and not properly managed. Various actual and potential perennial water sources exist in the Tswapong Hills. The spring north of Ratholo village is intensively used for human and livestock consumption and needs rehabilitation and protection. The spring and dam above Moeng College are neglected and under-utilized.

30. There is not much scope for irrigated agriculture in the AEA. Irrigation from boreholes will only be productive if the irrigated area is intensively used and well managed.

#### Potential for agro-industries

31. Groundnuts can only be sold in shelled form. Shelling could provide a labour intensive small-scale local industry which provides employment during the dry season. If sufficient groundnuts are produced, the production of peanut butter should be considered. Another possible small-scale agro-industry is the advanced processing and marketing of phane.

#### Extension

32. Advice given to farmers must be improved both in content and effort. The Agricultural Demonstrator (AD) and Stock Inspector (SI) must be provided with clear instructions and manuals to assist them in getting messages across to farmers. The AD must be freed from drought relief administration and the SI of participation in vaccination campaigns elsewhere. Additional extension staff may be required in the future. The AD and SI should continue to support the Farmers' Committee, which could be instrumental in the education and organization of farmers. Extension Officers should take into account the gender and age of the "average" farmer (see Paragraph 1). Different messages will be needed for different Groups of farmers (see Paragraphs 7, 22 and 23).

#### Institutions

33. Some of the suggestions given in the previous Paragraphs need additional support from various Government institutions. For example, seed and fertilizer for proposed crops should be readily available and pricing of produce and subsidies should encourage appropriate farming practices.

## CHAPTER 1

### INTRODUCTION

Land use planning is the assessment of the physical resources and the economic and social conditions of an area, and an evaluation of potential sustainable land-uses. Its purpose is to select and put into practice those land uses which will protect the long-term interests of the of present and future users.

Land use planning does not necessarily mean a complete change of land use and re-settlement. Present use of the land has developed over a long period of time and usually makes very good sense. However, because of rapidly changing social and economic conditions (e.g. population growth and changes in lifestyle and expectations), the present land use has to be adjusted and made more productive. The land use planner helps with making such adjustments.

#### 1.1 OBJECTIVES

The present study has two objectives:

The first objective is to create a land use plan for the benefit of the people of Ratholo AEA, drawn up in consultation with farmers, local authorities and relevant Government institutions. Since the area is thought to be representative of large parts of Palapye Agricultural District, it is hoped that the conclusions and recommendations of the plan can be extrapolated or replicated to similar areas in the District.

The second objective is to establish and test a methodology of land use planning, applicable to studies of similar nature and scale throughout the country. Land use planning is a relatively new discipline in Botswana, and the Ratholo study can be considered as one of the test cases for the planning of established communal areas in the country.

#### 1.2 METHODOLOGY

##### 1.2.1 Area selection

Land use planning can be done for any area of land, such as a single farm or an entire District or Region. The present study is a plan for an Agricultural Extension Area (AEA). The AEA is the smallest unit in the hierarchy of the Ministry of Agriculture. In conjunction with the RAO management and the District Land Use Planning Unit (DLUPU) <sup>(1)</sup>, Ratholo AEA was selected as the first area for study, using a number of criteria such as potential for crop production, high population density, presence of erosion problems, presence of land use conflicts, variation in land resources/production potential, and the presence of capable extension agents in the area.

<sup>1</sup> The DLUPU covers the Central District (Administrative), which is larger than the Central Region of the Ministry of Agriculture (see also Section 3.5)

### 1.2.2 Data collection and analysis

The following surveys were carried out in the area as part of the study:

- 1 Informal farm survey (1 week). Short interviews with 15 farmers were held. Local authorities and several key informants were also interviewed. The survey was carried out to develop an understanding of farming practices, constraints and opportunities, and farmers objectives and strategies. Another aim of the survey was to determine recommendation domains.
- 2 Additional farming systems survey (2 weeks) for collection of quantified data on key agricultural parameters. Interviews were held with some 30 farmers. Data were entered into the Land Use Database (FAO et al, 1994)
- 3 Natural resource survey (2 weeks). Soils were described from 36 augerings and 6 soil pits. Surface characteristics (slope, erosion and crusting) were also recorded. Twenty five topsoil samples were taken and sent to the laboratory for analysis of phosphorus, pH and organic carbon. Vegetation data were collected, including data on the tree and shrub layer in terms of species composition and canopy cover. The location and seasonality of water sources (bore holes, wells, springs, pans and streams) was also surveyed.
- 4 Herd survey (3 days) was carried out in cooperation with the Livestock Production Specialist of the LUPSAD project.
- 5 Vegetation and grasses survey (3 days) was carried out during the rainy season, also together with the Livestock Production Specialist.
- 6 Area boundary survey (1 day) was carried out together with the Agricultural Demonstrator (AD).

Other data collected include drought relief data, population census data, livestock census data, and meteorological data of recent years.

Other important sources of existing information were farm management surveys, tillage trials and agricultural statistics conducted or collected by the Ministry of Agriculture countrywide.

Extensive use was made of the following existing maps and photographs:

- Palapye sheet of the Soil Map, scale 1:250,000 (Rommelzwaal, 1989)
- Moeng sheet of the Geological Map, scale 1:125,000 (Geological Survey)
- Vegetation Map, scale 1:500,000 (Timberlake, 1980)
- Topographic map sheets, scale 1:50,000 (Dept. of Surveys and Lands, 1984-1986)
- Monochrome (B&W) aerial photography, scale 1:50,000, flown in 1988
- Satellite imagery (Landsat-TM) image, scale 1:250,000, recorded on 24 July 1993

The following computer programmes and applications were used:

- ILWIS GIS for map production (Version 1.4, ITC, 1993).
- CYSLAMB for crop yield simulation (De Wit et al., 1993-1994).
- METEO for retrieval of meteorological data (FAO, 1991).
- Botswana Soil Data Base for existing soils data (Van Waveren, 1988).
- Waterpoint Database/GIS for existing water points (Wellfield Consultants, 1992)
- Land Use Database for storage and retrieval of farming systems data (ITC/FAO/WAU, 1994).

- Carrying capacity and herd projection spreadsheets (Powell, 1994).
- LOTUS 123 for analysis and processing of various data and presentation of tables (Version 3.1+, 1989).

### 1.2.3 Consultation

The consultation process consisted of three stages:

- 1 Initial presentation of project activities and consultation with the DLUPU, District Development Committee (DDC), RAO staff, District Agricultural Office (DAO) staff, Agricultural Demonstrator (AD) and Stock inspector (SI), and local authorities at village level (Headman, Village Development Committee (VDC) and farmers committee).
- 2 Regular consultation of AD and other RAO staff during data collection and data analysis.
- 3 Presentation of results and further discussions and consultations with RAO, DLUPU, Landboard and local authorities.



## CHAPTER 2

### PHYSICAL ENVIRONMENT

#### 2.1 LOCATION

The Ratholo Agricultural Extension Area is located on the southern footslopes of the Tswapong Hills. It lies halfway between Palapye and Martins Drift (both are approx. 50 km away) and is easily accessible via the road which links these two places. The coordinates of the centre of the area are close to 22° 45' South and 27°35' East. See Map 1.

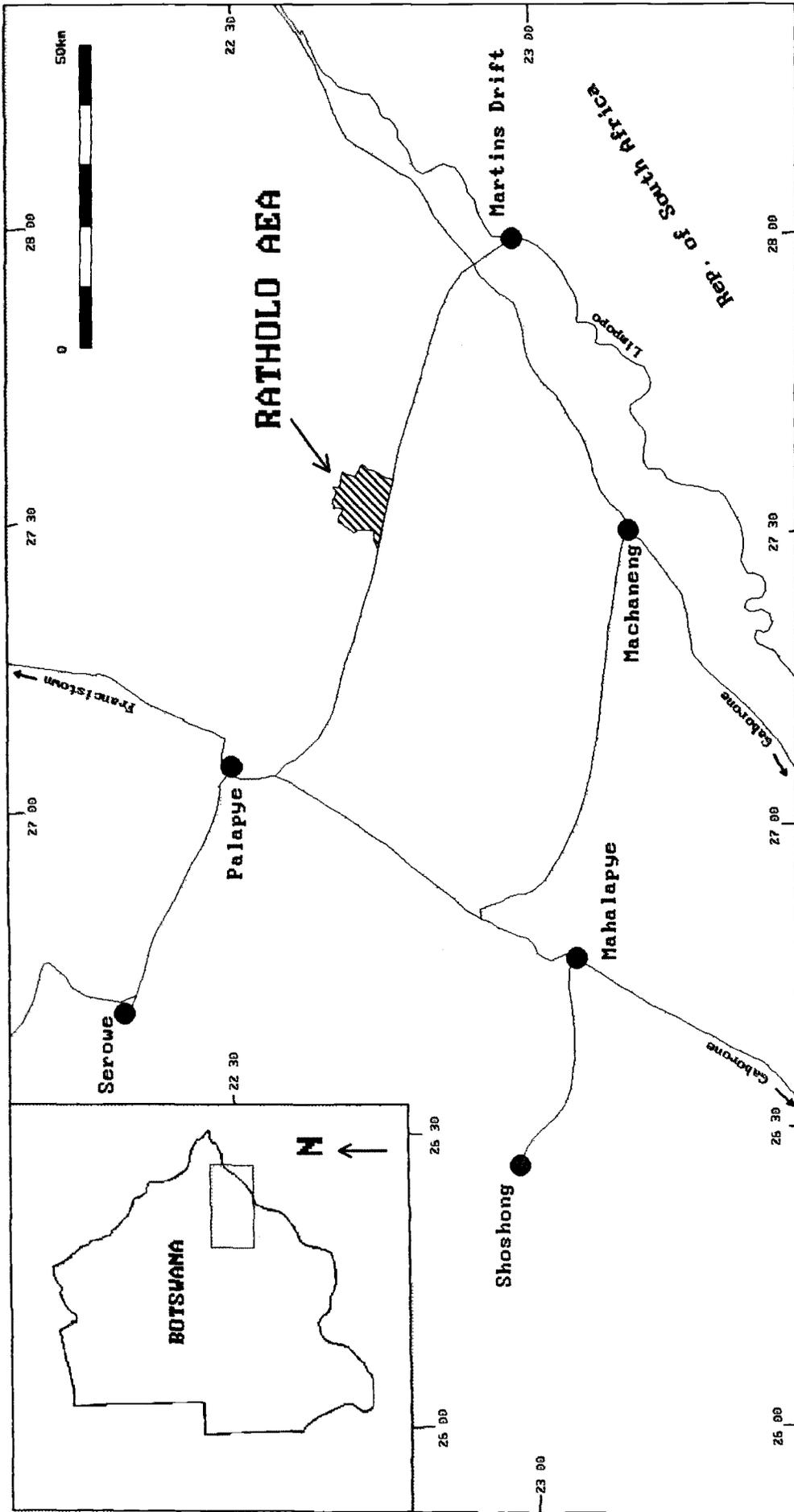
Ratholo AEA covers an area of approx. 270 km<sup>2</sup>. Its southern border is formed by the Palapye - Martins Drift road, which coincides with the Makoro cordon fence, while the northern border mostly follows south-facing escarpments of the Tswapong Hills near Moeng. The eastern and western boundaries do not follow any natural features.

Ratholo AEA encompasses the villages of Ratholo and Majwaneng and also includes Moeng college. In general administrative terms Ratholo AEA lies within Palapye/Serowe sub-District in the Central District. For agricultural administration it is located in Palapye Agricultural District (Offices in Palapye) in the Central Agricultural Region (Offices in Serowe).

#### 2.2 CLIMATE

The meteorological station nearest to Ratholo is Mahalapye (lying 90 km in south-westerly direction). Mahalapye has 27 years of record and its meteorological parameters are summarised in Table 1. The data from Mahalapye are used in the land evaluation procedure (Chapter 5). Inferred synoptic data for Ratholo are presented in Table 2. The nearest rainfall stations with reliable long term records are Martins Drift (50 km E), Machaneng (50 km S) and Palapye (50 km W). See Table 3. Other rainfall stations located nearby, such as Maunatlala (15 km N) and Lerala (20 km E), have records of fewer years and records are often incomplete. Rainfall station Palapye (for the period 1960-1992) is selected to be used for land evaluation of the Ratholo area, since its natural setting resembles the conditions in Ratholo best.

Mean annual rainfall is around 400 mm, the larger part of which falls during a limited number of showers during the rainy season, which lasts from October through April. Long term rainfall records of Palapye are presented in Table 4. The year-to-year variation in annual rainfall is high, about 150 mm on average. Dry spells may occur during middle of the rainy season. Table 4 shows that in 13% of all years the whole month of January received less than 25 mm of rain, and in 23% of all years the whole month of February was almost dry. Annual potential evapo-transpiration (PET) is high, about 1600 mm, with the highest monthly figures (180 mm) occurring during the rainy season. On average, the period that rainfall exceeds half PET is 54 days, from mid January to early March. This period is called the Length of Growing Period (LGP). The mean annual temperature is 20.5 °C. Average minimum temperatures vary from 4.6 °C in July to 19.1 °C in January and mean maximum temperatures from 22.5 °C to 30.9 °C in the same months.



MAP 1. LOCATION RATHOLD AEA

TABLE 1. SYNOPTIC METEOROLOGICAL DATA, MAHALAPYE

STATION: MAHALAPYE		Height: 1005 m asl	Latitude: 2307S											Years of record: 27	
			Longitude: 02650E												
METEOROLOGICAL PARAMETER	UNIT OF MEASUREMENT		J	F	M	A	M	J	J	A	S	O	N	D	ANNUAL AVERAGE or TOTAL
TEMPERATURE – mean max.	( C )		30.9	30.2	28.6	26.5	24.4	22.1	22.3	25.1	29.2	29.8	30.4	30.6	27.5
– mean min.	( C )		19.1	19.2	16.6	16.2	8.1	4.9	3.9	7.1	12.6	15.6	18.0	19.0	13.4
extreme max.	( C )		40.5	36.6	36.5	34.6	33.0	28.9	29.8	34.1	37.6	39.3	38.6	37.9	
– extreme min.	( C )		12.5	13.5	9.8	4.5	1.0	-5.4	-4.0	-6.0	1.7	6.2	8.6	11.6	
REL.HUMIDITY – 08.00 Hrs	(%)		58	64	68	64	62	64	54	56	50	52	60	60	59
– 14.00 Hrs	(%)		47	54	54	44	35	42	33	31	30	38	47	44	42
SUNSHINE	(hrs/day)		7	7	8	9	9	9	10	9	9	8	8	9	8
WIND SPEED	(km/hr)		3	3	3	2	2	2	2	3	4	4	4	4	3
RAIN	(mm)		88	82	67	26	9	3	2	2	8	31	67	79	464
PET	(mm)		172	149	136	110	89	72	80	105	136	159	164	180	1552
FROST – air	(days/month)		0	0	0	0	0	2	1	1	0	0	0	0	4
– ground	(days/month)		0	0	0	0	1	11	11	3	0	0	0	0	26

TABLE 2. INFERRED SYNOPTIC METEOROLOGICAL DATA, RATHOLO  
(Derived through interpolation of data for Mahalapye, Francistown and Thabazimbi)

STATION: RATHOLO		Height: 915 m asl	Latitude: 2245S											Years of record: 27	
			Longitude: 02735E												
METEOROLOGICAL PARAMETER	UNIT OF MEASUREMENT		J	F	M	A	M	J	J	A	S	O	N	D	ANNUAL AVERAGE or TOTAL
TEMPERATURE – mean max.	(C)		30.9	30.1	29.0	27.1	24.8	22.4	22.5	25.2	29.3	30.5	30.7	30.7	27.8
– mean min.	(C)		19.1	19.0	16.9	13.5	8.4	5.1	4.6	7.7	13.0	16.3	17.8	18.9	13.4
extreme max.	(C)		40.0	37.2	37.4	34.8	33.0	29.3	29.7	35.1	37.1	39.5	39.3	38.7	
– extreme min.	(C)		11.9	12.4	8.3	4.3	0.1	-3.3	-4.0	-3.8	1.9	6.1	7.9	10.9	
REL.HUMIDITY – 08.00 Hrs	(%)		63	68	70	68	67	66	61	57	50	53	59	63	62
– 14.00 Hrs	(%)		50	54	53	48	40	45	38	33	33	36	47	46	44
SUNSHINE	(hrs/day)		8	8	8	9	9	9	10	10	10	9	8	9	9
WIND SPEED	(km/hr)		5	4	4	4	3	3	3	4	5	6	5	5	4
PET	(mm)		175	153	143	116	95	78	86	113	145	169	170	160	1623
FROST – air	(days/month)		0	0	0	0	0	2	1	1	0	0	0	0	4
– ground	(days/month)		0	0	0	0	1	11	11	3	0	0	0	0	26

TABLE 3. MEAN MONTHLY AND ANNUAL RAINFALL OF SELECTED STATIONS

STATION	ALT. (m)	LAT. LONG.	NO. OF YEARS OF RECORD	J	F	M	A	M	J	J	A	S	O	N	D	YEAR SD(*)
PALAPYE	908	2233S 02708E	56	80.3	71.5	59.4	25.1	6.6	3.2	0.8	0.5	7.0	25.8	52.6	66.7	399.5
MAHALAPYE	1005	2307S 02650E	78	88.3	81.9	67.0	25.5	9.3	3.3	2.3	2.4	7.7	31.1	66.6	78.9	464.3
MARTIN'S DRIFT	673	2259S 2756E	23	102	50.8	46.1	30.8	7.4	0.8	0.6	0.5	4.5	29.1	66.0	62.4	401.2
SEFHOPE	673	2212S 2758E	20	53.3	65.4	29.0	25.8	6.5	4.9	0.2	0.8	5.6	27.6	57.6	60.1	336.7
MACHANENG	725	2311S 02730E	30	78.9	80.8	53.1	31.0	7.5	0.7	0.8	1.0	4.2	30.0	64.0	64.8	416.7
MAUNATLALA	840	2236S 2737E	16	77.1	58.5	40.2	27.4	7.3	2.4	0.0	1.5	3.1	27.0	65.6	64.4	374.5

\* SD = Standard Deviation

TABLE 4. MONTHLY RAINFALL DATA, PALAPYE (mm). Years with missing data are excluded.

STATION: PALAPYE													Height: 908 m asl	Latitude: 2233S	Longitude: 02708E	Years of record: 56
YEAR	J	F	M	A	M	J	J	A	S	O	N	D	ANNUAL TOTAL			
1923	240.3	111.6	100.3	2.0	2.5	0.0	0.5	0.0	0.0	0.3	76.0	74.2	607.7			
1924	19.3	92.7	98.3	0.0	48.8	0.0	0.0	0.0	0.0	56.9	67.7	177.6	561.3			
1925	127.8	18.3	205.5	36.1	84.7	33.3	0.0	0.0	98.3	28.5	18.6	50.3	701.4			
1929	134.7	61.3	51.2	3.3	1.0	0.0	0.0	0.0	27.4	66.6	69.2	97.4	512.1			
1930	105.2	73.8	34.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.5	86.6	328.0			
1931	43.2	19.0	41.9	71.2	0.0	0.0	2.5	0.0	0.0	17.7	157.1	9.2	361.8			
1932	121.3	47.6	92.1	73.0	0.3	0.0	0.0	0.0	0.0	3.6	10.5	33.3	381.7			
1933	145.6	23.6	7.9	0.8	0.0	0.0	0.0	0.0	0.8	0.3	98.9	67.3	345.2			
1934	92.9	77.5	44.6	2.0	1.3	0.5	0.0	1.3	0.0	0.0	35.6	120.2	375.9			
1935	5.3	15.1	28.5	3.3	6.7	0.0	0.0	0.0	7.1	0.0	4.8	44.2	115.0			
1936	129.7	59.4	107.8	1.6	18.3	0.0	0.0	0.0	0.0	53.1	73.5	74.4	517.8			
1937	102.3	258.8	34.6	5.6	0.0	0.0	0.0	0.0	1.3	6.4	3.5	86.2	498.7			
1938	65.1	5.9	44.3	41.7	0.0	0.0	0.0	0.0	8.9	12.5	138.0	179.3	495.7			
1939	110.3	126.6	27.2	0.0	0.0	0.0	7.4	0.0	2.5	2.8	54.6	0.0	331.4			
1940	45.9	30.9	151.2	49.5	0.0	36.3	0.0	0.0	21.8	7.6	92.6	204.2	640.0			
1941	76.7	49.1	3.3	49.2	0.0	10.4	0.0	0.5	1.3	50.3	7.8	48.4	297.0			
1942	78.2	2.8	67.7	1.0	12.7	6.4	0.0	1.8	0.5	43.5	21.1	60.2	295.9			
1943	58.0	17.1	88.0	69.1	15.8	0.0	14.8	2.3	2.1	42.7	158.1	58.2	526.2			
1944	62.5	259.3	56.4	47.5	0.0	8.6	0.0	0.0	0.0	59.0	49.3	0.0	542.6			
1945	17.8	0.8	99.8	0.0	0.0	0.0	0.0	0.0	0.0	17.7	21.8	10.9	168.8			
1946	157.6	195.5	16.0	0.0	0.0	0.0	0.0	0.0	0.0	4.8	4.3	71.1	449.3			
1947	49.0	30.0	54.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	133.2			
1949	148.1	49.8	66.4	0.0	0.0	0.5	0.0	0.0	0.0	16.3	40.2	43.2	364.5			
1960	52.2	59.7	68.0	58.0	5.0	0.0	0.0	3.0	18.5	0.2	91.5	147.5	503.6			
1961	62.5	101.0	116.5	58.5	19.0	5.0	0.0	0.0	3.0	3.8	45.7	16.0	431.0			
1962	39.4	6.6	22.0	36.0	1.5	0.0	0.0	0.0	11.0	0.0	69.5	82.6	268.6			
1963	100.6	12.0	36.5	105.1	12.6	5.0	0.0	0.0	0.0	40.7	52.0	71.0	435.5			
1964	50.4	9.9	5.5	1.7	0.0	0.0	0.0	0.0	0.0	37.0	111.8	31.2	247.5			
1965	48.5	14.0	2.5	18.0	0.0	0.1	0.0	0.0	0.2	1.0	77.3	11.2	172.8			
1966	37.0	99.0	4.0	0.0	2.0	0.7	0.0	0.0	4.0	23.0	58.4	54.8	282.9			
1967	144.0	139.0	9.6	0.0	0.0	0.0	0.0	0.0	0.0	1.2	28.4	24.6	346.8			
1968	53.6	49.0	42.3	81.2	19.8	2.5	0.0	0.0	0.0	17.5	107.0	103.8	476.7			
1969	27.9	68.3	108.6	23.0	14.0	0.0	0.0	0.0	0.0	60.0	50.0	55.3	407.1			
1970	3.4	87.0	25.5	14.6	0.0	11.0	0.4	0.0	0.0	26.0	46.8	143.3	358.0			
1971	129.6	26.8	7.4	33.0	21.0	0.0	0.0	0.0	13.7	54.6	89.7	19.8	395.6			
1972	227.6	14.8	119.4	8.0	10.4	0.0	0.0	0.0	13.2	1.2	22.5	7.0	424.1			
1973	30.5	33.0	8.9	19.0	0.0	0.0	0.0	0.0	26.5	91.8	40.4	92.0	342.1			
1974	114.1	76.7	32.2	84.0	0.5	0.0	2.9	0.0	0.0	0.0	55.2	87.2	452.8			
1975	207.5	75.0	67.3	71.0	22.2	0.0	0.0	0.0	0.0	0.0	37.4	141.2	621.6			
1976	60.1	60.5	94.0	0.0	2.0	0.0	0.0	0.0	22.6	32.3	69.0	57.0	397.5			
1977	73.0	150.0	154.7	0.0	2.5	0.0	0.0	1.2	33.8	9.0	25.0	81.0	530.2			
1978	101.6	48.9	59.0	26.5	0.0	0.0	0.0	0.2	15.2	55.9	49.0	62.0	418.3			
1979	33.1	21.0	59.0	0.0	6.0	0.0	0.0	18.0	0.0	67.0	12.0	106.0	322.1			
1980	53.0	292.4	51.9	11.0	0.0	0.0	0.0	0.0	9.0	73.0	169.0	42.0	701.3			
1981	212.0	62.2	56.1	13.8	0.0	0.0	0.0	0.0	0.0	8.5	15.0	33.5	401.1			
1982	39.2	36.3	11.0	17.0	2.2	0.0	0.0	0.0	0.0	82.5	20.0	7.2	215.4			
1983	49.0	18.5	84.3	1.5	7.0	2.0	0.0	1.0	0.3	11.6	58.0	61.4	294.6			
1984	16.5	59.0	192.2	6.9	0.6	0.0	17.7	0.0	2.0	42.1	47.0	12.8	396.8			
1985	22.6	19.4	2.4	0.0	22.0	0.0	0.0	0.0	0.0	28.8	0.0	72.5	167.7			
1986	19.0	96.6	14.0	114.9	0.0	0.0	0.0	0.0	6.0	63.6	127.0	8.9	450.0			
1987	60.1	39.8	50.0	8.5	0.0	0.0	0.0	0.0	4.8	5.0	25.4	254.1	447.7			
1988	107.0	405.3	112.6	73.3	0.0	0.0	0.0	0.0	33.8	43.5	1.0	16.7	793.2			
1989	93.9	70.8	21.8	50.4	0.0	17.5	0.0	0.0	0.0	17.0	48.0	8.6	328.0			
1990	4.4	45.2	43.3	12.4	8.0	0.0	0.0	0.0	0.0	0.2	11.5	86.1	211.1			
1991	85.8	71.0	124.0	0.0	0.0	37.0	0.0	0.0	0.0	27.0	40.0	89.0	473.8			
1992	0.0	9.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28.3	16.5	49.3	103.1			
MEAN	80.3	71.5	59.4	25.1	6.8	3.2	0.8	0.5	7.0	25.8	52.8	66.7	399.5			
SD(*)	57.1	77.4	46.1	30.8	13.8	6.4	3.2	2.4	15.3	25.4	41.9	53.6	146.7			

\* SD = Standard Deviation

## 2.3 GEOLOGY AND LANDFORMS

Ratholo AEA is made up of three major landforms (see Map 2):

- T - Tswapong Hills
- F - Foothslopes of the Tswapong
- M - Molapo plain

The northern half of the area is taken up by rolling, and in some places strongly dissected flat-topped hills of the Tswapong range at an altitude of 1000-1150 m above sea level (asl). The hills are bisected by a 2 km wide valley, which runs from WNW to ESE. The valley is bounded by escarpments and its bottom (categorised as foothslopes) lies about 100 m below the level of the hills. To the south, the Tswapong hills are bounded by a steep escarpment of 100-150 m high which separates them from the foothslopes and plain below. The foothslopes zone to the south of the Tswapong, is about 4 km wide and has an average slope of less than 2 %. The southern half of the study area consists of a slightly undulating plain which very gentle slopes with a gradient of 0.5 % towards the south and south-east. Drainage on the plain is from north to south through shallow, broad, almost invisible depressions. In addition to these drainage lines, small, circular depressions (pans) occur throughout the plain which may contain water during the rainy season.

Information on the hardrock geology of the area is taken from Moeng Sheet of the Geological Survey of Botswana at scale 1:125 000. The Tswapong hills consist of Quartzites (and possibly Andesites) of the Palapye Group which dates from the Middle Precambrian age. The foothslopes of the Tswapong consist of recent alluvial and colluvial deposits derived by weathering from the Tswapong Quartzites and associated rocks. The Molapo plain is underlain by Granitoid rocks of Early Precambrian age. Although colluvial and alluvial processes have played an important role in shaping this plain, the material covering these plains is primarily residual in nature.

## 2.4 SOILS

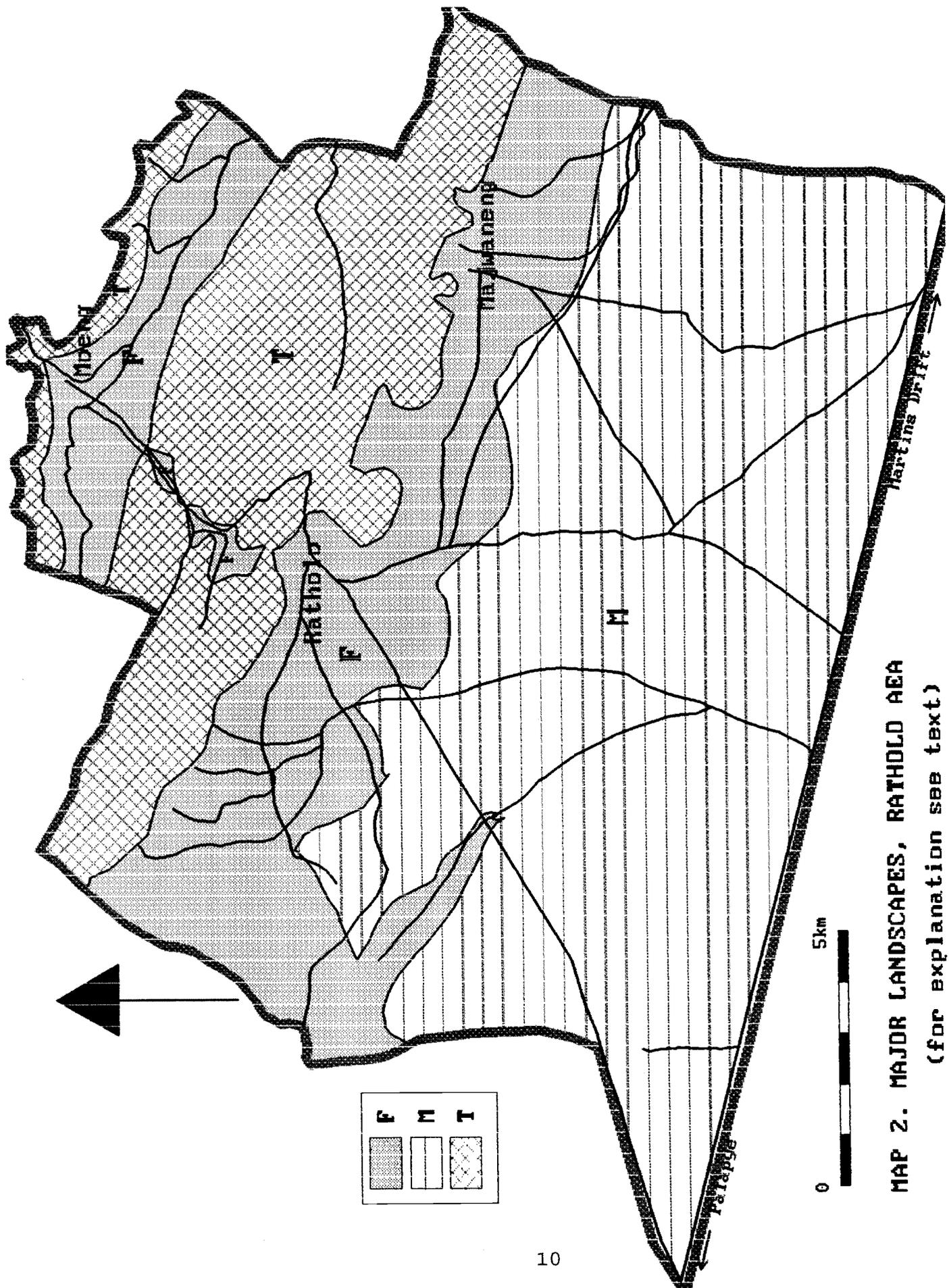
### 2.4.1 Characteristics and distribution

The distribution of soils in the Ratholo AEA is shown on Map 3. The main soil characteristics are presented in the legend (Table 5). The map and legend are partly based on information derived from the Soil Map of Botswana, scale 1:250 000 (Remmelzwaal, 1989) and partly on data gathered by additional fieldwork. Analytical data of representative soil profiles are given in Table 6.

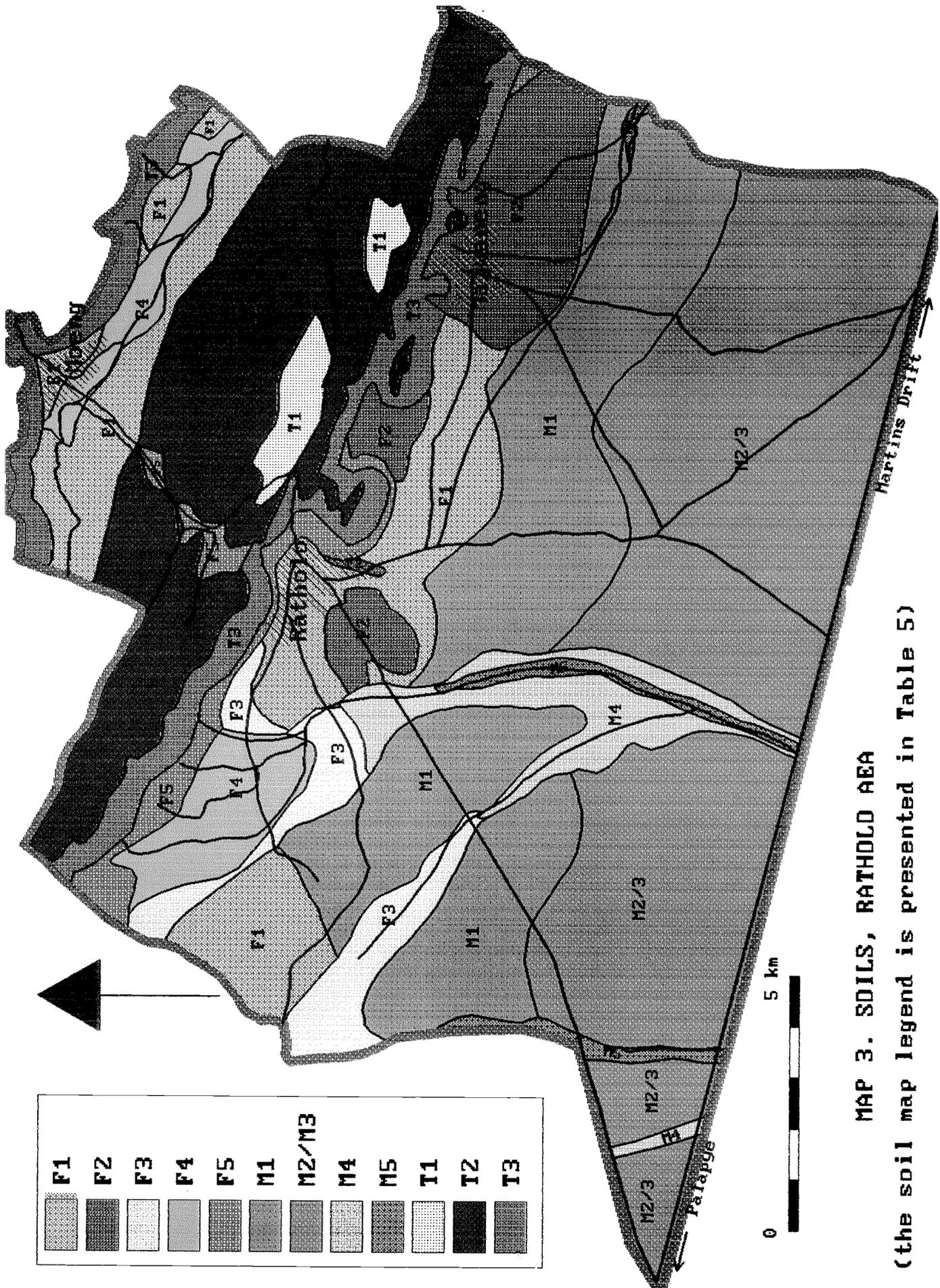
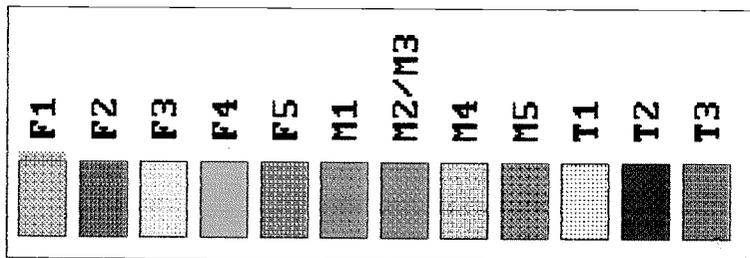
The three major landscapes which were identified in Section 2.3, i.e. Molapo plain, Foothslopes of the Tswapong, and the Tswapong Hills, are again used for major subdivision. Homogeneous soil units have been mapped, which are different from each other in terms of characteristics most relevant for their use. Both inherent soil characteristics, such as depth and texture, and surface characteristics, such as slope and erosion status, have been used for separation of soils on the map.

#### - Soils of the Molapo plain

Most soils of the Molapo plain are medium textured (sandy loam over sandy clay loam), acid and have free drainage. Only close to drainage ways is the drainage slightly impeded and do occasional flashfloods



**MAP 2. MAJOR LANDSCAPES, RATHOLD AEA**  
 (for explanation see text)



MAP 3. SOILS, RATHOLD AREA  
 (the soil map legend is presented in Table 5)

TABLE 5. SOIL MAP LEGEND RATHOLO AEA

1	2	3	4	5	6	7	8	9	10	11	12	13	14
SYM - SOIL CLASS (FAO 1988) BOL	SOIL CLASS (FAO 1988) CLASS	SOIL DEPTH (cm)	DRAINAGE CLASS	TEXTURE		pH Topsoil	AWHC (t/m/m)	COLOUR moist subsoil	EROSION (***)	STONINESS surfaces	ROCKINESS	AREA (ha)	
				Topsoil (**)	Subsoil (**)								
<b>MOLAPO PLAIN - residual soils on granitoid rocks, frequently having a thin alluvial cover</b>													
M1	Chromic Luvisols (LVx)	A13	100-150	well	LS + SL	SL + SCL	5.5-6.4	110	reddish brown	-	-	-	4,907
M2	Ferric/Haplic Luvisols, petro ferric (LVfp/LVhpf)	A11a	50-100	well	LS + SL	SL + SCL	5.0-6.2	100	reddish brown	-	-	-	5,401
M3	Eutric Regosols, petric (RGept)	A34	<50	moderately well	SL	SL	5.7-7.1	80	dark reddish brown	-	-	-	2,492
M4	Ferric/Haplic Luvisols, petro ferric (LVfp/LVhpf)	A11a	50-100	moderately well	SL	SL + SCL	5.0-6.2	100	dark reddish brown	-	-	-	877
M5	Calcic Cambisols (CMc)	A4	50-100	imperfect	SL	SL + SCL	6.5	110	dark reddish brown	-	-	-	333
<b>FOOTSLOPES OF TSWAPONG HILLS - alluvial and colluvial soils</b>													
F1	Chromic Luvisols (LVx)	A13	>150	well	LS + SL	SL + SCL	5.4-6.2	110	yellowish red	-	-	-	3,111
F2	Chromic Luvisols (LVx)	A13	>150	well	LS + SL	SL + SCL	5.4-6.2	110	yellowish red	common	-	-	1,578
F3	Haplic/Ferric Luvisols (LXh/LXf)	A11	>150	well	CL	C	6.4	140	dark reddish brown	common	-	-	1,408
F4	Haplic/Ferric Luvisols (LXh/LXf)	A11	>150	well	SL + CL	SCL + C	6.4	140	dark reddish brown	frequent	-	-	593
F5	Eutric Regosols, petric (RGept)	A34	50-100	well	SL	SCL	5.4-6.2	80	dark reddish brown	common	very stony	-	635
<b>TSWAPONG HILLS - residual soils on quartzites</b>													
T1	Haplic Luvisols, petric (LXhpt)	D2	50-100	well	SL	SCL	6.2	80	dark reddish brown	-	very stony	-	339
T2	Eutric Leptosols (LPe)	R	<50	excessive	-	-	-	50	-	-	very stony	very rocky	3,977
T3	Lithic Leptosols (LPq)	R	<30	excessive	-	-	-	50	-	-	very stony	very rocky	1,373

TOTAL RATHOLO AEA 27,024

\* The equivalent soil unit of the general soil legend of Botswana is given.

\*\* LS = Loamy Sand; SL = Sandy Loam; SCL = Sandy Clay Loam; CL = Clay Loam; C = Clay.

\*\*\* Both the process of erosion and the status of the land surface are described.

TABLE 6. SOIL ANALYTICAL DATA FOR REPRESENTATIVE PROFILES

SOIL MAPPING UNIT	SOIL TYPE	PEDON	DEPTH	PH		P ppm	ORG. C %	CEC CLAY me/100g	CEC SOIL me/100g	CA me/100g	MG me/100g	K me/100g	NA me/100g	BASE SAT %
				H2O	CACL2									
				0 - 20	0 - 20									
M1, F1, F2	LVx	MC64	0 - 20	6.3	5.8	7	0.5	28	4.4	3.0	0.6	0.4	0.0	91
			30 - 50	5.8	5.2	3	0.3	27	4.4	2.5	0.5	0.4	0.1	80
			80 - 100	6.3	5.8	2	0.2	39	7.4	4.6	1.2	0.4	0.1	85
F1, F2	LVx/LVh	SP17	0 - 15	6.8	5.8	22	0.2	41	3.8	1.6	0.6	0.3	0.1	68
			20 - 40	6.9	6.0	5	0.1	53	4.5	2.2	1.0	0.3	0.1	80
			60 - 80	7.2	6.5	5	0.1	42	7.1	4.0	1.6	0.5	0.1	87
			110 - 130	7.3	6.7	6	0.0	58	5.9	3.8	1.2	0.4	0.1	93
M2, M4	LV/pf/LV/hpf	MC58	0 - 20	6.5	6.0	8	0.6	25	6.4	3.6	0.7	1.2	0.1	88
			30 - 50	6.0	5.4	6	0.4	23	8.1	4.2	1.0	0.5	0.2	73
			90 - 110	6.4	5.8	4	0.2	36	11.5	6.2	1.3	0.6	0.3	73
			130 - 150	6.5	6.0	3	0.1	35	11.0	7.0	1.9	0.8	0.4	90
M3	RGept	PS136	10 - 30	7.1	6.4	1	0.3	34	7.2	2.9	1.4	0.7	0.1	71
M5	CMc	M902	0 - 17	6.8	6.4	5	0.4	25	5.7	7.0	0.7	1.1	0.1	100
			17 - 29	6.8	6.1	2	0.4	20	4.8	6.6	0.7	1.2	0.1	100
			40 - 60	6.5	5.9	1	0.4	18	5.0	6.3	0.0	0.5	0.1	100
			75 - 90	7.2	6.6	1	0.2	17	3.9	5.2	0.5	0.2	0.1	100
F3, F4	LXh/LXf	MC59	0 - 20	6.3	5.6	2	0.3	27	3.4	1.9	0.2	0.3	0.0	71
			50 - 70	6.6	6.1	2	0.2	21	3.6	1.7	1.0	0.2	0.1	83
			90 - 130	6.5	5.9	1	0.2	20	4.3	1.6	1.4	0.1	0.1	74

occur. A petroferri<sup>2</sup> or gravelly layer occurs universally in the soil profile, at a depth of less than 50 cm in the south, 50-100 cm in the central plain and at more than 100 cm depth towards the north. The depth of this layer has been used as the main criterion for subdivision of soils in the plain. Most soils derive from residual material of the underlying granitoid rocks and are moderately weathered and leached (depleted of nutrients). They mainly classify as Ferric or Haplic Luvisols, petroferri phase (FAO, 1988).

#### - Soils of the Foothills

The soils of the foothills of the Tswapong Hills are medium (sandy loam over sandy clay loam) or fine textured (clay loam over clay), acid and freely drained. They are situated on gentle slopes (1-2 % gradient), have no stones at the surface and are very deep (no impediment to root development). Only close to the northern escarpment do the soils occur on somewhat steeper slopes, and are locally stony and shallow. Rill and sheet erosion is a frequent phenomenon in the foothills, and its presence has been used as a criterion for subdivision on the soil map. These soils have developed in alluviated weathering materials derived from the Tswapong Quartzites and related rocks and are moderately weathered and leached. They classify as Chromic Luvisols and Haplic or Ferric Lixisols (FAO, 1988).

#### - Soils of the Tswapong Hills

The soils of the Tswapong hills are mostly (very) shallow and very stony. Rock outcrops occur frequently. These soils classify as Leptosols (FAO, 1988). Gently sloping (2-4 % gradient) areas with deeper soil occur in some places. These soils are medium textured and well drained and classify as Haplic Luvisols, petric phase (FAO, 1988).

#### 2.4.2 Soil degradation

Three types of soil degradation are widespread in Ratholo AEA:

- Sheet and rill erosion
- Splash erosion
- Crusting and loss of topsoil structure

A combination of sheet and rill erosion occurs in the foothills of the Tswapong hills. Very locally some rills have developed into gullies. An area of about 4,200 ha is affected (mapping units F2, F3, F4 and F5 on Map 3), about 15 % of which seriously (mapping unit F4). The erosion is the result of a decline of the protective vegetative cover and a loss of topsoil structure, caused by overgrazing and deforestation. With the natural protection partly removed, large amounts of water discharge from the hillsides after downpours, having a strong erosive effect on the gently sloping foothills.

Splash erosion is widespread throughout Ratholo AEA, both in grazing areas and on farmers' fields. Wherever the vegetative cover is poor, direct impact of raindrops causes a redistribution of finer particles on the surface, which leads to deterioration of topsoil structure and to sealing. The net loss of topsoil within a catchment is probably limited due to rapid re-deposition of soil particles on the very gentle to almost flat slopes.

<sup>2</sup> Gravelly and sometimes cemented material with a high content of iron oxides

Topsoil deterioration and crusting is very widespread in the area, particularly in farmers' fields and in intensively grazed rangeland. Because of a loss of topsoil structure, crusts of 1-2 mm thick will form after heavy rainfall, sealing off the soil surface. In the dry season topsoil crusts are hard, in the rainy season they are less conspicuous. In farmers' fields crusts are regularly broken by cultivation and are therefore less well developed. There are many causes for topsoil deterioration: in cultivated fields it is mainly through repeated ploughing, nutrient extraction through harvesting, and sheet and splash erosion; on intensively grazed rangeland it is mainly through reduced leaf and litter fall, trampling and erosion.

## 2.5 LAND COVER AND PRESENT LAND USE

### 2.5.1 Land cover

The Vegetation Map of South East Botswana at scale 1:500 000 by Timberlake (1980) was used as a guide, but field observations constitute the main source of information for this Section.

#### 2.5.1.1 Vegetation zones

The vegetation in the area is affected in varying degrees by land clearing for arable farming, felling of trees for construction, collection of wood for fuel, and grazing and browsing by domestic animals. Three vegetation zones are distinguished in the area. They largely coincide with the major landscapes described in Section 2.3 and shown on Map 2. The subdivision is based on differences in composition of tree and shrub species and on the degree of influence by man:

##### - Shrub savanna of the Molapo plains

About 50 percent of the Molapo plains is cleared of woody vegetation for arable farming, while the remainder of this zone is dominated by low stands of pioneer species and other invading species (*Colophospermum mopane* and *Acacia tortilis*) or species selectively maintained by farmers for their usefulness (*C. mopane* for phane worm, *Sclerocarya caffra* for morula fruits and *Boscia albitrunca* for shade and browse). The shrubs reach a height of usually not more than two to three meters, except for the remaining morula trees which easily reach ten meters. Shrub density is usually between 10 and 20 percent ground cover. The area is heavily grazed and browsed mainly during the dry season. The shrub layer is dominated by *C. mopane* which often represents more than 50 percent of the woody vegetation and sometimes occurs in almost pure stands. *B. albitrunca*, *A. tortilis*, *S. caffra*, *Grewia flava* and *Dichrostachys cinerea* also occur frequently. Less frequent species include *Combretum apiculatum*, *Acacia erubescens*, *A. mellifera*, *A. nigrescens*, *Peltophorum africanum* and *Adansonia digitata*.

##### - Tree and shrub savanna of the footslope zones of the Tswapong hills

The footslope zone is characterised by very deep and freely drained soils. Grazing is the main land use, with tree felling and bush clearing only important close to the villages. Trees and shrubs are generally taller (commonly up to seven meters) than in the lands areas of the Molapo plain. Tree and bush density varies between 20 and 50 percent ground cover. The species composition is largely the same as for the plains area, although *C. mopane* occurs less frequently and dominates with species such as *G. flava*, *A. tortilis* and *C. apiculatum*. In addition to the species listed for the plains area, *Albizia anthelminthica*, *A. harveyii*, *Lonchocarpus capassa*, *Xanthocercis zambesiaca*, *Ximenia americana*, *Commiphora pyracanthoides* and *Cassia breviata* also occur.

## - Hill woodland of the Tswapong hills

Grazing and browsing is the only land use in the Tswapong Hills, together with collection of wood and other veld products. Density and height of vegetation varies much (between 20 and 70 percent ground cover), mainly as a function of soil depth and the occurrence of rock outcrops. Dominant species include *Acacia nigrescens*, *A. erubescens*, *Dichrostachys cinerea*, *Combretum apiculatum* and *Peltophorum africanum*. Other commonly occurring species are *Grewia flavescens*, *Kirkia acuminata*, *Zizyphus mucronata*, *Colophospermum mopane*, *Boscia albitrunca*, *Ximenia americana* and *Terminalia prunoides*.

### 2.5.1.2 Grass cover

Grass cover is good to fair during the rainy season and practically absent during the later part of the dry season. Grazing livestock, termites and natural mortality of annual species are the main reasons for the sharp decline of grass cover after the rainy season. Grass cover during the rainy season, both in terms of species composition and density of the stand, is strongly dependent on recent land use changes, degree of grazing and proximity of trees. It therefore varies over short distances and can change also fairly rapidly over time. The main grass species encountered include *Eragrostis biflora*, *E. rigidior*, *E. superba*, *Tragus berteronianus*, *Setaria sp.*, *Urochloa trichopus*, *Dactyloctenium aegyptium*, *Enneapogon cenchroides*, *Eustachys paspaloides*, *Panicum maximum*, *Digitaria milanjana*, *Cenchrus ciliaris*, *Aristida congesta*, *Rhyncelytrium repens* and *Juncus sp.* *Echinochloa holubii* is found in pans and along water courses.

Grasses occur in a remarkable pattern which is consistently found in all three vegetation zones. The more desirable species (e.g. *U. trichopus*, *D. milanjana*, *E. paspaloides*) occur frequently under trees and shrubs, but are uncommon in areas without a canopy of woody vegetation. In open spaces, less desirable species (e.g. *T. berteronianus*, *E. rigidior*, *A. congesta*, *Juncus sp.*) are found. The poor grazing conditions away from canopy are enhanced by the low density of grasses (20-50 % ground cover). Directly under trees and shrubs, grass density approaches 100 % ground cover. This dependence on canopy cover causes the good-fodder species to occupy not more than 20 percent of the land in most areas. The determining factor lies probably in the quality of the topsoil: under the trees the soil is higher in organic matter and nutrients (notably nitrogen) and less crusted (better aeration and higher infiltration) than out in the open. The reasons for this pattern are to be found in differences in trampling by cattle, grazing intensity, sheet and splash erosion, temperature, leaf and litter fall, and seed germination.

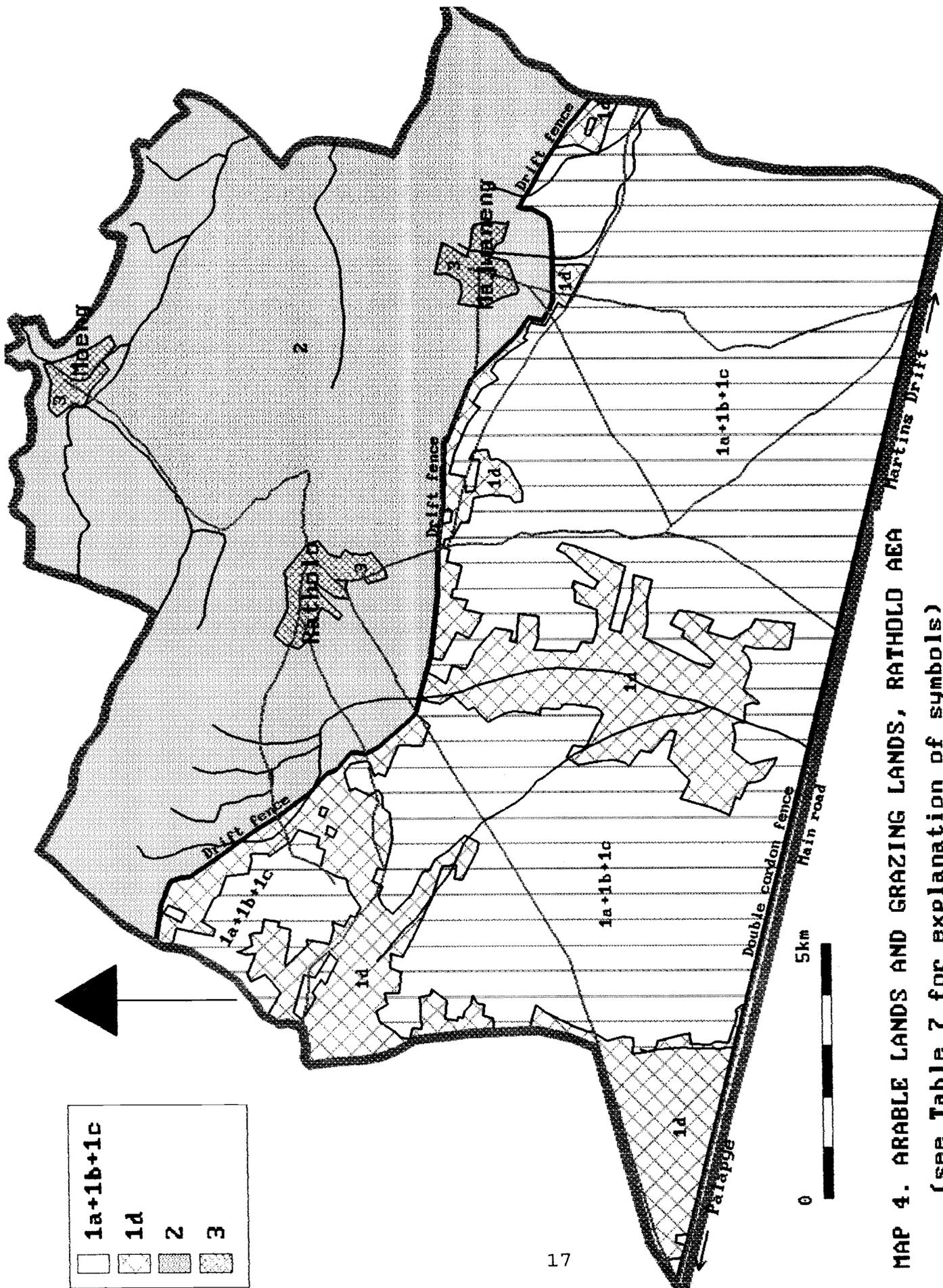
The main agricultural weeds found in the area are *Abutilon austro-africanum*, *Hibiscus meeusei* ("mmabasete"), *Ipomoea obscura* ("motantanyane" or "motsididi"), *Eragrostis rigidior*, *Striga asiatica* ("matabele" or "molelwana"), and "mabetsane" (scientific name not identified).

### 2.5.2 Present land use

Present agricultural land use in Ratholo AEA is classified in four categories of major land use:

- Arable farming (rainfed)
- Extensive grazing and browsing
- Collection of veld products, fuel wood and poles
- Irrigated farming

The distribution of arable farming is presented on Map 4 and summarised in Table 7 in relation to other land uses. For a description of the present farming systems see Chapter 3.



MAP 4. ARABLE LANDS AND GRAZING LANDS, RATHOLD AREA

(see Table 7 for explanation of symbols)

TABLE 7. SUBDIVISION IN MAJOR LAND USES, RATHOLO AEA

	AREA (ha)	PORTION OF AEA (%)	PORTION OF LANDS AREA (%)	AVERAGE AREA/FARMER (ha)	DATA SOURCE
<b>TOTAL RATHOLO AEA</b>	27,023	100	—	40.5	AD, Maps, GIS
<b>1. DESIGNATED ARABLE AREA (LANDS)</b>	16,040	59	100	24.0	APs, Maps, GIS
1a Cultivated fields (1992/93)	3,884	14	24	5.8	DRP Registration
1b Areas cleared of woody vegetation; fallow	4,656	17	29	7.0	APs estimate
1c Minor areas of secondary growth, in between farmers' fields	3,660	14	23	—	APs estimate
1d Major areas of shrub savanna, used for winter grazing	3,840	14	24	—	APs, GIS
<b>2. COMMUNAL GRAZING AREA</b>	10,512	39	—	15.7	APs, Maps, GIS
<b>3. BUILT-UP AND ASSOCIATED AREAS</b>	471	2	—	—	APs, Maps, GIS

AD = Agricultural Demonstrator  
APs = Aerial Photographs  
DRP = Drought Relief Programme  
GIS = Geographical Information System

Arable farming is practised in the designated lands areas<sup>3</sup> (approx. 16,000 ha), which are located in the plain south of Ratholo village, and separated by a drift fence<sup>4</sup> from the rest of the area to the north. About 8,500 ha of the lands area is cleared of vegetation. Only a part of the cleared area is actually cultivated in any one year (less than 4,000 ha in the 1992/93 season). Irrigated farming is practised by only two farmers, who have recently started growing vegetables and fruits on small plots with water from a borehole. Grazing and browsing by cattle, goats and donkeys occurs throughout the area. The communal grazing areas are grazed and browsed year round, while grazing in the lands area is mainly restricted to the dry season. Collection of veld products and fuel wood and poles is practised throughout the area.

## 2.6 WATER RESOURCES

Sources of water in the area are streams, springs, natural pans and ponds, dams, boreholes and hand dug wells.

### - Natural streams

A few ephemeral streams occur in the area, of which the Manaledi and Bolowa are the most prominent (see Map 5). These streams only carry water for a short period after significant rainfall.

### - Springs

Natural springs occur in and around the Twapong Hills. Those above near Ratholo and Moeng carry water all year round and are an important source of water for both man and livestock. Attempts have been made to develop and protect both the Ratholo and the Moeng spring, but they are now neglected. Water from the Ratholo spring is valued by the villagers because of its taste, but the conditions around the spring are far from hygienic. Halfway between Ratholo and Moeng there is an area with perennial shallow groundwater used by both livestock and wildlife. Similar areas exist elsewhere in the hills.

### - Natural pans

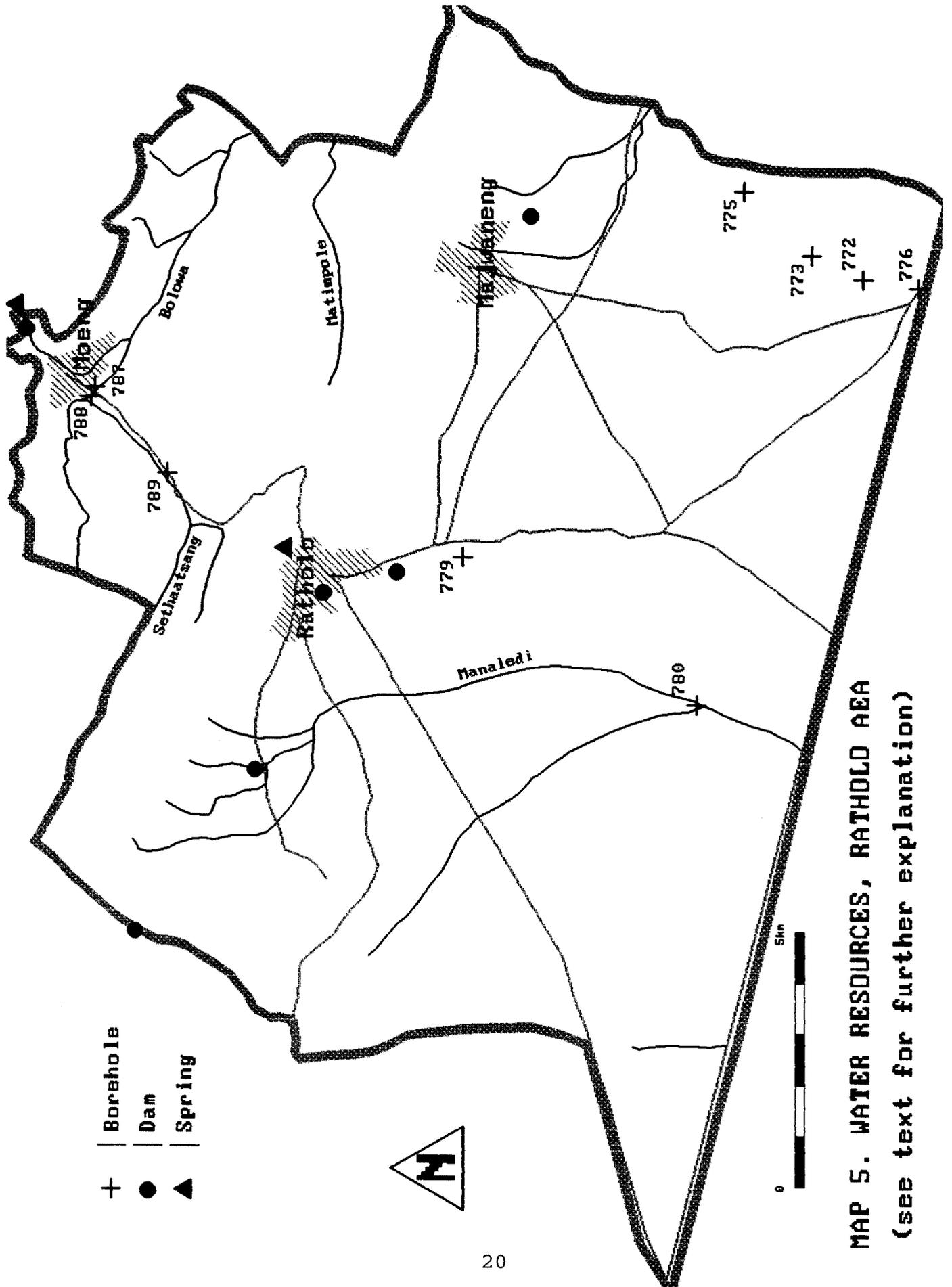
The footslopes and plains abound with small natural pans and ponds, in which local run-off collects during the rainy season. They frequently dry out during dry spells in the rainy season and carry no water during the dry season.

### - Boreholes

There are two types of boreholes in the area: privately owned boreholes for agricultural purposes and boreholes of the Department of Water Affairs for domestic consumption. Most privately owned boreholes are found in the south-eastern corner of the area where a contractor was active in the early nineties. They vary in depth from 30 to 100 m and have a yield of up to 60 m<sup>3</sup>/hour (Wellfield Consulting Services,

<sup>3</sup> "Lands" is a local term denoting the arable fields of a farmer or community

<sup>4</sup> A drift fence is a permanent fence erected to exclude livestock from the lands area during the cropping season



**MAP 5. WATER RESOURCES, RATHOLD AEA**  
 (see text for further explanation)

1992). Some of these boreholes have a diesel pump, others are hand-operated. Two boreholes are used for small-scale irrigation. Water is frequently sold by borehole owners to farmers for watering of livestock.

Ratholo village has piped water supplied by borehole in the Twapong Hills halfway between Ratholo and Moeng. Similarly, Majwaneng village is serviced by a borehole situated outside the study area, halfway between Majwaneng and Lerala. Moeng derives its water from a few boreholes situated south of the College.

#### - Hand-dug wells

There are an unknown number of several deep hand dug wells (10 meter or more) throughout the plain area. They are important for both people and livestock as a source of drinking water. Most of them run dry in September/October.

#### - Dams

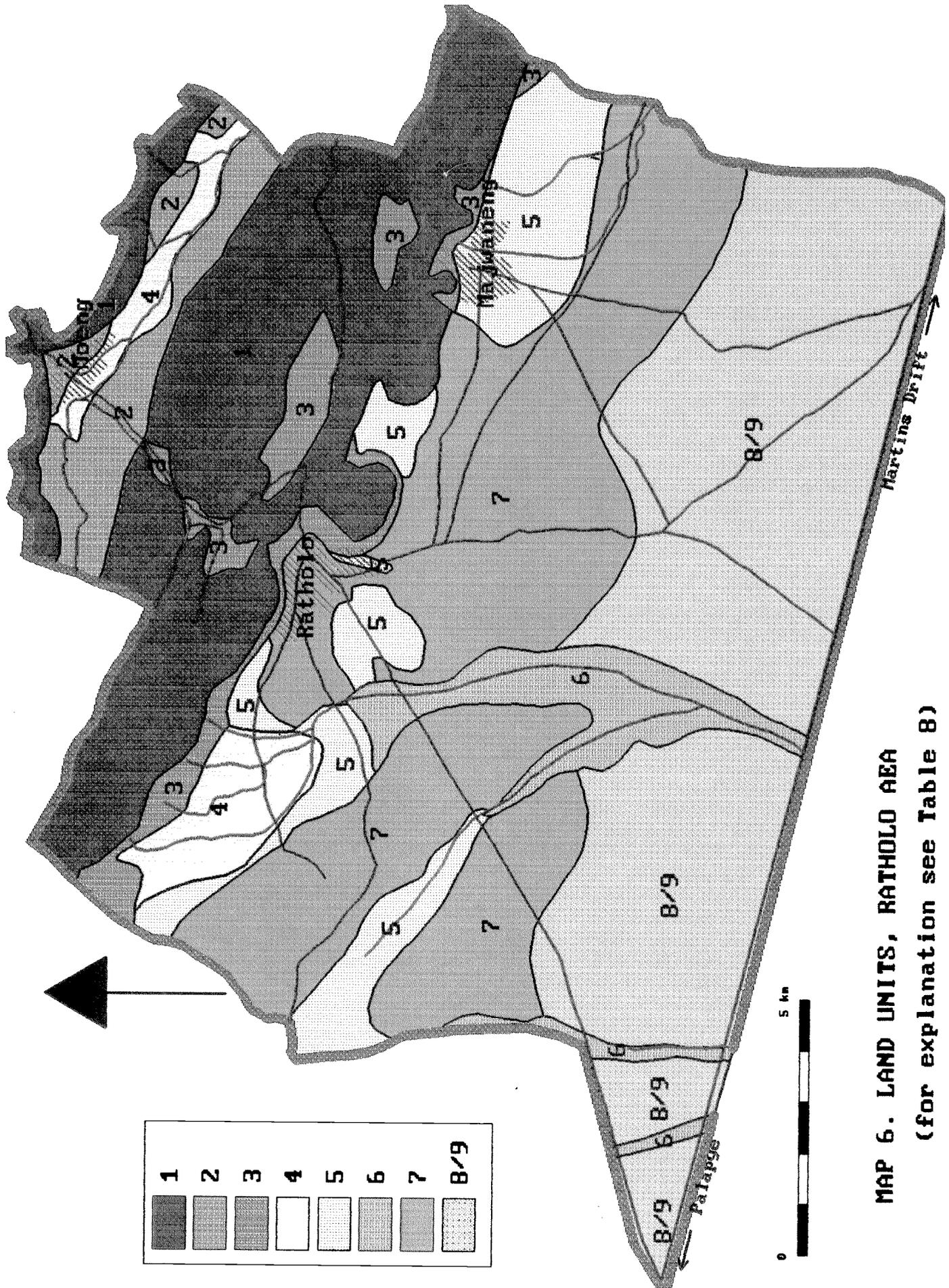
There are five small dams in the study area, one of which is situated at the border with Gootau AEA. They were built to provide drinking water for livestock. They consist of earth walls thrown up around natural depressions and can only hold a shallow depth of water. All run dry around August and although useful, are ineffective in taking livestock through the dry season. Some have fallen in disrepair. The footslopes and plains of Ratholo AEA have very few good dam sites, because of its flat topography. Above Moeng College there is a concrete dam holding water from a perennial spring. The dam was once used for irrigation and domestic purposes, but is now neglected and used by roaming cattle and wildlife only.

#### - Water catchment tanks

A few farmers have installed underground tanks at their lands for rainwater harvesting. Water caught in these tanks is meant to supply drinking water for the farmer and draught animals to facilitate early ploughing. Such tanks are part of the ALDEP package.

## 2.7 LAND UNITS

Land Units (LUs) are areas which are relatively homogeneous in terms of landform, soil, vegetation and availability of perennial water. LUs form the basis for land evaluation (Chapter 5) and Recommended Land Use (Chapter 7). Nine different LUs have been distinguished for Ratholo AEA. They are listed and described in Table 8 and depicted on Map 6.



**MAP 6. LAND UNITS, RATHOLD AREA**  
 (for explanation see Table 8)

TABLE 8. LAND UNIT MAP LEGEND

LAND UNIT	AREA (ha)	LANDFORM	SLOPE (%)	SOIL & PRESENT EROSION	WATER (perennial)	VEGETATION
1	5500	Hills and Escarpments	4-40	Shallow, stony	Few springs	Woodland
2	1000	Footslopes	1-3	Deep, well drained, medium textured	Few boreholes (Moeng)	Tree/shrub savanna
3	1000	Hills and Footslopes	2-8	Moderately deep, well drained, medium textured; moderate sheet and rill erosion	Minor areas with shallow groundwater; few boreholes (Ratholo)	Tree/shrub savanna
4	800	Eroded footslopes	1-3	Very deep, well drained, medium to fine textured; severe sheet and rill erosion	Few boreholes (Moeng)	Shrub savanna
5	2700	Footslopes and Plain	1-2	Very deep, well drained, medium to fine textured; moderate sheet and rill erosion	Nil	Shrub savanna
6	1200	Drainage depressions	< 1	Moderately deep, moderately well to imperfectly drained, medium textured	Very few boreholes	Mostly cleared
7	7000	Upper plain	< 1	Deep, well drained, medium textured	Very few boreholes	Mostly cleared
8	5400	Middle plain	< 1	Moderately deep, well drained, medium textured	Few boreholes	Mostly cleared
9	2500	Lower plain	< 1	Shallow, moderately well drained, medium textured	Few boreholes	Mostly cleared

## CHAPTER 3

### SOCIO-ECONOMIC CONDITIONS

#### 3.1 POPULATION

The total population of Ratholo and Majwaneng villages and associated localities was 4,563 persons in 1991 (Central Statistics Office, 1992), 55 percent of them female and 45 percent male. Assuming an annual population increase of 3.3 percent, the 1994 total population is estimated at 5,031 persons or about 840 families (assuming an average family size of 6 persons (Division of Planning and Statistics, 1991). See Table 9. An additional 173 people were registered in Moeng College in 1991.

The number of registered farmers in 1993/1994 cropping season, i.e. farmers registered for drought relief, totals 668 farmers (713 farmers in the 1992/93 season). The average farmer's age is 49.2 years. A breakdown of the farm population in age groups is presented in Table 10. Eighty two percent of those registered are female.

Three main conclusions can be derived from these statistics:

- The majority of households (80 percent) is involved in arable farming.
- The majority of farm households (82 percent) is de-facto headed by a female. Many males (notably the younger ones) are not permanently based in the village but have sought alternative employment elsewhere.
- The average farmer's age is high (49.2 years).

The majority (estimated 80 percent) of farmers reside in the villages of Ratholo and Majwaneng. The remainder reside on their land. All farmers have lands areas within Ratholo AEA, the very few without land share with others. Only very few farmers in Ratholo AEA reside in surrounding villages located outside the AEA. The majority of farmers maintain a second dwelling on their lands. The distance from homestead to lands varies from a few hundred meters to up to 10 km.

#### 3.2 LAND TENURE AND LEGISLATION

Under customary law, every tribesman is entitled to sufficient land to meet his subsistence needs for housing and arable farming. Housing compounds and arable fields may be fenced to preclude other people or other people's livestock. Every tribesman has also open access to the communal grazing lands and to surface water for feeding and watering his livestock.

All land in Ratholo AEA is communally owned. Housing compounds and arable fields have been allocated by the chief in the past. Formal land certificates, issued by the Land Board, are held by only few inhabitants who have major investments on their land (e.g. boreholes). In some cases grazing areas of considerable size are included in the fenced-off areas leading to de-facto reservation of land for dry season grazing of the own herd.

### 3.3 GROUPS OF FARMERS

Farmers have been stratified into four homogeneous groups on the basis of farm size and livestock ownership:

- 1 Farmers in group 1 own no cattle and no donkeys. They depend on hired or borrowed draught power for ploughing. They practice arable farming for food subsistence. Farm size is 1-4 ha. They often own up to 10 goats. This group includes 20 percent of farmers.
- 2 Farmers in group 2 own some draught animals but have to hire or borrow additional animals to plough. They own between 1 and 10 cattle and no donkeys or no cattle but 3 or less donkeys, and have a small income from livestock. These farmers practice arable farming for food subsistence. Farm size is 3-6 ha. In addition they usually have 10-20 goats. Stock is based in the communal grazing area near the villages. This group includes 40 percent of farmers.
- 3 Farmers in group 3 have their own draught power and have some income from livestock. They depend on arable farming (farm size 7-10 ha) for food subsistence, and own between 10 and 20 cattle or less than 10 cattle and at least 4 donkeys. In addition they usually have 10-40 goats. Cattle is mainly based at cattle posts elsewhere. This group includes 32 percent of farmers.
- 4 Farmers in group 4 own 20 to 40 cattle (5 percent of farmers) or more than 40 head of cattle (3 percent of farmers), which are permanently based at cattle posts. Other livestock varies in number. They often practice arable farming (farm size >8 ha) for food subsistence. The total percentage of farmers included in this group is 8.

Farmers practicing (small-scale) irrigated agriculture number only two at present, and started operations in 1993.

### 3.4 FARMING SYSTEMS

The prevalent farming system has three components: livestock grazing, arable farming and collection of veld products. There are some obvious linkages between the livestock and arable cropping components. Significant in this respect are the grazing by livestock of crop residues and weeds which are left in farmers fields after harvesting, the application and deposition of limited amounts of manure in the fields, and the provision of traction by oxen and donkeys for ploughing and transport.

Agriculture accounts only for a part of the income of the average household in the area. In the prevailing pattern, some family members preserve the subsistence agricultural base in the village, while often the younger or better trained seek paid employment elsewhere. The amount of time and money spent on farming by individuals and households depend mainly on whether returns from farming can be expected to be higher than from other gainful activities.

#### 3.4.1 Arable farming

Arable farming is rainfed and involves the cultivation of a mix of crops. The main crop is sorghum, grown together with millet, maize, vegetables and pulses. Crops are mainly grown for subsistence. Yields are usually low, but in a good year surplus is marketed. The cropping season lasts from November through

May. The amount of land cultivated varies from year to year, mainly as a function of the amount and distribution of the rainfall during the season.

#### 3.4.1.1 Farm size

The area cultivated per farmer varies from year to year. In the 1993/94 season, 668 farmers ploughed up a total area of 3,884 ha or an average of 5.8 ha per farmer. This is only about half of the area cleared of vegetation for cultivation. It follows that enough land in the AEA is cleared for cultivation.

Farm size (i.e. area ploughed per year) varies from 1 to 12 ha. Farmers are approximately evenly distributed over three farm size classes: 1-4, 5-8 and 9-12 ha. See Table 11.

#### 3.4.1.2 Farming operations and labour use

A very large majority of arable farmers (estimated 99 percent) practice a traditional method of land preparation and cultivation, i.e.:

- 1 Broadcasting of a mixture of seeds of subsistence crops on unprepared soil, followed immediately by ploughing by either draft animals or tractor.
- 2 One time weeding by hoe, thirty to forty days after sowing.
- 3 Bird scaring.
- 4 Harvesting.

The timing in the year of each of these operations (seeding and ploughing taken as one operation), as observed during the 1992/93 season, is included in Figure 1. The time at which an individual farmer starts ploughing depends on many factors: rainfall pattern, availability of draughtpower and inputs, availability of labour, and tradition. During the 1994/95 season the Ministry of Agriculture advised farmers to plough and plant with the first rain after Botswana Day (30 September). This advice was repeated by the Chief of the area, who officially opened the growing season in the first week of October. And indeed, in 1994, some farmers ploughed as early as the last week of October<sup>5</sup>. On the other hand, some farmers may delay ploughing until February. Farmers often carry out several broadcasting/ploughing operations during one season in adjacent plots, using several planting opportunities during the rainy season.

In the 1992/93 season, which was a season when drought relief (<sup>6</sup>) was in operation, an estimated 50 % of farmers used their own animals or hired animals for traction for ploughing while the remaining 50 % hired a tractor. In other years the percentage of farmers hiring tractors is very much lower. Both donkeys and cattle are used for ploughing in spans of four to eight animals. Male animals are preferred. An estimated 60 % of farmers do not own enough animals for traction. An estimated 70 percent of farmers own their own plough. There are many reasons for untimely ploughing, but shortage of draught power and a poor physical condition of draft animals at the end of the dry season are amongst them. Tractor services are usually provided on a first-come-first-serve basis, after the tractor owner has ploughed his own field. There are eight tractors within the area, all privately owned. Some additional tractors are hired from commercial farmers of the Tuli Block and from South Africa. Some farmers, seeking tractor services, have to wait till January or February.

<sup>5</sup> The crop failed, as it did not rain in November.

<sup>6</sup> Drought relief comprises of direct assistance to farmers in the form of a subsidy and of community oriented projects, in times of drought. See also Table 30.

TABLE 9. POPULATION COMPOSITION, RATHOLO AEA (1994)

	TOTAL		FEMALE		MALE	
	No.	No.	%	No.	%	
<b>TOTAL POPULATION</b>	5031	2756	55	2275	45	
<b>HOUSEHOLDS</b>	839	-	-	-	-	
<b>FARM HOUSEHOLDS</b>	668	551	82	117	18	

Based on population census data (1991) adapted for 1994 and on analysis of drought relief data (1993/94)

TABLE 10. AGE DISTRIBUTION OF FARMERS

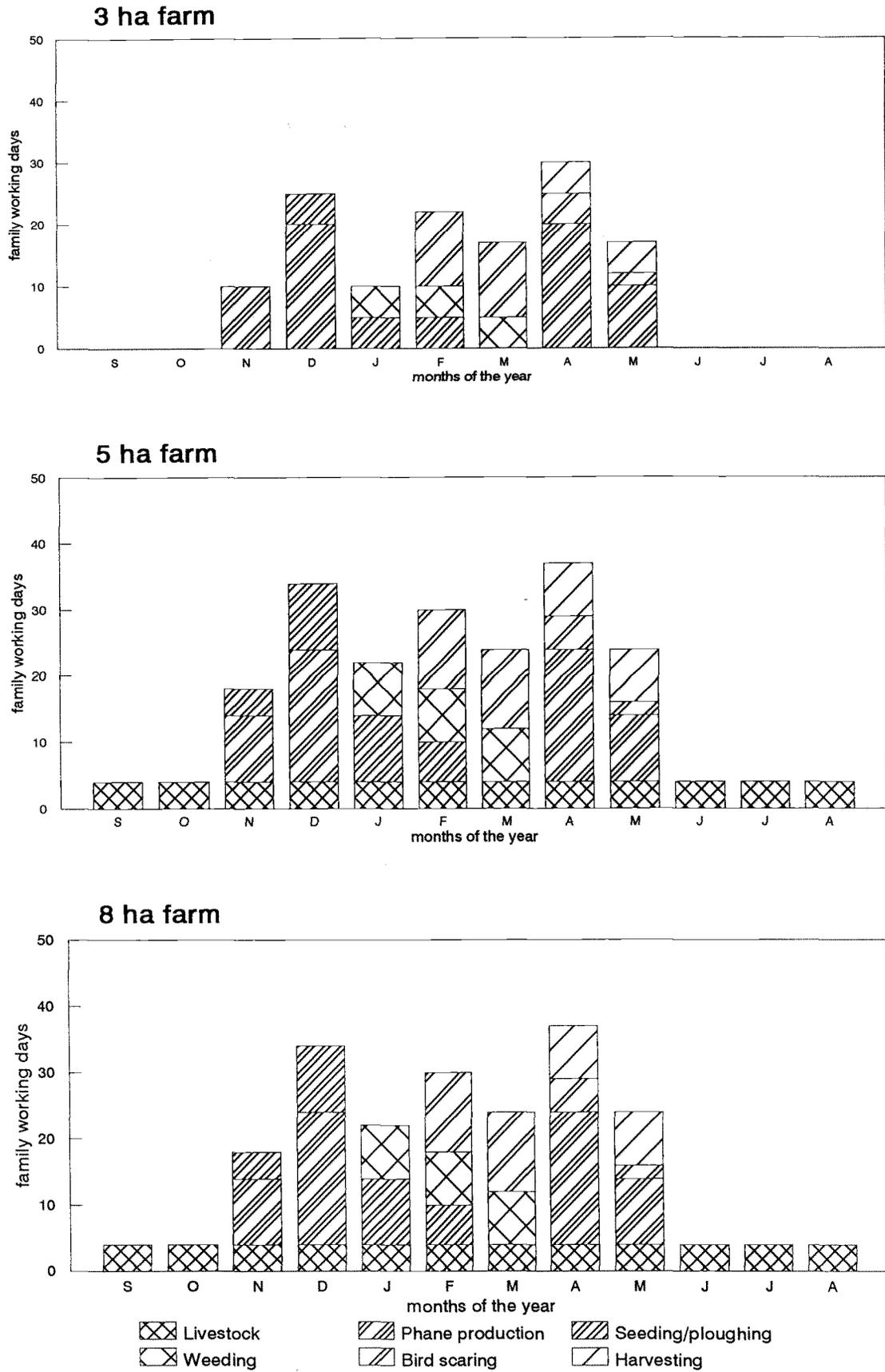
	AGE CLASS (years)						
	20-29	30-39	40-49	50-59	60-69	70-79	=>80
<b>Number</b>	38	137	148	94	110	46	16
<b>Percentage</b>	6.5	23.3	25.1	16	18.7	7.8	2.7

Based on analysis of drought relief data (1993/94)

TABLE 11. MAJOR CHARACTERISTICS OF FARMS, RATHOLO AEA  
(farm size, herd sizes, distribution of livestock and phane collection)

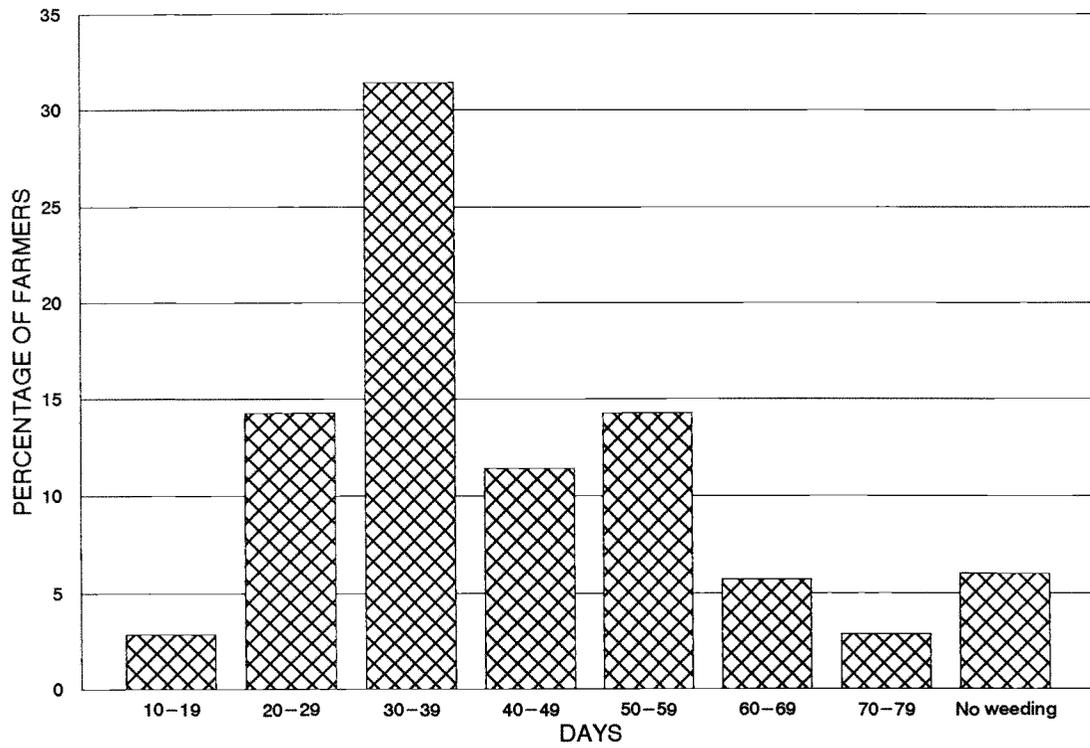
MIXED CROPPING	Farm size (ha)						TOTAL
	1-2	3-4	5-6	7-8	9-10	>10	
Farms (number)	59	163	151	93	187	15	668
Farmers' distribution (%)	9	24	23	14	28	2	100
CATTLE PRODUCTION	Herd size					TOTAL	
	0	1-10	11-20	21-40	>40		
Permanently based inside AEA (head)	0	1,400	0	0	0	1,400	
Seasonally based inside AEA (head)	0	0	400	100	100	600	
Permanently based outside AEA (head)	0	0	1,910	950	950	3,810	
All cattle owned by AEA farmers (head)						5810	
Farmers' distribution (%)	30	40	22	5	3	100	
GOAT PRODUCTION	Herd size				TOTAL		
	0	1-10	11-20	21-40			
Permanently based inside AEA (number)	0	1,750	1,811	735	4,296		
Permanently based outside AEA (number)	0	0	604	735	1,339		
Farmers' distribution (%)	20	50	23	7	100		
DONKEY PRODUCTION	Herd size				TOTAL		
	0	1-5	6-10	11-15			
Permanently based inside AEA (number)	0	350	490	420	1,260		
Farmers' distribution (%)	60	25	10	5	100		
PHANE COLLECTION	Farmers involved		Farmers not involved		TOTAL		
Estimated farmers involved (number)	534		134			668	
Farmers' distribution (%)	80		20		100		

FIGURE 1. LAND USE CALENDAR AND LABOUR USE, OF PATTERN FARMS, RATHOLO AEA \*



\* Pattern farms are defined in Chapter 6.  
 Note: Only ploughing by animal traction is considered here.  
 Note: All labour use in excess of 30 days is hired.

FIGURE 2. TIME LAPSE BETWEEN SEEDING AND WEEDING (in days)\*  
(by comparison of starting dates of operations)



\* Based on a sample of 35 farmers.

Most farmers practice weeding. It is done once using hand hoes, about thirty to forty days after sowing. This is a labour intensive activity, mostly carried out by woman and children. In Figure 2 the time lapse between seeding and weeding is depicted for a sample of 35 farmers.

Farming is a family activity. The "average" farmer is assisted by one close relative; children and other relatives may make a contribution during peak periods, but are often only available during holidays or weekends. Farmers with sufficient resources may try to hire labour during peak periods of ploughing, weeding and harvesting. Farm labour use for three typical farm sizes and for each of the farming operations mentioned above is presented in Figure 1. Labour use as shown in Figure 1 is for a farm run by two adults, assuming that ploughing is carried out with animal draught power. The Figure shows that peak labour demand is during the months of December and April, and that even a small farm can not be managed by one full-time farmer. There seems to be a lot of labour available during the period from June to October.

#### 3.4.1.3 Crops

Typically, a farmer grows a mixture of crops, dominated by sorghum (var. Segalane) with beans (*Phaseolus vulgaris*), jugobean<sup>7</sup>, melon and watermelon as dominant intermixed crops. Sorghum represents 90 percent of the plant cover. Maize and millet are also common grain crops, usually grown intermixed with sorghum. Other secondary crops are cowpea, groundnut and pumpkin. Lablab was grown as a fodder by one farmer in the 1992/93 season. Most crops are grown for subsistence. Grain crops provide staple food; beans, peas and fruits are grown to supplement the diet. Cowpea and pumpkin leaves are eaten as a vegetable. Watermelon is grown for consumption as a fruit and for beer brewing. Crop rotation is not normally practised, since the majority of farmers grow a similar crop mixture every year. A few progressive farmers grow crops in single stands using rowplanters and practice a simple rotation. They follow an alternate-year rotation schedule: 1-millet/2-sorghum, or 1-beans/2-jugobean, or 1-sorghum/2-beans, or 1-millet/2-beans (in which 1 = year 1 and 2 = year 2).

Crop yields are usually very low. In the 1992/93 season, an average of less than 100 kg of sorghum was obtained from one hectare of mixed cropping in which sorghum was the dominant crop. Many farmers obtained no yield at all. Yields for selected farms for the 1992/93 season are presented in Table 12. These yields are the take-home yields as estimated by the farmer. Actual yields may have been somewhat higher as part of the crop is harvested and consumed during the ripening stage (e.g. green maize). Surplus, if it occurs, is marketed through local traders or the Botswana Agricultural Marketing Board (BAMB).

Traditionally, seeds of crops are kept by farmers from the previous harvest. However, because of drought relief in recent years, farmers have become more and more dependent on seeds distributed free of charge by the Government. In the 1994/95 season farmers with at least five hectares were entitled to 40 kg sorghum seed and 10 kg maize seed. Prices of inputs (seeds, implements etc.) and of saleable produce are presented in the Annex (Tables A1 and A4).

#### 3.4.1.4 Soil fertility maintenance

Crops extract nutrients from the soil and have to be replenished to maintain productivity. In Ratholo AEA few farmers deliberately maintain soil fertility. Livestock manure is rarely applied, even in cases where kraal manure is readily available, and not much of the crop residues are ploughed into the soil. In the 1992/93 season only one farmer was encountered who ploughs stover into the topsoil after harvest. The

<sup>7</sup> Also known as Bambara groundnuts; scientific name: *Vigna subterranea* or *Voandzeia subterranea*

TABLE 12. MIXED CROP YIELDS FOR SELECTED FARMS (1992/93)

FARM ID	CROP	PRODUCE	PLOT SIZE (ha)	YIELD (kg)	YIELD (kg/ha)
1	Sorghum, potse	Grain	1	35	35
	Melon	Fruits		120	120
	Watermelon	Fruits		120	120
2	Sorghum, segaolane	Grain	2	136	68
	Millet, tswana	Grain		170	85
	Cowpea	Leaves		100	50
	Melon	Fruits		20	10
	Watermelon	Fruits		20	10
3	Sorghum, segaolane	Grain	2	17	9
	Sorghum, potse	Grain		17	9
	Millet, serere	Grain		17	9
	Sweetreed	Stems		75	38
	Cowpea	Leaves		17	9
	Watermelon	Fruits		120	60
4	Sorghum, segaolane	Grain	2	68	34
	Sorghum, potse	Grain		17	9
	Sweetreed	Stems		75	38
	Cowpea	Leaves		34	17
	Melon	Fruits		400	200
	Watermelon	Fruits		200	100
5	Sorghum, potse	Grain	3	105	35
	Sweetreed	Stems		80	27
	Jugobean	Beans		70	23
	Melon	Fruits		400	133
	Watermelon	Fruits		1,200	400
6	Sorghum, segaolane	Grain	2.5	51	20
	Watermelon	Fruits		1,200	480
7	Melon	Fruits	4.25	120	28
	Watermelon	Fruits		120	28
8	Sorghum, segaolane	Grain	4.75	200	42
	Millet, serere	Grain		17	4
	Cowpea	Leaves		17	4
	Watermelon	Fruits		400	84
9	Sorghum, segaolane	Grain	5	140	28
	Sorghum, potse	Grain		70	14
	Sweetreed	Stems		150	30
10	Sorghum, segaolane	Grain	5.75	518	90
	Watermelon	Fruits		2,000	348

Source: 1992/93 farm survey in Ratholo AEA.

use of artificial fertilizer is practically absent, and nobody was seen to make compost. Occasional use of fertilizer in the past was inspired by the free distribution through the Accelerated Rainfed Arable Programme (ARAP).

#### 3.4.1.5 Pests and diseases

Infestation of crops by pests varies strongly from year to year and from one area to the next. The extent of the impact of pests is therefore difficult to quantify. The pests most frequently quoted by farmers are corncricket and Quelea birds. Other common infestations are stalkborer, bollworm, stink bug, bagrada bug, ants, termites, beetles and aphids. Crop damage by cattle and goats as a result of inadequate fencing is also common. Baboons are locally an important pest, particularly in the vicinity of the Tswapong Hills. Corncricket had a ruinous effect in many areas on the crop harvest of the 1992/93 season. Breeding sites of Quelea are sprayed by Plant Protection Office (PPO) of the Department of Crop Production and Forestry. No data are available on production losses as a result of pests and diseases.

#### 3.4.2 Livestock production

Stock is kept through a system of extensive grazing in which the fodder base consists of untended natural grasslands and shrubs, fallow and harvest residues. Cattle are dominant but goats and donkeys are also significant. Livestock is raised as a source of draught power and animal products (mainly milk), and for sale. Livestock also represents wealth and status.

##### 3.4.2.1 Numbers and other main aspects

It is estimated that all farmers in Ratholo AEA combined own 5,810 cattle, 5,635 goats and 1,260 donkeys. Estimated livestock numbers by herd size are given in Table 11. The number of cattle kept in the area permanently is estimated at 1,400. The remainder are kept outside the Ratholo AEA at cattle posts, but some of these cattle are tracked back to the area for a short period after the harvest, taking the total number of cattle inside the AEA to about 2,000 during the period from May to August. Most goats and donkeys are kept inside the area all year round. It is important to note that the residents of Ratholo AEA obtain income from livestock roaming a much larger area than Ratholo AEA alone.

Livestock numbers for the area are estimated from farm survey data and Agricultural Statistics of 1990 (Division of Planning and Statistics, 1991). On the basis of the farm survey it is estimated that 30 % of farmers own no cattle, 40 % own 1 to 10 head of cattle, 22 % own 10 to 20 head, 5 % own 20 to 40 head and 3 % own more than 40 head (<sup>8</sup>). Extrapolation from these figures leads to a total estimate of 5,000 to 7,000 head of cattle owned by farmers residing in Ratholo and Majwaneng. The Agricultural Statistics support the accuracy of this estimate. In 1990 there were 332,000 head of cattle in Serowe/Palapye Sub-District. For a total human population of 128,431 (Census 1991) there were about 2.5 head of cattle per person in the area. This agrees well with the above estimate for Ratholo AEA, given the relative emphasis on arable farming in the area. Numbers for goats and donkeys were estimated in a similar manner.

Birth rates for cattle naturally depend on the availability of feed and the general health of the cow, but ranges between 27 and 50 percent depending on the year (Division of Planning and Statistics, 1992).

<sup>8</sup> Stock census data (Jan/Feb 1993) based on vaccination campaigns give incorrect livestock numbers for the area (169 heads of cattle, 347 goats and 83 donkeys distributed over 24 farmers)

Mortality varies widely according to occurrence of drought and outbreak of diseases, and lies between 4 and 36 percent. Off-take rates vary between 5 and 10 percent.

Most of the cattle in the area is of local Tswana stock. Generally farmers are geared to herd expansion, mainly through natural increase. There are no cattle posts inside Ratholo AEA. Large scale commercial livestock production is not found in the area. Prices of inputs (feed, equipment etc.) and of saleable produce (milk, stock) are presented in the Annex (Tables A1 and A4).

#### 3.4.2.2 Grazing patterns

Livestock is grazed on the range. Cattle depends on herbage and to some extent on browse. Goats and also donkeys rely to a large extent on browse. Grazing patterns and livestock movements in the area are complex and largely uncontrolled. During the rainy season most livestock is kept north of the drift fence on communal grazing lands, and further away from the villages at cattle posts outside Ratholo AEA, but some livestock remains behind in the lands area, thus often causing damage to crops. Both grazing and drinking water are normally adequate during the rainy season, although in poor rainfall years shortages may occur. After harvest of the crop, livestock is free to roam. Early in the dry season feed is ample in the lands areas due to undergrazing during the preceding cropping season and due to crop residues left in the fields. At this time of the year (May - August) some livestock is moved into the area from outlying cattle posts. Later in the dry season when the range becomes depleted and water in the plain becomes scarce, livestock turns more and more to browsing the remaining green vegetation and concentrates near the foot of the escarpment where a few natural wells and springs provide water. Towards the end of the dry season most livestock depends on accumulated body fat and drinking water is in short supply. Goats survive this difficult period with greater ease than cattle.

Physical weakness, both of breeding cows and animals for traction, is a widespread problem. Only few farmers provide supplementary feed to their animals during the dry season, including crop residues (grain stalks, bean leaves, grain husks, left-over vegetables), bonemeal and cattle maintenance licks (both purchased from the Livestock Advisory Centre (LAC)). Only one farmer grew fodder (lablab) in the 1992/93 season.

The Mafisa system is prevalent in the area, under which cattle is lend out by the owner to relatives or others on a semi-permanent basis. The caretaker usually benefits from their draft power, milk and possibly a calf.

#### 3.4.2.3 Animal health

Livestock suffer from a range of diseases, causing general weakness and mortality. Vaccination campaigns are run annually by the Department of Animal Health and Production (DAHP) at no cost to the farmer. These vaccinations are for cattle only and are against Anthrax, Quarter Evil, Contagious Abortion and Foot and Mouth Disease. Animals vaccinated during a campaign are recorded, but not all cattle is presented by their owner or caretaker. In the campaign of 1993, 169 head of cattle were recorded in the Ratholo area, which suggests that only a fraction of all cattle is regularly vaccinated. In drought years vaccination against Botulism is provided. Vaccination against Rabies is only carried out locally after an outbreak is detected, in which case all livestock in a locality is vaccinated.

Any other animal health precautions which livestock owners feel necessary are at their own expense. Very few owners vaccinate cattle against Lumpy Skin Disease and Pasteurellosis, or small stock against Pulpy Kidney. Also very few owners apply vermifuges. Sprayers for tick control are owned by some farmers or farmer groups, but are often not used.

Hyenas, jackals and baboons occasionally kill young cattle and small stock.

The nearest artificial insemination centres are located in Palapye and Sefophe, but are too far away for farmers to take their cattle to.

#### 3.4.2.4 Drinking water

Dams, wells, springs and pans provide drinking water during the rainy season, and hold out during the first part of the dry season. The pans are unreliable sources and often periodically dry up even during the rainy season. During the dry months of July through October, drinking water shortages occur. Livestock are often watered at privately owned boreholes, with a fee paid to owner. In good years natural springs in and around the Tswapong Hills provide water all year round. See for more information Section 2.6.

#### 3.4.2.5 Fencing

The Makoro cordon fence, erected in 1977, forms the southern boundary of Ratholo AEA and effectively seals off the area for livestock movements towards or from the south. A drift fence separates the arable area from the grazing area. Most livestock are kept behind the drift fence during the cropping season, but considerable numbers remain in the lands area in spite of strict regulations to the contrary laid down by the community.

Many individual farmer's fields are fenced. An estimated 50 percent of fields are wire fenced (often subsidised by drought relief in the past). Another estimated 30 percent are fenced by thorny branches. The remainder of fields are not fenced. Livestock remaining in the lands area are more closely herded than livestock kept outside, but unfenced fields in the lands area suffer from intrusion by animals (cattle and goats) during the cropping season. There are no fences surrounding the villages.

#### 3.4.3 Collection of veld products, fuel wood and poles

Collection and sale of veld products (phane, fruits) and secondary products (beer) is an important activity for almost all households. The most significant veld product is phane (also called mopane worm), the larval stage of the Mopane moth (*Gonimbrasia belina*), which feed in large number on the mopane tree (*Colophospermum mopane*), and are an important source of income and a much liked and nutritious supplement of the diet. They are collected in December and to a lesser extent again in April. On the basis of the farm survey it is estimated that up to 80 percent of the population is involved in the collection of phane at least for some time within a period of 3 to 6 weeks in November and December and to a lesser extent again in April. Between 2 and 10 hectares of mopane bush is harvested per family. The caterpillars are squeezed, boiled and sun-dried or cured over a fire and sold in bags<sup>9</sup>. The average number of bags collected and sold annually varies from 4 to 6, with an average of 3 in December and 2 in April. The prices offered to farmers by traders are 100 to 130 Pula per bag. Most produce is taken to South Africa and sold for human consumption or as supplementary cattle feed at prices as high as 400 Pula per bag. Tables 11 and 25 give the production characteristics of phane.

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<sup>9</sup> Either 50 kg fertilizer bags or 70 kg grain bags are used as a measure of volume: the actual weight of phane is much less

Fruits of the morula tree (*Sclerocarya caffra*) are another favoured veldproduct, both for direct consumption and beer brewing. Morula ripens in February and March. Fruits from *Grewia flava* ("moretlwa") are also collected from the veld.

Collection of fuel wood and poles for construction and fencing is practised throughout the area. Most households collect their own. Close to villages it has caused considerable degradation of the vegetation.

Preferred species are: *Colophospermum mopane*, *Dichrostachys cinerea* ("moselesele"), *Combretum apiculatum* ("mohudiri"), *Acacia erubescens* ("molotheo"), *A. nigrescens* ("mokoba") and *A. tortilis* ("moshu"). Grass for thatching (mainly *Eragrostis pallens*) is also collected by many during the dry season.

#### 3.4.4 Irrigated agriculture

There is no surface water available for irrigation. Two irrigated farms started operations in the area in 1993, assisted by a loan from the Financial Assistance Policy (FAP). Fruits (citrus, peaches and mangos) and vegetables are grown on fenced plots measuring less than half a hectare, taking water from boreholes. Produce is marketed in Palapye and Mahalapye. Some irrigated gardening is also done at Moeng College, mainly for educational purpose. There is a Horticultural Association at Regional level providing technical and marketing support. Only very few farmers are able to make use of FAP assistance because of quite rigorous requirements: the applicant should possess a borehole, make a considerable cash contribution and hold a land certificate issued by the Land Board.

#### 3.4.5 Forestry

Firewood, fencing poles and construction materials are collected by individual farmers from shrub- and woodlands throughout the area. Some enterprising people may use donkey carts to collect large quantities in the Tswapong Hills and offer it for sale. There are no managed indigenous or planted forests in the area. Various organizations (Palapye Development Trust, Ministry of Agriculture) occasionally give free tree seedlings to farmers. Most of these trees end up in farmers' compounds in the main villages. They include fruit trees (citrus, guava, mango, peach), ornamentals (oleander), shade trees (pepper tree) and others (Eucalyptus and Acacia sp).

### 3.5 INSTITUTIONS AND ORGANIZATIONS

Ratholo AEA falls under the Bamangwato Tribal Administration, with the Chief in Serowe, the Senior Sub-tribal Authority in Palapye and the Sub-tribal Authority in Lerala. The main villages of Ratholo AEA (Ratholo and Majwaneng) have a Headman each; with several Ward Headmen in each village.

The Ratholo AEA falls under the jurisdiction of the Ngwato Land Board, which has its headquarters in Serowe, and the sub Land Board based in Palapye. The Land Board, which comprises of Government officials and elected representatives of the community, has the executive authority for allocating land to individuals for arable farming or other uses. The District Officer Lands (DOL) and the District Land Use Planning Unit (DLUPU) provides technical advice to the Land Board on matters of land allocation.

The Department of Crop Production and Forestry (DCPF) has a regional office (RAO) in Serowe and a district office (DAO) in Palapye. Specialist officers dealing with crop production, horticulture, irrigation, soil conservation, land use, forestry, beekeeping and plant protection are based in the RAO office.

Agricultural Demonstrators are responsible for providing agricultural extension in their areas. One AD is responsible for agricultural extension in Ratholo AEA.

The Department of Animal Health and Production (DAHP) has a regional office in Francistown and a sub office in Palapye. The Department is responsible for providing extension in all aspects of livestock husbandry and health through Stock Inspectors (SIs) and Veterinary Assistants (VAs). Ratholo AEA falls under the responsibility of a SI based in Ratholo.

The Palapye Development Trust is the only other organization active in the area in the field of agricultural development. It is based in Palapye and sponsored by the Government and a number of external donors. It provides training to ADs and farmers, and operates small scale programmes for selected farmers or villages in soil conservation, livestock breeding, horticulture and agroforestry. It has two "pioneer farmers" in Ratholo.

At the village level Ratholo has a Village Development Committee (VDC) who assess needs, make plans, and solicit support and funds for community projects (e.g. provision of piped drinking water, building of schools). The farmers committee is an elected body made up of area representatives and are concerned with agricultural issues (e.g. erection of drift fences, assessing training needs). The Village Extension Team meets once a month and includes the AD, SI, VA, Clinic staff and the Headman. Other committees include the Parent Teacher Organization and the Crime Prevention Committee.

## CHAPTER 4

### LAND USE PROBLEMS AND SUGGESTED OPTIONS

#### 4.1 INTRODUCTION

There are many problems which stand in the way of a more productive and more sustainable land use. In this Chapter the main problems are discussed, segregated into a number of constraints. Possible interventions which may lead to the mitigation of constraints are discussed separately. In Chapter 5 these possible interventions will be subjected to land evaluation.

Problems identified vary between one group of farmer to the other and between the farmer and the land use planner. The following problems were amongst those cited by farmers:

i) Crop production:

- Seed not available or very expensive (e.g. groundnuts)
- Unreliable and decreasing rainfall
- Farmers are not ready and alert
- No drinking water at the lands during ploughing
- Animals left unattended inside drift fence during cropping season and causing damage to crops
- Pests in connection with crops (Quelea, baboons)
- Land not fertile and fertilizer expensive
- Low prices for produce

ii) Livestock production:

- Livestock diseases and infection through animals which are not properly managed
- Lack of drinking water during the dry season, both for human consumption and livestock
- Low selling prices for cattle

iii) General:

- Average farmer is not supported enough by the Government, unlike poor farmer through ALDEP and rich farmer through FAP

In addition to the problems mentioned by farmers, the following issues also need attention:

i) Crop production:

- Presence of aggressive weeds
- Soil degradation and decreasing soil fertility
- Shortage of draft power

- ii) Livestock production:
  - Poor range condition
  - High stocking rates
  - Absence of supplementary feeding
  - Inferior breeds
  
- iii) General:
  - Poor uptake of extension messages
  - Land degradation
  - Negative side effects of drought relief programme

## 4.2 LOW CROP PRODUCTION

Low crop yields are the standard. The yield of sorghum in Botswana, over the last 10 years, was 110-250 kg/ha (Division of Planning and Statistics, 1991). There are no reasons to think that the situation in Ratholo AEA is different.

### 4.2.1 Constraints

The main reasons for low crop yields are listed below and are combined into three groups: constraints posed by the natural environment (I), constraints related to poor farm management (II), and institutional, infrastructural or market related limitations (III).

#### I. Physical constraints related to the natural environment

Ia. Natural constraints. The natural environment is marginal for the cultivation of crops.

Low and erratic rainfall. Average annual rainfall is about 400 mm. The variation from year to year is high (as low as 100 mm in a drought year and as high as 700 mm in a very good year). Rainfall is poorly spread over the rainy season, which is characterised by long dry spells.

Low nutrient levels in soils. Topsoils are commonly rather coarse textured with low levels of organic matter, phosphorus and nitrogen. In addition most soils are leached and therefore deprived of nutrients such as potassium, calcium and magnesium.

Incidence of pests. Both migratory pests (notably *Quelea*), and non-migratory pests (corn cricket and bollworm) are common. Damage to crops is frequent but erratic. Other causes for loss of crops are livestock and baboons. Inadequate or late spraying and inadequate bird scaring are common.

Presence of aggressive weeds. Weeds are numerous and provide competition to crops for moisture, nutrients and light. Poor weeding is common, mainly because it is labour intensive.

Ib. Constraints related to land use. Farmer's practices are generally not geared towards conservation of the production base, i.e. the soil.

Soil degradation in the form of the depletion of nutrients, loss of topsoil, and the formation of surface crusts are widespread. Crops are harvested every year, but little organic waste is returned to the soil.

## II. Management related constraints

Appropriate land and crop husbandry is essential to mitigate the constraints posed by the natural environment, which is marginal for crop production. Unfortunately inadequate farming practices are widespread.

### IIa. Crop related management constraints

The traditional method of broadcasting a mixture of seeds, followed by ploughing leads to an irregular distribution of seeds and a variable planting depth. As a consequence, plant densities vary considerably over a farmer's field. Subsequent weeding is inefficient since it has to be carried out by hand. Pest control is more difficult because of the mixture of crops.

Late ploughing and seeding are common due to shortage of draught power at the time it is required. Physical weakness of draught animals and the limited availability of tractors are the main reasons.

### IIb. Land related management constraints

Absence of fertility maintenance. Most crop residues are consumed by livestock and termites. Compost production is non-existent. No inorganic fertilizers are used. No organic waste is added to the soil, except for some manure left by roaming animals and some crop residues and weeds not consumed by livestock.

## III. Institutional, infrastructural or market related constraints

Lack of advice. In recent years the AD has been given the additional task of drought relief administration and can not concentrate fully on his advisory task.

Present drought relief subsidies are given on the basis of the area ploughed with no conditions regarding production level or farming methods attached to it.

Market prices for farmer's products are often not high enough to stimulate the production of cash crops.

Distance to fields. Most farmers have their base in the village, and have to travel a long way to their fields.

Distance to markets where produce can be sold is long. Means of transport are often inadequate.

### 4.2.2 Suggested options

Changes which would have a positive impact on increased output and better sustainability of rainfed arable farming are grouped under a few headings:

- Improved land management

Concentration of arable farming on the better soils. At present some shallow soils are cultivated, while some deep soils are not.

Complete fencing of arable fields. At present not all arable fields are fenced and damage of crops by livestock during the cropping season is common. This in spite of the presence of a complete drift fence.

- Improved crop management and crop selection

Cultivation of crops and varieties which are appropriate for the natural environment. This means drought resistant and not very demanding crops and varieties with a short growing period.

Widespread adoption of modern cropping practices, including row planting, row inter-cropping, row weeding, early ploughing and planting, improved pest and disease control.

The physical condition of draught animals could be improved by the supplementary feeding of hay, fodder crops and crop residues, stored during the winter.

- Improved soil management

Widespread adoption of fertility maintenance by one or more of the following: application of manure, ploughing in of unused stover, use of fertilizer, rotational cropping and intercropping of sorghum with legumes, will improve the production base, i.e. the soil in many ways, thus contributing to increased production and higher sustainability of production systems.

Water conservation by tied bunding of fields which have a slope of more than 1%, would reduce overland flow and increase infiltration, thus making a contribution to increased production and reduced erosion.

- Improved institutional support

Re-direct drought relief funds. Funds used for providing ploughing subsidies to farmers could be re-directed into programmes oriented towards higher production or investment in agricultural development.

Improvement of extension advice by enabling extension staff to spend more time on extension work instead of drought relief administration.

Improvement of marketing channels, both for inputs and outputs. Seeds and fertilizer should be available in time and an accessible market for produce should exist. Farmers should organize themselves to make marketing more efficient (see below).

Support the organisation of farmers to facilitate training in improved farming methods and to assist with marketing.

### 4.3 INADEQUATE OR UNSUSTAINABLE LIVESTOCK PRODUCTION

The main problem related to livestock production is poor herd management leading to overstocking of communally owned fragile range lands. A number of natural, managerial and infrastructural constraints are considered to be important and discussed below.

#### 4.3.1 Constraints

I. Physical constraints related to the natural environment. The quantity of consumable biomass varies strongly both in time (from one year to the other) and space (differences within an area at a given point in time). Water availability naturally also varies over the years.

##### Ia. Natural constraints

Low and erratic rainfall. The annual variation is high and rainfall is poorly spread over the rainy season (see also Section 4.2), resulting in varied range conditions.

Drinking water shortages during the dry season.

##### Ib. Constraints induced by land use

Generally degraded nature of range, due to overgrazing and lack of range management. Compared with less heavily grazed areas in the same general ecological zone, there is a distinct impoverishment of the herbaceous layer in terms of species composition and plant density.

Poor topsoil quality in much of the rangelands. Topsoil is compacted and low in nutrients and organic matter away from trees and shrubs. Under trees and shrubs the topsoil is in much better condition. This pattern of soil degradation is attributed to high grazing intensity, trampling by livestock, increased sheet and splash erosion and reduced leaf and litter fall away from trees and shrubs.

#### II. Management related constraints

##### Ila. Range management constraints

High stocking rates. Communal land ownership leads farmers to maximise herd size in the face of competition by other herds for the same grazing area.

Uncontrolled grazing and browsing. A system of controlled grazing of the communal grazing lands by paddocking or herding is generally absent.

##### Iib. Animal husbandry constraints

Inferior animal health. Improved animal health by vaccination of all animals would cause lower mortality rates and contribute to higher calving rates.

Lack of additional feeding. Few farmers provide additional fodder, bonemeal, salts etc. to their animals. Better supplementary feeding would improve health, increase weight, and raise growth rates and calving rates.

Cross breeding with cattle having better production properties might be beneficial. Such cattle however is generally more vulnerable to drought, diseases etc., and such intervention can only be effective with greatly improved nutrition and under vastly improved management.

### III. Infrastructural constraints

Distance to markets. The distance of about 40 km to the nearest railway station (Palapye) for transport of animals to the abattoir makes marketing difficult and costly.

#### 4.3.2 Suggested options

Changes which would have a positive impact on increased output and better sustainability of livestock production are grouped under a few headings:

##### - Improved land management

Improvement of existing springs and dams. Some of the existing dams and springs would be more productive if managed properly.

##### - Improved range management

Subdividing the range area in a number of fenced units. Paddocking would, in combination with rotational grazing and stock density control, combat degradation and increase the sustainability of grazing systems.

##### - The cultivation of fodder crops

Winter grazing of arable land could be improved by the cultivation of fodder crops, either as a monocrop or as a relay crop with sorghum.

##### - Improved herd management

Improved animal health by regular vaccination of young stock and adequate dispensation of drugs when required, will lower mortality rates of cattle.

Provision of supplementary feed to all cattle will improve the general health condition of cattle and in particular increase calving rates. Supplementary food can be purchased or (partly) grown as fodder.

##### - Improved institutional support

Improvement of extension advice.

Establishment of a local market outlet would reduce the cost of transport for the farmer and reduce high mortality in dry years.

## 4.4 LAND DEGRADATION

### 4.4.1 The problem

Topsoil deterioration and crusting is very widespread in the area. Organic matter in topsoils is decreasing, crusts of 1-2 mm thick seal off the surface. In the dry season they are hard, in the rainy season they are less conspicuous but still existing. The causes are multiple: trampling by cattle, intensive grazing, sheet and splash erosion, reduced leaf and litter fall, no return of organic matter in arable fields. Crusting forms an essential, but much underestimated, link in the vicious circle of environmental degradation: crusts reduce infiltration, amplify run-off and inhibit seed germination. These consequences of crusting in turn lead to increased erosion, reduced vegetative growth, reduced production and reduced incorporation of valuable organic matter into the topsoil, etc. In farmers' fields crusts are broken by cultivation, yet the situation is exacerbated by the consumptive farming methods which remove nutrients continuously from the system without replenishment.

Severe rill erosion is confined to the footslope zone of the Tswapong hills. An area of about 4,000 ha is affected, of which approx. 600 ha seriously. Decline of the protective vegetative cover as a result of overgrazing and deforestation has destabilised this fragile environment. Some of the rills have developed into gullies.

### 4.4.2 Suggested options

Options for the recuperation of topsoils pertain to improved soil and range management and are listed in Sections 4.2.2 and 4.3.2.

Controlled grazing will be required. This could be achieved by (expensive) fencing or by herding. To slow down erosion, a protective plant cover has to be established. This may involve ripping of bare and crusted soil and seeding with fast growing forestry and grass species. A few gullies need conservation structures. The less severely affected areas may be subjected to limited grazing.

## 4.5 THE FARMERS' SOCIO-ECONOMIC ENVIRONMENT

The motivation of farmers to adopt more modern farming practices is limited. Improved methods, as propagated by ALDEP, ARAP and other programmes in the past have had a very low uptake by farmers. This may have been caused partly by the pre-occupation of the Extension Service with drought relief over the last 10 years, but the lack of enthusiasm for change and intensification also has a number of rational causes:

- Risk avoidance and conservatism. Present farming methods have proved their worth in the past for farmers having to operate in a high risk environment (low and unreliable rainfall), and having limited inputs (funds, labour and traction) available.
- The way drought relief works. Farmers receive a subsidy from Government for every hectare they plough (to a maximum of 5 ha), without any condition for performance attached to it. Farmers are thus invited to plough the maximum area whenever draught power is available, even if the rains are insufficient to plant or not enough labour is available to manage the crop.
- Most farmers are old and not very innovative.

- Farmers have many interests, besides farming.. Some activities are more profitable, or give an immediate return. E.g. construction work in the context of drought relief provides a predictable and immediate income.
- Lack of market incentives. Prices are not attractive enough and markets are distant.

## CHAPTER 5

### LAND EVALUATION

Land evaluation estimates the performance of production systems on specified land units. In the semi-arid conditions of Botswana, there is a large difference in performance between years due to variations in annual rainfall. For this reason, land evaluation for crop based production systems is based on a year by year modelling of crop production using historic rainfall data. For this purpose the Crop Yield Simulation and Land Assessment Model for Botswana (CYSLAMB) was developed by the Ministry of Agriculture (De Wit et al, 1994). An Animal Production System and Resource Assessment Model for Botswana (APSRAMB) for the land evaluation for livestock based production systems is presently being developed. A carrying capacity estimation model and herd projection model developed in preparation of a more definitive model are used for the present evaluation.

In land evaluation individual Land Units are evaluated for specific production systems. Relevant LUs have already been defined in Chapter 2. A first screening of relevant production systems is carried out in Section 5.1. The production systems considered in the present study can be grouped under three headings: crop production, livestock production and phane production, and are listed in Tables in the respective Sections below. The relevant present and potential production systems are subjected to financial analysis in Chapter 6.

#### 5.1 RECOMMENDED USES FOR LAND UNITS

The Land Units (LUs) of Ratholo AEA are defined in Section 2.7 and delineated on Map 6. Present land use of the Land Units is presented on Map 7 (see backpocket of this Report).

##### LU 1

The hills and escarpments are steep, have shallow soils and many rock outcrops. Extensive grazing and browsing is the only possible use, together with the collection of wood and other veld products.

##### LU 2

This unit is used for grazing. The soils are also suitable for arable farming, although the gentle slopes will pose an erosion risk.

##### LU 3

Most of this unit has severe limitations for agricultural land use because of moderately steep slopes, erodibility, and stoniness. Only extensive uses as browsing and forestry must be considered here. An exception form pockets of gently sloping land with shallow groundwater, found locally in LU 3. This land, although small in area, provides precious grazing and water in the dry season for livestock and wildlife.

#### LU 4

Year round grazing and browsing is the dominant land use. The area is moderately to severely eroded as a result of overgrazing. Fencing of the area to control grazing and to improve soil cover must be considered.

#### LU 5

Year round grazing and browsing is the dominant land use. A small area in the eastern part of the AEA is used for arable farming. The area is gently sloping and rill erosion is a common phenomenon. The soils are similar to those of LU 7 and are suitable for arable farming, but since there is no shortage of arable land elsewhere, expansion of farming should not be considered here. Better control of grazing should be considered to curb erosion.

#### LU 6

Grazing and browsing during the dry season and veld product collection are the dominant land uses. The area is unsuitable for arable farming due to occasional flooding. Since there is sufficient arable land elsewhere (LU 7), no attempts are required to curb flooding and to try to make arable farming possible.

#### LU 7

At present arable farming is the dominant land use. The best arable soils in Ratholo AEA are found in this unit. Future arable farming should therefore remain to be concentrated in this area. The erosion hazard is low as a result of very gentle slopes.

#### LU 8

Arable farming is the dominant land use. The soils are moderately deep soils, and suitability for arable farming. The erosion hazard is very low as a result of the very gentle slopes. LU 8 occurs in association with LU 9; a detailed soil survey would be needed to separate the two.

#### LU 9

Arable farming is the dominant land use. The soils are shallow and not suitable for deep rooting crops, such as sorghum. The erosion hazard is very low as a result of the very gentle slopes. LU 9 occurs in association with LU 8; a detailed soil survey would be needed to separate the two.

## 5.2 EVALUATION OF CROP BASED PRODUCTION SYSTEMS

### 5.2.1 Introduction

#### 5.2.1.1 CYSLAMB

Crop based production systems are evaluated using a computer programme called CYSLAMB (De Wit et al, 1994). The characteristics of the selected land units (effective rainfall and synoptic meteorological data, soil and 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 what would be the maximum possible biomass yield for the crop under the specified management conditions if there are no constraints due to soils or rainfall. This theoretical maximum yield is determined by solar radiation and temperature. 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 then 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 to take account of the effects of drainage conditions, nutrient supply and toxicities. The biomass yield is converted to the yield of economic product by the harvest index.

The output yields reflect the production on the specified soil type under the climatic conditions over a period of years. In the case of the Ratholo evaluation, the model is run over a period of 32 years, from 1960 till 1992. The outputs are analysed 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 output yields are expressed on the basis of a 'total plot'. CYSLAMB assumes that draught power is only sufficient to 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 crop production systems.

#### 5.2.1.2 Initial analysis and assumptions

Land evaluation has been carried out using CYSLAMB to simulate the following three farming situations:

- 1 The entire field is ploughed and planted at the first planting opportunity in the period November 1st - February 20th. In this case the farmer is assumed to have unrestricted access to a tractor for farm operations.
- 2 The field is ploughed and planted during three successive planting opportunities in the period November 1st - February 20th. In this case the farmer must have access to animal or mechanical draughtpower at all times.
- 3 Ploughing and planting is carried out late in the season, making use of the first two opportunities in the period January 1st - February 20th. In this case the farmer is a slow starter or is forced to hire or borrow draughtpower when everybody else is finished.

The number of planting opportunities which occurred after November 1st<sup>10</sup> during the 32 years analysed (1960-1992) is shown in Table 13.

<sup>10</sup> It is assumed that farmers rarely plough before November 1st, also not in an optimal potential situation. In 19 % of the 32 years analysed an early planting opportunity occurred already in October.

TABLE 13. NUMBER OF PLANTING OPPORTUNITIES PER YEAR (1960-1992)

NO. OF PLANTING OPPORTUNITIES	NO. OF YEARS (from a total of 32)	PERCENTAGE OF YEARS
3	18	56 %
2	5	16 %
1	6	19 %
0	3	9 %

In only 56 % of the years three planting opportunities occurred, as required in farming situation 2. In one out of every 10 or 11 years severe drought was experienced without a single planting opportunity. Analysis of planting opportunities during the later period from January 1st to February 20th shows that only 25 % of years have the minimum two opportunities as required in farming situation 3. This means that farmers who always plant after January 1st, have to plant their entire field at the first opportunity as in most years there will not be another.

For crop based production systems those three LUs are evaluated, which are presently used, or have potential for arable farming. They are LUs 7, 8 and 9. Both present and potential production systems are simulated using CYSLAMB<sup>11</sup>, which result in estimates of *dependable* and *median* yields for the present and potential systems, and enable a comparison of the two situations.

CYSLAMB assumes that crops are grown in pure stands and that no yield losses occur as a result of the incidence of pests and diseases. It also assumes that weeding, if carried out, is completely effective. These assumptions are not met by the presently prevailing production systems. Farm data for the 1992/93 season and general field experience suggest that, under traditional management, sorghum yields are reduced by as much as 50 % as a result of the combined effects of uneven planting, competition by intermixed crops, occurrence of pests and diseases and incomplete weeding. A yield reduction of 50 % has therefore been assumed to calculate present yields.

Under improved management, all of the above yield reducing causes are removed, except for the one related to pests and diseases. It is assumed that pests and diseases are combatted more effectively under improved management, but resulting yield losses will still be considerable. Tentatively, a yield reduction of 20 % is assumed to predict yields under improved management.

For the CYSLAMB simulation of present production systems, phosphorus (P) levels were assumed to be at a low level of 3 ppm, which is the level most commonly found in cultivated topsoils. For the simulation of potential systems, P levels of 5 ppm and 7 ppm have been introduced, which reflect various levels of fertilizer use.

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<sup>11</sup> A CYSLAMB simulation of the present production system was needed because actual long-term yield data are not available

### 5.2.2 Present crop production system

The present production systems are characterised by a mixture of crops dominated by sorghum (var. Segalane) which takes up 90 % of the plant cover. There is no use of fertilizer. Main operations include broadcasting-cum-ploughing during one or more planting opportunities and (incomplete) weeding after 30 to 40 days after planting. Plant densities, as observed in the field, vary from 15,000 to 55,000 pl/ha with 25,000 to 35,000 pl/ha in the majority of cases. Typical production systems, which vary according to planting dates and number of planting occasions, are Ms1, Ms2 and Ms3 (see Table 14). CYSLAMB yields are given in Table 15. Analysis of results leads to the following observations:

- The *dependable* yield of sorghum in production system Ms1 (entire field planted at first opportunity, yields at 50 % reduction level) is about 200 kg/ha. *Median* yields for this group are about 400 kg/ha.
- The *dependable* yield of sorghum in production system Ms2 (field planted successively during first three planting occasions, yields at 50 % reduction level) is less than 100 kg/ha for LUs 7 and 8. This accords well with recorded yields in the area and in Botswana as a whole. *Median* yields are 200-300 kg/ha.
- The *dependable* yield of sorghum in production system Ms3 (planting after Jan 1st during first two planting occasions, yields at 50 % reduction level) is around 40 kg/ha. *Median* yields are about 200 kg/ha.
- *Dependable* yields are higher at 15,000 pl/ha than at 55,000 pl/ha, as a result of less competition for water. However, in years with relatively high rainfall the trend is reversed, except for the shallow soils of LU 9. *Median* yields are lower at 15,000 pl/ha than at 55,000. For traditional type farming, 15,000 pl/ha is the recommended plant density, but for more progressive farmers higher plant densities could be recommended.

Maize is grown at present only in mixed stands with sorghum and other crops and is a minor crop in Ratholo AEA. If it would be grown in a traditional way but as a dominant crop (90 % maize and 10 % other crops), the *dependable* yield would be very low, as shown in Table 18. CYSLAMB has not been used to simulate other traditional crops.

### 5.2.3 Potential crop production system

#### 5.2.3.1 Crops and yields

Sorghum and groundnuts are evaluated for potential production systems, as listed in Table 14 (indicated by codes Rs1 to Rs5, and Rg1 to Rg3). Other suitable crops, not yet incorporated in the CYSLAMB model, will be discussed in Section 5.5. Maize is not considered under improved management because of its low potential.

Potential CYSLAMB yields for sorghum, assuming the introduction of improved farming practices, are presented in Table 16. Comparison of yields of sorghum produced under traditional and improved systems (Tables 15 and 16) leads to the following observations:

- The *dependable* yield of sorghum of production system Rs1 (improved management, entire field planted at first opportunity, limited use of fertilizer, assumed yield reduction of 20 % because of pests and diseases), is 400 - 450 kg/ha. This is about double the

TABLE 14. CROP BASED PRODUCTION SYSTEMS, ANALYSED USING CYSLAMB

	CODE	TIME OF PLANTING (period)	PLANTING OCCASIONS (number)	FERTILIZER USE		WEED COVER *	WEEDING (days after seeding)	PLANT DENSITIES			YIELD REDUCTION FACTOR ** (% loss)	
				(yes/ no)	P (ppm)			(pl/ha)	(pl/ha)	(pl/ha)		
MIXED CROPPING	SORGHUM (Segadlane)	Ms1	1 Nov - 20 Feb	1	no	3	70	30	15000	35000	55000	50
		Ms2	1 Nov - 20 Feb	3	no	3	70	30	15000	35000	55000	50
		Ms3	1 Jan - 20 Feb	2	no	3	70	30	15000	35000	35000	50
	MAIZE (Kalahari EP)	Mm1	1 Nov - 20 Feb	1	no	3	70	30	15000	35000	55000	50
		Mm2	1 Nov - 20 Feb	3	no	3	70	30	15000	35000	55000	50
ROW CROPPING	SORGHUM (Segadlane)	Rs1	1 Nov - 20 Feb	1	yes	5	80	30	35000	55000	75000	20
		Rs2	1 Nov - 20 Feb	3	yes	5	80	30	35000	55000	75000	20
		Rs3	1 Jan - 20 Feb	2	yes	5	80	30	35000	55000	55000	20
		Rs4	1 Nov - 20 Feb	1	yes	7	80	30	35000	55000	75000	20
		Rs5	1 Nov - 20 Feb	3	yes	7	80	30	35000	55000	75000	20
	GROUNDNUTS	Rg1	1 Nov - 20 Feb	1	no	3	70	30		50000		20
		Rg2	1 Nov - 20 Feb	1	yes	5	70	30		50000		20
		Rg3	1 Nov - 20 Feb	1	yes	7	70	30		50000		20

\* For sorghum and maize, weed cover is assumed to increase from 70 % without fertilizer use to 80 % with the use of fertilizer. This effect is assumed not to occur in the case of groundnuts due to its higher ground cover.

\*\* This factor represents yield losses due to competition by other plants, incomplete weeding and/or pests and diseases -- see also main text.

TABLE 15. CYSLAMB YIELDS OF SORGHUM (SEGAOLANE) IN TRADITIONAL MIXED CROPPING (KG/HA)

WITHOUT USE OF FERTILIZER (P = 3 ppm)

PRODUCTION SYSTEM			LAND UNIT	DEPENDABLE YIELD			MEDIAN YIELD		
Code	Period of seeding	Planting occasions		15,000 pl/ha *	35,000 pl/ha	55,000 pl/ha	15,000 pl/ha *	35,000 pl/ha	55,000 pl/ha
Ms1	1 Nov– 20 Feb	1	7	440	390	370	760	820	910
			8	440	420	370	760	820	910
			9	420	380	330	630	650	670
Ms2	1 Nov– 20 Feb	3	7	200	180	140	560	610	670
			8	190	180	140	530	560	600
			9	160	160	110	410	390	390
Ms3	1 Jan– 20 Feb	2	7	90	30		460	510	
			8	80	20		390	430	
			9	60	0		330	310	

\* pl/ha = plants per hectare

The figures in this table are based on CYSLAMB calculations. A yield reduction factor of approx. 50 % should be applied to accommodate for the combined effect of the competition by intermixed crops, occurrence of pests and diseases and incomplete weeding

TABLE 16. CYSLAMB YIELDS OF SORGHUM (SEGAOLANE) IN IMPROVED SINGLE CROPPING (KG/HA)

WITH LIMITED USE OF FERTILIZER (P = 5 ppm)

PRODUCTION SYSTEM			LAND UNIT	DEPENDABLE YIELD			MEDIAN YIELD		
Code	Period of seeding	Planting occasions		35,000 pl/ha *	55,000 pl/ha	75,000 pl/ha	35,000 pl/ha *	55,000 pl/ha	75,000 pl/ha
Rs1	1 Nov– 20 Feb	1	7	560	590	550	1100	1230	1330
			8	560	540	500	1100	1210	1250
			9	530	510	490	880	920	990
Rs2	1 Nov– 20 Feb	3	7	240	250	220	800	890	940
			8	240	250	200	740	810	860
			9	220	200	170	530	550	570
Rs3	1 Jan– 20 Feb	2	7	60	30		660	730	
			8	60	10		520	570	
			9	40	0		450	430	

\* pl/ha = plants per hectare

WITH USE OF FERTILIZER (P = 7 ppm)

PRODUCTION SYSTEM			LAND UNIT	DEPENDABLE YIELD			MEDIAN YIELD		
Code	Period of seeding	Planting occasions		35,000 pl/ha *	55,000 pl/ha	75,000 pl/ha	35,000 pl/ha *	55,000 pl/ha	75,000 pl/ha
Rs4	1 Nov– 20 Feb	1	7	640	680	680	1250	1410	1520
			8	640	660	620	1250	1380	1490
			9	630	620	610	1010	1100	1130
Rs5	1 Nov– 20 Feb	3	7	290	300	300	910	1030	1110
			8	290	300	280	840	930	1000
			9	260	260	220	610	640	670

\* pl/ha = plants per hectare

The figures in this Table are based on CYSLAMB calculations. A yield reduction factor of approx. 20 % should be applied to account for losses due to incomplete protection against pests and diseases

*dependable* yield under traditional management. *Median* yield for this production system is 900 - 1,000 kg/ha.

- The *dependable* yield of sorghum of production system Rs2 (improved management, planting during first three planting occasions, limited use of fertilizer, 20 % yield reduction) is about 200 kg/ha for LUs 7 and 8 and somewhat less for LU 9. This is about double the *dependable* yield under traditional management and only a relatively small increase given the increased labour and costs involved. *Median* yields are 600-750 kg/ha and represent an increase of about 300-400 kg as compared to *median* yields under traditional management.
- Yields of late planted crops are very low also under improved management.

The result of CYSLAMB yield simulation for groundnuts is given in Table 18. The *dependable* yield of production system Rg1 (improved management, entire plot planted at first opportunity, no use of fertilizer, 20 % yield reduction because of pests and diseases) is about 430 kg/ha (unshelled) for LUs 7 and 8. *Median* yields are 500-600 kg/ha. As a result of modest fertilizer use, a yield increase of about 100 kg/ha can be expected. Plant densities do not seem to be important, as in the range of 30,000 to 70,000 pl/ha yields do not vary.

#### 5.2.3.2 Possible interventions in the present system

Several possible agronomic interventions in the traditional mixed cropping system can be recognized, on the basis of past research and present CYSLAMB analysis. Their possible contribution to increased productivity or better sustainability are discussed below.

- 1 Making use of early planting opportunities (i.e. before the end of December) increases the probability of higher yields and higher production from a farm. Comparison of yields under production systems Rs2 and Rs3 makes this clear (see Table 16).
- 2 Row planting enables the farmer to control plant densities and to improve germination (seeds are closer to the surface and placed at constant depth, causing rapid and even emergence). Rowplanting contributes to yield increase (EFSAIP, 1976-1984), with reduced labour requirements for weeding (see below) and harvesting, but increased labour requirements for ploughing and planting. It should be noted that row planting entails a shift from mixed to single cropping, and that, although the yield of the main crop is significantly raised, the other crops in the mix are eliminated. Some beneficial effects of minor crops on sorghum in mixed cropping are removed. Such effects include the provision of groundcover by pulses and melons, and nitrogen fixation by beans and groundnuts.

Yield simulation using CYSLAMB suggests that, in the case of sorghum, an increased plant population has no positive effect on the *dependable* yield, either with or without the use of fertilizer. However, *median* yield is increased with around 20 % if plant density is raised from 35,000 to 75,000 pl/ha (see Table 16).

- 3 Row weeding can only go together with row planting (see above). Weeding can be more effectively done if crops are planted in rows. The effect of improved weeding cannot be quantified at present, but is certain to reduce yield losses. The optimal time lapse in Botswana between planting and weeding is approximately 30 days. Since farmers in

TABLE 17. CYSLAMB YIELDS OF MAIZE (KALAHARI EARLY PEARL) IN TRADITIONAL MIXED CROPPING (KG/HA)

WITHOUT USE OF FERTILIZER (P = 3 ppm)

PRODUCTION SYSTEM			LAND UNIT	DEPENDABLE YIELD		MEDIAN YIELD	
Code	Period of seeding	Planting occasions		15,000 pl/ha *	35,000 pl/ha	15,000 pl/ha *	35,000 pl/ha
Mm1	1 Nov– 20 Feb	1	7	110	0	790	700
			8	110	0	790	700
			9	80	0	510	380
Mm2	1 Nov– 20 Feb	3	7	40	0	600	580
			8	40	0	520	470
			9	30	0	280	180

\* yield is given for a specific plant density (pl/ha = plants per hectare)

The figures in this Table are based on CYSLAMB calculations. A yield reduction factor of approx. 50 % should be applied to account for the combined effect of competition by intermixed crops, the occurrence of pests and diseases, and incomplete weeding.

TABLE 18. CYSLAMB YIELDS OF GROUNDNUTS (PODS), IN IMPROVED SINGLE CROPPING (KG/HA)

WITHOUT USE OF FERTILIZER (P = 3 ppm)

PRODUCTION SYSTEM			LAND UNIT	DEPENDABLE YIELD	MEDIAN YIELD
Code	Period of seeding	Planting occasions		50,000 pl/ha*	50,000 pl/ha*
Rg1	1 Nov– 20 Feb	1	7	540	700
			8	550	710
			9	540	630

WITH LIMITED USE OF FERTILIZER (P = 5 ppm)

PRODUCTION SYSTEM			LAND UNIT	DEPENDABLE YIELD	MEDIAN YIELD
Code	Period of seeding	Planting occasions		50,000 pl/ha*	50,000 pl/ha*
Rg2	1 Nov– 20 Feb	1	7	660	850
			8	670	860
			9	650	770

WITH USE OF FERTILIZER (P = 7 ppm)

PRODUCTION SYSTEM			LAND UNIT	DEPENDABLE YIELD	MEDIAN YIELD
Code	Period of seeding	Planting occasions		50,000 pl/ha*	50,000 pl/ha*
Rg3	1 Nov– 20 Feb	1	7	720	940
			8	740	950
			9	720	850

\* yield is given for a specific plant density (pl/ha = plants per hectare)

The figures in this Table are based on CYSLAMB calculations. A yield reduction factor of approx. 20 % should be applied to account for the effect of incomplete control of pests and diseases diseases, and incomplete weeding.

The technical coefficients used here are again taken from FMS (1988) (top 1/3 of farms) and from field data. The mortality rates are set at 6 % for adults and at 8 % for calves (as compared to 10 % and 12 % respectively without improvement). The calving rate is increased to 50 % for small herds and to 55 % for medium sized herds (as compared to 40 % and 43 % without improvements). By how much calving rates would increase and mortality rates would be reduced as a result of a given improvement in veterinary care and/or supplementary feeding is not known. The production characteristics of cattle herds under improved herd management are presented in Table 22. Only herds of 5 and 15 cattle are evaluated (typical of farmers of Group 2 and 3). Production figures below are given for groups of hundred herds to avoid divided numbers and are based on the per farmer data presented in the table. With improvements, hundred small cattle herds produce 67 cull animals annually. Hundred medium sized cattle herds produce 223 cull animals. The increase in total culls is about 100 % for both herd sizes. Even with improvements, the herd take-off rates are only a modest 11 % for both herd sizes (was 7 % without improvements). The annual milk production of small herds go up to 160 liters per herd, and to 526 liters for medium sized herds, in both cases an increase of 60 %.

#### 5.4 POTENTIAL FOR AGROFORESTRY

Agroforestry is the productive use of trees and shrubs within the farming system. In this context trees on the farm are used for many purposes, including soil fertility improvement (mainly leguminous trees), fodder, firewood, fencing, shade, edible fruits and medicine. Agroforestry includes the cultivation of planted trees, as well as the protection and use of remaining indigenous trees.

Ratholo AEA, and probably Botswana in general, is not very suitable for most agroforestry practices, particularly if it involves the planting of trees. Most newly planted trees would need watering and protection from livestock during the first one or two years. This could be done in a well-managed woodlot or around the homestead but is often difficult in the lands area. Also, many agroforestry practices are labour intensive and most farmers will not have the time or the interest to spend so much time on planting, watering and pruning trees.

If water is available on the lands and the farmer has the time and motivation to develop his/her farm the planting of leguminous trees on fenced fields could be considered. Trees could be planted either along the perimeter of the field or on permanent contour strips. The main purpose of these trees would be to improve soil fertility, and to provide fodder, shade, firewood and poles. Some species which may have potential are given in Table 23. However, more research is needed on this subject to make general recommendations.

#### 5.5 POTENTIAL CROPS

This Section lists some of the crops which could possibly be grown under dryland conditions in the lands area of Ratholo AEA. The agronomic and economic aspects of the production of most of these crops would need further investigation and some of them would have to be tried out before generally recommended. Table 23 lists the suitability of the "candidate crops" crops in qualitative and relative terms. A few of the crops listed are already grown in the area (e.g. cowpea), but at a small scale and not necessarily for the use given.

TABLE 19. LIVESTOCK BASED PRODUCTION SYSTEMS

CODE	HERD SIZE (No of animals)	LOCATION		SEASONAL MOVEMENTS			FEED SOURCE		CALVING		MORTALITY		MILK OFF-TAKE (liter)
		In AEA (% herds)	Cattle post (% herds)	Occurr- ence (yes/no)	Part of herd (%)	Period spent in AEA (months)	Grazing (%)	Browsing (%)	(%)	(%)	Adults (%)	Calves (%)	
CATTLE	C5a	5	100	0	no	0	12	90	10	40	10	12	1.2
	C15a	15	0	100	yes	20	4	90	10	43	10	12	1.2
	C30a	30	0	100	yes	10	4	90	10	43	10	12	1.2
	C50a	50	0	100	yes	10	4	90	10	43	10	12	1.2
	C5b	5	100	0	no	0	12	90	10	50	6	8	1.5
	C15b	15	0	100	yes	20	4	90	10	55	6	8	1.5
GOATS	G5a	5	100	0	no	0	12	40	60	?	?	?	?
	G15a	15	67	33	no	0	12/0	40	60	?	?	?	?
	G30a	30	50	50	no	0	12/0	40	60	?	?	?	?
DONKEYS	D2a	2	100	0	no	0	12	90	10	?	?	?	?
	D6a	6	100	0	no	0	12	90	10	?	?	?	?
	D12a	12	100	0	no	0	12	90	10	?	?	?	?

Livestock/Range Ecology Specialist of the LUPSAD project, in preparation of a more definitive and complete model<sup>12</sup>.

### 5.3.1 Present livestock production system

Ratholo AEA is really too small for a balanced evaluation of livestock production under communal grazing. In the communal grazing system herds move over large distances and are often split into separate entities at different times of the year. The system can best be evaluated in much larger areas, within which a number of herds are confined without significant movements in or out. Nonetheless, an evaluation for Ratholo AEA is attempted here.

It is estimated that the average livestock population of Ratholo AEA consists of 2,000 cattle, of which about 600 are brought in seasonally, 4,296 goats and 1,260 donkeys (see Section 3.4.2 and Table 11). To meet the grazing requirement of these animals within Ratholo AEA an average annual grazing capacity for 2,346 Livestock Units (LSUs) is required. See Table 20. In years when this figure is not met, both cattle and donkeys will turn to browsing shrubby vegetation after depletion of the herbaceous layer. Dependency of cattle and donkeys on browse therefore varies from one year to the other, and is probably higher than 10 % in poor rainfall years.

The carrying capacity of grazing land of Ratholo AEA in the year 1993/94 is estimated at 2,282 LSUs. See Table 21. Grazing in this season falls short for only ten days, and the dependency on browse of cattle and donkeys in this year is therefore a low 3 %. Since 1993/94 was a relatively good rainy season, the grazing capacity of the area is assumed to be lower in most years. Grazing in Ratholo AEA is adequate in good rainfall years, but in poor rainfall years grazers are forced to turn to browse quite early in the dry season thus straining their health and requiring flexibility of the system (by sale of animals in time or movement of animals to elsewhere).

The production characteristics of cattle herds averaging 5 and 15 head, owned at present by farmers residing in Ratholo AEA, are presented in Table 22. Herds averaging 5 and 15 head are typical for farms of Groups 2 and 3 respectively (see Section 3.3). The technical coefficients used are indicative figures based on FMS (1988) (mid 1/3 of farms), and on data collected in the field. There are no reliable data on the year to year variation of individual coefficients.

Herd production figures below are given for groups of hundred herds to avoid divided numbers and are based on the per farmer data presented in Table 22. Hundred small cattle herds based in Ratholo AEA (5 cattle average, 40 % of farmers), produce 34 cull animals annually. Hundred medium sized cattle herds (15 head average), based outside Ratholo AEA, produce 108 cull animals. The herd take-off rate is about 7 % for both herd sizes. The annual milk production is estimated at 102 liters per herd for 5-cattle-herds, and at 329 liters per herd for 15-cattle-herds.

For goats and donkeys no production simulation has been carried out.

### 5.3.2 Potential livestock production system

Interventions which are likely to have a positive impact on the production characteristics of the range are listed in Chapter 4. The advantages and disadvantages of these and some other options are discussed below.

<sup>12</sup> The Animal Production System and Resource Assessment Model for Botswana (APSRAMB) is expected to be ready in 1995

TABLE 20. LIVESTOCK FEED REQUIREMENTS, RATHOLO AEA.

LIVESTOCK TYPE	PRESENCE IN THE AREA	PRODUCTION SYSTEMS	ANIMALS		GRAZING *		BROWSING **	
			(number)	(LSUs)	Dependency factor (%)	Grazing requirement (LSUs)	Dependency factor (%)	Browse requirement (LSUs)
<b>TOTAL</b>	-	-	7,556	2,861	82	2,346	18 or larger	516 or larger
<b>CATTLE</b>	Permanent	C5a	1,400	980	100	980	Variable	Variable
	Seasonal	C15a,C30a,C50a	600	140	100	140	Variable	Variable
<b>GOATS</b>	Permanent	G5a,G15a,G30a	4,296	859	40	344	60	516
<b>DONKEYS</b>	Permanent	D2a,D6a,D12a	1,260	882	100	882	Variable	Variable

\* Cattle and donkeys will graze out all herbaceous species before they are forced to turn to browse.

\*\* The degree in which cattle and donkeys depend on browse is variable and will depend on the grazing carrying capacity of that particular year.

TABLE 21. GRAZING CARRYING CAPACITY, RATHOLO AEA (1993/94)

AREA	(ha)	PORTION OF AEA (%)	HERBACEOUS LAYER (dry matter) (kg/ha/yr)	USE FACTOR (%) **	CARRYING CAPACITY (days/LSU/ha)	CARRYING CAPACITY (ha/LSU/yr)	CARRYING CAPACITY (LSU/yr)
<b>TOTAL RATHOLO AEA</b>	27,023	100	-	-	31	11.8	2,282
<b>1. DESIGNATED ARABLE AREA (LANDS)</b>	16,040	59	-	-	31	11.7	1,375
1a Cultivated fields	3,884	14	330	60	18	20.3	192
1b Areas cleared of woody vegetation; fallow	4,656	17	963 *	60	53	6.9	670
1c Minor areas of secondary growth, in between farmers' fields	3,660	14	303	60	17	22.1	166
1d Major areas of shrub savanna, used for seasonal grazing	3,840	14	606 *	60	33	11.0	348
<b>2. COMMUNAL GRAZING AREA</b>	10,512	39	-	-	31	11.7	900
2a Footslope zone	4,823	18	963	60	53	6.9	694
2b Tswapong Hills	5,689	21	242 *	60	13	27.7	206
<b>3. BUILT-UP AND ASSOCIATED AREAS</b>	471	2	100 *	60	5	66.9	7

Calculations are based on the assumption that the average consumption per LSU is 11 kg of dry matter per day.

Dry matter weights of the herbaceous layer are based on measurements done by M. Powell.

\* Estimated figures.

\*\* Grazing is performed by cattle, donkeys and goats alike. The use factor is therefore set at 60 %, which is slightly higher than the usual 50 % for cattle alone.

TABLE 22. PRODUCTION OF CATTLE AND CATTLE PRODUCTS, RATHOLO AEA (stable herds)\*

		PRESENT PRODUCTION SYSTEMS		POTENTIAL PRODUCTION SYSTEMS	
		C5a (1 Farmer equivalent of Group 2)	C15a (1 Farmer equivalent of Group 3)	C5b (1 Farmer equivalent of Group 2)	C15b (1 Farmer equivalent of Group 3)
<b>HERD COMPOSITION</b>					
Breeding cows	Unit	1.92	5.74	2.00	6.00
Bulls	Unit	0.10	0.29	0.10	0.30
Heifer calves	Unit	0.42	1.37	0.53	1.75
Bull calves	Unit	0.43	1.37	0.54	1.76
Heifers, 1-2 yrs	Unit	0.38	1.21	0.50	1.62
Steers, 1-2 yrs	Unit	0.37	1.21	0.49	1.61
Heifers, 2-3 yrs	Unit	0.33	1.09	0.46	1.51
Steers, 2-3 yrs	Unit	0.34	1.09	0.47	1.52
Heifers, 3-4 yrs	Unit	0.04	0.17	0.17	0.63
Steers, 3-4 yrs	Unit	0.30	0.98	0.43	1.42
Steers, 4-5 yrs	Unit	0.25	0.79	0.38	1.26
Cull cows	Unit	0.06	0.17	0.14	0.42
<b>TOTAL animals</b>	<b>Unit</b>	<b>4.94</b>	<b>15.48</b>	<b>6.21</b>	<b>19.80</b>
<b>TOTAL LSUs</b>	<b>Unit</b>	<b>3.28</b>	<b>10.17</b>	<b>3.96</b>	<b>12.49</b>
<b>PURCHASES</b>					
	Unit	0.00	0.00	0.00	0.00
<b>DEATHS</b>					
Breeding cows	Unit	0.21	0.64	0.13	0.38
Breeding bulls	Unit	0.01	0.03	0.01	0.02
Calves, heifers + bulls	Unit	0.10	0.32	0.08	0.28
Heifers, 1-2 yrs	Unit	0.04	0.12	0.03	0.10
Steers/bulls, 1-2 yrs	Unit	0.04	0.12	0.03	0.10
Heifers, 2-3 yrs	Unit	0.03	0.11	0.03	0.09
Steers/bulls, 2-3 yrs	Unit	0.03	0.11	0.03	0.09
Heifers, 3-4 yrs	Unit	0.00	0.02	0.01	0.04
Steers/bulls, 3-4 yrs	Unit	0.03	0.10	0.03	0.09
Steers/bulls, 4-5 yrs	Unit	0.03	0.08	0.02	0.08
Cull cows	Unit	0.00	0.01	0.01	0.02
<b>TOTAL animals</b>	<b>Unit</b>	<b>0.52</b>	<b>1.66</b>	<b>0.41</b>	<b>1.29</b>
<b>SALES</b>					
Cull cows	Unit	0.06	0.16	0.13	0.40
Cull bulls	Unit	0.02	0.06	0.02	0.06
Cull heifers	Unit	0.00	0.01	0.01	0.02
Surplus heifers	Unit	0.04	0.14	0.15	0.57
Cull steers, 4+ yrs	Unit	0.22	0.71	0.36	1.18
<b>TOTAL animals</b>	<b>Unit</b>	<b>0.34</b>	<b>1.08</b>	<b>0.67</b>	<b>2.23</b>
<b>TOTAL LSUs</b>	<b>Unit</b>	<b>0.37</b>	<b>1.19</b>	<b>0.71</b>	<b>2.38</b>
<b>MILK</b>					
Offtake	Liter	102.0	329.0	160.0	526.0
Home consumption	Liter	51.0	164.5	80.0	263.0
Sale as sour milk	Liter	16.8	54.3	26.4	86.8
<b>TECHNICAL COEFFICIENTS</b>					
Calving rate	%	40	43	50	55
Mortality rate, adults	%	10	10	6	6
Mortality rate, calves	%	12	12	8	8
Culling rate, bulls	%	20	20	20	20
Culling rate, breeding cows	%	3	3	7	7
Culling rate, heifers	%	3	3	3	3
Bull joining rate (cows/bull)	%	20	20	20	20
Age at bulling of heifers	years	2	2	2	2
Age at sale bulls/steers	years	4	4	4	4
Age at sale cull heifers	years	3	3	3	3
Age at sale breeding heifers	years	3	3	3	3
Milk offtake	l/cow/day	1.2	1.2	1.5	1.5
Lactation (days)	days	100	100	100	100
Reduction factor milk - sour milk	-	0.33	0.33	0.33	0.33
<b>HERD TAKE-OFF RATE</b>	<b>%</b>	<b>6.9</b>	<b>7.0</b>	<b>10.8</b>	<b>11.3</b>

\* Herds larger than 10 animals are mainly based outside Ratholo AEA.

- Convert arable land into communal grazing land

Enlargement of the communal range area at the expense of arable land is no option, since the per hectare income potentially derived from farming is much higher than for raising livestock (see Chapter 6).

- Rangeland improvement

Some of the degraded rangelands could be improved through ripping and seeding. Both grasses and legumes could be introduced. *Stylosanthesis guianensis* is a promising species in this context (APRRU, 1991). However rangeland improvement of this nature is costly and can only be considered in the context of controlled grazing.

- Fodder production

Production of fodder, to provide supplementary feed to cattle, could be an option for farmers with sufficient resources, but would not be easy for small farmers with limited labour and draught power. It is also doubtful whether the production of fodder crops would show a positive economic return. If fodder crops are considered, they should be integrated into the present farming system, either as a relay crop<sup>13</sup> with sorghum in years with sufficient rain, or as a rotational crop. A leguminous crop, such as *Dolichos lablab*, will not only provide fodder but also improve the soil through nitrogen fixation. For such an intensive land use an adequate level of phosphorus in the soil is essential and some modest fertilizer application may be needed. Relay cropping, will reduce the yields of individual crops through competition for moisture and nutrients, but the overall yield is expected to be higher than for single cropping (Rowland, 1993). If a leguminous fodder crop is grown in rotation with sorghum, most farmers will have less land available for their traditional crops. It is therefore necessary they crop the land more intensively to keep up production levels. Crop rotations including a fodder crops and green manure should go together with improved crop husbandry as described in Section 5.2. Some potential fodder crops are given in Section 5.5.

- Increased stocking rates

There is no scope for expansion of existing cattle herds within the confines of Ratholo AEA. Availability of grazing is just adequate for the present herds in good years, and already lacking in poor rainfall years (see also Section 5.2.2).

- Improved veterinary care and supplementary feeding

Other possible interventions in the livestock management system are a combination of improved veterinary care, and the provision of supplementary feed to all cattle. Such improved herd management would result in higher calving rates and lower mortality rates. As a result, without allowing present herds to grow in size or number, both culling rates and milk production would increase. In such a scenario controlled stocking, however, is essential. The total number of grazing animals should not be allowed to grow, and individual herd sizes should be controlled. This problem, common to communal grazing lands, will be further discussed in Chapter 7.

<sup>13</sup> Relay cropping is the planting of one crop into another at a significant later period

The technical coefficients used here are again taken from FMS (1988) (top 1/3 of farms) and from field data. The mortality rates are set at 6 % for adults and at 8 % for calves (as compared to 10 % and 12 % respectively without improvement). The calving rate is increased to 50 % for small herds and to 55 % for medium sized herds (as compared to 40 % and 43 % without improvements). By how much calving rates would increase and mortality rates would be reduced as a result of a given improvement in veterinary care and/or supplementary feeding is not known. The production characteristics of cattle herds under improved herd management are presented in Table 22. Only herds of 5 and 15 cattle are evaluated (typical of farmers of Group 2 and 3). Production figures below are given for groups of hundred herds to avoid divided numbers and are based on the per farmer data presented in the table. With improvements, hundred small cattle herds produce 67 cull animals annually. Hundred medium sized cattle herds produce 223 cull animals. The increase in total culls is about 100 % for both herd sizes. Even with improvements, the herd take-off rates are only a modest 11 % for both herd sizes (was 7 % without improvements). The annual milk production of small herds go up to 160 liters per herd, and to 526 liters for medium sized herds, in both cases an increase of 60 %.

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Ratholo AEA, and probably Botswana in general, is not very suitable for most agroforestry practices, particularly if it involves the planting of trees. Most newly planted trees would need watering and protection from livestock during the first one or two years. This could be done in a well-managed woodlot or around the homestead but is often difficult in the lands area. Also, many agroforestry practices are labour intensive and most farmers will not have the time or the interest to spend so much time on planting, watering and pruning trees.

If water is available on the lands and the farmer has the time and motivation to develop his/her farm the planting of leguminous trees on fenced fields could be considered. Trees could be planted either along the perimeter of the field or on permanent contour strips. The main purpose of these trees would be to improve soil fertility, and to provide fodder, shade, firewood and poles. Some species which may have potential are given in Table 23. However, more research is needed on this subject to make general recommendations.

#### 5.5 POTENTIAL CROPS

This Section lists some of the crops which could possibly be grown under dryland conditions in the lands area of Ratholo AEA. The agronomic and economic aspects of the production of most of these crops would need further investigation and some of them would have to be tried out before generally recommended. Table 23 lists the suitability of the "candidate crops" crops in qualitative and relative terms. A few of the crops listed are already grown in the area (e.g. cowpea), but at a small scale and not necessarily for the use given.

TABLE 23. SELECTED POTENTIAL CROPS

MAIN USE	COMMON NAME	SCIENTIFIC NAME	SUITABILITY
Green manure, fodder	Sunhemp Cowpea Moth bean Soya bean Lablab bean	<i>Crotalaria juncea</i> <i>Vigna unguiculata</i> <i>Phaseolus aconitifolius</i> <i>Glycine max</i> <i>Lablab purpureus</i>	high high moderate moderate moderate
Range improvement		<i>Stylosanthesis guianensis</i>	?
Vegetable, relish or cash	Pigeon pea Cowpea Jugo bean Tepary bean Mung bean Groundnuts Lima bean Common bean	<i>Cajanus cajan</i> <i>Vigna unguiculata</i> <i>Vigna subterranea</i> <i>Phaseolus acutifolius</i> <i>Phaseolus aureus</i> <i>Arachis hypogaea</i> <i>Phaseolus lunatus</i> <i>Phaseolus vulgaris</i>	high high high high moderate moderate moderate moderate
Cereals	Finger millet (Rapoko)	<i>Eleusine coracana</i>	moderate
(Other) cash crops	Sunflower Sesame Chicory Guar Chillies	<i>Helianthus annuus</i> <i>Sesamum indicum</i> <i>Cichorium intybus</i> <i>Cyamopsis tetragonoloba</i> <i>Capsicum frutescens</i>	mod. –high moderate moderate moderate moderate
Soil conservation	Sisal Prickly pear Vetiver grass	<i>Agave sisalana</i> <i>Opuntia</i> <i>Vetiveria zizanioides</i>	moderate high moderate
Agroforestry		<i>Acacia albida</i> <i>A. nilotica/indica</i> <i>Cassia rotundifolia</i>	moderate moderate moderate

## 5.6 EVALUATION OF IRRIGATED AGRICULTURE

Irrigated cultivation of vegetables and fruit trees is presently practised by two farmers on plots of one or two hectares, using water from privately owned boreholes. There is no reason why other wealthy farmers could not set up similar projects, but the profitability of this sort of enterprise has not yet been proven. Certainly, the irrigated plot should be very intensively used and carefully managed to make it productive. Unfortunately, in the area where there are good soils, there is no perennial surface water and there are no suitable dam sites. Water for irrigation can only be drawn from deep boreholes. Because of the lack of cheap and abundant water and uncertain markets, irrigated agriculture is not considered in the present land evaluation for Ratholo AEA.

## 5.7 EVALUATION OF THE PHANE PRODUCTION SYSTEM

Phane production is described in Section 3.4.3. Phane is collected from mopane trees which grow in large numbers on plains south of the Tswapong Hills. With sufficient rain, hatching takes place in two separate cycles, in December and April. Present yields are given in Table 25 in Chapter 6. The caterpillars are picked by hand and either boiled and sun-dried, or cured over a fire. The whole process is very labour-intensive. There is little scope for improvement of the system, except maybe in marketing. At present the farmers receive 110 Pula per bag from local traders who reportedly sell it in South Africa for three to four times this price. Collective arrangement of transport, or the installation of a marketing channel, could increase producers' profitability. A negative side effect of phane collection is the fact that peak production periods coincide with the peak labour demands for cropping (see Section 3.4) and some farmers may be tempted to neglect their farms.

## CHAPTER 6

### ANALYSIS OF PRODUCTION AND FINANCIAL EVALUATION

The results of the evaluation, as described in Chapter 5, receive close examination in the present Chapter. A production analysis and a financial analysis of some aspects of present and potential ("improved") farming situations are presented. The analyses are carried out for three different "pattern farms", which represent the main groups of farmers in Ratholo AEA (see Section 3.3). The pattern farms are coded as *Farm 1*, *Farm 2* and *Farm 3*, and are representative for farmer groups 1, 2 and 3 respectively. The pattern farms are defined in Table 25. In the initial analysis, separate attention was given to the three land management units which are suitable for arable farming: LUs 7, 8 and 9. However it appeared that the results do not differ significantly between these three LUs, and only the results for LU 7 are given in this report.

#### 6.1 PRODUCTION IMPACT

##### 6.1.1 Arable component

*Farms 1, 2 and 3* are assumed to have a cropped area of 3, 5 and 8 ha respectively. *Farm 1* is without animals for traction and crops are planted late (production systems Ms3 and Rs3), while *Farms 2 and 3* are ploughed and planted earlier on in the season (production systems Ms2 and Rs2). The production analysis is carried out for a present situation, in which a mix of traditional crops is grown, and for a potential (improved) situation, in which single row cropping of sorghum and groundnuts using fertilizer is practiced. Groundnuts are grown as a cash crop; the crop is selected because of its production potential and because it is the only cash crop presently included in CYSLAMB. Sunflower would be another potential cash crop (see also Section 5.5.). Yield figures for sorghum and groundnuts result from CYSLAMB (see Tables 15, 16 and 18) with a reduction factor of 50 or 20% as explained in Section 5.2.1.2). Yield figures for crops not yet incorporated in CYSLAMB, are based on data from the farm survey.

The yield and production characteristics of *Farms 1, 2 and 3*, for LU 7 are presented in Table 26 (for *dependable* yields) and in Table 27 (for *median* yields). If the full extent of the farms is planted in a traditional way (present situation), *dependable* yields fall short of subsistence requirements for sorghum, even on the largest farm (*Farm 3*). If the whole farm is used for improved cropping of sorghum, *dependable* yields are adequate to cover subsistence requirements on middle sized and larger farms (*Farms 2 and 3*), but not on small farms (*Farm 1*).

A potential situation is evaluated, for which it is assumed that the farms are split into three sub-units: 2 ha planted to single-row sorghum, 0.25 ha planted to broadcasted mixed crops, and the remainder of the farms (respectively 0.75, 2.75 and 5.75 for *Farms 1, 2 and 3*) allocated to single-row groundnuts. In this situation, food production does not cover subsistence requirements (as a result of the lower hectareage allocated to sorghum), but a considerable amount of valuable cash crop (groundnuts) replaces subsistence crops, even on the smallest farm (*Farm 1*). In good years (based on *median* yields) subsistence requirements are covered by farm production and all surplus produced is valuable cash crop.

TABLE 24. DEFINITION OF PATTERN FARMS

FARM CODE	DEVELOPMENT STATUS	CROPS		CATTLE		GOATS		VELD PRODUCT COLLECTION
		Production systems	Planted area (ha)	Production systems	Herd size (head)	Production systems	Herd size (head)	
1	Present	Ms3	3	None	0	G5a	5	yes
	Potential	Rs3, Rg2		None		G5a		
2	Present	Ms2	5	C5a	5	G15a	15	yes
	Potential	Rs2, Rg2		C5b		G15a		
3	Present	Ms2	8	C15a	15	G15a	15	yes
	Potential	Rs2, Rg2		C15b		G15a		

TABLE 25. YIELD AND PRODUCTION OF VELD PRODUCTS, OF PATTERN FARMS, PRESENT AND POTENTIAL (Dependable yields)

PRODUCT	PERIOD OF YEAR	YIELD	PRODUCTION
Phane (dried)	December	0.6 bags/ha of mopane bush	Farms 1, 2 and 3 2.0 bags 1.5 bags 3.5 bags
	April	0.6 bags/ha of mopane bush	
		1.2 bags/ha of mopane bush	
Total		??	50 liter

TABLE 26. YIELD AND PRODUCTION OF ARABLE FARMING, OF PATTERN FARMS, DEPENDABLE YIELDS for sale and household consumption

Land Unit: 7

		Farm 1			Farm 2			Farm 3		
		YIELD (kg/ha)	PRODUCTION (ha) (kg)		YIELD (kg/ha)	PRODUCTION (ha) (kg)		YIELD (kg/ha)	PRODUCTION (ha) (kg)	
PRESENT	Sorghum	45 <sup>1</sup>	3	135	100 <sup>4</sup>	5	500	100 <sup>4</sup>	8	800
	Millet	20 <sup>1</sup>		60	20 <sup>1</sup>		100	20 <sup>1</sup>		160
	Sweetreed	150 <sup>1</sup>		450	150 <sup>1</sup>		750	150 <sup>1</sup>		1,200
	Cowpea	40 <sup>1</sup>		120	40 <sup>1</sup>		200	40 <sup>1</sup>		320
	Melon	80 <sup>1</sup>		240	80 <sup>1</sup>		400	80 <sup>1</sup>		640
	Watermelon	400 <sup>1</sup>			400 <sup>1</sup>			400 <sup>1</sup>		
	- Fresh			400			400			400
- For beer			800			1,600			2,800	
POTENTIAL	Sorghum	48 <sup>5</sup>	2.00	96	192 <sup>6</sup>	2.00	384	192 <sup>6</sup>	2.00	384
	Groundnuts	528 <sup>7</sup>	0.75	396	528 <sup>7</sup>	2.75	1,452	528 <sup>7</sup>	5.75	3,036
	Sweetreed*	165 <sup>2</sup>	0.25	41	165 <sup>2</sup>	0.25	41	165 <sup>2</sup>	0.25	41
	Cowpea*	44 <sup>2</sup>		11	44 <sup>2</sup>		11	44 <sup>2</sup>		11
	Melon*	88 <sup>2</sup>		22	88 <sup>2</sup>		22	88 <sup>2</sup>		22
	Watermelon *	440 <sup>2</sup>			440 <sup>2</sup>			440 <sup>2</sup>		
	- Fresh			37			37			37
- For beer			73			73			73	

\* It is assumed that farmers remain growing mixed subsistence crops, but not necessarily enough to meet their requirements.

<sup>1</sup> Estimated figures on the basis of farm survey

<sup>2</sup> Yields are assumed to be 10 % higher due to the absence of sorghum from the crop mix.

<sup>3</sup> Production system Ms3, dependable CYSLAMB yield, 15,000 pl/ha (see Table 15) MINUS 50% (see Section 2.5.1.2)

<sup>4</sup> Production system Ms2, dependable CYSLAMB yield, 15,000 pl/ha (see Table 15) MINUS 50% (see Section 2.5.1.2)

<sup>5</sup> Production system Rs3, dependable CYSLAMB yield, 35,000 pl/ha (see Table 16) MINUS 20% (see Section 5.2.1.2)

<sup>6</sup> Production system Rs2, dependable CYSLAMB yield, 35,000 pl/ha (see Table 16) MINUS 20% (see Section 5.2.1.2)

<sup>7</sup> Production system Rg2, dependable CYSLAMB yield, 50,000 pl/ha (see Table 18) MINUS 20% (see Section 5.2.1.2)

TABLE 27. YIELD AND PRODUCTION OF ARABLE FARMING, OF PATTERN FARMS, MEDIAN YIELDS for sale and household consumption

Land Unit: 7

		Farm 1			Farm 2			Farm 3		
		YIELD (kg/ha)	PRODUCTION (ha) (kg)		YIELD (kg/ha)	PRODUCTION (ha) (kg)		YIELD (kg/ha)	PRODUCTION (ha) (kg)	
PRESENT	Sorghum	230 <sup>3</sup>	3	690	280 <sup>4</sup>	5	1,400	280 <sup>4</sup>	8	2,240
	Millet	40 <sup>1</sup>		120	40 <sup>1</sup>		200	40 <sup>1</sup>		320
	Sweetreed	300 <sup>1</sup>		900	300 <sup>1</sup>		1,500	300 <sup>1</sup>		2,400
	Cowpea	80 <sup>1</sup>		240	80 <sup>1</sup>		400	80 <sup>1</sup>		640
	Melon	160 <sup>1</sup>		480	160 <sup>1</sup>		800	160 <sup>1</sup>		1,280
	Watermelon	800 <sup>1</sup>			800 <sup>1</sup>			800 <sup>1</sup>		
	- Fresh			400			400			400
- For beer			800			1,600			2,800	
POTENTIAL	Sorghum	528 <sup>5</sup>	2.00	1,056	640 <sup>6</sup>	2.00	1,280	640 <sup>6</sup>	2.00	1,280
	Groundnuts	680 <sup>7</sup>	0.75	510	680 <sup>7</sup>	2.75	1,870	680 <sup>7</sup>	5.75	3,910
	Sweetreed *	330 <sup>2</sup>	0.25	83	330 <sup>2</sup>	0.25	83	330 <sup>2</sup>	0.25	83
	Cowpea *	88 <sup>2</sup>		22	88 <sup>2</sup>		22	88 <sup>2</sup>		22
	Melon *	176 <sup>2</sup>		44	176 <sup>2</sup>		44	176 <sup>2</sup>		44
	Watermelon *	880 <sup>2</sup>			880 <sup>2</sup>			880 <sup>2</sup>		
	- Fresh			73			73			73
- For beer			147			147			147	

\* It is assumed that farmers remain growing mixed subsistence crops, but not necessarily enough to meet their requirements.

<sup>1</sup> Estimated figures on the basis of farm survey

<sup>2</sup> Yields are assumed to be 10 % higher due to the absence of sorghum from the crop mix.

<sup>3</sup> Production system Ms3, median CYSLAMB yield, 15,000 pl/ha (see Table 15) MINUS 50% (see Section 5.2.1.2)

<sup>4</sup> Production system Ms2, median CYSLAMB yield, 15,000 pl/ha (see Table 15) MINUS 50% (see Section 5.2.1.2)

<sup>5</sup> Production system Rs3, median CYSLAMB yield, 35,000 pl/ha (see Table 16) MINUS 20% (see Section 5.2.1.2)

<sup>6</sup> Production system Rs2, median CYSLAMB yield, 35,000 pl/ha (see Table 16) MINUS 20% (see Section 5.2.1.2)

<sup>7</sup> Production system Rg2, median CYSLAMB yield, 50,000 pl/ha (see Table 18) MINUS 20% (see Section 5.2.1.2)

### 6.1.2 Livestock component

The analysis is carried out for small herds (5 cattle) and medium sized herds (15 cattle), which are found on Farms 2 and 3 respectively. *Farm 1* has no cattle. The present and potential situations differ in herd management, as is reflected in more favourable technical coefficients for the higher productive potential situation. The present and potential production characteristics are presented in Table 22 and described in Section 5.3. The fact that most of the medium sized herds are based at cattle posts outside Ratholo AEA should again be noted.

### 6.1.3 Veld product component

Production of veld products is the same for present and potential situations. A *dependable* yield is defined, and taken as 70 % of the yield recorded in the reasonably productive season of 1993/94. Production characteristics are given in Table 25.

## 6.2 FINANCIAL ANALYSIS

### 6.2.1 Valuation of farm production

The producer prices for items entering the financial analysis are gathered from various sources and are presented in Table A1 of the Appendix of this report. Combining producer prices with the production characteristics of the various farms in LU 7 results in the valuation of farm production, which is presented in Tables A2 and A3 of the Annex. All production available for sale and home consumption is valued, with the exception of produce that can not be readily sold (e.g. melon and fresh milk). Farm labour is also entered in the analysis, but only the portion which can be sold as a service to other farmers (by small farmers with excess labour to larger farmers with shortage of labour). The amounts and percentages provided in the Tables give an indication of the value produced by different farm activities and of the share of each activity of the total value produced. A representative example is given in Table 28. At present, veld products and labour are major sources of income for small farms (*Farm 1*), while income from livestock is dominant on larger farms (*Farm 3*). In the potential situation, income from arable farming becomes dominant for all farms (*Farms 1, 2 and 3*), with veld products remaining important on the small farms (*Farm 1*) and livestock on the large farms (*Farm 3*).

### 6.2.2 Operating expenditure

Price lists for operating expenditures, investment costs and drought relief subsidies are compiled from data originating from diverse sources and are presented in Tables A4 and A5. Prices from these lists are used to calculate the operating expenditure of the three farms for both present and potential situations (see Table A6). Variations in farmers' expenditures for the different LUs are minor and not considered here. In the present situation, the annual cost of production is Pula 353 for a small farm (*Farm 1*) going up to Pula 614 for a large farm (*Farm 3*). When drought relief in its present form is included, operating costs are close to zero for the small farm and large farm and become negative for the medium farm. The main component of the subsidy is for annual cost of production is Pula 353 for a small farm (*Farm 1*) going up to Pula 614 for a large farm (*Farm 3*). When drought relief in its present form is included, operating costs are close to zero for the small farm and large farm and become negative for the medium farm. The

TABLE 28. CONTRIBUTION OF FARMING SYSTEM COMPONENTS TO THE VALUE OF FARM PRODUCTION, FOR PATTERN FARMS (*dependable* yields have been used for crops)

	PRESENT			POTENTIAL		
	Farm 1 (%)	Farm 2 (%)	Farm 3 (%)	Farm 1 (%)	Farm 2 (%)	Farm 3 (%)
Crops	21	30	31	37	54	55
Livestock	6	30	49	6	25	37
Veld products	35	28	20	32	16	8
Farm labour	38	12	0	25	5	0
	---	---	---	---	---	---
Total	100	100	100	100	100	100

main component of the subsidy is for ploughing, and is thus of greater benefit to farms which are able to provide draught power themselves (larger farms). In the potential situation, operating costs increase from Pula 1,047 for a small farm (*Farm 1*) to Pula 1,726 for a large farm (*Farm 3*). It should be noted that in day to day life operating expenditures may be much lower than cited above. Not considered in the calculations are the use of the labour of small children and free or cheap assistance from neighbours and relatives. Also exchange of labour and "work parties" are not included.

### 6.2.3 Investments and labour use

A number of farmer's investments are required to attain the described potential situation. Farmers will have to invest in a set of ALDEP implements<sup>14</sup> (including a scotch cart for large farmers), spraying equipment and animal health equipment<sup>15</sup>. The estimated cost of one full package is Pula 1,141, not counting the scotch cart which may cost between Pula 1,400 and 2,000. For large farms purchase of this package is a financially attractive proposition. For smaller farms sharing equipment may be a possibility, for example by contributing to a communally organised equipment pool. However, the problem with shared equipment is that everybody needs ploughs and planters at the same time.

Labour availability is an essential factor determining the feasibility and sustainability of potential developments. It is estimated that the change to rowplanting and related operations increases labour demands by 25 % for sorghum and 50 % for groundnuts during the cropping season. Harrowing, row planting and cultivating (weeding) are additional operations as compared to the present situation, but weeding by hand hoe is strongly reduced. It is possible that many of the female headed households will not have the necessary labour. Groundnut production poses additional labour requirements for shelling, since BAMB only buys shelled groundnuts. However, this activity can be performed after the cropping season when labour is less restricted, and it adds value to the product.

### 6.2.4 Gross margins

Gross margins for the main farming system components are presented in Table 29. Potential gross margins for rainfed cropping on *Farms 2* and *3* are Pula 303 and Pula 1,569 respectively, or 288 % and 344 % higher than at present. The figures given here represent an almost ideal situation. The potential increase

<sup>14</sup> A planter, harrow and cultivator.

<sup>15</sup> A knapsack sprayer, dehorning iron, burdizzo and syringes.

in gross margin for *Farms 2* and *3* is mainly based on the assumptions that the farmer plants more than half of his/her farm with groundnuts (5.75 ha out of 8 in case of *Farm 3*), has a successful harvest of grade 2 quality, and does not hire labour for groundnut shelling.

### 6.2.5 Farm budgets

The farm budget presented in Table 30 is based on *dependable* yields for the valuation of the crop component. Input data are taken from Tables discussed in the previous Sections. For both present and potential situations, the net benefit is virtually the same for LUs 7, 8 and 9, and only the results for LU 7 are given in Table 30. After deduction of farm production consumed at home, the present net benefit amounts to Pula 330 for *Farm 1*, and increases to Pula 555 and Pula 985 for *Farms 2* and *3* respectively. When the effect of drought relief is included, higher benefits appear. In absolute terms, larger farms benefit more than smaller farms from drought relief, because small farms cannot plough the maximum of 5 ha for which subsidy is given and usually cannot rowplant themselves. The net benefit for the potential situation (without drought relief) is negative for *Farm 1*. Introduction of improved management practices, such as harrowing, rowplanting and rowweeding, is clearly pointless on small farms which are without means of traction and without farm machinery, and therefore have a high operation cost. If harrowing was left out and weeding was done manually by the farmer, the net benefit in the potential situation would be close to zero. (For details on expenditure see Table A6). For *Farms 2* and *3*, the potential net benefit is Pula 770 and Pula 2,713 respectively, and are higher than at present, representing an increase of 39 % for *Farm 2* and 175 % for *Farm 3*. For large farms, the potential situation is also distinctly more advantageous than the "present + drought relief" situation. Introduction of improved management is therefore viable on the larger farms.

In Table 31 a farm budget is presented which uses *median* yields for the valuation of the crop component. The present net benefits are about twice the net benefits based on *dependable* yields (Table 30). The potential net benefits are still not attractive for the small farmer. For the medium and large farm the potential net benefit is respectively 38 % and 127 % higher than the present situation. Production costs for small farms (*Farm 1*) under improved management are high and would be much reduced if these farms would possess their own means of traction. A programme assisting small farmers in obtaining donkeys or cattle, as in present ALDEP assistance, is desirable from a production cost point of view, but is only justifiable if the animals are obtained from large livestock owners from within the AEA, so as not to put more pressure on the already scarce grazing resources in the area.

TABLE 29. GROSS MARGINS FOR MAIN FARMING SYSTEM COMPONENTS

LAND UNIT 7		PRESENT			POTENTIAL		
		Farm 1 (Pula)	Farm 2 (Pula)	Farm 3 (Pula)	Farm 1 (Pula)	Farm 2 (Pula)	Farm 3 (Pula)
CROPS	value	247	449	657	466	1,427	2,701
	cost	351	371	304	940	1,124	1,132
	margin	-104	78	353	- 474	303	1,569
LIVESTOCK	value	72	441	1,013	72	666	1,808
	cost	0	42	132	2	120	377
	margin	72	399	881	70	546	1,431
VELD PRODUCTS	value	410	410	410	410	410	410
	cost	0	0	0	0	0	0
	margin	410	410	410	410	410	410

Note: *dependable* yields have been used to calculate the value of crops; only hired services are costed, labour and service available at the farm have not been costed; gross margins also do not include fixed costs (e.g. tools)

TABLE 30. FARM BUDGETS OF PATTERN FARMS, PRESENT AND POTENTIAL,  
DEPENDABLE YIELDS

LAND UNIT: 7			Farm 1	Farm 2	Farm 3
			(Pula)	(Pula)	(Pula)
<b>PRESENT</b>	Value of production	+	1,163	1,476	2,079
	Operating expenditure	-	353	441	614
	(Drought relief income)	(+)	351	585	585
	Home consumed production *	-	480	480	480
	<b>Net benefit</b>	=	<b>330</b>	<b>555</b>	<b>985</b>
	<b>Net benefit incl. drought relief</b>	<b>(=)</b>	<b>681</b>	<b>1,140</b>	<b>1,570</b>
<b>POTENTIAL</b>	Value of production	+	1,275	2,635	4,919
	Operating expenditure	-	1,047	1,385	1,726
	Home consumed production *	-	480	480	480
	<b>Net benefit **</b>	=	<b>(252)</b>	<b>770</b>	<b>2,713</b>

\* Home consumed production includes the cost for 1,000kg of sorghum, 60 kg of millet and 120 kg of cowpeas. It also includes non-saleable farm produce which is not valued. In some cases the cost of home consumption exceeds the value of production.

\*\* Drought relief applies only to the present situation. In the potential situation subsidy flows are assumed to be different.

TABLE 31. FARM BUDGETS OF PATTERN FARMS, PRESENT AND POTENTIAL,  
MEDIAN YIELDS

LAND UNIT: 7			Farm 1	Farm 2	Farm 3
			(Pula)	(Pula)	(Pula)
<b>PRESENT</b>	Value of production	+	1,470	1,977	2,881
	Operating expenditure	-	353	441	614
	(Drought relief income)	(+)	351	585	585
	Home consumed production *	-	480	480	480
	<b>Net benefit</b>	=	<b>637</b>	<b>1,056</b>	<b>1,787</b>
	<b>Net benefit incl. drought relief</b>	<b>(=)</b>	<b>988</b>	<b>1,641</b>	<b>2,372</b>
<b>POTENTIAL</b>	Value of production	+	1,745	3,326	5,977
	Operating expenditure	-	1,047	1,385	1,726
	Home consumed production *	-	480	480	480
	<b>Net benefit **</b>	=	<b>218</b>	<b>1,461</b>	<b>3,771</b>

\* Home consumed production includes the cost for 1,000kg of sorghum, 60 kg of millet and 120 kg of cowpeas. It also includes non-saleable farm produce which is not valued. In some cases the cost of home consumption exceeds the value of production.

\*\* Drought relief applies only to the present situation. In the potential situation subsidy flows are assumed to be different.

## CHAPTER 7

### CONCLUSIONS AND RECOMMENDATIONS

The main land uses in Ratholo AEA are: arable farming, livestock grazing and veld product collection. It is expected that all three components will remain important in the foreseeable future. Potential for future development lies in the intensification of existing land uses, which would then make a contribution to increased food security. There is little scope for the introduction of other land uses. In this study, emphasis is placed on the increase of farm output, through adoption of improved farming practices and diversification into economically profitable cash crops, on the increase of livestock production, through improvement of herd and range management, and on the achievement of sustainability of production. Present and recommended land use are shown on Map 7<sup>15</sup>.

#### 7.1 RAINFED ARABLE FARMING

##### 7.1.1 Field pattern and suitability of Land Units

It seems that the drift fence (Map 7) is well placed and arable farming should be confined to the area between the drift fence and the veterinary cordon fence. It is recommended to maintain existing pattern of arable fields, although there is an argument against it. A partial relocation of fields to areas having better soils would optimize resource use, as arable fields are located in land units (LUs) 7b, 8 and 9 (see Map 7), of which the first two LUs are most suitable for arable farming. LU 9 is less suitable because of shallow soils. However, changing the location of fields would bring about social and infrastructural disruption. It is considered that such disturbance does not outweigh the potential benefits.

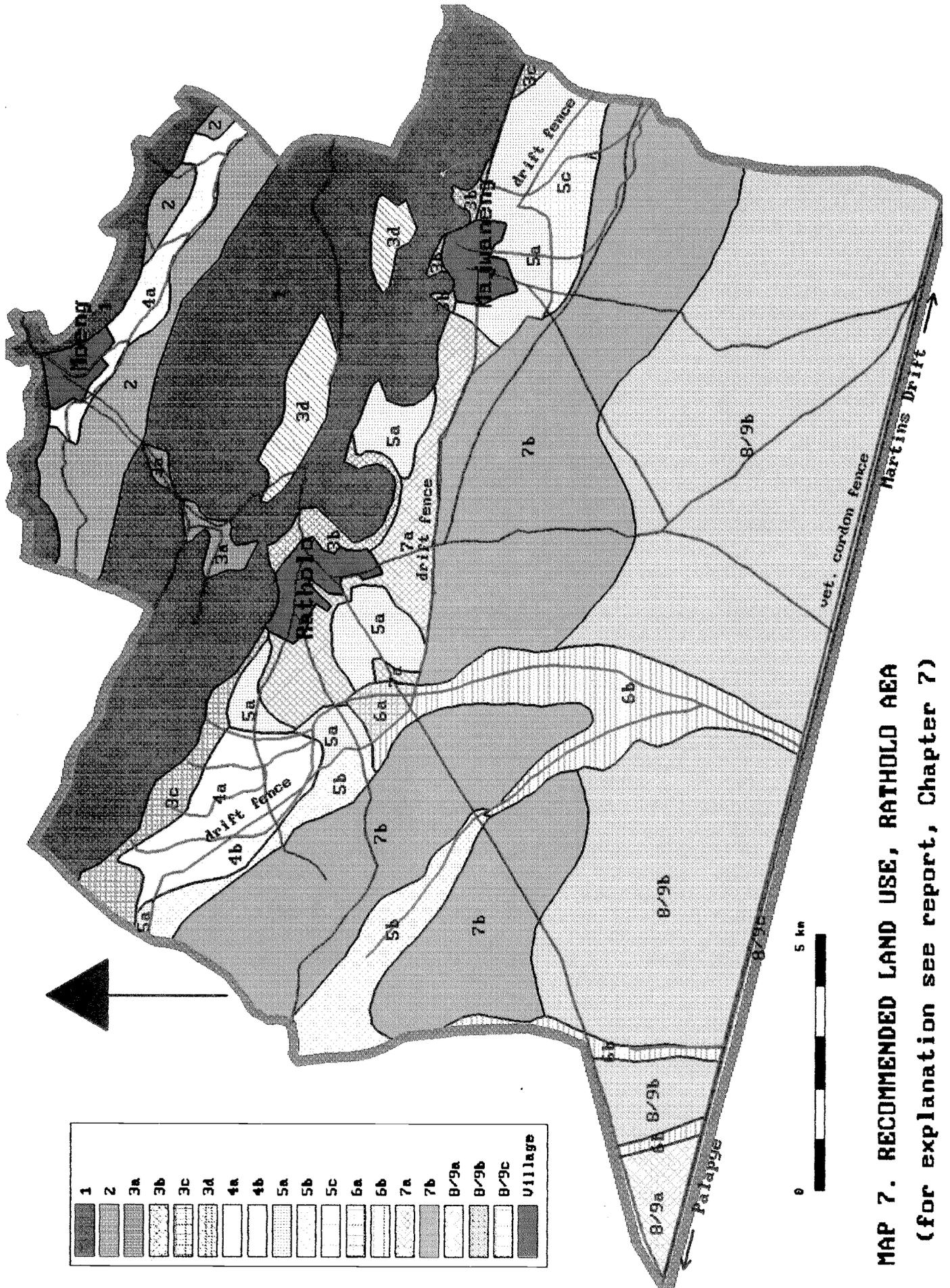
If the total hectareage of arable fields is to increase in the future, it is recommended to expand within LU 7b or 8. On LU 9 cultivation of deep rooted crops (sorghum) should be discouraged, and emphasis be placed on the cultivation of more shallow rooting crops. Unfortunately LU 8 (moderately deep soils) and LU 9 (shallow soils) occur in close association and a detailed soil survey would be needed to map them separately. On Map 7 they are shown together as mapping unit 8/9. Arable farming should not be considered in any of the other LUs south of the drift fence for reasons of flood risk (LU 6b) or erosion hazard (LUs 4b, 5b and 5c).

##### 7.1.2 Crop production

Presently crop production is low. Dependable yields are estimated at 120 kg, 500 kg and 800 kg of sorghum on small farms (typically 3 ha), medium sized (typically 5 ha) and larger farms (typically 8 ha) respectively. Other traditional crops, such as watermelon and sweetreed, provide important additional staple. Yields are low as a result of erratic rainfall, poor soils, inadequate farming practices and high incidence of pests and diseases.

Potentially, under improved farm management, a sorghum yield of 200 to 450 kg/ha can be realised in

<sup>15</sup> Map 7 is presented at scale 1:100,000 on the following page. The Map is also available at scale 1:50,000 from the Land Utilisation Division, MoA, Gaborone



**MAP 7. RECOMMENDED LAND USE, RATHOLD AEA**  
 (for explanation see report, Chapter 7)

TABLE 32. LEGEND MAP 7: RECOMMENDED LAND USE

LAND MANAGEMENT UNIT	AREA (ha)	PRESENT USE (1)	RECOMMENDED USE	REMARKS	RELEVANT SECTIONS IN REPORT
Moeng village	130	Settlement	As present	Dam north of College needs rehabilitation	
Ratholo and Matwaneng villages	210 170	Settlement	As present, with controlled drainage system	Villages not to expand northwards	
1	5500	Year-round communal grazing	Controlled year-round grazing	Ratholo spring needs protection	5.1; 5.3.2; 7.2
2	970	Year-round communal grazing	Controlled year-round grazing	Suitable for cultivation (with soil conservation)	5.1; 5.3.2; 7.2
3a	130	Intensive year-round communal grazing	As present	Locally shallow groundwater used by livestock and wildlife	5.1; 5.3.2; 7.2
3b	210	Year-round communal grazing	Forestry; soil and water conservation		5.1; 5.3.2; 7.2; 7.5
3c	330	Year-round communal grazing	Soil and water conservation		5.1; 5.3.2; 7.2
3d	360	Year-round communal grazing	Controlled year-round grazing	Marginally suitable for cultivation	5.1; 5.3.2; 7.2
4a	880	Year-round communal grazing	Controlled year-round grazing	Eroded area; needs careful management	4.4.2; 5.1; 5.3.2; 7.2
4b	140	Cultivation and winter grazing	Controlled winter grazing	Eroded area; needs careful management	2.4.2; 5.1
5a	1190	Year-round communal grazing	Controlled year-round grazing	Suitable for cultivation (with soil conservation)	4.4.2; 5.1; 5.3.2; 7.2
5b	800	Winter grazing and minor cultivation	Controlled winter grazing	Suitable for cultivation (with soil conservation)	5.1; 7.2
5c	330	Cultivation and winter grazing	Improved dryland farming and winter grazing		5.1; 7.1.2; 7.1.3
6a	100	Year-round communal grazing	Controlled year-round grazing		5.1; 5.3.2; 7.2
6b	1140	Winter grazing	As present	Suitable for cultivation, except for imperfectly drained sites	5.1
7a	770	Year-round communal grazing	Controlled year-round grazing	Suitable for cultivation	5.1; 5.3.2; 7.2
7b	6120	Cultivation and winter grazing	Improved dryland farming and winter grazing	The most suitable arable land in the AEA; lack of water on the lands	5.1; 5.5; 5.2.3.2; 7.1.2; 7.1.3
8/9a	250	Winter grazing	As present	Sites with deep soil are suitable for cultivation	5.1; 5.5; 5.2.3.2; 7.1.2; 7.1.3
8/9b	7300	Cultivation and winter grazing	Improved dryland farming and winter grazing	Patches of shallow soil occur which are not suitable for cultivation	5.1; 5.5; 5.2.3.2; 7.1.2; 7.1.3
8/9c	50	Double cordon fence	As present	Patches of good grass can be cut and used as fodder	

(1) Firewood and other veld products are collected in nearly all land management units; phane collection mainly in units 4 to 9

at least 75 % of years (see Section 5.2.3.1). If farms would then be planted to sorghum only, subsistence staple requirements would be met on farms of 5 ha and more. Although in exceptional years good maize yields can be achieved, *dependable* maize yields are very low (around 50 kg/ha). It is therefore recommended to keep sorghum as the main cereal crop.

Potentially, assuming the adoption of improved farm practices, a groundnut yield (unshelled) of 430 kg/ha (unfertilized) to 580 kg/ha (fertilized) can be realised in at least 75 % of years (see Section 5.2.3.1). To reach this yield level, farmers would be required to plough and plant their entire groundnut field at the first planting opportunity after November 1st.

Adoption of improved farm practices is essential in order to raise dependable yields to the levels stated above for sorghum and groundnuts. These recommended practices include:

- Rowplanting and row weeding; this requires investment in farm implements and training of farmers
- Making use of early planting opportunities occurring after November 1st
- Careful planting, thinning and in-filling to achieve an uniform plant density of 35,000 to 55,000 plants per hectare
- Timely weeding (about 30 days after seeding)
- Use of fertilizer at a rate of at least 50 kg/ha (2:3:2 compound or superphosphate)
- More effective spraying against pests and diseases; this requires investment in equipment and training of farmers

The scope for groundnut production in the area is considerable. It is therefore recommended that farmers are urged to grow groundnuts and increase their market orientation. Both improved extension and improved market infrastructure will be instrumental in achieving this, and are further detailed in Section 7.7. Other legumes, such as cowpea, jugo bean and tepary bean are also recommended.

It is assumed that even those farmers interested in cash crop production want to retain part of their farms for subsistence food crops. A subdivision of farms is proposed, in which the production of food crops is limited to an area of about 2 ha and the remainder of the farm is planted to cash crops. Production of partly unsaleable traditional crops would then be replaced by high value saleable produce.

For large farms, whose owners have their own means of traction, the production of sorghum and groundnuts under improved farming methods would provide modest financial returns. Table 29 shows a potential gross margin for crop production of Pula 1,569 for farms of 8 ha. For small farms, which are without means of traction, the value of increased production does not outweigh the increased costs: Table 29 shows a gross margin of minus Pula 474 for farms of 3 ha. Improved farming methods which need additional draught power can therefore only be recommended for small farms if well targeted subsidies are provided.

Drought relief, used in its present form, benefits all farmers. However, large farmers are likely to benefit more than small farmers, mainly because owners of larger farms usually have their own means of traction and will cash the money themselves rather than hand it over to a contractor. It is recommended that a subsidy is introduced which is directed to the needs of small farmers interested in intensification of farming and cash crop production. This subsidy should cover the rental of traction for field operations as in present drought relief, but conditions of good farm management should be attached to it. Presently,

under ALDEP, farmers can get loans for the purchase of donkeys or oxen for ploughing. This form of assistance is somewhat problematic in Ratholo AEA, because of limited availability of grazing and fodder.

### 7.1.3 Soil degradation and conservation in farmers' fields

Topsoils in farmers fields are often degraded. Organic matter and nutrients are reduced as a result of present farming methods and surface crusts are widespread. Maintenance of soil fertility is not practiced, except for some manure deposited by animals grazing crop residues in winter.

It is strongly recommended that farmers practice soil and water conservation in their fields to protect the resource base of farming. Fertility maintenance can be realised by the application of kraal manure, ploughing-in of crop residues and/or green manure, crop rotation, and the application of chemical fertilizer. Mixed cropping in the form of alternate rows of sorghum and legumes will also enhance soil fertility. The installation of tied bunds may be considered in the future to conserve water and curb overland flow on land with a slope of more than 1%. Both soil fertility improvement and soil conservation can be achieved through the planting of permanent contour strips with leguminous trees.

## 7.2 ANIMAL PRODUCTION

### 7.2.1 General

Ratholo AEA presently supports an estimated 2,000 cattle, 4,300 goats and 1,300 donkeys. Although the present cull and milk production are modest, livestock is an important source of income for about 30 % of households. Livestock is an essential part of most large farms, but is insignificant on small farms.

The herbage requirements of cattle, donkeys and goats can be met by natural range production in years with good rainfall. However, in years with poor rainfall grazers are forced to turn to browse quite early in the dry season because of lack of grass. In spite of insufficient natural grazing, adoption of improved herd management would bring about an important increase in cattle production. Improved management includes improved veterinary care and the provision of supplementary feed to all cattle, as detailed in the next Paragraphs. Total culls could increase with 100 %, and milk production with 60 %. Even with the improvements, the herd take-off rates would be a modest 11 % as compared to 7 % without improvements.

It is recommended, that the DAHP makes a serious effort to vaccinate more cattle during their vaccination campaigns than at present. It is also recommended that more farmers introduce vaccination against Enterotoxemia, Lumpy Skin, and Calf paratyphoid for immature stock, and provide supplementary feed in the form of maintenance licks and bonemeal to all cattle. The SI should conduct training courses for farmers to this effect.

It will be essential to control stocking rates. The total number of grazing animals should not be allowed to grow, and individual herd sizes should be controlled. This may be difficult to realise without a means of enforcement endorsed by Government.

Shortage of drinking water for livestock occurs during the dry season. There is limited scope for the construction of small heifer dams in streams in the footslope zones west of Ratholo and near Moeng. Development of this potential must be considered, but the tight schedule of the Regional Dam Unit is likely to prevent swift execution. Protection of the spring above Ratholo village and the dam above Moeng College will improve water quality and animal health.

### 7.2.2 Grazing patterns and range conservation

At present livestock roams freely in the communal grazing areas, and is allowed into the lands area after the crop harvest. Degradation of both soils and vegetation are widespread in grazing areas due to overstocking and overgrazing. Serious sheet and rill erosion is found in LUs 4 and 5; some gullies also occur in these units. Crusting of topsoils is widespread. As a result of overgrazing and deterioration of topsoils, the herbaceous layer is dominated by undesirable species in many areas.

It is recommended that the grazing of livestock is controlled. At present, the communal grazing areas are continuously grazed and certain desirable grass and forb species have no chance to recover and propagate. Control of grazing can be achieved by herding or by fencing. Livestock numbers, grazing patterns and control measures should be worked out in co-operation with the community of Ratholo AEA and surrounding communities. The introduction of rotational grazing may not be enough to restore the productivity of seriously degraded land. Land unit 4a, for example, will need prolonged protection from livestock, a mechanical break-up of the compacted topsoil and the introduction of desirable grasses and shrubs by seeding and planting. Sheet and rill erosion should also be brought under control before limited grazing is allowed.

Seasonal or permanent stall feeding of animals of high value is another option to be considered. Protected grazing areas, if well managed, could become a source of fodder, to be cut and carried to penned-in animals. Fodder crops could also be introduced for this purpose. Although labour intensive, stall feeding of animals for beef production or draught power may prove productive and will have the additional advantages of easy veterinary care, manure production and possibly milk production.

Winter grazing in the lands area should be continued in order to make full use of the herbage available.

### 7.3 PHANE PRODUCTION

Mopane worm is collected in the plain and footslope areas, where *Colophospermum mopane* is often a dominant shrub or tree. Mopane worm constitutes an important source of income for the majority of households, and is often the main source of cash for small farmers. Production is limited by labour availability during short periods of the rainy season when the worm can be collected. There is no scope for increase of production.

### 7.4 IRRIGATED AGRICULTURE

Scope for irrigated farming is very limited due to the absence of surface water. Irrigation from boreholes is possible, but will only be productive if the land and irrigation water is very intensively used. For example, in a citrus orchard the area between the trees should be planted with vegetables and/or fodder crops. The area immediately surrounding the fruit trees should be mulched. Multipurpose trees and shrubs should be planted along the perimeter of the irrigated plot and the land should be protected from erosion. Beekeeping should be considered in conjunction with fruit production. Stall feeding of a few selected animals should also be considered. Irrigated agriculture is only recommended for determined farmers who have access to a starting capital, managerial skills and sufficient labour.

## 7.5 FORESTRY

It is desirable to establish woodlots in the vicinity of the villages for the production of firewood and poles, in order to prevent further depletion of natural woody vegetation which is taking place around villages. Such woodlots could be established in eroded areas near villages and near a source of water. Unit 3b (Map 7), north and east of Ratholo is such an area. The villages of Ratholo and Majwaneng are dissected by gullies and tree planting should be considered in the catchment area of the gullies as well as along the gullies themselves. Tree planting could also be considered in combination with range rehabilitation and soil conservation in unit 4a, a few km west of Ratholo village (Map 7). *Eucalyptus camaldulensis* or other species could be considered for planting. Although the climate is too dry for easy establishment of young trees, additional subsoil moisture in this relatively low lying area makes it a better site than most. A committee at village level should then be installed to establish and maintain the woodlot.

Some residents have already planted trees in their compounds, usually as the result of free seedling distribution. This practice should be encouraged. Farmers should be educated as to the specific uses of various trees, including indigenous species. The placing of mulch (cut grasses, weeds, crop residues) around young trees will help to preserve soil moisture.

## 7.6 SMALL SCALE AGRO-INDUSTRIES

Specialised production of small stock, such as pigs or poultry, is not feasible as markets are either distant or saturated. Substantial production of groundnut in the area as envisaged by the land use plan could result in the installation of a local groundnut shelling industry providing employment during the dry season. In case groundnut production has become a success in the area, the fabrication of peanut butter could be considered. Phane could also be processed and sold in small quantities out of season.

## 7.7 INSTITUTIONAL SUPPORT

The proposed land use changes can only find a wide adoption among farmers, if farmers are motivated to accept them. Motivation for change does not come automatically due to ingrained attitudes and mechanisms (see Section 4.5). Change will only come if farmers perceive there is a problem and are convinced that the proposed changes in land use and management will help to solve that problem. For example, if residents of Ratholo do not think there is a shortage of wood, there is no point in starting a woodlot. Land use changes which are known to be productive and appropriate, can be introduced through field demonstrations, training for farmers, well-targeted subsidies and credits, and the creation of market incentives. Other suggested improvements in land use, which have not yet been properly researched, have to be tested through on-farm field trials.

### 7.7.1 Extension

Advice given to farmers must be improved both in content and effort. The AD and SI must be provided with clear instructions and manuals to assist them in getting messages across to farmers. It is recommended that special training courses be organised to update the knowledge of ADs and SIs. The AD and SI must be made full time available to conduct extension work, for which it will be required to liberate the AD of drought relief administration and the SI of participation in vaccination campaigns elsewhere. Additional extension staff may be required in the future.

The activities on which the AD and SI should concentrate are listed below. Some of these activities are already carried out, others are not. In these activities the AD and SI will be supported by District and Regional extension staff and specialists.

- The AD will have to conduct, more intensively than at present, on-farm demonstrations of farm operations including rowplanting, row weeding, application of fertilizer and spraying against pests and diseases.
- The AD will have to conduct a demonstration programme on the fertility maintenance of farmers' fields, including the use of kraal manure, ploughing in of crop residues, crop rotation and the use of various tree species. A demonstration programme concerning the construction of tied bunds on sloping land with permeable soil may be considered in the future.
- Through the Farmers Committee, and other appropriate institutions, the AD and SI together will have to start a dialogue with the farmers and discuss problems related to land use and possible solutions.
- The AD will have to vitalise the Farmers Committee to help organise farmers and to help supervise sale and distribution of implements, fencing materials, etc.
- The AD will have to run training courses for farmers in fence construction.
- The AD will have to form a woodlot Committee, responsible for establishment and maintenance of woodlots, and gully control in and around villages.
- The SI will have to conduct training courses for livestock owners in the vaccination of cattle, donkeys and small stock.
- The SI will have to conduct a demonstration programme on the advantages of supplementary feed for livestock.
- The SI will have to advise farmers on the recommended size of herds. The SI will have to supervise stocking rates, and form a Committee of livestock owners, able to assist him in the task.
- Generally, advice given should be specific for the various groups of farmers in the AEA (see also Chapter 3.3). The gender and age of the majority of farmers should also be taken into account.

### 7.7.2 Financial assistance and infrastructure

Government will have to provide the back-up system which will enable the anticipated agricultural development. It has two components: subsidies and credit facilities on the input side and infrastructure and marketing channels on the output side.

#### 7.7.2.1 Subsidies and credit facilities

Input subsidies covering farm implements and veterinary implements are required. A special rate should be employed for implements purchased by small farmers who have organised themselves in pooling groups. Other inputs including seed, fertilizer, pesticides and vaccines should also be offered to the farmer at a subsidised rate. BAMB, BCU and LAC should make an effort to make these inputs readily available to farmers in the area. The availability of good quality seed for promising crops (groundnut, cowpea and

other legumes), in addition to sorghum, should have special attention.

A ploughing subsidy should be available but it is only indispensable for small farmers. Performance should be verified under guidance of the AD.

#### 7.7.2.2 Marketing infrastructure

For cash crops, the BAMB will have to install a local depot, which can both serve as a selling point for farm inputs and as an intake point of farm produce. Transport to and from farmers' fields will have to be provided against a cost.

For livestock, the BMC will have to create a local livestock buying point, where livestock owners can sell their surplus animals. The facility should be large enough to absorb a large number of animals at once in times that farmers are compelled to sell (as a result of drought, feed shortage or disease).

For phane, the installation of a marketing channel should be considered, preferably organised by the BAMB, to let farmers take better advantage from high market prices in S-Africa.

#### 7.7.2.3 Fencing

If farmers in Ratholo AEA jointly decide on controlled grazing and/or projects such as range rehabilitation, gully control, protection of waterpoints and woodlots, perimeter fencing will be required in many cases. Financial assistance may be required to purchase the necessary materials.

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ANNEX

TABLES SUPPORTING FINANCIAL ANALYSIS

TABLE A1. PRODUCER PRICES (1993/94)

TYPE	PRODUCT	UNIT	GRADE	PRICE (Pula)	SOURCE
CROPS	Sorghum, Segaolane	kg*	Grade 1	0.39	BAMB
	Maize, Kalahari	kg*	Grade 1	0.40	BAMB
	Millet	kg*	—	0.31	BAMB
	Sweetreed	kg	—	0.40	Local farmers
	Cowpea	kg*	—	0.60	BAMB
	Groundnut (shelled)	kg*	Grade 1	1.39	BAMB
	Groundnut (shelled)	kg*	Grade 2	1.20	BAMB
	Groundnut (shelled)	kg*	Grade 3	0.83	BAMB
	Watermelon	kg	—	0.70	Local farmers
CROP PRODUCTS	Watermelon beer	liter	—	1.00	Local farmers
LIVESTOCK	Breeding cows	unit	—	700.00	BMC
	Bulls	unit	—	800.00	BMC
	Cull cows	unit	—	400.00	BMC
	Cull bulls	unit	—	500.00	BMC
	Cull heifers	unit	—	400.00	BMC
	Surplus heifers	unit	—	700.00	BMC
	Steers, 4 years or more	unit	—	600.00	BMC
	Goats, 1 year	unit	—	50.00	Local farmers
	Goats, adult	unit	—	70.00	Local farmers
ANIMAL PRODUCTS	Cattle skins (green)	unit	Grade 1	15.00	S.M.Lurie
	Cattle skins (dry salted)	unit	Grade 1	10.00	S.M.Lurie
	Goat skins, medium size	unit	Grade 1	2.00	S.M.Lurie
	Milk	liter	—	1.00	Local farmers
	Sour milk	liter	—	3.50	Local farmers
VELD PRODUCTS	Phane	50 kg bag**	—	110.00	Local farmers
	Morula beer	liter	—	0.50	Local farmers
LABOUR	Manual labour	manday	—	5.50	Local

Note: Producer prices for sorghum and maize, grade 2 and grade 3, are only marginally lower than for grade 1 and are not used in the present evaluation

\* Converted from standard prices for 70 kg bags

\*\* The bag is used as a measure of volume, the actual weight is less. Other size bags are also used.

TABLE A2. VALUE OF ANNUAL AGRICULTURAL PRODUCE AND LABOUR OF PATTERN FARMS  
DEPENDABLE YIELDS, LAND UNIT 7

PRESENT			Farm 1		Farm 2		Farm 3	
			(Pula)	(%)	(Pula)	(%)	(Pula)	(%)
CROPS	TOTAL		247	21.2	449	30.4	657	31.6
	Crops	Sub-total	220		422		630	
		Sorghum	53		195		311	
		Millet	19		31		50	
		Sweetreed*	30		30		30	
		Cowpea	72		120		192	
		Watermelon*	47		47		47	
	Products	Sub-total	27		27		27	
		Watermelon beer*	27		27		27	
	LIVESTOCK	TOTAL		72	6.2	441	29.9	1,013
Animals		Sub-total	70		369		793	
		Cull cows	0		24		64	
		Cull bulls	0		10		30	
		Surplus heifers	0		28		98	
		Cull steers****	0		132		426	
		Cull goats	70		175		175	
Products		Sub-total	2		72		220	
		Sour milk	0		59		190	
		Cattle skins	0		8		25	
	Goat skins	2		5		5		
VELD PRODUCTS		TOTAL	410	35.3	410	27.8	410	19.7
		Phane	385		385		385	
		Morula beer	25		25		25	
FARM LABOUR***		Daily labour	435	37.4	176	11.9	0	0.0
ALL PRODUCE		TOTAL	1,163	100	1,476	100	2,079	100

POTENTIAL			Farm 1		Farm 2		Farm 3	
			(Pula)	(%)	(Pula)	(%)	(Pula)	(%)
CROPS	TOTAL		466	37.0	1,427	54.0	2,701	55.0
	Crops	Sub-total	439		1,400		2,674	
		Sorghum	37		149		149	
		Groundnuts**	318		1,167		2,441	
		Sweetreed*	30		30		30	
		Cowpea	7		7		7	
		Watermelon*	47		47		47	
	Products	Sub-total	27		27		27	
		Watermelon beer*	27		27		27	
	LIVESTOCK	TOTAL		72	5.6	666	25.0	1,808
Animals		Sub-total	70		562		1,480	
		Cull cows	0		52		160	
		Cull bulls	0		10		30	
		Cull heifers	0		4		8	
		Surplus heifers	0		105		399	
		Cull steers****	0		216		708	
Cull goats		70		175		175		
Products		Sub-total	2		104		328	
		Sour milk	0		92		304	
	Cattle skins	0		6		19		
	Goat skins	2		5		5		
VELD PRODUCTS		TOTAL	410	32.0	410	15.5	410	8.3
		Phane	385		385		385	
		Morula beer	25		25		25	
FARM LABOUR***		Daily labour	325	25.5	132	5.0	0	0.0
ALL PRODUCE		TOTAL	1,275	100	2,635	100	4,919	100

\* The market for sweetreed, watermelon and watermelon beer is limited; not saleable produce is not valued.

\*\* Grade 2 and a shelling coefficient of 0.67 are assumed

\*\*\* Labour available after deduction of labour spent on own farm.

\*\*\*\* Four years old, or more

TABLE A3. VALUE OF ANNUAL AGRICULTURAL PRODUCE AND LABOUR OF PATTERN FARMS  
MEDIAN YIELDS, LAND UNIT 7

PRESENT			Farm 1		Farm 2		Farm 3	
			(Pula)	(%)	(Pula)	(%)	(Pula)	(%)
CROPS	TOTAL		553	37.6	950	48.1	1,458	50.6
	Crops	Sub-total	527		924		1,432	
		Sorghum	269		545		872	
		Millet	37		62		100	
		Sweetreed	30		30		30	
		Cowpea	144		239		383	
		Watermelon	47		47		47	
	Products	Sub-total	27		27		27	
		Watermelon beer	27		27		27	
	LIVESTOCK	TOTAL		72	4.9	441	22.3	1,013
Animals		Sub-total	70		369		793	
		Cull cows	0		24		64	
		Cull bulls	0		10		30	
		Surplus heifers	0		28		98	
		Cull steers, 4+	0		132		426	
		Cull goats	70		175		175	
Products		Sub-total	2		72		220	
		Sour milk	0		59		190	
		Cattle skins	0		8		25	
	Goat skins	2		5		5		
VELD PRODUCTS		TOTAL	410	27.9	410	20.7	410	14.2
		Phane	385		385		385	
		Morula beer	25		25		25	
FARM LABOUR**		Daily labour	435	29.6	176	8.9	0	0.0
ALL PRODUCE		TOTAL	1,470	100	1,977	100	2,881	100

POTENTIAL			Farm 1		Farm 2		Farm 3	
			(Pula)	(%)	(Pula)	(%)	(Pula)	(%)
CROPS	TOTAL		938	53.8	2,118	63.7	3,759	62.9
	Crops	Sub-total	911		2,091		3,732	
		Sorghum	411		498		498	
		Groundnuts*	410		1,503		3,144	
		Sweetreed	30		30		30	
		Cowpea	13		13		13	
		Watermelon	47		47		47	
	Products	Sub-total	27		27		27	
		Watermelon beer	27		27		27	
	LIVESTOCK	TOTAL		72	4.1	666	20.0	1,808
Animals		Sub-total	70		562		1,480	
		Cull cows	0		52		160	
		Cull bulls	0		10		30	
		Cull heifers	0		4		8	
		Surplus heifers	0		105		399	
		Cull steers, 4+	0		216		708	
Products		Sub-total	2		104		328	
		Sour milk	0		92		304	
		Cattle skins	0		6		19	
	Goat skins	2		5		5		
VELD PRODUCTS		TOTAL	410	23.5	410	12.3	410	6.9
		Phane	385		385		385	
		Morula beer	25		25		25	
FARM LABOUR**		Daily labour	325	18.6	132	4.0	0	0.0
ALL PRODUCE		TOTAL	1,745	100	3,326	100	5,977	100

Note: The market for most traditional mixed crops is very limited; not saleable produce is not valued.

\* Grade 2 and a shelling coefficient of 0.67 are assumed

\*\* Labour available after deduction of labour spent on own farm.

TABLE A4. ITEMIZED LIST OF OPERATING EXPENDITURE AND INVESTMENT COSTS

	TYPE	ITEM	UNIT	PRICE (Pula)	SOURCE
ANNUAL FARMER OPERATING EXPENDITURE	LABOUR	Manual labour	day	5.50	Local
	SEEDS	Maize, Kalahari Early Pearl	10kg	2.60	OSSCA
		Sorghum, Segaolane	10kg	7.00	Estimate
		Groundnuts	10kg	4.40	SMCS
		Cowpea, Tswana/Blackeye	10kg	4.30	OSSCA
	FERTILIZERS	Superphosphate 2:3:2	50kg	23.25	BAMB
			50kg	29.65	BAMB
	PESTICIDES	??	dose/ha	40	LAC
	OPERATIONS	Ploughing	ha	110	Estimate
		Harrowing	ha	40	Estimate
		Row planting	ha	45	Estimate
		Cultivation	ha	40	Estimate
	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	75.00	Estimate	
FARMER INVESTMENT COSTS	CROPPING	VS10 plough (single furrow)	unit	76.58	BCU
		Planter (Sebele)	unit	364.70	OSSCA
		Zigzag harrow (single)	unit	187.57	BCU
		Cultivator	unit	198.00	BCU
		Hand hoe	unit	13.10	OSSCA
		Scotch cart	unit	1,437.50	OSSCA
	LIVESTOCK	Knapsack sprayer	unit	185.90	LAC
		Dehorning iron	unit	17.60	LAC
		Burdizzo	unit	132.15	LAC
		Syringe	set	3.15	LAC

\* Calculated from commercially sold bottles/packs/rolls: Livestock Specialist assessment

\*\* Vaccines against Enterotoxaemia, Pasteurella, Lumpy skin and Cell paratyphoid (immature stock only)

\*\*\* Terramycin and Sulphamezathin

\*\*\*\* Cattle maintenance lick, salt and bonemeal

TABLE A5. DROUGHT RELIEF SUBSIDIES (1993/94)

ITEM	UNIT	PRICE (Pula)	SOURCE
Ploughing	ha	110.00	MoA
Row planting	ha	45.00	MoA
Sorghum seed	10kg	7.00	MoA

Subsidies are issued to farmers for a maximum of 5 ha and 50 kg respectively

TABLE A6. ANNUAL OPERATING EXPENDITURE OF PATTERN FARMS

PRESENT		INPUTS	Farm 1		Farm 2		Farm 3		
			(Pula)		(Pula)		(Pula)		
CROPS		TOTAL	351		310		56		
	Mixed crops	Sub-total	21		35		56		
		Sorghum	Seed	21		35		56	
		Cowpea	None *	0		0		0	
		Sweetreed	None *	0		0		0	
		Melon	None *	0		0		0	
		Watermelon	None *	0		0		0	
	Operations	Sub-total	330		275		0		
	Ploughing	330		275		0			
LIVESTOCK		TOTAL	0		43		161		
	Cattle	Sub-total	0		40		158		
		Minerals	0		0		42		
		Vacc/d/d**	0		0		4		
		Transport	0		40		112		
	Goats	Sub-total	0		3		3		
		Vacc/d/**	0		3		3		
		0		0		0			
VELD PRODUCTS	None	0		0		0			
LABOUR	Daily labour	0		61		248			
DEPRECIATION OF EQUIPMENT	Equipment	2		8		100			
CONTINGENCIES		0		20		50			
<b>TOTAL</b>		<b>353</b>		<b>441</b>		<b>614</b>			
DROUGHT RELIEF INCOME	***	351		585		585			
<b>TOTAL, WITH DROUGHT RELIEF</b>		<b>2</b>		<b>-144</b>		<b>29</b>			

POTENTIAL		INPUTS	Farm 1		Farm 2		Farm 3	
			(ha)	(Pula)	(ha)	(Pula)	(ha)	(Pula)
CROPS		TOTAL	3.00	940	5.00	1,039	8.00	776
	Sorghum	Sub-total	2.00	153	2.00	153	2.00	153
		Seed		14		14		14
		Fertilizer		59		59		59
		Pesticides		80		80		80
	Groundnuts	Sub-total	0.75	81	2.75	298	5.75	623
		Seed		17		61		127
		Fertilizer		35		128		267
		Pesticides		30		110		230
	Cropmix *	Sub-total	0.25	0	0.25	0	0.25	0
		None *		0		0		0
	Operations	Sub-total		705		588		0
		Ploughing		330		275		0
		Harrowing		120		100		0
		Rowplanting		135		113		0
Cultivation			120		100		0	
LIVESTOCK		TOTAL	2		111		294	
	Cattle	Sub-total	0		106		289	
		Minerals	0		63		168	
		Vacc/d/d**	0		3		9	
		Transport	0		40		112	
	Goats	Sub-total	2		5		5	
		Vacc/d/**	2		5		5	
		0		0		0		
VELD PRODUCTS	None	0		0		0		
LABOUR ****	Daily labour	0		85		356		
DEPRECIATION OF EQUIPMENT	Equipment	80		100		200		
CONTINGENCIES		25		50		100		
<b>TOTAL</b>		<b>1,047</b>		<b>1,385</b>		<b>1,726</b>		

Note: All traction is assumed to be carried out with domestic animals (cattle or donkeys).

\* Seeds are kept from the previous harvest, no fertilizers or pesticides are applied.

\*\* Vaccines, drugs (and dips)

\*\*\* Compensation for cost of hired ploughing + payment for ploughing with own animals (max. 5 ha) + compensation for cost of seed (max. 50 kg). Farm 1 only hires, Farm 2 hires for half the farm and ploughs other half himself, Farm 3 ploughs all with own animals

\*\*\*\* The relative labour requirements during the growing season for sorghum (potential) and groundnut (potential) are assumed to be higher than those for sorghum (present) with a factor of 1.25 and 1.5 respectively

# BOTSWANA

## NORTHERN STATE LANDS

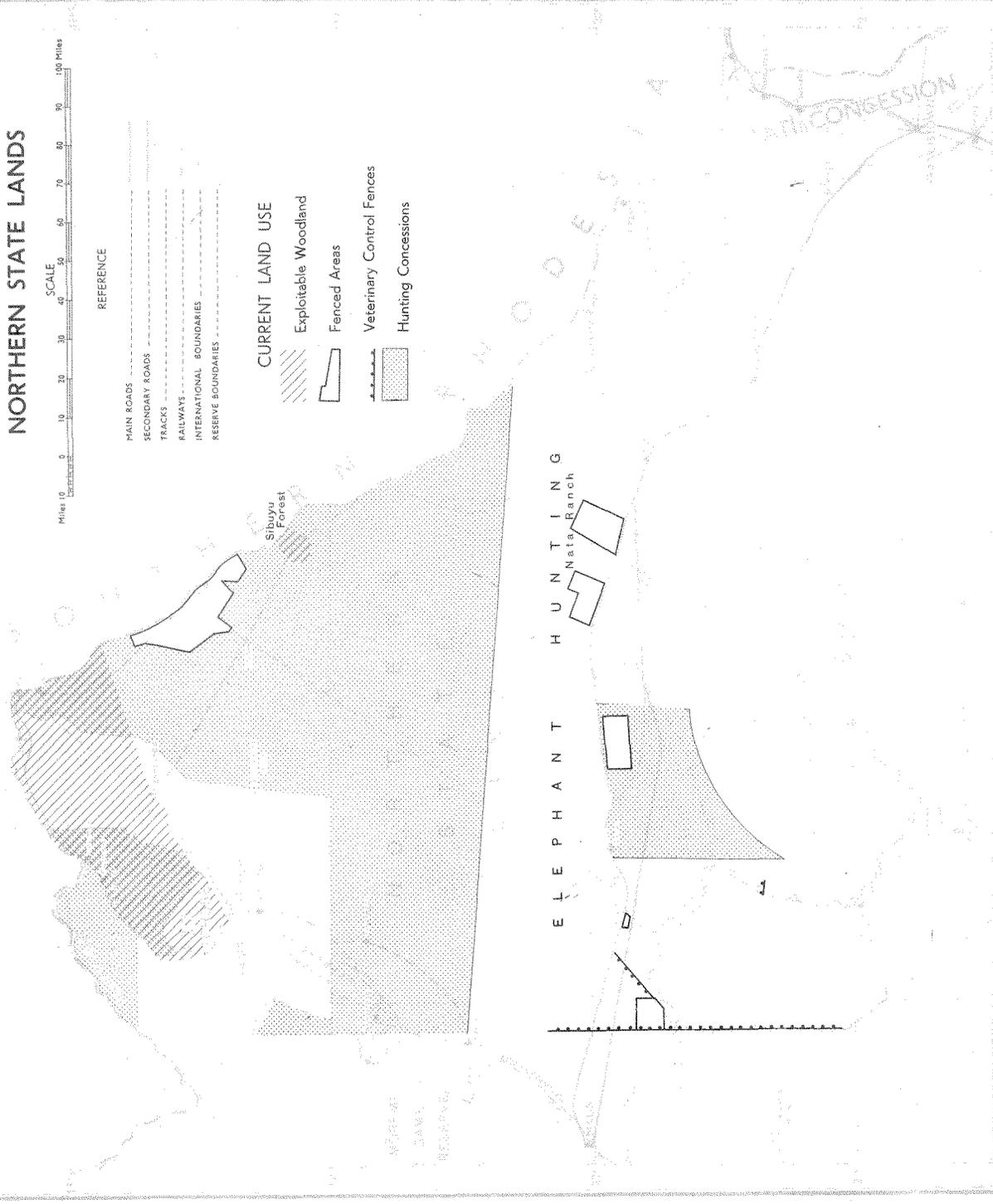


### REFERENCE

- MAIN ROADS
- SECONDARY ROADS
- TRACKS
- RAILWAYS
- INTERNATIONAL BOUNDARIES
- RESERVE BOUNDARIES

### CURRENT LAND USE

- Exploitable Woodland
- Fenced Areas
- Veterinary Control Fences
- Hunting Concessions

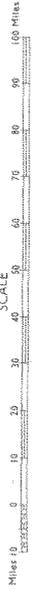


Drawn and photographed by the Directorate of Overseas Surveys, 1968  
 Printed for D.O.S. by S.P.C. R.E.  
 This map accompanies a report entitled 'A Land Use Survey of the Northern State Lands, Botswana' by the Land Resources Division, Directorate of Overseas Surveys, 1968

D.O.S. (Misc) 449 c  
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# BOTSWANA

## NORTHERN STATE LANDS

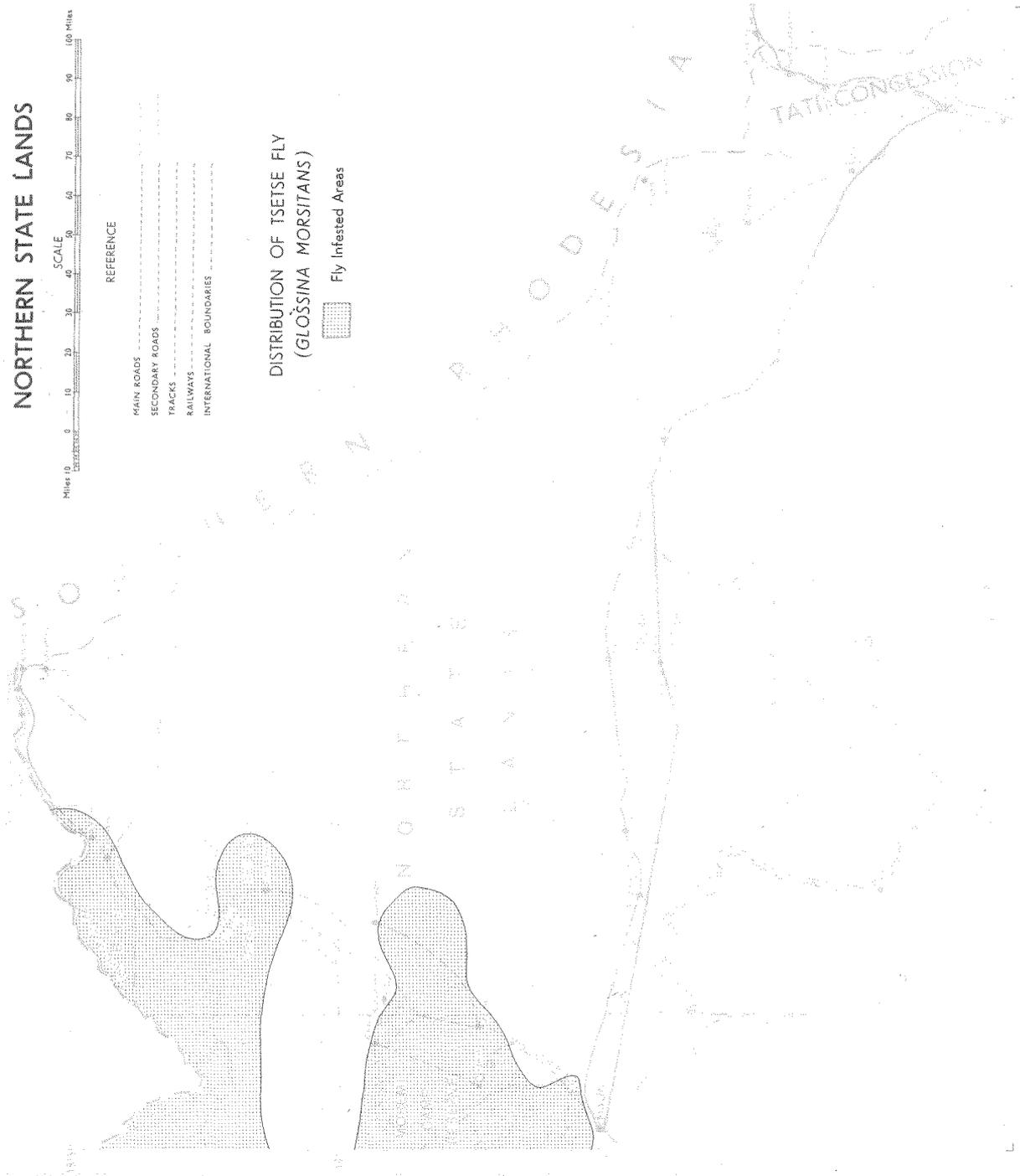


REFERENCE

- MAIN ROADS
- SECONDARY ROADS
- TRACKS
- RAILWAYS
- INTERNATIONAL BOUNDARIES

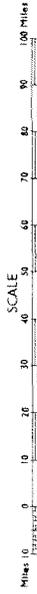
### DISTRIBUTION OF TSETSE FLY (GLOSSINA MORBITANS)

Fly Infested Areas



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# BOTSWANA NORTHERN STATE LANDS

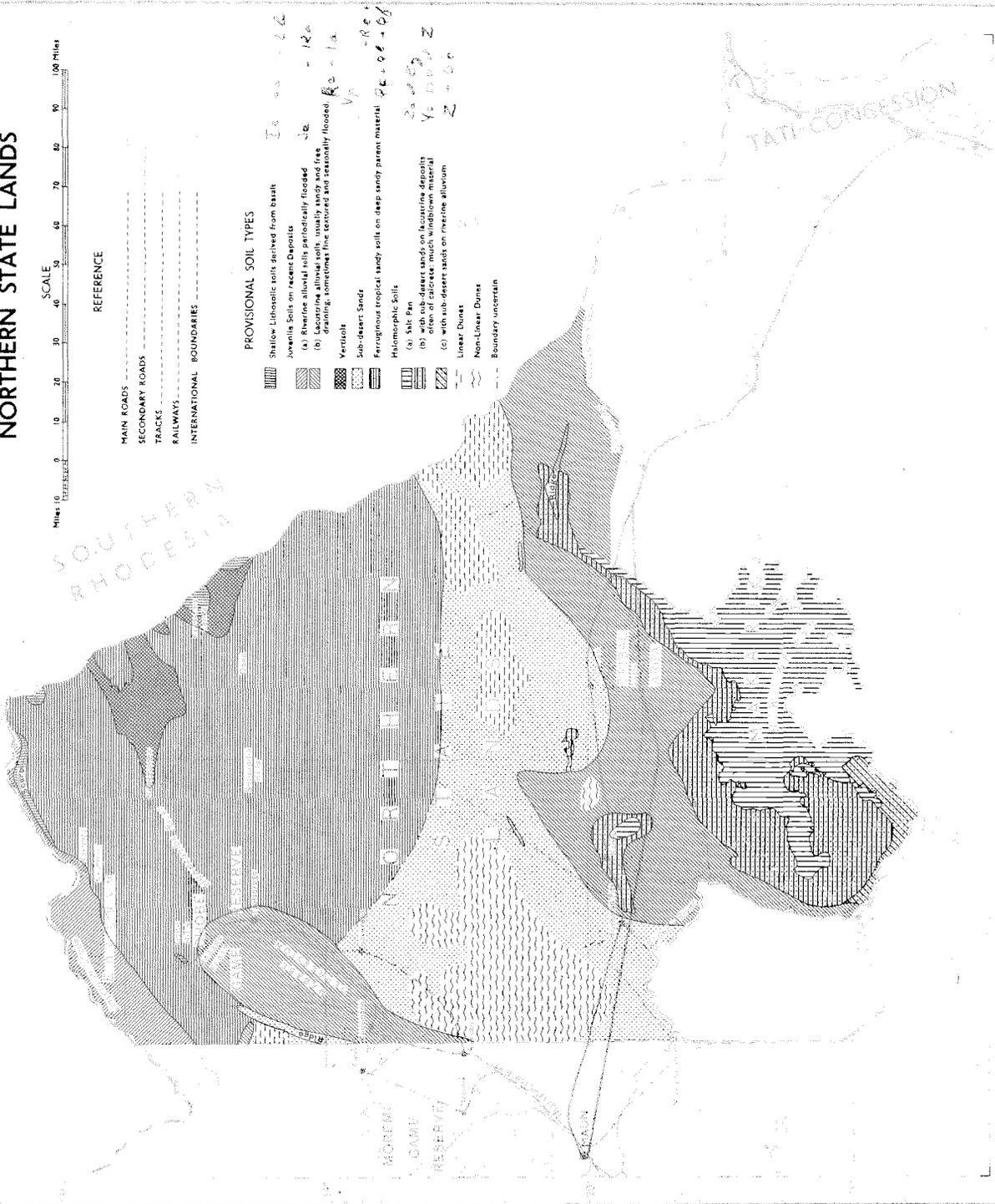


## REFERENCE

- MAIN ROADS
- SECONDARY ROADS
- TRACKS
- RAILWAYS
- INTERNATIONAL BOUNDARIES

## PROVISIONAL SOIL TYPES

- Shallow Lithologic soils derived from basalt
- Juvvella Soils on recent Deposits
  - (a) Riverine alluvial soils periodically flooded
  - (b) Lacustrine alluvial soils, usually sandy and free draining, sometimes fine textured and seasonally flooded
- Vertisols
- Sub-desert Sands
- Ferrous-tropical sandy soils on deep sandy parent material
- Heteromorphic Soils
  - (a) Salt Pan
  - (b) with sub-desert sands on lacustrine deposits often of calcareous much windblown material
  - (c) with sub-desert sands on marine alluvium
- Linear Dunes
- Non-Linear Dunes
- Boundary uncertain



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 This map accompanies a report entitled 'A Land Use Survey of the Northern State Lands, Botswana', by the Land

# BOTSWANA

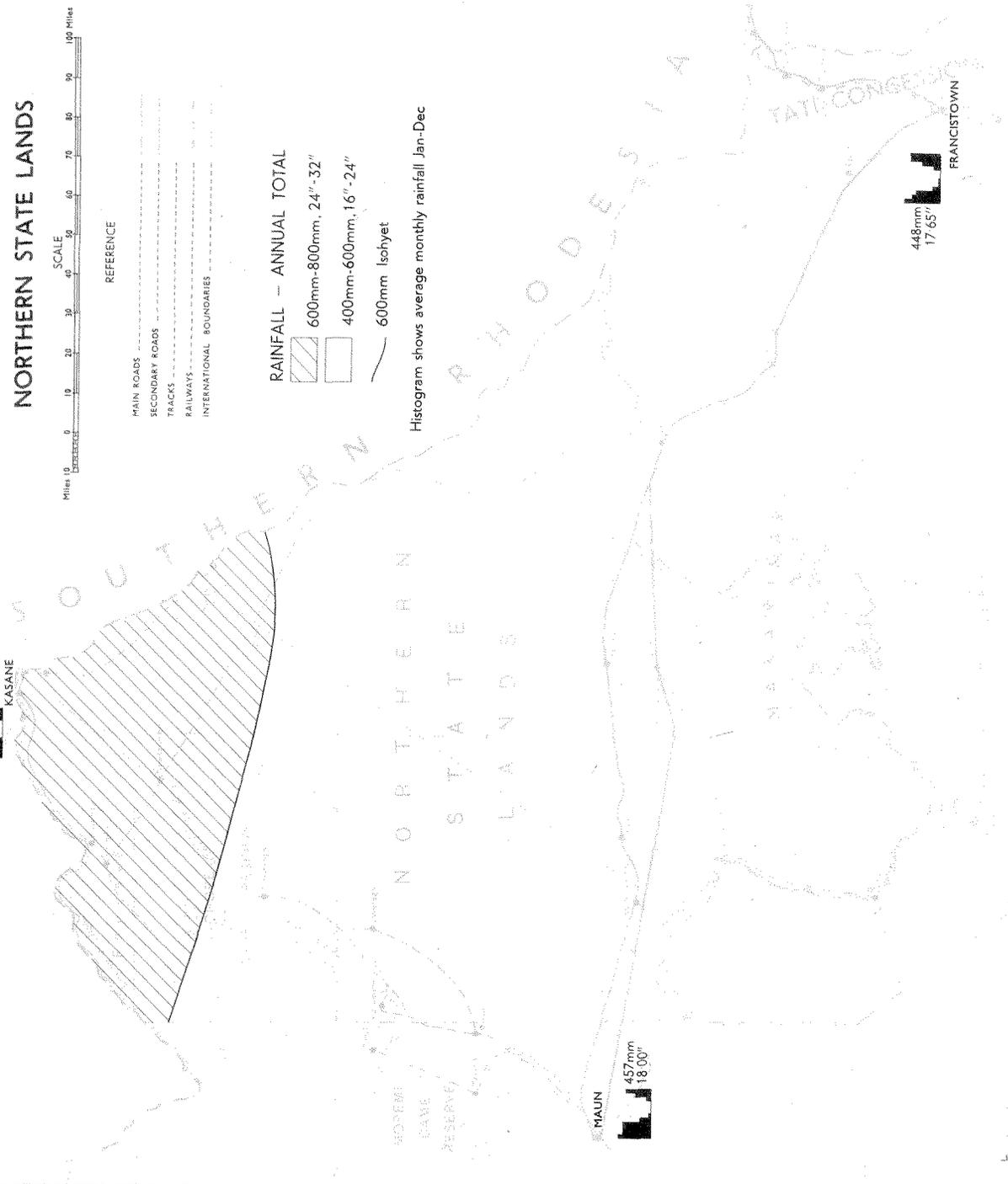
## NORTHERN STATE LANDS



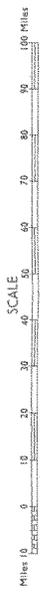
- REFERENCE
- MAIN ROADS
  - SECONDARY ROADS
  - TRACKS
  - RAILWAYS
  - INTERNATIONAL BOUNDARIES

- RAINFALL — ANNUAL TOTAL
- 600mm-800mm, 24"-32"
  - 400mm-600mm, 16"-24"
  - 600mm Isohyet

Histogram shows average monthly rainfall Jan-Dec



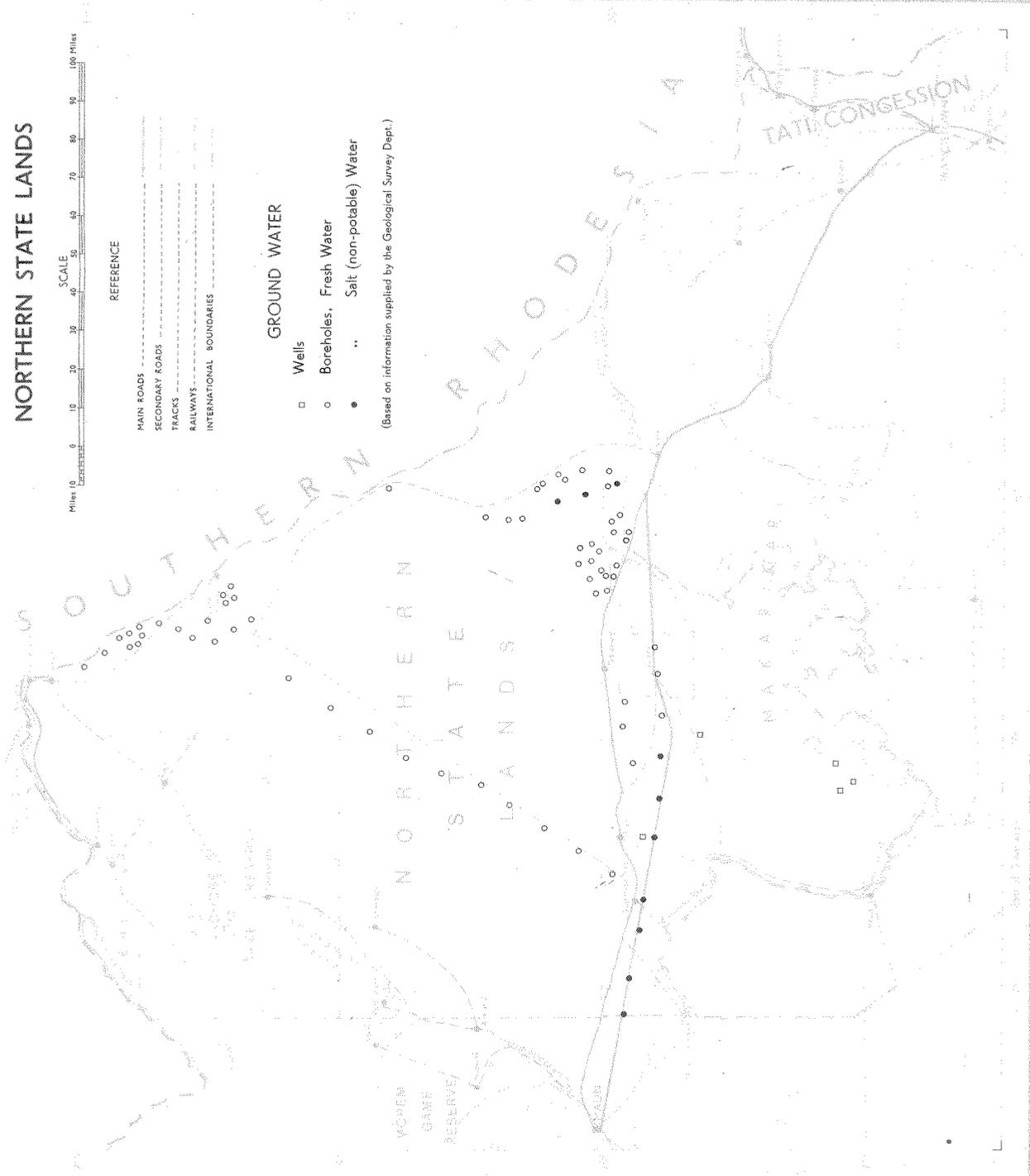
# BOTSWANA NORTHERN STATE LANDS



- REFERENCE
- MAIN ROADS
  - SECONDARY ROADS
  - TRACKS
  - RAILWAYS
  - INTERNATIONAL BOUNDARIES

- GROUND WATER
- Wells
  - Boreholes, Fresh Water
  - Salt (non-potable) Water

(Based on information supplied by the Geological Survey Dept.)



Drawn and photographed by the Directorate of Overseas Surveys, 1966

This map accompanies a report entitled 'A Land Use Survey of the Northern State Lands, Botswana', by the Resources Division, Directorate of Overseas Surveys, 1967

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# BOTSWANA

## NORTHERN STATE LANDS



### REFERENCE

- MAIN ROADS ————
- SECONDARY ROADS - - - - -
- TRACKS ————
- RAILWAYS ————
- INTERNATIONAL BOUNDARIES - - - - -

### RECOMMENDED LAND USE

Areas to be protected for the conservation of Game.

Area suitable for Ranching	Carrying capacity cows per annual unit	Area sq. miles
A Good potential: Minimal deficiencies	20	234
B Moderate potential	25	280
C Moderate potential	30	340
D Poor potential: water may limit development	10	70
E Moderate potential: Minimal deficiencies; water probably not available	40	290
F Moderate potential: Minimal deficiencies; water probably not available	35	54
G Moderate potential: Minimal deficiencies; water probably not available	25	625
H Immediate Destocking, after recovery period moderate water probably not available	30	650
I Low potential: Dispersed cynodon occurs frequently on the ridges (dunes)	50	970
J Low potential: Dispersed cynodon occurs frequently on the ridges (dunes)	50	190

———— Predominantly savanoid north of this line  
 [Hatched Box] Black clay soils (verticals)  
 † potential refers to herbage production



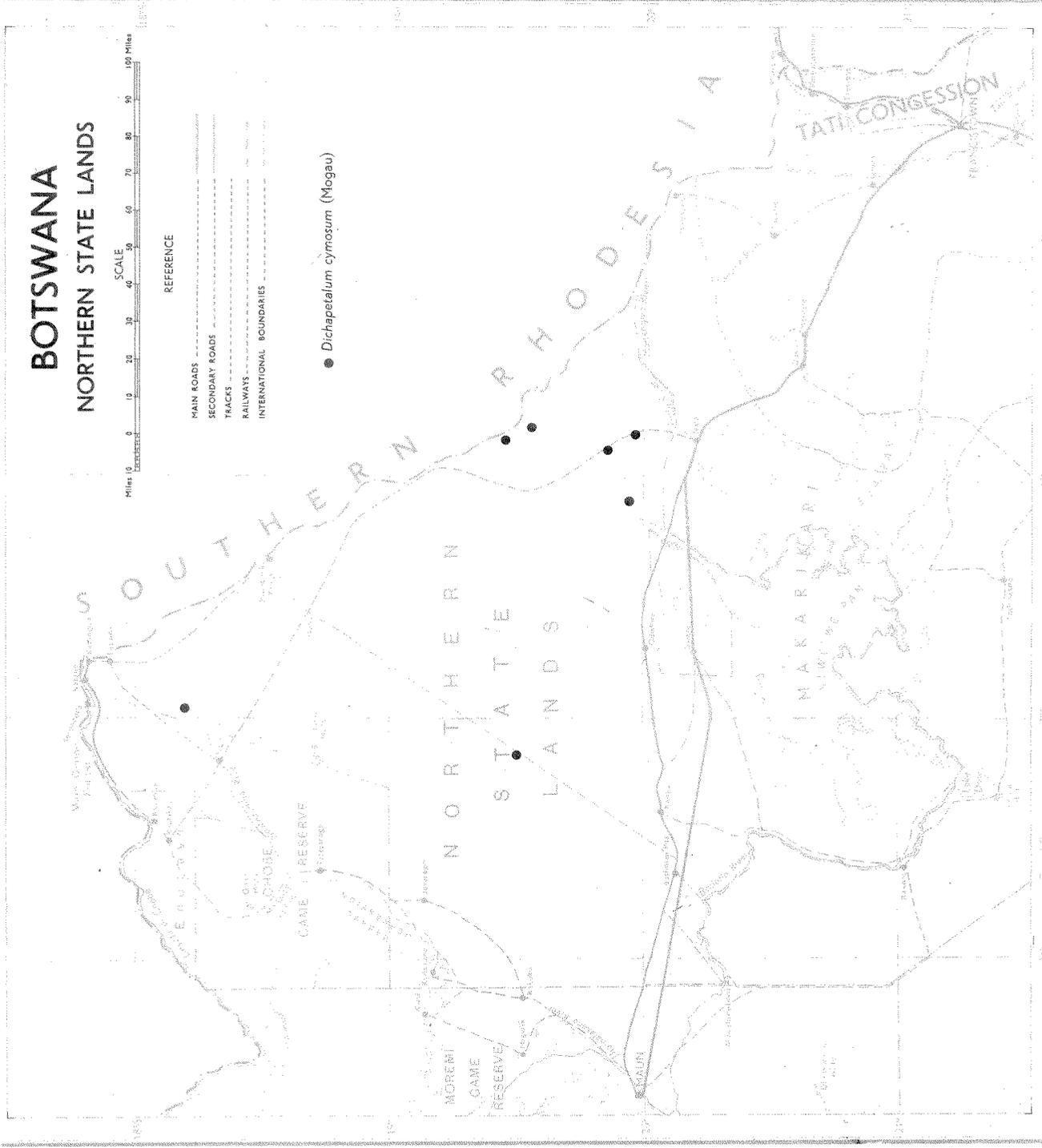
# BOTSWANA NORTHERN STATE LANDS



REFERENCE

- MAIN ROADS
- SECONDARY ROADS
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- INTERNATIONAL BOUNDARIES

● *Dichapetalum cymosum* (Mogau)



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TABLE 1 Scheme L. A breeding herd (commercial development). Labour costed at R250 per year. Return per unit of 10 000 ac (4 047 ha)

Costs and returns	Year of operation																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Capital and occasional costs																				
Borehole and pump	3 000							1 000												
Purchase of foundation stock, 150 females at R40, 5 males at R80	6 400														1 000					
Purchase of trade cattle at R30	7 500	6 000	3 000																	
Construction of kraal and crush	200																			
Housing for herdsmen	400																			
Fencing 10 miles at R210/mile	2 100																			
Cleaning out borehole											250									
Annual Costs																				
Labour at R250	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000
Inoculations and supplements	800	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000
Pumping and maintenance	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250
Total costs	21 650	8 250	5 250	2 250	2 250	2 250	2 250	3 250	2 250	2 250	2 500	2 250	2 250	2 250	3 250	2 250	2 250	2 250	2 250	2 250
Revenue																				
Sale of good grade beef at R50					1 750	1 750	1 750	1 750	1 750	1 750	1 750	1 750	1 750	1 750	1 750	1 750	1 750	1 750	1 750	1 750
Sale of old stock at R40					1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000
Sale of trade cattle at R45		10 800	8 736	4 365																
Total revenue		10 800	8 736	4 365	2 750	2 750	2 750	2 750	2 750	2 750	2 750	2 750	2 750	2 750	2 750	2 750	2 750	2 750	2 750	2 750
Net gain or loss	-21 650	+2 550	+3 486	+2 115	+500	+500	+500	-500	+500	+500	+250	+500	+500	+500	-500	+500	+500	+500	+500	+500

If the project is terminated in the twentieth year the additional revenue in that year is : Sale of livestock 12 550

Value of improvements 2 500  
R15 050

TABLE 2 Scheme 2. A flying herd (commercial development). Labour costed at R250 per year. Return per unit of 10 000 ac (4 047 ha)

Costs and returns	Year of operation																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Capital and occasional costs																				
Borehole and pump	3 000							1 000												
Purchase of trade cattle at R30	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000
Construction of kraal and crush	200																			
Housing for herdsmen	400																			
Fencing 10 miles at R210/mile	2 100										250									
Cleaning out borehole																				
Annual costs																				
Labour 4 at R250	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000
Innoculations and supplements	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800
Pumping and maintenance	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250
Total costs	19 750	14 050	14 050	14 050	14 050	14 050	14 050	15 050	14 050	14 050	14 300	14 050	14 050	14 050	15 050	14 050	14 050	14 050	14 050	2 050
Revenue																				
Sale of trade cattle at R45	-	17 550	17 550	17 550	17 550	17 550	17 550	17 550	17 550	17 550	17 550	17 550	17 550	17 550	17 550	17 550	17 550	17 550	17 550	17 550
Net gain or loss	-19 750	+3 500	+3 500	+3 500	+3 500	+3 500	+3 500	+2 500	+3 500	+3 500	+3 250	+3 500	+3 500	+3 500	+2 500	+3 500	+3 500	+3 500	+3 500	+15 500

TABLE 4 Scheme 4. A breeding herd (African owned) employing family labour. Return per unit of 10 000 ac (4 047 ha)

Costs and returns	Year of operation																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
<b>Capital and occasional costs</b>	3 000						1 000								1 000					
Borehole and pump																				
Purchase of stock																				
Purchase of trade cattle																				
Construction of kraal and crush	200																			
Housing for herdsmen																				
Fencing 10 miles at R160/mile	1 600										250									
Cleaning out borehole																				
<b>Annual costs</b>	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400
Labour & at R100																				
Inoculations and supplements	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000
Pumping and maintenance	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250
<b>Total costs</b>	6 450	1 650	1 650	1 650	1 650	1 650	1 650	2 650	1 650	1 650	1 900	1 650	1 650	1 650	2 650	1 650	1 650	1 650	1 650	1 650
<b>Revenue</b>																				
Sale of good grade beef at R50	1 500	1 500	1 500	1 500	1 500	1 500	1 500	1 500	1 500	1 500	1 500	1 500	1 500	1 500	1 500	1 500	1 500	1 500	1 500	1 500
Sale of old stock at R40	1 200	1 200	1 200	1 200	1 200	1 200	1 200	1 200	1 200	1 200	1 200	1 200	1 200	1 200	1 200	1 200	1 200	1 200	1 200	1 200
<b>Total revenue</b>	2 700	2 700	2 700	2 700	2 700	2 700	2 700	2 700	2 700	2 700	2 700	2 700	2 700	2 700	2 700	2 700	2 700	2 700	2 700	2 700
<b>Net gain or loss</b>	-3 750	+1 050	+1 050	+1 050	+1 050	+1 050	+1 050	+50	+1 050	+1 050	+800	+1 050	+1 050	+1 050	+50	+1 050	+1 050	+1 050	+1 050	+1 050

TABLE 3. Scheme 3. Breeding herd from which weaners are sold at 10-12 months (commercial development). Labour costed at R250 per year. Return per unit of 10 000 ac (4 047 ha)

Costs and returns	Year of operation																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Capital and occasional costs								2 000							2 000					
Borehole and pump, 2 at R300	6 000																			
Purchase of foundation stock, 320 females at R40, 10 males at R80	13 600																			
Construction of kraal and crush	200																			
Housing for herdsmen	400																			
Fencing 10 miles at R210/mile	2 100																			
Cleaning out borehole									250											
Annual costs																				
Labour 4 at R250	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000
Immunisations and supplements 330 at R2, 192 at R1	852	852	852	852	852	852	852	852	852	852	852	852	852	852	852	852	852	852	852	852
Pumping and maintenance	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250
Total costs	24 402	2 102	2 102	2 102	2 102	2 102	2 102	4 102	2 102	2 102	2 352	2 102	2 102	2 102	4 102	2 102	2 102	2 102	2 102	2 102
Revenue																				
Sale of cull females at R40	-	1 400	1 400	1 400	1 400	1 400	1 400	1 400	1 400	1 400	1 400	1 400	1 400	1 400	1 400	1 400	1 400	1 400	1 400	1 400
Sale of 93 male weaners at R20	-	1 860	1 860	1 860	1 860	1 860	1 860	1 860	1 860	1 860	1 960	1 860	1 860	1 860	1 860	1 860	1 860	1 860	1 860	1 860
Sale of 51 female weaners at R20	-	1 020	1 020	1 020	1 020	1 020	1 020	1 020	1 020	1 020	1 020	1 020	1 020	1 020	1 020	1 020	1 020	1 020	1 020	1 020
Total revenue	-	4 280	4 280	4 280	4 280	4 280	4 280	4 280	4 280	4 280	4 280	4 280	4 280	4 280	4 280	4 280	4 280	4 280	4 280	4 280
Net gain or loss	-24 402	+2 178	+2 178	+2 178	+2 178	+2 178	+2 178	+178	+2 178	+2 178	+1 928	+2 178	+2 178	+2 178	+178	+2 178	+2 178	+2 178	+2 178	+2 178

If the project is terminated in the twentieth year the additional revenue in that year is : Sale of livestock

13 600

Value of improvements

2 500

16 100