BOT/91/001
Field Document 11

Land Use Planning for Sustainable Agricultural Development

B O T S W A N A

PROPOSED

AGRICULTURAL LAND USE PLAN OF MOSHUPA SOUTH AGRICULTURAL EXTENSION AREA

by

S.P. Kristensen and M. Molelo

*Agricultural Land Use Planners,
Southern Region*

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A very special thanks is due to the farmers in Moshupa South Agricultural extension area for their time and cooperation in the planning exercise

LIST OF ABBREVIATIONS

AD	-	Agricultural Demonstrator
AEA	-	Agricultural Extension Area
ALDEP	-	Arable Lands Development Programme
ALUP	-	Agricultural Land Use Planner
APSRAMB	-	Animal Production and Range Assessment Model for Botswana
AWC	-	Available Waterholding Capacity
BAMB	-	Botswana Agricultural Marketing Board
BLDC	-	Botswana Livestock Development Committee
BSD	-	Botswana Soil Database
CPO	-	Crop Production Officer
CPP	-	Council Physical Planner
CYSLAMB	-	Crop Yield Simulation and Land Assessment Model for Botswana
DAO	-	District Agricultural Officer
DAHP	-	Department of Animal Health and Production (MoA)
DAR	-	Department of Agricultural Research (MoA)
DAS	-	District Agricultural Supervisor
DCPF	-	Department of Crop Production and Forestry (MoA)
DLUPU	-	District land Use Planning Unit
DMI	-	Dry Matter Intake
DOD	-	District Officer Development
DOL	-	District Officer Lands
DSL	-	Department of Survey and Lands (now Department of Survey and Mapping)
DWA	-	Department of Water Affairs
FAO	-	Food and Agriculture Organization of the United Nations
FAP	-	Financial Assistance Policy
FMS	-	Farm Management Survey, MOA.
ILWIS	-	Integrated Land and Water Information System
LAC	-	Livestock Advisory Center
LPS	-	Livestock Production Specialist (LUPSAD project)
LSU	-	Livestock Unit
LU	-	Land Unit
LUPSAD	-	Land Use Planning for Sustainable Agricultural Development
MoA	-	Ministry of Agriculture
PET	-	Potential Evapotranspiration
PPM	-	Parts per million
RAO	-	Regional Agricultural Officer
RIIC	-	Rural Industries Innovation Centre
SSP	-	Single Superphosphate fertilizer
STD	-	Standard Deviation
SVO	-	Senior Veterinary Officer
UTM	-	Universal Transverse Mercator (map projection)
VA	-	Veterinary Assistant
VDC	-	Village Development Committee

EXECUTIVE SUMMARY

BACKGROUND

1. The Moshupa South Agricultural Extension Area is situated in Southern District and falls within Ngwaketse North Agricultural District in the Southern Agricultural Region. It is located 60 km southwest of Gaborone and measures 12046 ha.

2. The extension area is situated in the densely populated eastern hardveld part of Botswana. Increasing population and livestock numbers put increasing pressure on the environment for land, grazing and firewood and may threaten the production base for the future

PHYSICAL ENVIRONMENT

3. The climate is semi-arid with hot summers and cool winters. The average rainfall is 530 mm with a standard deviation of 171 mm. The evapotranspiration is highest during the summer months and totals 1670 mm over the year. The winters have an average 10 frostdays.

4. The landform is a flat to gently undulating pediplain bordered to the south by the Polokwe hill escarpment, which rises 100 m. above the plain. The Moshupa South agricultural extension area is dissected by streams and contains many rock outcrops. The soils vary from shallow Leptosols and Regosols near to rock outcrops on the higher slopes to more deep and loamier Luvisols on the lower slopes. Wind and water erosion has deposited material from the sandstone parent material of Polokwe Hills adjacent to the escarpment, where coarser textured, sandier Arenosols are found.

5. Sheet and gully erosion are the dominating erosion types in the area. Erosion is accelerated with the destruction of the vegetative cover due to cultivation, livestock grazing and fuelwood collection.

6. Most of the extension area is covered by degraded acacia shrub savannah. Invader species, such as *Acacia tortilis* and *Euclea undulata* dominate the plains, while *Terminalia sericea* and *Combretum apiculatum* are found in the adjacent Polokwe hills. The many rock outcrops are characterized by *Croton gratissimus* as dominant cover.

SOCIO-ECONOMIC ENVIRONMENT

7. The population of Moshupa South extension area is estimated at 2100 persons in 400 households in 1995. The population of neighbouring Moshupa is estimated at 15.000 persons, who utilize some of the resources in Moshupa South extension area, notably fuelwood and material for construction.

8. The most important source of income is remittances from relatives, with income from arable and livestock production being negligible in comparison. The average annual income is 3000 Pula per household.

9. 30% of the households are female headed, with the husband working in the mines in RSA or in towns. These households belong to the most vulnerable group of households and are often deficient in labour and draught power.

10. 30% of the households are characterized as poor, with little animal capital (smallstock and cattle) lacking labour and often draughtpower. The middle-section of the community is composed of 35% of the households who own a significant number of animal units (cattle and smallstock). The richest segment consists of 35% of the households. Half of these still

have serious draughtpower constraints but a high annual income, while the remaining half all have high levels of animal capital.

PRESENT LAND USE

11. The present land uses are: crop production, livestock production, residential, veld product collection (mainly firewood and material for construction).

12. The area is intensively used for traditional rainfed crop production and has been cultivated for decades. About 4000 ha (33% of the area) is cleared but only 1600 ha is presently cultivated. The average area cultivated per household in the 1994-95 crop season was 4.4 ha. 7% of the area is covered by rocky outcrops or other obstacles for crop production while 1.6% is occupied by Moshupa Village. 130 abandoned fields covering approximately 775 ha are claimed by individuals but have been uncultivated for an average period of 12 years.

13. Crop yields are low and average 50-150 kg/ha for maize and sorghum. Most households practice intercropping (grains and melons), broadcast seeds and plant late. No fertilizer is used. 75% of the households use animal draught power and the remaining 25% use tractors. 48% of the households do not have sufficient draught power and borrow or hire draught power. Manure is used by 75% of the households but in small amounts and infrequent.

14. The livestock population is estimated at 3700 head of cattle, 13200 smallstock and 2600 donkeys. Extensive cattle grazing takes place in the grazing areas in Polokwe hills whereas smallstock graze in the lands area. The carrying capacity in the area is exceeded by 1708 Livestock Units.

15. The collection of veld products is not an important economic activity, and is generally limited to subsistence gathering of thatching grass, some medicinal plants and firewood. Some farmers sell firewood in neighbouring villages.

LAND USE PROBLEMS AND OPPORTUNITIES FOR CHANGE

16. Crop production is hampered by unfavorable environmental conditions (low rainfall and depleted soils), poor land management (degradation of soil by gully erosion, grazing and removal of vegetation), poor soil management (inefficient recycling of nutrients), poor crop management (late ploughing and planting, poor germination, low plant population, inefficient weeding, birdscaring, pest and disease control) and poor institutional support (extension workers engaged in drought relief activities, low BAMB prices). As a result, crop yields fail to meet subsistence needs in most years and only 12% of the households have ever sold harvest surplus.

17. Livestock production is extensive and suffers from lack of inputs (minerals, supplementary feed). Smallstock forage in the Lands area and cause crop damage. The area is overstocked and grazing quality and quantity must be improved.

18. The increase in demand for firewood and other veld products foreseen will become one of the major land use problems if action is not taken now. The establishment of woodlots and other agroforestry projects are options for improving the future firewood situation.

CONCLUSIONS AND RECOMMENDATIONS

- Improved rainfed crop production

19. CYSLAMB simulations of the potential crop yields indicate a large scope for increasing crop yields. A **dependable** yield (a yield which is exceeded in 75% of all years) of grain crops

(maize, sorghum and millet) of 500-1600 kg/ha, 200-260 kg/ha for cowpeas and 800-1000 kg/ha of unshelled groundnuts can be achieved by introducing improved crop husbandry.

20. Targeted extension recommendations are likely to help increase crop yields. The poorest households should be encouraged to carry out efficient and timely weeding. If serious labour and/or draughtpower constraints exist, cultivation should be limited to a smaller area (size depending on soiltype and household needs) to ensure planting at first rains and using one planting opportunity. Households with larger resource availability could consider applying moderate fertilizer rates (100 kg Single Superphosphate) and increasing plant densities. Households with no labour constraints and substantial capital could increase topsoil levels of phosphorus to 10 ppm on loamy soils and apply moderate fertilizer rates on sandy and stoney soils in addition to increasing plant density.

21. Owners of abandoned fields should be approached and encouraged to start cultivation. If farmers do not possess adequate draught power they should be made aware of Government schemes which may assist them. If farmers are unlikely to start cultivation in the near future, it should be investigated if they would enter a long term lease to allow more motivated farmers to start cultivation. It should also be investigated if they would be interested in establishment of agroforestry projects in the abandoned fields.

22. Land management should be improved to halt gully erosion and preserve the future production base. Farmers should be encouraged to combat the problem on a catchment area basis and should be supported by technical staff. Severely degraded areas should be fenced off and allowed to regenerate to preserve the future production base. Any incentive must be implemented after consultation with households using the area for grazing, firewood collection etc.

- Increased household income

23. CYSLAMB simulation of groundnut production indicates the potential of groundnut as a cash crop, with economic returns of 548 P/ha (no shelling costs included). The existing ADF crop trials with groundnuts should receive priority from extension staff and be extended to other farmers.

24. The cultivation of alternative crops may generate income and improve soil fertility and resource availability. Cultivation of grass species (eg. *Eragrostis pallens*) in strips will provide thatching grass and diminish erosion in fields. Cultivation of Sunflower, Jugo and Tepary beans can provide additional income. Siratro can be used as green manure if ploughed in when green or dried.

25. The borehole (BH 7006) in Sobe sub-extension area should be equipped and used for a horticultural and/or agroforestry project.

- Increased firewood supply

26. The establishment of woodlot projects is seen as a priority issue, to prepare for a anticipated future rise in demand from neighbouring villages over the medium to long-term. They may be of several kinds, including a three ha woodlot next to borehole 7006, agroforestry projects and windbreaks according to various household's needs and resource availability.

- Improved grazing availability

27. Several options are available to improve the livestock production system. Crop residue can be collected from the field and stored near kraals to permit more regular subsistence feeding during the dry season. The nutritional value can be improved by ammonification of crop

residue with urea in a pit. Cultivation of fodder crops will improve overall fodder availability and increase soil fertility as part of a **3**-course crop rotation. The fencing of the grazing area in the Polokwe hills will improve herd management and help control stocking rates. The planned livestock watering reservoir in Polokwe grazing area should be under efficient supervision to avoid abuse and stock control implemented to avoid overgrazing in the area.

- Increased motivation and confidence

28. The proposed land use options can only be adopted on a large scale if household are motivated to accept them. Motivation for change and the creation of confidence must be inspired by intensive training and demonstration programmes for farmers and by improving the institutional support.

29. The agricultural demonstrator should have better access to transport, and it should be considered to place a second agricultural demonstrator and divide the extension area in two, to allow better farmer/extension worker ratio. The agricultural demonstrator should be liberated from drought relief administration.

30. Ploughing subsidy funds should be redirected to more productive programmes, which motivate households to carry out proper crop husbandry.

CHAPTER 1

INTRODUCTION

The area around the village of Moshupa in Southern District experiences many of the land use problems common to the southeastern part of Botswana. Rapid population growth during the past decades has increased pressure on the environment for arable land, grazing and fuel wood supply. The increased demand in turn leads to diminished vegetation cover and increases erosion hazards.

There is an urgent need to develop plans and management guidelines which indicate how continued, sustainable production may take place, in order to preserve the natural resource base for arable and livestock production in the future.

The ALUP team in Southern Agricultural Region was requested by the District Agricultural Officer (DAO) in Ngwaketse North Agricultural District to prepare an agricultural land use plan for the area around Moshupa facing these challenges, which led to the identification of Moshupa South Agricultural Extension Area (AEA) for the planning exercise.

Although the main part of the land use plan is concerned with the Moshupa South AEA, the adjacent grazing area will also be included in (some parts of) the analysis, since it forms an integral part of the livelihood of the population and thus must be taken into account when management strategies are formulated.

1.1 OBJECTIVES

The first objective of the land use plan is to evaluate the agricultural production potential of the Moshupa South extension area and indicate methods by which the present production levels may be increased to improve the living conditions of the population. It will mainly focus on crop and livestock production, which are the main farming activities, but will also indicate alternative production systems where possible.

The second objective of the plan is to deal with problems considered to be widespread in Southern Agricultural Region in order for the recommendations to be applicable in other agricultural extension areas with similar physical and socio-economic conditions.

1.2 STRUCTURE OF THE REPORT

The first chapters describe the physical environment (chapter 2) and the socio-economic situation (chapter 3) of the Moshupa South AEA. The major land use problems are presented in chapter 4 and followed by the evaluation of the present land use systems in chapter 5. Chapter 6 presents the results of a financial appraisal of alternative land use options. The recommended land use is presented in chapter 7 along with conclusions and recommendations. Chapter 8 contains a plan of implementation which details the input required from all parties involved in the implementing phase of the land use plan.

The report is primarily intended for technical staff who will be engaged in the implementation of the agricultural land use plan (Agricultural Extension Area, District and Regional staff from the Department of Crop Production and Forestry and the Department of Animal Health and Production). It is also relevant for staff from other departments involved in planning issues, such as DLUPU, Land Board and Council.

1.3 METHODOLOGY

Existing information at Extension area, District and Regional level was consulted and complemented where necessary by the following surveys:

1. Soil survey. The existing 1:250.000 soil map (MoA., 1991) was complemented by a soil survey undertaken by the Soil Survey Section of the Ministry of Agriculture (MoA) in 1994. The survey was done on a scale of 1:50.000 and it allowed a more detailed description of soil units, although most of them still contain associations of soil types.

2. Vegetation survey. A survey was carried out by Messrs. M. Powell and M.C. Bonyongo in 1994-95 on a 1:50.000 scale to separate and describe vegetation units in the planning area.

3. Socio-economic survey. Forty farming households, which corresponds to approximately 10% of the population in Moshupa South AEA, were interviewed to collect information about existing production systems, income sources, land tenure situation and household composition in the planning area. The data served as the basis for the classification of farming households in the area.

Additional information was collected from:

- Drought Relief reports for the 1993-94 and 1994-95 crop seasons from the Agricultural Demonstrator (AD) in Moshupa South AEA.
- Livestock census data from the SLO in Kanye and the VA in Moshupa.
- Information on farming systems from the Farm Management Survey project at MoA (Macala, 1992).
- Population census information from the 1991 Population Census (CSO, 1992).
- Moshupa Development Plan, 1992-2012 (DTRP, 1992)
- Southern District Planning Study (Environmental Consultants, 1988).
- The results of the in-service training course on land use planning held at Sebele, June 1995 for technical staff from MoA.

The Topographic Maps 2425 CA and D3 of the 1:50.000 topographical map series (DSL, 1982) were used to prepare basemaps. Aerial photographs at a 1:50.000 scale (1982 and 1988) were used extensively for the delineation of arable lands, vegetation units and eroded areas. A 1:50 000 scale SPOT satellite image from June 1986 was used for the delineation of vegetation units.

The following software packages and databases were used:

- CYSLAMB for crop yield simulation (De Wit et al., 1993, Radcliffe et al., 1994, Bekker et al., 1994)
- ECOCROP 1 for selection of alternative crops (Sims, 1994)
- APSRAMB for livestock carrying capacity calculations (Powell and Sebego, 1993-1994)
- METEO Database for retrieval of meteorological data (Schalk, 1990)
- BSD (Botswana Soil Database) for retrieval of soil profile data (Van Waveren, 1988)
- ILWIS Version 1.4 for map production and spatial analysis (ITC, 1993)

1.3.1 Consultations

During the preparation of the land use plan, consultations were held with the farmers in the area, the four farmers committees in Moshupa South, the District Agricultural Office for Ngwaketse North Agricultural District and the Village Development Committee (VDC) for Polokwe and Kgotla sub-extension areas.

CHAPTER 2

PHYSICAL ENVIRONMENT

2.1 LOCATION

The Moshupa South AEA is one of five agricultural extension areas in the Ngwaketse North agricultural district in Southern Agricultural Region. It is located due south of Moshupa in Southern district, approximately 60 km south of Gaborone. It is confined by the Polokwe Hills escarpment to the south, and shares its western boundary, the Tlhokwane river, with the Lothlakane West extension area. The northern boundary is defined by the Moshupa - Manyana road while the eastern boundary is formed by a series of hills: Ngolo, Seokangwane and Setswamothlabe Hills, separating it from the Manyana extension area. The NE corner of the area corresponds to 7259000 Mn UTM Northing/352000 Me UTM Easting and the SW corner to 7249000mN UTM Northing/328000 Me UTM Easting (UTM zone J 35). The area is located on map sheet 2425 CA and D3 of the 1:50.000 topographical map series (DSL, 1982). The Moshupa South AEA measures 12046 ha and is divided into 4 sub-extension areas: Polokwe, Kgotla, Sobe and Mathlakola.

The grazing area for the population in Moshupa South AEA is located due south of the area, confined to the Polokwe hills. It covers an area of 13583 ha. As indicated in the Introduction, the grazing area will be included in the planning area, which means that the total area covered by the agricultural land use plan measures 25629 ha.

Figure 2.1 Location of Moshupa South AEA

2.2 CLIMATE

The climate of the Moshupa South AEA is semi-arid with summer rainfall.

The mean annual rainfall in the area is approximately 530 mm with a standard deviation of 171 mm. This information comes from Kanye climatic station, situated 25 km south of Moshupa, and is based on historic rainfall data from 1925-1989. It should be kept in mind that Kanye is situated on a plateau overlooking the planning area, and the higher altitude may increase rainfall amounts compared to the Moshupa South AEA.

Rainfall recording at Moshupa started in 1986, and only data from six years is available at present. It is very unlikely that this rainfall data is representative of a "typical" rainfall pattern, which is generally believed to follow a 20 year cycle (Tyson, 1978). The small number of observations from this station makes the calculation of an average figure unreliable. For this reason, it has been decided to use the rainfall and synoptic data from Kanye in the analysis.

Annual rainfall figures from Moshupa and Kanye are presented in Table 2.1

Table 2.1 Climatic data for Moshupa

MOSHUPA 24° 47 S 25° 26 E	TEMPERATURE				RELATIVE HUMIDITY (%)		SUN-SHINE	WIND	RAINFALL		PET
	MEAN		EXTREME						Moshupa[1]	Kanye[2]	
MONTH	max	min	max	min	08h.	14h.	hrs/day	km/h	mm	mm	mm
SEPTEMBER	27.8	10.3	36.6	-2.9	51	24	9.6	7.8	22	15	148
OCTOBER	29.9	14.4	39	2.1	53	29	9.3	9.1	33	43	178
NOVEMBER	30.4	16.2	39.1	6.2	59	34	8.8	8.2	70	67	187
DECEMBER	31.2	17.3	41.5	6.4	64	39	8.6	7.2	57	82	196
JANUARY	31.4	18.1	41.3	8.6	67	41	8.5	6.9	31	99	187
FEBRUARY	30.2	17.6	38.8	8.3	72	44	8.5	5.9	112	87	161
MARCH	29.3	16.1	38.3	6.3	74	45	8.1	5.0	48	72	147
APRIL	26.4	11.6	34.2	-2.3	77	41	8.3	4.8	39	40	115
MAY	23.6	6.4	32.4	-3.8	75	34	9.1	5.1	3	12	88
JUNE	21.1	2.8	29.1	-6.6	74	30	8.5	4.8	0	6	72
JULY	21.2	2.6	28.4	-7.8	69	28	9.7	5.0	0	6	81
AUGUST	24.3	5.4	32.4	-5.9	58	24	9.9	6.4	5	3	110

[1] Data from the period 1986-93
[2] Data from the period 1925-89

Most of the rainfall occurs during the six month period from October to March, often concentrated in a few rainfall events between December and February. Inter-annual variation in rainfall is considerable, with 100 mm and 1000 mm as minimum and maximum values of annual rainfall respectively (1925-1989). Dry spells often occur during the period with negative impact on crop production.

Synoptic values recorded at the Kanye climatic station are presented in table 2.1. Evapotranspiration is high, about 1670 mm/year, with a peak of approximately 200 mm/month in December and a decline to 72 mm/month in June. The minimum temperatures in winter are quite low with an average of 10 frostdays (ground) in both June and July. The risk of early frost encountered in this part of Botswana is particularly a constraint for late planted crops. Mean minimum temperatures range from 3°C in July to 18°C in January while mean maximum temperatures range from 21°C in June to 31°C in January.

2.3 GEOLOGY AND GEOMORPHOLOGY

The eastern part of Southern Region, including the Moshupa South AEA, belongs to the Hardveld area of Botswana.

Based on the 1:250.000 scale soil survey report ("Jwaneng sheet") and the 1:50.000 complementary soil survey the planning area may be divided into four major land forms:

- the Polokwe hills
- a stretch of sandy colluvium at the foot of the hills
- the Moshupa pediplain
- river valley floors dissecting the pediplain

The Polokwe hills can be divided into two parts: The western part (where the tar road crosses in the direction of Kanye) belongs to the felsic Kanye Volcanic Formation while the eastern part belongs to the Waterberg Supergroup of well-cemented, hard, ferruginous sandstones, grits and conglomerates with minor shales. The topography is rolling to hilly. The hills rises ca. 100 m above the pediplain.

The colluvial area represents a discontinuous transition between the Polokwe hills escarpment and the Moshupa pediplain and consists of sandy material eroded from the Polokwe hills area. The topography is almost flat to gently undulating.

The Moshupa pediplain is underlain by intrusive rocks (e.g. granites of various compositions) and is characterized by frequent granitic rock outcrops. The topography is almost flat to gently undulating. The area is dissected by many gullies and ephemeral streams, which all flow into the Metsemothlaba river in a NE direction.

The river valleys consist partly of alluvial material and partly in situ weathered granitic material. The overall topography is flat to almost flat but close to the drainage channels slopes may increase sharply over short distances. Such areas are particularly prone to gully formation.

2.4 SOILS

A soil survey was carried out by the Soil Survey Section of the Ministry of Agriculture in 1994. The survey was done on a scale of 1:50.000 and the results complement the existing 1:250.000 soil map (sheet no. 34, "Jwaneng sheet") (MoA., 1991). The soil map is presented in figure 2.2 and the main characteristics of the most common soil types are summarized in table 2.4.

It was not possible to separate the individual soil types in most units at the 1:50.000 mapping scale. Instead the **association** of soil types found in the different units have been mapped. Table 2.2 indicates the proportions of individual soil types which are found in each association and the area covered by each soil mapping unit.

The total areas of the individual soil types are shown in table 2.3. The areas have been calculated from the proportions of each soiltype listed in table 2.2.

The distribution characteristics of the different soils can briefly be described as follows:

Polokwe hills

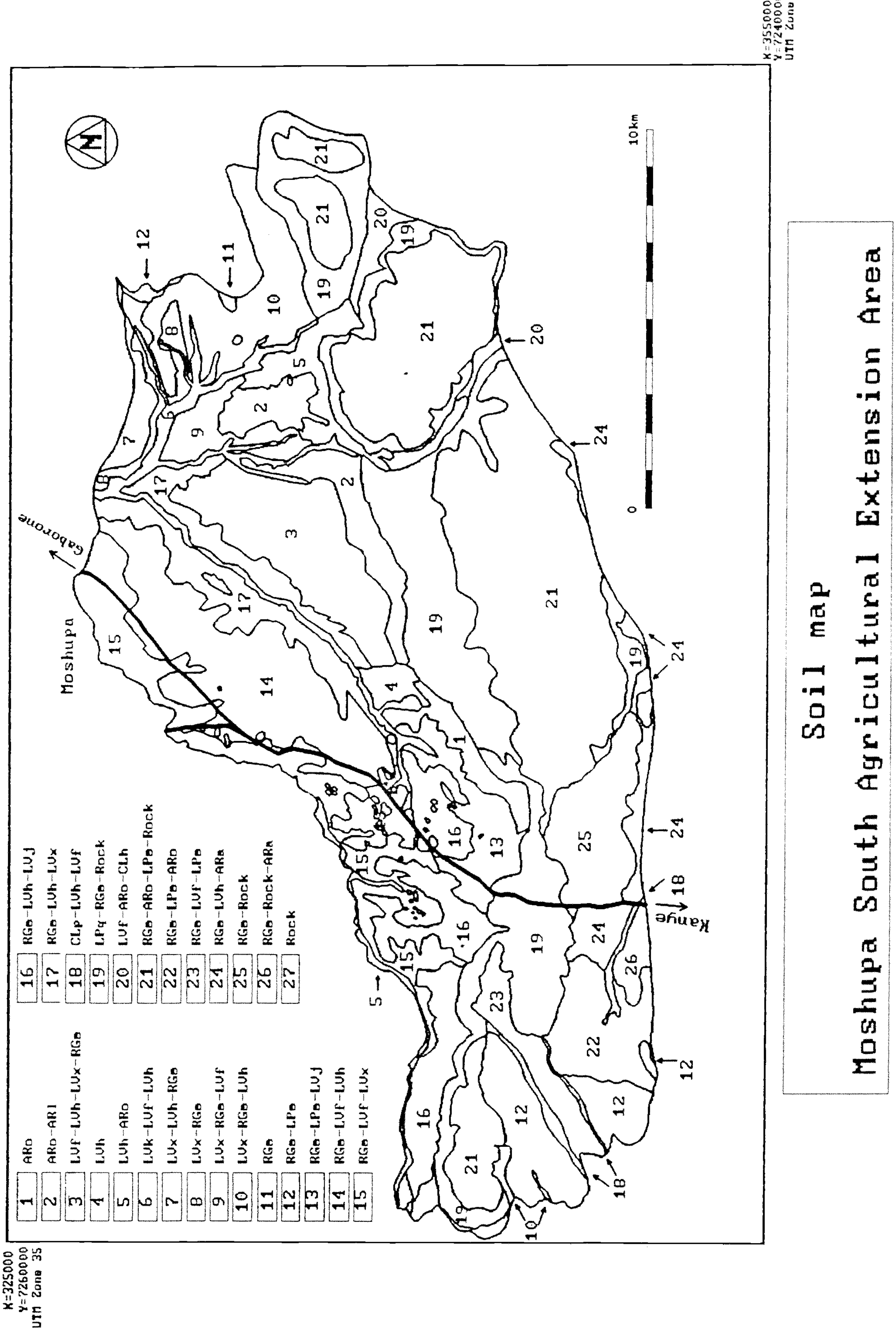
The sandstone formation in the eastern part of the unit is characterized by flat plateaus which are steeply dissected by valleys. The topography of the western part of the unit, consisting of bedrock of felsic origin, is rolling to hilly. The dominant soils in the hills are poorly structured soils (Regosols), sandy soils (Arenosols) and very shallow soils (Leptosols). In the valleys dissecting the hills in a South-North direction and on the lower slopes of the hills, occasional medium to deep medium-textured soils (Luvisols) are encountered, along with Arenosols and soils with a high carbonate content (Calcisoils). The latter soiltype covers such a limited area that it is not included in the further analysis for practical reasons. The bedrock is exposed in many places and covers 14% of the area.

Table 2.2 Proportions of soil types in different soil units

Land form	Soil mapping unit	Soiltype(s)[1]	Proportion of soiltype(s)	area (ha)	area in % of total
Polokwe hills	18	CLp-LVh-LVf	50-30-20	171	1
	19	LPe-RGe-Rock	50-30-20	3847	15
	20	LVf-ARo-CLh	50-30-20	298	1
	21	RGe-ARo-LPe-Rock	40-30-20-10	5627	22
	22	RGe-LPe-ARo	50-30-20	715	3
	23	RGe-LVf-LPe	50-30-20	396	2
	24	RGe-LVh-ARo	50-30-20	477	2
	25	RGe-Rock	70-30	811	3
	26	RGe-Rock-ARo	50-30-20	159	1
Sandy colluvium	1	ARo	100	291	1
	2	ARo-ARl	70-30	755	3
Moshupa Pediplain	3	LVf-LVh-LVx-RGe	40-30-20-10	1297	5
	4	LVh	100	129	1
	5	LVh-ARo	70-30	398	2
	7	LVx-LVh-RGe	50-30-20	206	1
	8	LVx-RGe	70-30	266	1
	9	LVx-RGe-LVf	50-30-20	358	1
	11	RGe	100	15	0
	13	RGe-LPe-LVj	50-30-20	536	2
	14	RGe-LVf-LVx	50-30-20	1435	6
	15	RGe-LVf-LVh	50-30-20	1892	7
	16	RGe-LVh-LVj	50-30-20	1177	5
	17	RGe-LVh-LVx	50-30-20	1345	5
River valley floors	6	LVk-LVf-LVh	50-30-20	807	3
Moshupa pediplain/ Polokwe hills	10	LVx-RGe-LVh	50-30-20	1058	4
	12	RGe-LPe	70-30	936	4
	27	Rock	100	213	1
		TOTAL AREA		25629	100

[1] According to FAO (1990) revised soil classification

Figure 2.2 Soil map of Moshupa South AEA



Sandy colluvium

The soils are classified as Ferralic Arenosols (ARo) with very little clay content or Luvic Arenosols (ARl) which have a slightly higher claycontent which increases with depth. They are found adjacent and parallel to the Polokwe Hills in the southern part of the Moshupa pediplain. The topography is flat to gently undulating, with a slope of 1-2 %. The texture of these soils is medium to coarse sand. They are excessively drained and slightly acid. The fertility status of these soils is very low. The agricultural potential of these soils is intermediate due to their limited capacity to retain moisture. The advantage of these soils is the good workability, which is appreciated by farmers. They are also deep and give no obstruction for root development and little run-off occurs due to the low infiltration rates.

Table 2.3 Areas covered by individual soil types

soiltype	area (ha)	area covered by soiltype in % of:		
		total area	Moshupa AEA	Grazing area
RGe	10510	41	32	44
ARo	2987	12	8	21
ARl	227	1	2	0
LVx	1813	7	15	2
LVh	2562	10	20	1
LVk	404	2	3	0
LVf	2133	8	15	2
LVj	343	1	3	0
LPe	2659	10	1	16
Rock	1836	7	1	14
CLp	86	0	0	0
CLh	60	0	0	0
TOTAL	25629	100	100	100

Moshupa pediplain

The eastern part of the pediplain is dominated by medium-textured, moderately deep to deep soils classified as Luvisols (LV) because of the increasing claycontent with depth whereas the western part is dominated by coarse to medium-textured, generally shallow to deep soils classified as Regosols (RG). In addition to these soil types, rock areas and rock outcrops can be found. The soils in these locations, if any, are very shallow and are classified as Leptosols (LP). The pediplain being dissected into sections (interfluves) by the drainage system, a soil pattern may be distinguished according to the topographical position.

Upper slope: The most shallow soils are found in this position. The soils are often shallow Regosols (RGe) or shallow Ferric Luvisols (LVf). It has not been possible to map the location of these soils at the mapping scale, and they are therefore not included in further analysis. However, locally they present serious constraints for arable farming due to their shallow depth and a hardened layer which can be found within the top 50 cm.

Table 2.4 Characteristics of representative soil types.

Soil type	Profile	Profile depth (cm)	Ph ($CaCl_2$)	P ppm	Org. C %	CEC me/ 100g	CA me/ 100g	MG me/ 100g	K me/ 100g	NA me/ 100g	Base sat. %	Soil depth	drain-age class	AWC (mm/m)	Textu-ral class	P[1] (ppm)	Soil mapping units
ARo	L0192	0 - 30	4.9	4	0.5	1.8	1.3	0.1	0.2	0.0	89	170	S	70	C	4	1,2,5,20, 21,24,26
		40 - 60	4.3	2	0.3	2.1	0.8	0.1	0.1	0.0	48			70			
		90 -120	4.3	1	0.3	2.4	0.8	0.3	0.1	0.0	50			70			
ARl	L0206	0 - 20	4.54	2	0.7	1.6	1.1	0.0	0.2	0.0	81	130	S	70	C	2	2
		30 - 60	4.88	3	0.9	0.7	1.1	0.0	0.2	0.0	186			70			
		70 -100	5.27	1	0.2	0.6	1.1	0.0	0.2	0.1	233						
LVf	L0200	0 - 20	4.1	6	0.6	1.9	1.9	0.4	0.2	0.0	132	130	W	130?	M	5	3,6,9,14, 15,18,20,23
		30 - 50	4.3	1	0.6	4.2	1.9	0.4	0.5	0.0	67						
LVk	MW0901	0 - 10	7.5	3	0.6	9.8	36.5	1.7	1.2	0.2	404	125	MW	120	M	2	6
		20 - 40	8.3	1	0.5	12.4	20.3	2.6	0.2	0.2	185			130			
		50 - 70	8.4	0	0.3	12.2	43.2	3.4	0.2	0.1	384			130			
		90 -110	8.7	0	0.3	12.2	51.0	4.1	0.2	0.7	459			130			
		120-140	8.7	0	0.3	12.8	54.7	5.3	0.1	0.9	476			130			
LVx	L0195	0 - 10	5.0	1	0.8	5.6	2.8	1.1	0.6	0.1	82	190	W	80	M	5	3,7,8,9,10, 14,17
		20 - 50	5.6	7	1.0	12.9	8.3	3.5	0.6	1.0	104			130			
		60 - 90	6.0	5	0.8	14.9	9.9	4.0	0.4	2.1	110			120			
		100-125	7.3	6	0.6	14.3	12.0	4.0	0.2	4.4	144			120			
LVj	L0207	0 - 20	4.24	2	0.5	4.7	0.9	0.7	0.2	0.0	38	?	?	?	?	2	13,16
		20 - 40	5.01	0	0.4	4.2	1.8	1.2	0.1	0.1	76						
		50 - 80	7.24	0	0.4	6.2	2.5	1.3	0.1	2.5	103						
		80 -110	7.37	2	0.3	6.1	2.0	1.2	0.1	2.8	100						
LVh	L0228	0 - 20	5.07	2	0.7	3.0	1.2	0.8	0.4	0.0	80	130	W		M	2	3-7,10, 24, 25-28
		30 - 50	5.00	2	0.6	5.2	2.1	1.6	0.3	0.0	77						
		50 - 70	4.95	2	0.6	6.9	2.4	1.9	0.3	0.3	71						
		80 -100	5.27	2	0.6	6.8	2.6	2.2	0.3	0.1	76						
RGe	L0191	0 - 10	4.86	2	0.7	2.0	1.1	0.1	0.2	0.0	70	100	W	70	C	3	3,7-17,19, 21-26
		20 - 40	4.94	5	0.5	2.2	1.1	0.1	0.1	0.0	59			70			
LPe	KS0136b	?	?	?	?	?	?	?	?	?	?	10	M	10	W	2	12,13,19, 21-23

[1] This is a weighted value for the 0-25 cm layer, which is used for CYSLAMB and APSRAMB simulations (see chapter 5)

Middle slopes: In a few areas, especially in the eastern part of the pediplain, the soils are deep and no obstruction to root penetration occurs. These soils are dark brown to dark red, have a relatively high fertility status, and are defined as Chromic Luvisols (LVx). The higher clay content is favorable for moisture retention and soil structure and these soils have the highest potential for arable agriculture in the area. The heavy texture may cause problems for soil workability.

Lower positions: The soils in the lower positions are more loamy and deeper soils (sandy loam-sandy clay loam). If the clay increases with depth, they are defined as Luvisols. A number of different Luvisols have been identified, according to specific characteristics (color, presence of nodules, etc). The dominant are Ferric Luvisols (LVf) and Haplic Luvisols (LVh). If the soil type in this position is stoney, has no evidence of clay increase and no well-developed structure, they are classified as Eutric Regosols (RGe). Most soils contain a coarse gravel and nodule layer in the contact zone with the granitic parent material. Although this layer of nodules and gravel is penetrable for roots, it must affect root development negatively and the effect on water movement most also be negative (bypass phenomena). The potential for agriculture in the area is negatively affected by these factors. In the SE corner of the Moshupa pediplain (soil map units 13 and 16), evidence of reducing conditions created by standing surface water for part of the year causes a classification of the soil as Stagnic Luvisol (LVj).

River valley floor

At the edges of the valley floors soils similar to those found in lower positions of the pediplain can be found (LVh). The soils found directly adjacent to the streams may contain layers of calcaric material and are then classified as Calcic Luvisols (LVk).

Moshupa pediplain/Polokwe hills

A few units are found in both the pediplain and in the hills. The extent of unit 10 (LVx-RGe-LVh) is greatest in the Moshupa pediplain, while both unit 12 and 27 are predominantly found in the Polokwe hills. Units 12 and 27 occur in association with rock outcrops and areas of shallow soil in the Moshupa pediplain.

The characteristics of representative soil types are listed in table 2.4.

2.4.1 Land degradation

Based on the extent and severity of degradation, the overall erosion level for Moshupa South AEA is classified as **low**. This means that areas affected by light erosion cover less than 10% and/or moderate erosion covers less than 5% of total area (after LUPSAD, 1995b). The delineation of areas affected by erosion was done by interpretation of Aerial Photographs and a SPOT satellite image.

Most of the erosion in Moshupa South AEA occurs as gully and sheet erosion, while wind erosion is a minor problem. Badly eroded areas are displayed in Figure 2.3. It is apparent that most of the erosion is related to areas close to the ephemeral streams.

The following degree of erosion has been encountered (see table 2.5).

Figure 2.3 Degraded areas in Moshupa South AEA

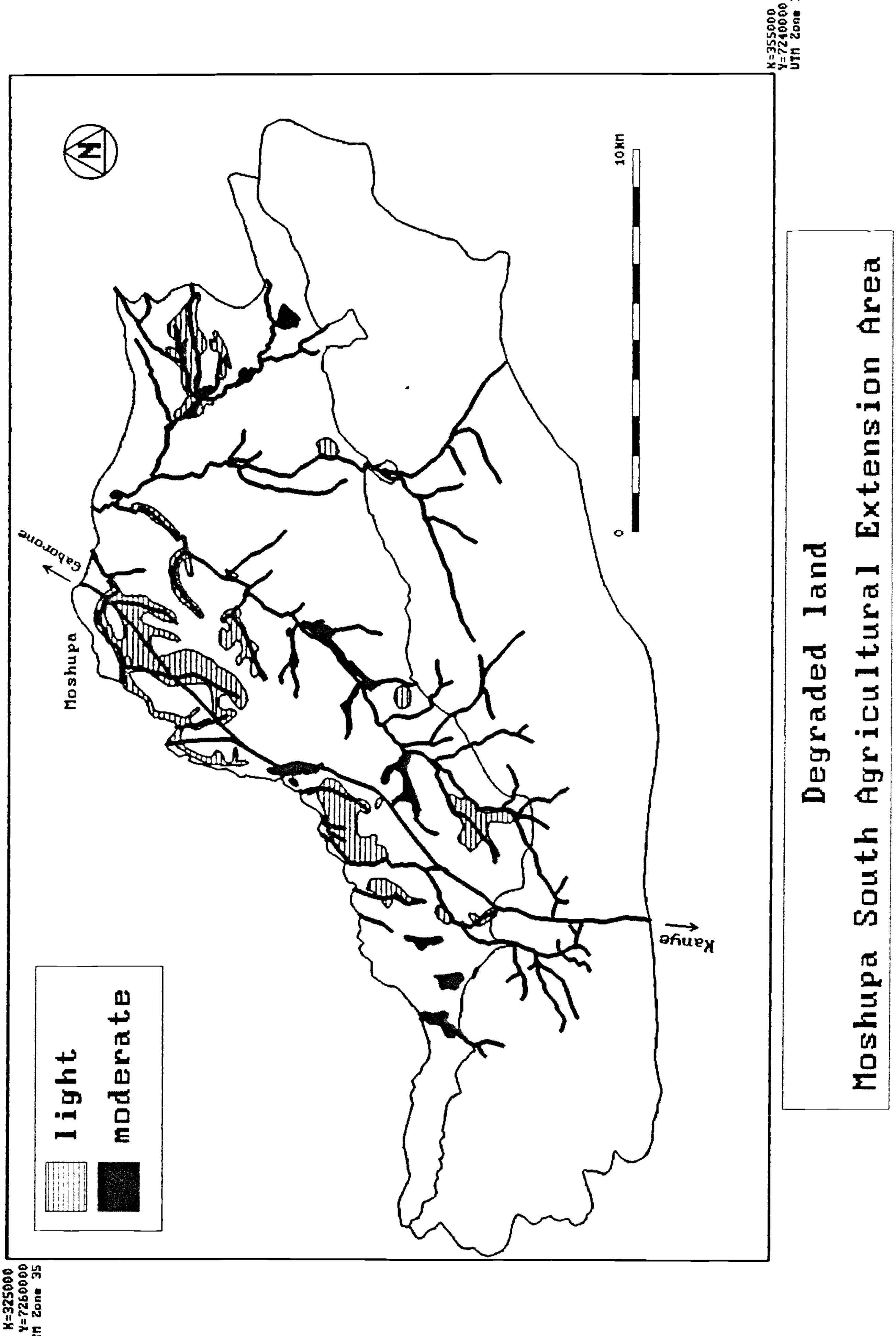


Table 2.5 Classification of soil erosion in Moshupa South AEA

Degree of degradation	percentage of Moshupa AEA affected	Type and description of erosion	
		Gullies (Wg)	Sheetwash (Ws)
Light	10	Gullies active (U-shaped) but small (less than 1.5 m deep, narrow); little exposure of bedrock.	minor accumulation of coarse sand along paths and tracks; rills hardly visible
Moderate	1.9	Gullies active (U-shaped) several meters deep and wide and/or common exposure of hard weathered rock	surfaces covered by 'lag' gravel or stones, rills clearly visible, exposed roots frequent, formation of accretion mounds around clumps of vegetation; removal or redistribution of litter

Source: LUPSAD (1995b)

Both types of erosion occurs in the areas indicated in figure 2.3. While sheet wash erosion is found throughout an affected area, gulley erosion can be limited to a few gulleys developing in depressions. However, the moderately affected areas generally have a higher frequency of gulley formation.

2.5 VEGETATION

2.5.1 Existing information

The vegetation in Moshupa South AEA is classified as a transition between type B4 (*Acacia erubescens* tree savanna) and B5 (*Terminalia sericea* tree+shrub savanna), while the vegetation in the adjacent Polokwe hills (and on the rocky outcrops in the Moshupa pediplain) is classified as C1 (*Croton gratissiumus* hill woodland). The riverine vegetation in valleys along seasonal watercourses in the pediplain is classified as type E1 (*Acacia Tortilis* fringing Woodland) (Timberlake, 1980).

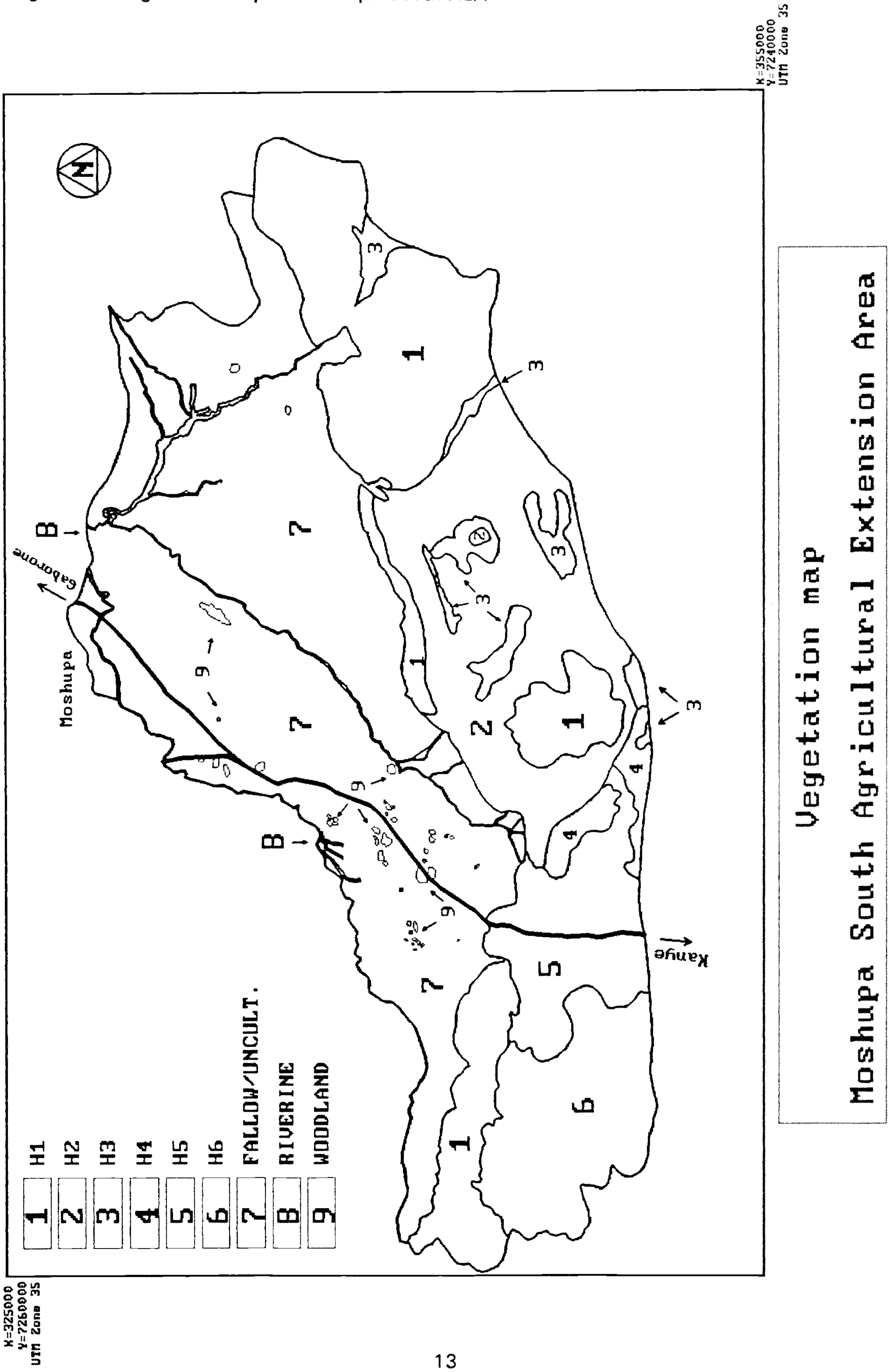
The Timberlake classification is based on a small-scale reconnaissance survey and is not sufficiently detailed, especially for the herbaceous species, to be used for quantification purposes. It was therefore supplemented by a vegetation survey carried out on a 1:50.000 scale.

2.5.2 Survey methodology

A qualitative vegetation survey was carried out by the Mrs. T. Molefe, Range Ecology Section of Southern Region, which was later supplemented by a quantitative survey by Messrs. M. Powell and M.C. Bonyongo to identify vegetation units and collect data to enable simulation of the potential biomass production. Vegetation units were delineated using aerial photographs and a 1986 SPOT satellite image, both on a 1:50.000 scale. The units were field checked and one or more sites per unit described using the variable plot method developed by Bitterlich (1948). The information per site includes the following:

- percentage total canopy cover
- percentage canopy cover by species within the bush stratum above 3 meters
- average height and circumference of trees within this stratum by species
- percentage canopy cover by species within the bush stratum between 1.5 and 3 meters
- average circumference of trees within this stratum by species and their growth habit (single or multi-stemmed)
- percentage canopy cover by species within the bush stratum below 1.5 meters
- percentage basal and canopy cover by species in the herbaceous layer under canopy
- percentage basal and canopy cover by species in the herbaceous layer away from canopy
- evidence of fire, termite activity and soil crusting

Figure 2.4 Vegetation map of Moshupa South AEA



The data collected were entered into the Botswana Vegetation Database and averaged using the program CREVEG.EXE to produce vegetation units.

2.5.3 Vegetation units

A total of 10 vegetation units were identified (see figure 2.4). H1-H6 are vegetation units in the Polokwe hills area and the rest are found in the Moshupa pediplain below the hills. In this area, four units have been identified: the riverine vegetation along the seasonal watercourses (RIV), the fallow plots in the arable area (FAL), the uncultivated areas between the fields (UNC) and finally the vegetation found on the rocky outcrops and shallow soils (ROK). A brief description of each unit is given in table 2.6 and more detailed information is included in annex F.

2.6 WATER RESOURCES

The sources of water in the Moshupa South AEA can be divided into the following categories:

Natural streams and springs

Three main streams dissect the Moshupa pediplain: Tlhokwane stream, which defines the western boundary of the agricultural extension area, Sobe and Monname streams which run from their source in the Polokwe hills through the pediplain towards the NE. Several smaller tributaries and gullies feed the three main streams. The waterways are ephemeral streams and will only flow briefly after heavy rains. The streams are extremely important locations for hand-dug wells which are used for livestock and human consumption.

An underground spring is said to feed the wellsite at Kgotla (WS12 in figure 2.5) which rarely dries up. Another spring is located in the grazing area, in the valley leading from the Sobe wellsite southward through the Polokwe hills towards Ranaka (S1 in figure 2.5). This spring is used for livestock watering only.

Man-made dams, boreholes, hand-dug wells

Three large dams were constructed in Moshupa South AEA during the 1960s, of which only one is in use today (D1 in fig. 2.5).

A number of smaller dams (typically measuring 500 m^2 in area) have been constructed in the area through drought relief assistance or on people's own initiative. They are used for livestock and/or human consumption. Thirty five small dams were visited during the field work. Out of this number, 32 are used by individual households, while three serve groups of households (between two and 15 households). The dams generally hold water for seven to ten months and mainly supply water for smallstock and donkeys as well as domestic use.

There is only one borehole operating within the extension area, located at the Polokwe primary school and mainly providing water for the small settlement there as well as the school, VDC housing and agricultural extension staff. Residents close to schools and villages collect water from stand pipes at those centres in drums which are then transported by donkey cart to their homesteads in the area. Other sources are dams, wells and seasonal bodies of surface water in the area. Two other boreholes were drilled by the Department of Water Affairs and are presently not in use. The yield of borehole no. 7006 (BH2 in figure 2.5) is reported to be 4.5 m^3/hour (45000 liters/hour) and for borehole no. 7175 (BH1 in figure 2.5) is only 5000 liters/hour.

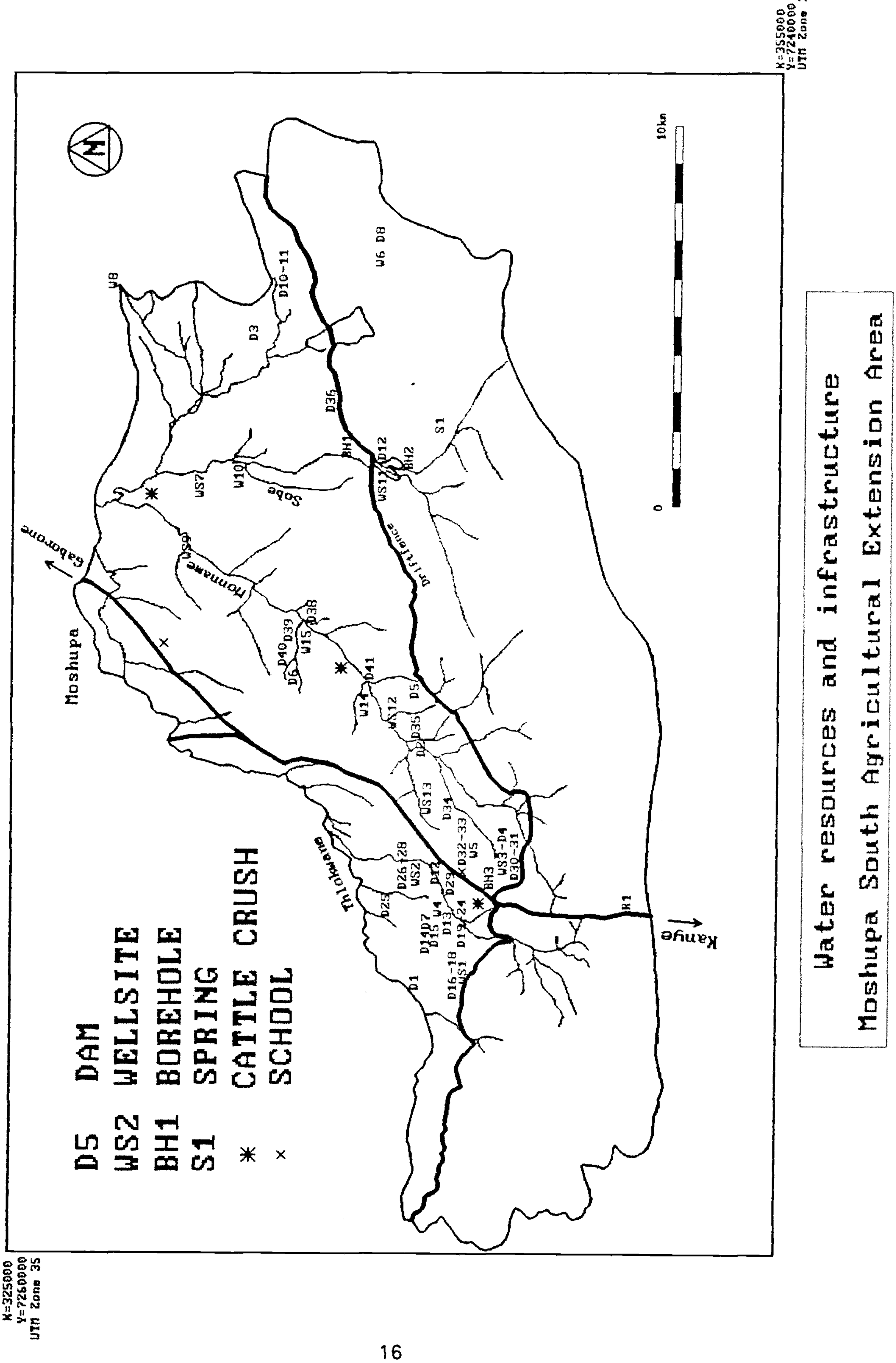
A survey revealed that a total of 261 households (62% of total number of households) rely on the 35 waterpoints to water 1300 head of cattle, 700 goats and 160 donkeys. This implies that a substantial number of livestock and households consume water from other sources than those visited in the course of the survey. The results of the water point survey are listed in annex F.

Table 2.6 Vegetation units in the planning area

Vegetation unit	H1	H2	H3	H4	H5	H6	ROK	FAL	UNC	RIV
Vegetation structure[1]	Hill wood-land	Hill wood-land	Hill wood-land	Hill wood-land	Hill wood-land	Hill wood-land	Hill wood-land	Tree and shrub savanna	Tree and shrub savanna	riverine grassland
Landform	Polokwe hills	Polokwe hills	Polokwe hills	Polokwe hills	Polokwe hills	Polokwe hills	Moshupa pediplain	Moshupa pediplain	Moshupa pediplain	Moshupa pediplain
Topography	flat plateau[2]	undulating hill[2]	valley[2]	Undulating hill	Undulating hill[3]	Undulating hill[3]	Rock outcrop	Flat to gently undulating	Flat to gently undulating	River valley floor
Area (ha)	5001	3732	692	394	1677	2087	92	3225	7922	807
Bush canopy: > 3m (%)	33	16	23	8	9	4	10	7	9	16
Bush canopy: 1.5-3m (%)	13	15	21	8	9	20	29	11	9	29
Bush canopy: < 1.5m (%)	23	22	17	10	8	9	11	18	13	25
Total bush canopy (%)	53	43	48	14	24	30	30	31	29	50
Grass canopy cover: away from canopy (%)	15	37	21	52	23	39	7	23	42	20
Grass canopy cover: under canopy (%)	15	16	12	8	9	16	3	13	17	20
Basal cover (%)	9	22.5	8	14	13.5	10.5	2.5	8.5	12	8
litter (%)	33	45	12	6	4.5	12	12	16	20.5	0.5
bare ground (%)	58	32.5	80	80	82	77.5	85.5	75.5	67.5	91.5
Prominent species	Acacia fleckii, Croton zambesicus, Pelthophorum africanum	Terminalia sericea, Combretum molle, Aristida stipitata	Boscia albitrunca, Combretum zeyheri, Digitaria species	Acacia caffra, Acacia tortilis, Pappea capensis, Eragrostis lehmanniana	Combretum apiculatum, Dichrostacys cinerea, Aristida congesta,	Combretum molle, Terminalia sericea, Eragrostis rigidior	Croton gratissimus, Pappea capensis, Eragrostis rigidior	Acacia tortilis, Pelthophorum africanum, Eragrostis bicolor	Acacia erubescens, Rhus lancea, Aristida congesta, Eragrostis species	Acacia karro, Acacia tortilis, Cynodon dactylon, Panicum maximum

[1] According to Timberlake (1980)
[2] Found on sandstone rock in the eastern part of the Polokwe hills
[3] Found on felsic parent material in the western part of the Polokwe hills

Figure 2.5 Water resources and infrastructure in Moshupa South AEA



2.7 PRESENT LAND USE

The major forms of land use presently found in the planning area (Moshupa South AEA and adjacent grazing area) are summarized in table 2.7 and presented in figure 2.6.

2.7.1 Arable farming

Approximately 33% of the Moshupa South AEA is presently cleared and cultivated, covering an area of 4008 ha[1]. Interpretation of aerial photographs shows that most of the remaining area has at some stage been under cultivation, and although it may presently be fallow, it may only have been 5-10 years ago it was last cultivated. Fields are located in most areas except the most rocky and stony areas or in areas with severe gully erosion. The area cultivated per year varies according to rainfall conditions and the households' involvement in other activities. In the 1994-95 season, 352 farmers cultivated 1542 ha, which corresponds to an average of 4.4 ha per household and 26% of the 4008 ha presently cleared and utilized for arable farming.. When comparing this figure to the total area of the field, as reported by farmers during the household survey, this indicates that approximately 40% of each field was cultivated while the remaining portion was left as short-term fallow.

2.7.2 Cattle grazing

Cattle is normally kept at the cattleposts in the adjacent Polokwe hills, and only allowed into the lands area after harvest, to forage on the crop residue on the fields. The short-term fallows in the fields, uncultivated areas and abandoned fields in the Moshupa South AEA are also used for extensive grazing, especially for smallstock.

Table 2.7 Land use in Moshupa South AEA

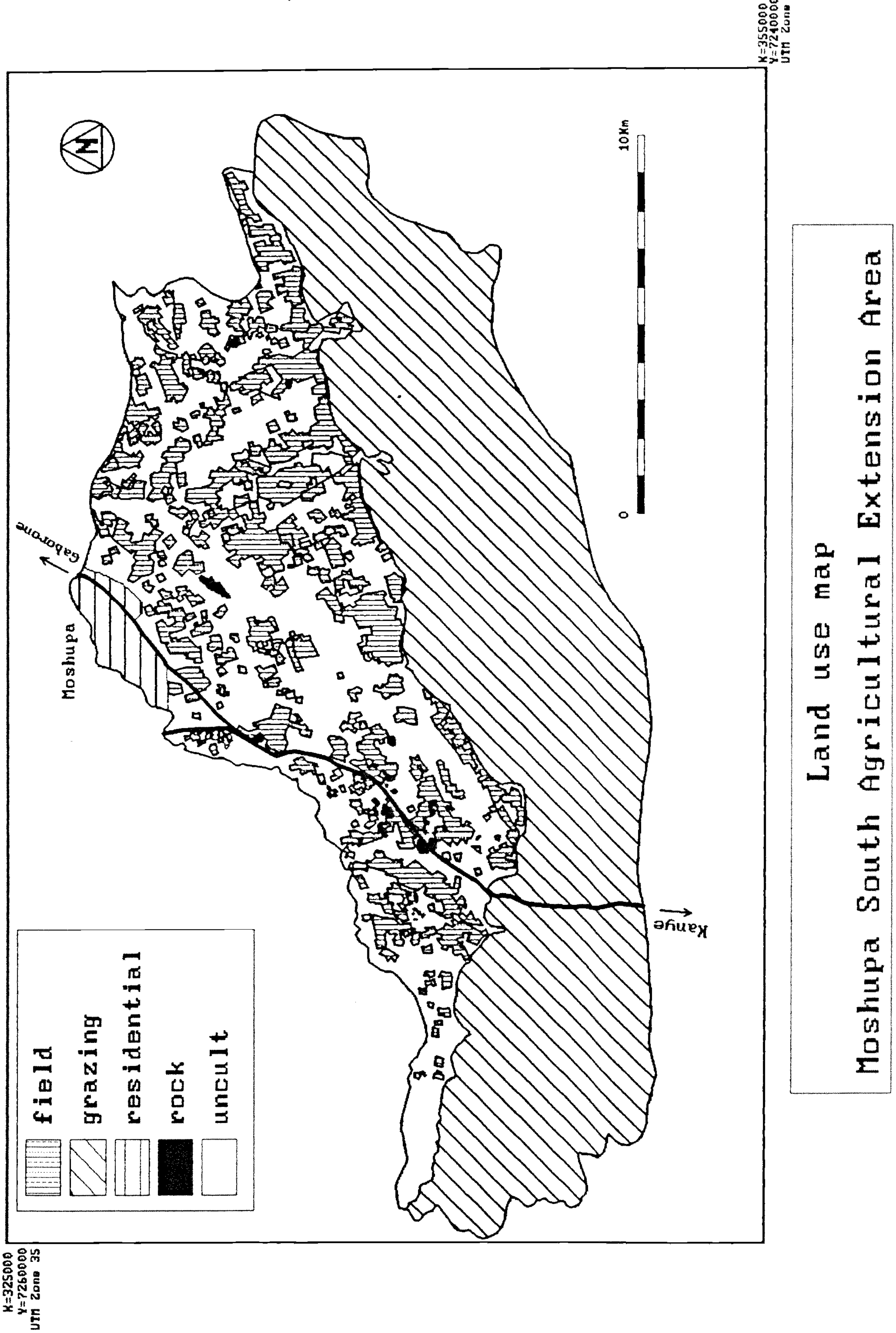
Location	Land use types	ha	% of total
Polokwe hills	cattle grazing, firewood and veld product collection (Polokwe hills)	13583	53
Moshupa South AEA	Arable farming (land cleared in Moshupa South AEA)	4008	15.8
	smallstock grazing, veld product collection, wells (rock outcrops, river valley floors)	1500	5.8
	smallstock grazing, veld product collection, fallows (Moshupa South pediplain)	5950	23.4
	Kanye-Moshupa road (road reserve)	180	0.4
	Residential (present)	408	1.6
	Total area of planning area	25629	100

[1] Based on the assumption of 400 households in the area.

Cattle is brought to watering points in the lands area to be watered and some cattle are kraaled at the homesteads at night to be milked in the morning. Smallstock and young calves are kept in the lands area to avoid predators from the hills, mainly jackals.

[1] Toposheet 2425 C4 with adjustments according to aerial photograph interpretation

Figure 2.6 Present land use in Moshupa South AEA



2.7.3 Firewood and veld product collection

Firewood is collected in both the Moshupa South AEA (in the uncultivated parts, on rock outcrops and especially in the Polokwe hills which has more woody biomass. It is used for personal consumption or sold in Moshupa and Kanye occasionally. Some farmers who specialize in the sale of firewood will transport and sell two loads a week in one of the villages.

Most farmers declare that the firewood resource is rapidly being depleted and blame outsiders who come to collect firewood in the area to sell in Moshupa or Kanye. M.v. Heist and A. Kooiman (1992) assess the standing tree biomass in the area closest to Moshupa to be less than 7.5 T/ha, while the major part of the Moshupa South AEA has a biomass between 7.5 and 17.5 T/ha.

Veld product collection (other than firewood) is presently limited to thatching grass and a few medicinal herbs, which are collected in the Polokwe hills. Thatching grass is collected by individual households when need arises, and only a few households sell grass on a commercial basis in Moshupa or Kanye. Farmers state that the resource is diminishing with the increased harvest by villagers from Kanye and Moshupa or commercially oriented outsiders.

2.7.4 Drift fence

A drift fence has been under construction since 1994. It runs along the foot of the Polokwe hills, and separates the grazing area in the Polokwe hills from the fields in the Moshupa South AEA. The fencing is carried out by farmers in the various sub-extension areas involved, and the progress differs from area to area, so that stretches of fenced and non-fenced distances alternate. By September 1995 a distance of 25.4 km was fenced with approximately 7 km still missing to join the drift fence running along the escarpment with the Tlhokwane drift fence at the Tlhokwane dam (The drift fence location is indicated in figure 2.5).

2.7.5 Residential

There are no structured settlements such as villages in the area, and people stay at homesteads next to the fields scattered throughout the extension area. The Polokwe primary school at Polokwe provides primary education and a number of extension agents are stationed at that location where a number of houses have been constructed by the Polokwe VDC.

The area is strongly dominated by the village of Moshupa as far as provision of Government services, shopping facilities, part-time residence, infrastructure and to some extent employment is concerned. The proximity of a major settlement also puts increased pressure on the physical environment of the Moshupa South AEA for firewood, poles for construction, etc. A small portion (1.6%) of the planning area is used for residential purposes for Moshupa. Most of the houses in the area south of the Moshupa-Kanye road (Jerusalem ward) are very recent as is the Baitirile J.C.S.S located in the same area. An area of similar size is planned to be used for the future expansion of the village (see section 4.1.1.2).

2.8 LAND UNITS

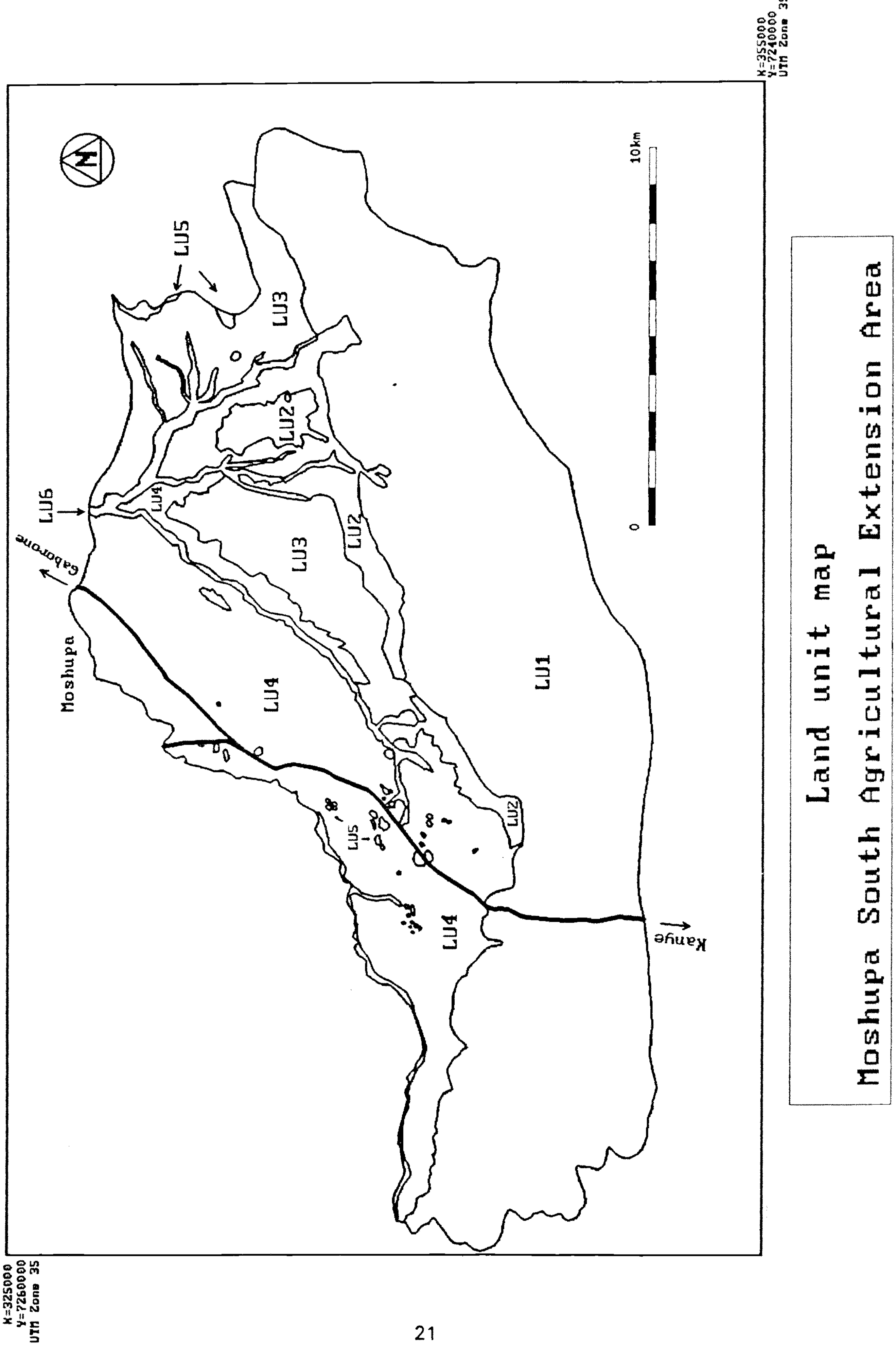
Land units (LU) are areas with relatively homogenous soil properties, surface characteristics, vegetation cover and land use. They form the basis for the land evaluation and recommended changes in land use. Six Land Units have been identified in the Moshupa South AEA and the adjacent grazing area. They are listed and described in table 2.8 and figure 2.7.

Table 2.8 Land units in Moshupa South AEA

Land unit (LU)	Land form	Dominating soil type(s)[1]	Slope (%)	Vegetation unit[2]	Present land use	area (ha)	area in % of total
LU1	Polokwe hills	RGe, ARo, LPe, CLp, LVf	5-40	H1-H6 (hill woodland)	extensive grazing, veld product collection[3]	13583	53
LU2	Sandy colluvium	ARo, ARl	1-2	UNC, FAL (open tree and shrub savanna)	rainfed arable farming	1046	4
LU3	Moshupa pediplain	LVf, LVh, LVx, RGe, ARo	2-3	UNC, FAL (open tree and shrub savanna)	rainfed arable farming	3667	15
LU4	Moshupa pediplain	RGe, LVh, LVj, LVf, LVx	2-3	UNC, FAL (open tree and shrub savanna)	rainfed arable farming	6384	25
LU5	Rock outcrops	RGe, LPe	>5	ROK (hill woodland)	smallstock grazing, veld product collection	142	0
LU6	Rivervalley floor	LVk-LVf-LVh	1-2	RIV (riverine grassland)	wells, veld product collection	807	3
TOTAL						25629	100

[1] According to FAO (1990) revised soil classification
[2] The vegetation codes are those used in section 2.5
[3] "Veld product collection" includes firewood collection

Figure 2.7 Land units in Moshupa South AEA



CHAPTER 3

SOCIO-ECONOMIC ENVIRONMENT

3.1 POPULATION

Although the focus of the planning exercise is the Moshupa South AEA, the existence of Moshupa village can not and should not be ignored, as it exerts pressure on the environment for firewood supply and offers many facilities for the population of Moshupa South AEA. It therefore seems relevant to mention briefly a few points about Moshupa. The population of the village was estimated at 6.612 in 1981 and had risen to 11.661 in 1991, corresponding to an annual growth rate of 5.8%. The rapid growth reflects the general trend in Botswana's larger villages, especially in those close to major centres like Kanye and Gaborone. The Moshupa Development Plan (DTRP, 1992) assumes a similar growth rate for the present planning period (1992-2012) which would bring the population level to approximately 15.000 in 1995 and 38.000 in 2012.

The population of the Moshupa South AEA is estimated at 2100 persons in 1995 and expected to rise to 3575 persons in 2012. These figures are based on the 1991 "Botswana population and housing census" figure of 1980 persons (CSO, 1992) and allowing for an annual growth rate of 3% per year. The lower growth rate compared to Moshupa reflects the current pattern of high growth rates in major settlements and slower/reduced growth rates in rural areas.

This number corresponds to the population actually residing in the area. An additional 10-20 persons are estimated to reside in the neighbouring villages of Moshupa and Kanye and to farm in the Moshupa South AEA.

The survey with 40 farming household reveals that the majority of the persons responsible for the arable activities of the households are women (62.5%). If husbands are present in the family, they tend to concentrate more on livestock production. 30% of the households are female-headed (no husbands presents). Out of these, 12.5% are *de jure* female-headed (widows and unmarried women), whereas the remaining 17.5% are *de facto* female-headed households, with the husband working away from home, often in South Africa.

All households have absent family members who are either studying or working away from home. Their demand on household resources in terms of food is limited, whereas their contribution to the household in the form of cash remittances and labour is important. The households will often look after young children from absent daughters.

The general impression is that two types of households can be identified, corresponding to different phases in the household "lifecycle":

1) The "young" household, consisting of a young couple with small children. This group of households also count many *de facto* female-headed households. The fields are often newly cleared and the area cultivated by these households small.

2) The "mature" households consisting of the parents, often middleaged and very young children, either their own or grandchildren, while most of the older sons and daughters are away for study or work or have started their own family elsewhere. A few adult sons and daughters may also be present.

The mature type of household is dominating in the area (77.5% of the households belong to this category).

This pattern seems to fit with the traditional family development cycle in Botswana, as was illustrated by Ø. Guldbrandsen (1984). Young men, still living at home, do not cultivate a field of their own, but may assist their parents. Once married, they will start ploughing for a few years in the field of their wife's mother, who is responsible for teaching the new household, and especially her daughter, good farming practice (this practice, whereby newly married couples cultivate a field by the parents of the wife seems to be a local tradition, where in other places in Botswana, the couple may borrow a field from the husbands parents). Later the woman starts cultivating a new field or one inherited from parents or their relatives, while the husband only assists at certain operations, such as ploughing and fencing, and is mostly engaged in other income generating activities (traditionally working in the mines in the Republic of South Africa. At this stage, his main contribution to the family is in the form of cash remittances rather than labour. At a mature age of 40-45 years, the husband joins the family and increases his contribution of labour to the arable production. However, men usually concentrate on livestock rearing and leave the main work load and decision making in the crop production system to the women.

3.2 LAND TENURE AND LEGISLATION

All of the Moshupa South AEA falls within the area designated as communal land.

Before the Tribal Land Act came into effect in 1974, land allocation was traditionally the responsibility of the Chief and his representatives, the Headmen. Today, farmers intending to cultivate new areas have to ask the nearest neighbor for permission and then register the field with the sub-Land Board in Moshupa. However, the farming household survey revealed that only 20 % of the households at present hold a certificate to their field with Land Board. It appears that farmers consider this a practice for "young people" and do not consider it an important step. However, if the new ALDEP programme (phase II) requires possession of a Land Board certificate as a precondition for assistance, obviously many households will not be eligible for assistance.

Guldbrandsen (1984) found that land allocation since the inception of Land Boards was still dominated by the traditional inheritance of fields, passing on the field from parents to their children. It appears that more than a decade later, the same pattern still dominates.

The farmers committees in Moshupa South AEA explain that it is difficult for new farmers to find unclaimed land for cultivation any longer, and they advise their off-spring to start cultivation in other areas (see section 4.1.1.2).

3.3 ECONOMIC ACTIVITIES

The main economic activities in Moshupa South AEA are:

- arable farming
- livestock rearing (cattle and smallstock)
- firewood collection/occasional veld product collection
- drought relief labour schemes

Another important source of income is remittances from absent relatives.

The main sources of income are described in table 3.1.

All households are engaged in the two first activities, while a few also collect firewood for sale. 25% of all the households are engaged in drought relief activities on a temporary basis.

The income generated from the agricultural activities is fluctuating and generally very low. Only a minority of the households (17.5%) report to ever have sold produce (grain) from their fields, and out of these only 10% did so within the last five years. Most households cultivate "sweetreed" (a sorghum variety) and watermelons, a portion of which are sold as a cash crop. However, farmers indicate that the income derived from the sale of these crops is negligible, as most is consumed in the household or given away. This source of income is therefore not included in the estimate of income from sale of crops.

An estimate of the value of produce consumed is difficult to make, since annual yields vary widely, and many households report no yields at all during the last 3-4 years. However, a positive estimate (no costs deducted) is indicated in table 3.1. It is based on information about average yields and cultivated areas collected during the farming household survey.

Most households sell some livestock, although none can be characterized as commercial projects. Farmers typically sell one to two goats a year and an ox once every 2-3 years to cover expenses for school fees, clothes, social obligations (marriage, funeral). The average annual income earned from the sale of livestock varies from 200 P to 2500 Pula.

The annual income generated from drought relief for the 25% of the households concerned is 360 Pula.

Firewood collection is reported to earn between 12% and 50% of the annual income for the 12.5% of the households concerned. One farmer earned 500 P per year from the sale of wooden chairs while another reported a similar income from the sale of traditional medicine. Sale of thatching grass may fetch 2-5 Pula a bundle but is only practiced by 2-3 households on a more commercially oriented level.

The main source of annual income is remittances from absent family members working in towns or in the mines in South Africa. 80% of all households receive some income in the form of remittances. Out of this percentage, 34% have a relative working in a mine in South Africa.

Table 3.1 Income sources in Moshupa South extension area

Source of income	Percentage of households engaged in activity	Income from activity	
		Pula	% of annual income
arable produce - sold	17.5	12	0.4
arable produce - consumed[1]	100	138	4.6
sale of smallstock	95	262	8.7
sale of cattle	27.5	198	6.6
Drought relief	25	90	3.0
remittances	80	2218	74
sale of firewood/other	12.5	80	2.7
annual income	TOTAL	2998	100

[1] Based on 1994-95 BAMB producer prices for grade 1 maize and sorghum, supposing each household cultivate 2 ha of maize and 2 ha of sorghum and achieve an average yield of 100 kg/ha for each crop. No costs deducted.

It must therefore be concluded that the main source of income originates from outside the Moshupa South AEA and is not related to the economic activities carried out by the population in the area directly. Any incentive to encourage increased agricultural production must take into account that arable and livestock production at present has very little financial importance in terms of annual income. It may therefore be more correct to see the role of agricultural production as reducing household expenses in terms of purchase of food rather than as an income generating activity.

This statement may seem to question the viability of the farming activities of the households in the Moshupa South AEA. It is therefore important to appreciate the social role of farming in the area and in Botswana as such. Although farming in a economic sense is marginal to other income sources, it still has an important role as employment provider, land management, reducing pressure in urban areas and preserving parts of the traditional Batswana culture.

Any feasibility study of the farming systems in the Moshupa South AEA must take these factors into consideration in order to capture the "real" importance of farming. However, the trend towards an increased urban population in Botswana, with fewer people engaging in arable farming and the small role crop production plays in the modern cash economy even in the rural areas, also affects the future potential for crop production in Moshupa South AEA in a largely unfavorable way.

3.3.1 Crop production system

The following description of production systems in Moshupa South AEA is based on information from a number of sources:

- Drought relief subsidy records from DAO and AD's office (1993-94 and 1994-95 season).
- Farm Management Survey information (FMS), Polokwe station (Macala, 1992).
- Survey of Agricultural Demonstration Farmers, Moshupa South AEA (1993-94).
- Survey of 40 farming households.
- Interview with the four farmers committees in the area.

The result of the farming household survey is summarized in annex C.

3.3.1.1 Crops

The dominant production system is based on the following crops: maize (var. Kalahari Early Pearl), sorghum (var. Segaolane), cowpeas, melons and pumpkins. Millet is not traditionally grown in the Moshupa South AEA and is only grown by a few farmers. Through the ALDEP programme, cashcrops such as groundnuts and sunflower are being promoted. Watermelons and "sweet reed" are occasionally grown as cash crops although the majority grow sweetreed for home consumption only.

Yields are generally low, averaging between 50 and 150 kg/ha for the grain crops (Macala, 1992). The reasons for the low yields are many and will be discussed in chapter 4. The production of grain crops in excess of household needs are seldom achieved and consequently little is sold commercially.

3.3.1.2 Ploughing

In the 1993-94 ploughing season, a total of 380 households benefitted from the Governments' ploughing subsidy scheme. The average hectarage ploughed was 4.15 ha which corresponded to about 40% of the cleared area (a total of 1578 ha). According to the records of the AD only a few farmers ploughed a larger area than the five ha which is the maximum area subsidized. Of the total area ploughed in Moshupa South AEA, one quarter was ploughed by tractor, and the remaining by animal draught power. According to the AD, only 8 tractors were operating in the area during the ploughing season, of which five belong to households in the area, and three came from other locations (Kanye and Jwaneng). This implies that each tractor on average ploughed 50 ha.

The ploughing statistics for the 1994-95 ploughing season were quite similar in terms of numbers of farmers and area cultivated.

Farmers generally plough according to rainfall events. They are interested in ploughing as early as possible, when they consider the rainy season has genuinely started and rainfall will be steady from that time onwards. However, many households are delayed in ploughing until after New Year. The factors which influence the timing of ploughing and planting will be discussed in chapter 4.

3.3.1.3 Planting

The vast majority of farmers broadcast seeds. Only 13% of the number of households benefiting from the Governments ploughing subsidy scheme also rowplanted their fields in the 1993-94 season. A similar proportion of farmers received Government subsidy for rowplanting in the 1994-95 season (11%). The reasons why broadcasting is more common than rowplanting are discussed in chapter 4.

The area rowplanted per farmer is small, amounting to 2.4 ha on average. However, variations in area rowplanted exist between the 14 households using tractor, which planted an average of four ha and the group using animal draught power, which only realized 1.8 ha on average.

Whereas the farmers who used tractors to plant in general rowplanted the total area cultivated that year, farmers using animal draughtpower to rowplant only planted about half the area this way and broadcast seeds on the other half or left it uncultivated.

Households which broadcast seeds basically combine the ploughing and planting operation in one operation, having broadcast seeds a few hours before ploughing them in the soil. Farmers using rowplanters separate the two operations, and often require more time to complete the land preparation and planting operations. In both cases, it has been observed that planting often occurs late (after several planting opportunities have occurred) and thereby does not utilize the total soil moisture content optimally. The reasons for delayed planting operations will be discussed in chapter 4.

3.3.1.4 Weeding

Weeding is generally done about 30-50 days after planting. Farmers who rowplant crops may use a cultivator when plants have reached a height of 15-20 cm to loosen the soil between rows and suppress weed regrowth. Farmers believe that too early weeding, while the plants are small may damage the crops, if hot soil, loosened during weeding is brought in contact with the plant stems.

3.3.1.5 Soil fertility

Chemical fertilizer is virtually unused. A high proportion of farmers report to use some sort of kraal manure application (50% within the last five years). However, the rate of application is very low (0.5-4 donkey cart loads pr. ha, average: one donkey cart load pr ha) and infrequent (every 3-5 years). The fertilizing effect of this application is rather limited. Crop residues are not incorporated into the soil as mulch, but normally eaten by livestock in the field. The grazing of crop residue in the field does entail a certain fertilizing through the droppings of grazing animals.

3.3.1.6 Birdscaring

Birdscaring becomes a very important and time-consuming activity after the sorghum plants have started grain filling. It requires presence in the fields most of the day, with the hours before sunrise and after sunset being the most critical periods. Due to labour shortage and engagement in other activities this is often not achieved and birdscaring is not optimal. Farmers report that they are reluctant to plant sorghum too early compared with other farmers, as they fear their field will be more prone to bird damage if their crop matures faster than the majority in the area. In the 1994-95 season bird damage was minimal in the Moshupa South AEA.

3.3.1.7 Pest and disease control

Very little pest control is done traditionally. At present assistance can be requested from the Plant Protection Unit at the Regional Agricultural Office in Kanye or at the District Office in Moshupa through the AD. The technical staff often has to respond to outbreaks of pests in many areas simultaneously, and pest control may therefore be delayed. Aphids are not a serious problem if heavy showers occur to wash them off the plants, while armyworm, which was a serious problem in the 1994-95 season is controlled with Alphametrin.

3.3.2 Livestock production system

All households in Moshupa South AEA are engaged in livestock production. Almost all households (95%) rear smallstock (mainly goats), whereas the percentage of households with cattle is lower (see table 3.2).

The management system can be classified as "traditional", aimed at fulfilling certain cultural obligations (brideprice "Lobola", food at weddings and funerals) and occasional sale to cover expenses for school fees, clothing, food, etc. As such, no commercially oriented production, with the improvements in productivity and investments associated with this kind of production, takes place.

Table 3.2 Livestock ownership in Moshupa South AEA.

no. owned		Cattle/calves	donkeys	goats/kids
cattle or donkeys	small-stock	% of households	% of households	% of households
0	0	15	20	5
1-5	1-10	40	30	5
6-10	11-20	10	22.5	37.5
>10	>20	35	27.5	52.5

The average and total herdsize is shown in table 3.3

3.3.2.1 Livestock population and grazing requirement

The following calculation of the number of Livestock Units (LSU) in the planning area (Moshupa South AEA and adjacent grazing area) is based on the assumption of one LSU being equivalent to a 450 kg head of cattle. The calculation of LSU's for different animal species is based on the average weight of each animal species compared to this figure (eg. an ox or a bull weighing 550 kg equals roughly 1.2 LSU, since 550/450/=1.2). Assuming a cow equals 1 LSU, a calf equals 0.30 LSU, bulls and oxen equal 1.2 LSU each, and heifers and tollies to equal 0.67 LSU each, this totals 2988 LSU. Adult smallstock is equivalent to 0.1 LSU while kids equal 0.02 LSU each and gives together with donkeys at 0.85 LSU and donkey foals at 0.40 LSU an additional 2541 LSU. The total number of LSU in the planning area is therefore estimated at 5529 LSU (see table 3.3).

The Dry Matter Intake (DMI) by the livestock population, based on a daily intake equal to 2.5% of empty liveweight, is estimated at 0.025*365*5529 = 50452 kg DM per year.

3.3.2.2 Cattle production.

The cattle production system is characterized as extensive, with cattle grazing without herding for most of the time in the Polokwe hills. The total cattle population (cattle and calves) is estimated at 3720, based on the farming household survey. The average number of cattle owned is 7 per household, varying from 0 to 28. The total cattle figure is five times larger than the figure recorded by the veterinary department during the November 1994 animal stock census. The veterinary extension agent covering the area points out that some farmers are reluctant to vaccinate their cattle and others vaccinate their cattle at other cattle crushes in the region (Kanye, Mmakgodumo dam, Moshaneng) which may help explain the discrepancy in figures. At least 80% of the farmers suffered heavy losses of cattle during the drought in the 1980s and 1991-92. On average farmers lost 15 head of cattle, with a total loss for the Moshupa South AEA of 4900 beasts. It should be pointed out that reliable livestock figures are notoriously difficult to obtain, and the mentioned figures can only be regarded as approximate.

Table 3.3 Livestock numbers in Moshupa South AEA.

	average per household	total livestock numbers for Moshupa South AEA	total LSU for Moshupa South AEA
bulls	0.6	250	305
bulls (improved)	0.1	50	61
cows	3.2	1290	1290
heifers	0.7	310	208
tollies	0.9	370	248
oxen	1.2	480	586
calves	2	970	291
donkeys	5	2020	1717
donkey foals	2	550	220
goats and sheep	12	4640	464
kids	21	8530	140
TOTAL			5529

The grazing area is divided into sub-sections according to the sub-extension areas. The boundaries between the sub-grazing areas are flexible, and farmers share the grazing areas in drought periods to some extent. Cattle are allowed into the lands area after harvest to forage on crop residue in fields. The positive effect of the fodder made available in this way is somewhat constrained by the negative effects the cattle grazing in the fields may bring, such as:

- import of (seeds of) weeds
- making cattle used to feeding in fields and thus encouraging possible crop damage during crop season by farmers who do not send their cattle to the grazing area.

Herding is limited to collecting cattle for watering and releasing them into the grazing area afterwards where they are allowed to roam and forage on their own all day. It is estimated that cattle herding takes an average of three hours per day (2 to 4 hours).

Milking cows are kraaled at night separate from their calves. They are milked in the mornings only. They are released after milking and move back into the grazing area for grazing. Only tollies and adult animals are allowed into the grazing area for fear of predators. Milk production for domestic use (excluding milk for calves) from lactating cows normally takes place for six months during the rainy season, and the average production varies between 3.5 l/day in the beginning to 1.5 l/day at the end of the lactating period. Milk is taken for domestic use, but generally not sold on a commercial basis.

Oxen are used as draughtpower for ploughing by 55% of the households. Cattle are reported sold by 27.5% of the households and average prices are 675 Pula (all cattle categories). Hides are used for mats and are occasionally sold.

3.3.2.3 Smallstock production.

The total smallstock population (mainly goats and kids) is estimated at 13170, with 1/3 being mature goats and 2/3 being kids. Smallstock herding is not always optimal and is limited to watering animals in the morning, taking them to the grazing areas within the lands area and kraaling at night. Herds are often found roaming freely around the extension area. They mainly graze in uncultivated areas during the day (either between fields or in hilly areas unsuitable for crop production) although crop damage is a familiar problem when goats enter fields during the cropping season. They return to the homesteads by themselves at dusk where they are kraaled for the night. Approximately half of the farming households own more than 20 goats, with 12.5% of the households owning more than 60 goats. The number of goats per household varies from 6 to 126 with an average of 33. The households adjacent to the Polokwe hill escarpment are vulnerable to attacks by predators kill kids. Farmers are forced to kraal the kids in roofed huts, which may still occasionally be insufficient to keep baboons out. Goat herding is usually the responsibility of women or children in the households, and normally requires three hours per day for herding, watering and milking.

Only a few farmers milk their goats for domestic use, in most cases small amounts for tea. Hides are frequently sold as mats.

3.3.2.4 Donkey production.

Donkeys are used as draughtpower for ploughing by 35% of the population. A much larger percentage of the population actually owns donkeys, namely 80%. Households which do not use donkeys for ploughing use them as draughtpower for scotchcarts to transport water, crops and manure. The total donkey population is estimated at 2570, being composed of 2020 adult donkeys and 550 foals. The donkey population was also severely affected by previous drought periods. Based on the farming household survey, it appears that each farmer on average lost five donkeys and a total of 1290 donkeys died during the drought periods. The average herd size is six and varies from 0 to 19.

3.3.2.5 Livestock watering points

Several important watering points are found in the area, notably in the river valley of the Monname river (Kgotla wells), where many wells have been constructed for year round livestock watering (see also figure 2.5). Likewise, 9-10 wells are found in association with the Sobe river in a valley behind the Polokwe escarpment. The wells contain water in most years, although in low rainfall years farmers explain they have to deepen the wells to reach water. Although each well belongs to an individual, several farmers will be using one well. Farmers from neighbouring areas are permitted to make wells in the area or use the wells in drought periods. It is estimated that 50 farmers water their livestock at Sobe wells and a similar number of farmers at Kgotla wells. A survey from April 1995 reveals that at least 428 LSUs (mostly cattle) are being watered at the Tlhokwane dam. Seasonal water sources are found throughout the Moshupa South AEA in river and stream beds, where traditional wells are dug in the dry river beds and fenced with thorn branches.

New waterpoints are planned or under construction:

- The construction of a livestock watering reservoir in the Polokwe/Mmakgoudoumo area in 1995. Farmers in the Polokwe area and neighbouring Mmakgoudoumo area have requested to use water from a borehole located at Mmakgoudoumo dam for livestock watering. The request has been approved and a reservoir will be constructed on top of Lotakane hill, 3.5 km from the borehole. About 50 farmers from the two areas will form a syndicate and manage the livestock watering. The project is scheduled to be complete at the end of 1995.

- The construction of a dam using drought relief funds at the Sobe well site (D12) has started in June 1995. The dam is estimated to have a capacity of 9000 m^3.

3.3.2.6 Inputs in livestock production

Farmers rely on the vaccination campaigns organized by MoA for vital vaccinations (H.A.), although the farm survey shows that only a fraction of animals are brought to the cattle crushes. In addition to this, households often provide other health care inputs, tick grease being the most common (see table 3.4). The average cost of inputs per household in Moshupa South AEA is 36 P/year. The most used sources of inputs are the Cooperative in Moshupa and the LAC in Kanye.

Table 3.4 Use of inputs in livestock production

Type of input	percentage of farmers using input	average cost/household (Pula)
Salt	57.5%	14
bonemeal	37.5%	21
terramycin	57.5%	11
tick grease	75%	15
other	20%	27

3.3.2.7 Toxic plants

One constraint to cattle grazing is the presence of the toxic "Mogau" (*Dichapetalum cymosum*) which is reported to have caused death of cattle in the Polokwe hills. It is mostly found in the rocky part of the area with shallow soils, but the distribution can not be related to easily defined areas. Mogau presents the most serious problem in the dry season and during drought periods, when cattle are attracted to the green plants. Farmers disagree about the frequency and number of cattle killed by the plant but agree that cattle are killed. An estimate of mortality numbers is 2-4 heads of cattle per year.

The seeds of the tree species *Ochna pulchra* are reported to be poisonous, although information from Zambia contradict this statement (Palgrave, 1990).

3.3.2.8 Summary on livestock production systems

Livestock production is an important activity for all households in Moshupa South AEA. It generally requires six hours per day for herding and watering of all animal classes. It is a more economically important activity than crop production and generates a modest income for most households. Very few farmers sell livestock to BMC due to lower prices compared to the local market. The use of inputs in livestock production is very limited and animal health care is mainly limited to Government vaccination campaigns.

3.3.3 Classification of farming households

In order for extension recommendations to have the greatest effect, they must be targeted to farmers who have the most urgent need for the specific recommendations as well as the capacity to adopt them. Consequently, a targeting of extension recommendations is only possible after the farming households have been grouped according to their needs and capabilities. The first step in a classification exercise is normally to identify the different farming systems and production systems in the area. This step was covered in sections 3.3.1 and 3.3.2. It follows from this analysis that all farming households follow the same basic farming system:

- **Mixed subsistence farming**

composed of two major production systems:

1) **Rainfed traditional crop production.** The characteristics of this production system are as follows:

* main grain crops: sorghum (var. Segaolane) and maize (var. Kalahari Early Pearl)
* management system: traditional

* planting method: broadcasting/intercropping
* use of inputs: limited to kraal manure
* planting dates: often after New Year
* weeding: after 50 days
* plant population: low (15.000 plants/ha)

2) communal grazing area livestock production. The characteristics of this production system are as follows:

* animal species: cattle, donkeys and goats
* management system: traditional
* use of inputs: animal health and salt/bonemeal

The differences in crop yields and animal production which can be found between households are mostly related to the resources available in the household. It is therefore decided to base the classification of farmers in the Moshupa South AEA mainly on resource availability. It expresses which resources are potentially available in the household, and which could be used to adopt changes in the present farming system.

3.3.3.1 Choice of parameters

The three basic resources available to all households are: land, labour and capital. The farming system followed by farmers involves a specific combination of these three parameters. It has therefore been decided to group the households in Moshupa South AEA according to the availability and quantity of these resources. A few comments are necessary to put the classification into perspective. Although it is assumed that the availability of these resources is virtually independent of major biases, a closer look indicates that this is not entirely true. One major factor, the drought periods in the 1980s and during 1991-92 has had a large impact on both the crop production and the livestock production systems. Firstly, it has decimated the livestock herds of many households, leaving them without draughtpower and hence forcing them to change strategy regarding the area that they are able to cultivate, the planting method in some cases, and the choice of planting period. The drought has also had an indirect effect on the area cultivated, since the Government ploughing subsidy scheme, which is limited to an area of five ha (1994-95) indirectly encourages farmers not to exceed this area. The livestock production system was directly affected by the decimation of livestock numbers, especially cattle while smallstock generally are more drought resistant.

However, although the households in the Moshupa South AEA have been severely affected by the droughts, and the present situation probably represents a sub-optimal system, it is nevertheless a typical illustration of farming conditions in Botswana, where periods of above and below average rainfall alternate. Another justification for using these parameters is, that virtually all households have been affected by the drought in a similar way, and the classification is therefore not biased towards certain individual or groups of households.

The following definitions of parameters have been used:

Capital

This refers mainly to animal ownership (smallstock and cattle) with adjustments made for other sources of income and capital ownership (implements). Donkeys are not included in the calculation, as they are not traded as regularly as cattle and goats, which are to be considered the "savings deposit" for farmers. The prices for cattle quoted during the survey are higher than those offered by BMC (average of 675 P (all categories), as opposed to 400-600 P per animal at BMC). Goats are sold at an average price of 100 P, mostly around christmas, to local buyers. The following conversion factor is used:

One Animal Unit[2]: one head of cattle or six goats

If the annual income level of a household, regardless of animal ownership, exceeds 3500 P it is automatically included in the richest group of farmers.

Labour

The available labour in the household has been calculated based on information regarding the household composition. It is only concerned with present household members, and does not take into account the contributions which may be made by absent household members. It should be remembered that these contributions may be very significant and even crucial, especially for households with less all year round labour availability, such as old couples, female-headed households, etc. For many of these households, cultivation would not be possible, if their absent household members, such as sons or husbands would not assist them with labour for ploughing and planting. The labour force is calculated as follows:

one labour unit: one adult male or female (> 18 years)
0.5 labour unit: one adolescent (15-17 years)
0.2 labour unit: one child (10-14 years)

Area cultivated

The area cultivated also constitutes a resource that contributes to agricultural production. It varies from year to year, as a result of rainfall and Government subsidy schemes. It was originally intended to use this parameter in the classification since it appears to be very relevant in other parts of Botswana. However, it appears that there is very little correlation between the area cultivated and the availability of other resources in the households, possibly due to the effect of the Government ploughing subsidy scheme as discussed above. This parameter was therefore omitted from the classification exercise, and is only mentioned when relevant.

The two parameters: capital and labour have been divided into three classes each, to distinguish between different resource levels. Similarly, the ownership status of the draughtpower used for ploughing and planting has been classified into two groups (see table 3.5).

Table 3.5 Limits between farming household groups

Labour units in household	L_1: 0-2	L_2: 2.1-3	L_3: >3
Capital/number of animal units	C_1: 0-10	C_2: 11-30	C_3: > 30
Draught power[1]	D-: not owned	D+: owned	

[1] Refers to the ownership status of draught power used for ploughing in the 1994-95 season

The following farming household groups have been identified in Moshupa South AEA (see also table 3.6)

FARMING HOUSEHOLD GROUP P1 (20%)

This group is composed of the poorest households in Moshupa South AEA as far as availability of agricultural resources is concerned.

The P1 group consists of young households or middle-aged to old couples with less than three Labour Units present in the household.

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[2] This unit represents an approximate value of 6-700 Pula. It should not be confused with the term Livestock Unit (LSU) which is used in carrying capacity calculations.

Only 37% of the P1 households own the draught power used (in all cases donkeys), whereas the remaining households all had to borrow or hire draught power to plough. The area cultivated is generally very small (average area: 2.1 ha).

Table 3.6 Farming household groups in Moshupa South AEA

description of household groups	P1	P2	W1	W2	R1	R2
percentage of households in group	20	10	15	20	17.5	17.5
main characteristics	C_1, L_1, D-	C_1, L_2, D-	C_2, L_1, D+	C_2, L_2, D+	C_3, L_1, D-	C_3, L_2, D+
average annual income	1859	2428	2553	1688	5234	3481
remittance as % of annual income	55	87	61	47	89	74
% of households without own draught power	62.5	75	33	50	57	14
average no. of labour units per household[1]	2.1	4.2	1.7	3.3	1.6	3.9
average area cultivated (ha)	2.1	2.9	3.2	3.8	3.3	4.6

[1] see definition of Labour Unit in text above table 3.5

Remittances form the main part of the annual income (90%) and sale of smallstock form the remaining portion for 62.5% of the households. 37.5% of the households receive no remittances, because of the young age, which means that no adult children are working away from home and send back money. These households derive their annual income from sale of smallstock and wages from drought relief activities.

Only 12.5% of the households achieved a yield in the 1993-94 crop season and none of the P1 households have ever sold grain produce.

The low level of labour available on a year round basis and the lack of draught power put serious constraints for crop production. The crop production of the P1 households suffers from delayed planting (after New year, using between 1 and 3 planting occasions), late weeding (after 50 days), crop damage by pests and diseases, low plant densities and low soil fertility.

FARMING HOUSEHOLD GROUP P2 (10%)

The P2 group of households is basically the same as the P1 group, as far as animal capital is concerned, but is in a better position concerning labour availability. This is due to the older age of the household, which means that several adolescent or adult children are present in the household. The higher number of Labour Units partly explains the slightly higher area cultivated (2.9 versus 2.1 ha).

The higher number of adult children also increases the share of remittances, which represents close to 90% of the annual income.

None of the households reported to have harvested anything in 1994 or to have ever sold grain produce.

The P2 households face similar constraints as the P1 households, but they are able to perform arable operations more timely than the P1 households due to a higher labour availability. Crop production suffers from late planting (after New Year, using 1 planting occasion), late weeding (after 50 days), crop damage by pests and diseases, low plant densities and low soil fertility.

FARMING HOUSEHOLD GROUP W1 (15%)

The W1 households are characterized by a higher level of animal capital ownership. The higher level of animal units is caused by considerable smallstock herds, which vary from 11-64 goats, and higher number of cattle (3-12 adult cattle) than the previous two groups. 50% of the W1 households in this group are young female headed households with a husband working in the mines in South Africa. Remittances play an important role in the annual income (average: 66% of annual income). The annual income is slightly higher than in the P2 group.

The number of labour units is low (<3) and poses a constraint for crop production. Most households in this group own the draught power used (66% of the households) which were donkeys in all cases. This is not reflected in the ploughing dates for the 1994-95 crop season, which was characterized by one major rainfall period around New Year, which most households, regardless of livestock status, took advantage of.

Although in possession of draught power, the low labour force and/or absence of adult males may not permit this group to utilize the first rainfall events. They may plant after New year, using 1 rainfall event or before New Year, using up to three rainfall events. Other constraints are late weeding, low plant densities, crop damage by pests and diseases and low soil fertility.

FARMING HOUSEHOLD GROUP W2 (20%)

The W2 households also own more than 10 Animal units and in addition have less labour constraints in comparison with the former group. The households often consists of a middleaged-old couple with one or two adult children at home. The average area cultivated in 1993-94 is higher than for the former groups (average area: 3.8 ha). 50% of the W2 households own the draughtpower used, while the remaining 50% of the households had to supplement (37.5%) or borrow (12.5%) draughtpower. The draughtpower used by 87.5% of the households was oxen. Remittances contribute 47% of the annual income while sale of smallstock and firewood contribute the remaining portion.

In years with several planting opportunities, this group of farmers can utilize the first rainfall events (planting before New Year, using one to three rainfall events). Most operations occur timely (weeding after 30 days), but the W2 households still face agricultural constraints, such as crop damage by pests and diseases, low plant density and low soil fertility.

FARMING HOUSEHOLD GROUP R1 (17.5%)

The 17.5% of the households belonging to this group can be divided into two groups: 10% owning less than 20 animal units, but with a high annual income (>3500 P) and 7.5% owning more than 20 animal units.

Half of the households in the first group are young female headed households, with an absent husband working in the mines in RSA. They are very deficient in terms of labour and animal capital, but are still considered belonging to the richer segment of the population because of the substantial income from remittances which would enable them to hire labour and draughtpower. The other 50% of the households in the first group also receive relatively high contribution in the form of remittances. The area cultivated by the young female headed households is quite small compared to the average for the group (average area: 1.42 ha compared to 3.3 for the group as a whole). None of these R1 households own the draughtpower used.

The 7.5% of the R1 households who own more than 20 animal units own the draught power used, which is donkeys for 5% and oxen for 2.5% of these households.

Due to their draught power ownership or income status these households are expected to be able to utilize the first rains of the season. However, the deficiency in labour may force them to either plough and plant using several occasions, in order to complete the area cultivated. The main agricultural constraints are delayed planting, delayed weeding, crop damage by pests and diseases, low soil fertility.

FARMING HOUSEHOLD GROUP R2 (17.5%)

The 17.5% R2 households either own more than 20 animal units (15%) or have an annual income higher than 3500 Pula (2.5%). The average area cultivated is high (average area: 4.6 ha). 57.5% of the R2 households use rowplanters, which is the highest percentage of all household groups. The R2 households are generally the most well-endowed in terms of labour and draughtpower availability. They are expected to utilize the first rainfall events of the season and finish ploughing and planting soon after the start of the rainy season. The main constraints to crop production are crop damage by pests and diseases, low plant densities and low soil fertility. The old age of the household heads may decrease acceptability of recommendations.

Households in both groups R1 and R2 are expected to be able to invest modest capital in farming inputs, notably fertilizer on account of the high annual income.

Annex G contains a summary of the main parameters which are at the base of the classification.

3.3.3.2 Summary of farming household classification

The classification reveals that the farming population in Moshupa South AEA is heterogenous in terms of resource availability. The exercise also demonstrates that self-sufficiency in one type of resource (eg. labour) does not necessarily imply that another resource (eg. draughtpower) is also available. Factors which were not analyzed in the household survey and are more difficult to discern, such as farmers attitude towards innovations also play a role when it comes to possibilities for adopting recommendations. Changes in resource availability can be quite dramatic as the recent losses of draughtpower for a majority of households illustrates, and will obviously affect any classification concerned with resource availability. The classification illustrates the current farming conditions and provides a reference for the development of improved farming recommendations.

3.4 INFRASTRUCTURE AND GOVERNMENT SERVICES

3.4.1 Roads and tracks

The Moshupa South AEA is dissected by the newly tarred Moshupa-Kanye road (from north to south), which is a major national road. Seen on a national and even regional level, the transport situation as well as access to major markets and suppliers must therefore be considered as very favorable. However, these advantages are somewhat unimportant in the daily life of farmers, as very few inputs are used and only little produced for sale at present. Indeed, the main lines of transport are the dirt tracks radiating from Moshupa towards the Polokwe hills. Few tracks run across the Moshupa South AEA in a east-west direction. It takes 15 minutes by car to reach the Polokwe hills from Moshupa.

3.4.2 Government institutions and services

There are only few Government institutions found in the Moshupa South AEA itself, which is primarily a Lands area. Locally the following services are found:

Primary school:	Polokwe
Village Development Committee:	Polowe
Agricultural Demonstrator:	Polokwe
Veterinary Assistant:	Moshupa
Cattle crushes:	Kgotla, Polokwe, Sobe
Health post:	Mathlakola

Many Government services used by the population of the Moshupa South AEA are presently provided from Moshupa, which is planned to become the sub-district center for the northern part of Southern District. These services include sub-Land board, post office, police station, education officers, community development officer, non-formal education officer. The closest agricultural institutions are:

District Agricultural Office	Moshupa
Regional Agricultural Office	Kanye
Livestock Advisory Centre	Kanye
Botswana Agricultural Marketing Board	Moshupa, Kanye
Livestock officer	Kanye

3.5 EXISTING PLANNING INFORMATION

The Moshupa development plan, 1992-2012 (DTRP, 1992) is mainly concerned with the future development of the Moshupa village *per se* in terms of future needs for health, educational, residential and industrial facilities. It does include a section on agriculture, but this is only concerned with horticultural gardens in the village itself. The most relevant information for the Moshupa South AEA concerns the land required for future residential areas south of the village and will be discussed in section 4.1.1.2. Other sectors of importance regard the increased need for fuelwood, construction material (thatching material and poles) which will have a significant impact on the physical resources of the area, but are difficult to quantify at present.

3.6 DATA FOR FINANCIAL ANALYSIS

The following information will be used in the financial analysis of the land use plan. The information comes from several sources, with BAMB (1994) being the most important.

<u>value of produce:</u>

1 kg sorghum:	0.34 P
1 kg maize:	0.33 P
1 kg millet:	0.34 P
1 kg cowpeas:	0.60 P
1 kg groundnuts (shelled)[3]:	0.85 P

<u>variable costs:</u>

1 kg Single Superphosphate fertilizer (10.5%):	0.55 P
1 pocket of seeds:	2.50 P
1 spraying session with alphametrin[4]	20.0 P

[3] Based on 50% produce of grade 2 quality and 50% of grade 3 quality

[4] based on a unit price for 2 l. of 320 Pula at Clover Chemical Ltd. (pers. comm., October 1995)

CHAPTER 4

LAND USE PROBLEMS AND OPPORTUNITIES FOR CHANGE

This chapter presents the main land use problems which have been identified in the Moshupa South AEA along with suggested options to improve the existing situation.

4.1 LOW CROP YIELDS

As mentioned in section 3.3.1.1, the average crop yields in Moshupa South AEA are very low (50-150 kg/ha) for maize and sorghum.

4.1.1 Constraints

Several factors interact to explain the low yields:

4.1.1.1. Constraints related to the natural environment

1) Low and irregular rainfall.

The average annual rainfall is about 530 mm, with large variations from year to year (from 100 mm to 1000 mm). The rainy season is characterized by long dry spells, which affect crop yields negatively.

2) low soil fertility

The soils are generally poor in nutrients (phosphorus, nitrogen), organic matter and become increasingly depleted due to the crop production system which does not systematically rebuild the fertility status. The area with soils with low to medium soil fertility status (Phosphorus level of five ppm: Chromic and Ferric Luvisols) only covers 30% of Moshupa South AEA. Soils with low soil fertility status (Phosphorus level of 3-5 ppm: Ferralic Arenosol) cover 8% and soils with very low soil fertility status (Phosphorus level of 1-3 ppm: Luvic Arenosols, Stagnic Luvisols, Haplic Luvisols, Calcic Luvisols, Eutric Leptosols and Eutric Regosols) cover 62% of Moshupa South AEA.

Chemical fertilizers are virtually unused save for a few Government initiatives in the 1980s. A high proportion of farmers report some application of kraal manure (75% of all households). However, the rate of application is very low (average dosage: one donkey cart load per ha) and infrequent (every 3-5 years). The fertilizing effect of this application is rather limited. Crop residues are not incorporated into the soil as organic matter, but normally eaten by livestock in the field. The grazing of crop residue in the field does entail a certain fertilizing through the droppings of grazing animals, but the scattered positive effect is probably not comparable to the harmful effect of the weed infestation introduced by the same mechanism.

3) Poor soil structure and shallow soils

A large proportion of the soils are shallow or contain gravel layers in the top 50 cm. These soils are cultivated but are far from preferable, as they cause problems of cultivation and are more prone to erosion. The shallow soils overlying granitic parent material or with an impenetrable nodule or gravel layer cause problems for root development. An increase of the organic matter content could improve nutrient availability, infiltration of rainwater and reduce soil erosion. However, the small quantities of organic material returned to the fields in the form of manure and the present crop residue management is not conducive to such an increase.

4) Damage by pests and diseases

It is reported that 57.5 % of the households in Moshupa South AEA did not harvest anything from their field in 1994 due to damage caused by pests (aphids, armyworm, corncricket, birds). Mammals (foxes, porcupines, baboons) mainly destroy watermelons but can also damage grain crops. Crop damage by livestock is also common. Pest control is traditionally not done and birdscaring is often not efficient.

5) Climatic hazards

Hail and frost are two additional constraints to crop production. The hailstorm of 31.03.94 was very intense and destroyed almost all crops in the Polokwe area (25% of all households in the Moshupa South AEA). The planning area is exposed to early frost, and late planted crops are often prone to frost-damage in June.

6) Presence of noxious weeds.

The weed density in fields is high and compete with crops for moisture, nutrients and light. Noxious weeds include "Mokhure" (*Datura ferox)* and "Motlho" (*Cynodon dactylon*). Weeding is often late or inefficient.

4.1.1.2 Constraints related to management

1) poor crop husbandry

A variety of sub-optimal crop management practices were observed in the data collection phase. Some of the main problems observed are:

- poor ploughing: ploughing at irregular depths and uneven surfaces causing water logging in some parts of the field, increasing gully formation and uneven germination
- late planting: planting after New Year, missing first rainfall events and increasing risk of frost damage
- poor germination: due to faulty planters or poor ploughing, resulting in uneven plant population
- low plant population: well below the recommended plant densities (35-50.000 plants/ha for sorghum and 15-25.000 for maize) contributing to low yields.
- poor weeding: fields weeded late or not properly
- inefficient birdscaring: birdscaring only done part-time
- no recycling of nutrients: very infrequent manure application

Two important operations warrant further analysis:

- <u>a high proportion of farming households broadcasting rather than rowplanting</u>

There may be several explanations for the low proportion of farmers rowplanting:

- many farmers lost their draught power during the drought of the 1980s and more recently in 1991-92.
- Few tractor available for timely planting.
- farmers prefer broadcasting, because it is combined with ploughing, thus less labour demanding than rowplanting.
- farmers do not have access to rowplanters.
- broadcasting allows quick response to planting opportunities.
- broadcasting allows simultaneous planting of different crops with different growth requirements. This diminishes the risk of total crop failure due to drought and diseases and therefore improves food security.

- late ploughing and planting

The following factors have been observed to cause delay in ploughing and planting operations:

- the animals used as draught power need to regain their condition after the dry season
- animals need to be brought to the fields from the grazing area and to be (re)trained to plough satisfactorily.
- on the heavier soils the first few showers may not provide adequate soil moisture for ploughing, as infiltration rates can be very low after the dry season (in loamy soils with low organic matter content, surface capping may cause significant amount of surface run-off). The first rainfall events, which may appear sufficient for seed germination, are therefore not utilized.
- other engagements may also delay the farmers in completion of the ploughing operation at once, as they may be required to plough for friends or relatives at the same time or may be engaged in drought relief activities.
- many households depend on absent family members to assist them with ploughing operations, especially female-headed households and those consisting of old people. They must therefore wait for sufficient labour before ploughing. This often correlates with the christmas season, when schoolkids and migratory workers return to their villages.
- households using hired tractors to plough for them, may need to wait until it becomes available.
- Households with insufficient draught power need to wait until friends and relatives can spare their animals and let them use them.

The area ploughed by animals per day is quite small (donkeys: 0.24 ha/day, oxen: 0.35 ha/day (Flint, 1986)), especially in the beginning of the ploughing season when they are weaker and not well-trained, and farmers may require several ploughing operations to complete the area they intend to cultivate in a particular year. Soil moisture is only adequate for ploughing for three to four days after a rainfall event, as high evaporation rates rapidly decrease moisture levels. Farmers therefore need two to three rainfall events to plough the entire field of four ha. Considering that there are only 15 planting days per year on average in Botswana (FAO,1994), the importance of timely draught power availability is clear.

2) labour shortage

The shortage of all-year round labour is a very serious constraint for more than half of the households in Moshupa South AEA. A particularly vulnerable sub-group consist of female-headed households which constitute nearly 50% of the households with low labour availability.

Although the problem is very real, the households nevertheless manage to cultivate and perform most agricultural operations. This is an encouraging fact, which illustrates that the households are able to deal with the constraints they face. However, the use of absent family members for critical operations, such as ploughing and planting, or the need to await a tractor to plough since not enough (male) labour is available makes it difficult for the households to adopt improvements in the management systems, which normally require increased care and precision during the whole crop growth cycle.

The labour shortage is caused by a number of factors. The more important are:

- increased school attendance by children
- the disappearance of communal work sessions ("beer parties") and the increased monetarization of the economy
- increased wage employment in other sectors
- lack of incentive to start farming due to frequent droughts and very low financial importance compared to other sectors
- the emigration of young farmers to other areas due to land shortage (see below)

Many of these factors interact on a national scale and are evidence of the changing structure of the economy of Botswana, from a traditional primary sector subsistence culture to a modern wage employment society. The trend is seen in many parts of the country and has a negative impact on the future of arable farming in Botswana.

3) draught power shortage

As in other parts of Botswana, households suffered heavy losses of cattle during the drought in the 1980s and 1991-92. At least 80% of the farmers lost cattle (average loss per household: 15 heads of cattle), with a total loss for of 4900 beasts for the Moshupa South AEA.

The serious reduction in livestock numbers has left 48% of the households without sufficient draughtpower to plough on their own. This group of households can be divided into three groups who manage to plough through different arrangements: 5% of the households borrow draughtpower from friends and relatives, 22% supplement their own draughtpower with borrowed or hired draughtpower while 20% rely on hired draughtpower. The households without sufficient draughtpower are more likely to delay ploughing and planting operations and might not be able to benefit from the first rainfall events of the season.

4) lack of implements

Only 33% of the households rowplant crops. 66% are not able to do so, due to lack of implements, broken planters or shortage of labour or draught power. Only five % of the households use harrows, which are therefore basically not used in the planning area. The lack of harrows can be due to a lack of interest, not enough time for that operation or lack of funds.

5) Lack of knowledge

Although households have great experience with production of the most common crops under the harsh natural conditions of a semi-arid environment, there is still a need to improve the knowledge of improved crop husbandry practices, conservation farming and alternative crops. The lack of knowledge concerning the relationship between fertilizer and weed growth and the lack of information concerning where to buy fertilizer and other inputs, prices and dosages, show that a genuine knowledge gap exists.

6) shortage of arable land

Two sources of land shortage are examined.

Abandoned fields

It appears at a first glance that only 26% of the Lands area is actually being cultivated (based on ploughing subsidy figures, 1993-94 and 1994-95). It could therefore be assumed that there is still sufficient land available in the area. However, interviews with the four farmer's committees of the Moshupa South AEA about this topic, reveals that on the contrary a *de facto* land shortage is the case. Much of the presently uncultivated land is in fact fields which have not been cultivated for a number of years. Through a survey of abandoned fields, in which location, area and reason for non-cultivation was recorded, it appears as that there are at least 130 abandoned fields, covering an approximate area of 775 ha. The fields have been abandoned between two and 50 years with an average of 12 years (see also annex D).

The most important reasons cited for not cultivating are (not prioritized):

1. Lack of rain. The poor rainfall conditions in the 1980s and 1991-1993 may have discouraged farmers to continue cultivation and rather engage in other income-generation activities, such as drought relief.

2. Poor soil fertility. In 11 cases (9%), the poor fertility status of soils, especially in land unit 2, the sandy area adjacent to the escarpment, was quoted as a reason for abandoning fields. In some cases the field had been passed on to a new owner, who was waiting to cultivate (see under point 6).

3. Fallow. In connection with the latter point, farmers will vacate their fields of low fertility status, and start cultivating another field to allow the first field to regain fertility. This practice is discouraged by the Land Board regulations concerning allocation of new fields. It states that farmers intending to cultivate a new field should first give up their claim to the first field. The practice of leaving part of the land fallow is well-known in many other countries, but becomes problematic as demand for land increases. It might be more wise to maintain the fertility level of the field by adding nutrients (manure, fertilizer) or crop rotation rather than the extensive, land-consuming practice of fallow.

4. Maintain land for future generations. In case farmers have given up cultivation for a shorter or longer period, they have little incentive to give up the right to the field completely, because of the increased demand for land. Farmers know that land is becoming scarce, and are therefore reluctant to give up land, since they want to ensure they can pass a field on to the next generation.

5. Lack of draught power. The reduction in herdsize by the recurrent droughts have left many households without complete draught power. In 10 cases (8%), farmers indicate that the lack of draught power prevents them from cultivating their fields. However, this statement should be contrasted with the fact, that many farmers with similar constraints still manage to cultivate their fields. In other words, this explanation may cover other reasons.

6. Waiting to cultivate. If the field has been inherited or otherwise passed on from one generation to the next, the present owners may still be engaged in other activities (ie. working in the mines in RSA) before taking up farming, or wait to acquire enough draughtpower to allow cultivation. This seems to be the most cited reason for not cultivating the field, although it is a general statement which could cover for other reasons. It was indicated as the main reason in 72 cases (56%).

7. Present owner unknown. In 51 cases (40%) the field had been abandoned for a variety of reasons (owner left the area, owner dead) and no present owner was known or unrecorded. This was especially true for the fields which have been left for more than 25 years.

8. Present owner old/sick. In 20 cases (8%) the original owner had stopped cultivation due to old age or sickness. In half of these cases, the field had not been passed on to any individual, and it is unlikely to be cultivated in the immediate future.

An attempt was made to quantify how many of the abandoned fields are likely to be cultivated in the future. The figure is based on different types of information (length of abandonment, explanation for abandonment, knowledge of present owner...) and should only be taken as indicative. A conservative estimate is that 50% (387.5 ha) will not be cultivated again in the present ownership situation.

It should be added that the issue of land abandonment is a very sensitive one, provoking many feelings to arise from the people involved. Farmers who do not have access to land request repossession of abandoned fields, while farmers with abandoned fields still consider it their property and do not accept interference.

Moshupa village expansion

Another source of land shortage is the future expansion of Moshupa village. Moshupa is experiencing rapid growth, with an estimate population of 16.000 in 1995 and 35.000 in 2012. The increased demand for residential and commercial plots has already caused an expansion of the

village southward into the Moshupa South AEA. In fact, most of the settlement south of the Kanye-Moshupa road (Jerusalem ward) is recent and occupies former lands area.
The future expansion of the village is foreseen to require a total of 1227 ha for residential purposes. A block of land measuring 367 ha in the Moshupa South AEA, centered around Jerusalem ward and Baitirile C.J.S.S. has been earmarked for this use, along with 20 ha for an industrial area adjacent to the Kanye-Gaborone road (the "N" plots in the development plan). The expansion into this area is not planned for the immediate future, as the main direction of development is **northward** from the village, in the opposite direction of the Moshupa South AEA (DTRP, 1992). Only at a later stage will the development take place in this area, to supplement the already existing residential land use in the area close to the road. The expansion will affect an estimated 15 arable fields covering 32.75 ha[5]in the Matlapa Lands area, which falls within land unit 4, consisting of mainly stoney and shallow Regosols.

The village expansion is not foreseen to cause any major problems in terms of loss of land as it will only affect 15 households. However, as is explained in the following sections, it will have a major impact through the increased pressure on the natural resources in the area.

Moshupa sub-Land Board has not yet started negotiations with the affected households, but are prepared to offer compensation in due course (pers. comm., 1995).

7) Cultivation of drought-sensitive crops

The main grain crops cultivated in the Moshupa South AEA are maize and sorghum. Maize is not very drought tolerant, and yields suffer heavily from periods of dry spells which often occur in January to March. Sorghum is more drought resistant, and produces higher yields with less moisture availability and more irregular rainfall than maize. However, maize is a favorite crop for its palatability, the fact that it can be harvested immature and that it is much less vulnerable to bird damage than sorghum.

4.1.1.3 Constraints related to institutions, infrastructure or market

The Moshupa South AEA AD post was vacant between 1992 and 1994, and was only filled with the present incumbent in November 1994. The agricultural demonstrator is often not available for extension work due to administrative responsibilities in connection with drought relief subsidies.

Present Drought Relief subsidies are given on the basis of the area cultivated and have no conditions concerning farming system or production attached. This system leaves many opportunities for abuse and does not encourage production.

BAMB producer prices are lower than those which can be realized locally. There is little incentive to sell to Government buyers.

Drought Relief activities often compete with agricultural activities for labour and time, as they are carried on in the rainy season.

Processing of ALDEP applications for implements and fencing material take very long to process and are sometimes handled by temporarily engaged staff (Field Assistants) rather than Ads.

The "Zimbabwe" planter, provided under the ALDEP program, is often malfunctioning (crushing seeds). This discourages farmers from adopting rowplanting.

Farmers without ploughs or planters cannot benefit from the Donkey cart program under ALDEP.

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[5] Based on 1:10.000 scale map interpretation (DSL, 1991)

4.1.2 Suggested options

4.1.2.1 Improved land utilization

Enlargement of cultivated area. At present only 33% of the Moshupa South AEA is cultivated. There are several options which could alleviate the problem.

Concentration of arable farming on the better soils. At presents, many fields are located on shallow or stony soils, while some deeper more loamy soils are not cultivated since these areas are claimed by households (this relates to the question of abandoned fields which was described earlier).

Relocation of fields to utilize the available land more rationally. At present, large areas of uncultivated areas separate fields in some areas (especially north of Monname river).

Repossession and reallocation of abandoned fields would allow young and interested farmers to start cultivation in the area. Land Board has the authority to repossess and reallocate uncultivated fields and would be able to immediately liberate 29 fields (22 % of all abandoned fields) covering an area of 186 ha by enforcing the 6-year rule. This assumes that the fields have been allocated by Land Board in the first place.

Concentration of cultivation on smaller areas. It appears that many households are not able to manage the areas cultivated properly. Due to labour constraints or engagement in other activities, crucial operations such as ploughing, weeding and birdscaring are not done in time or efficiently. The yields are consequently low and can not meet household requirements. It is therefore recommended that households use their resources more efficiently, by concentrating them on a smaller area. This would enable them to utilize the first rains for ploughing and planting, and carry out efficient crop husbandry during the crop growth cycle. This recommendation is especially relevant for the poorer segment of the community, particularly those deficient in labour resources.

Cultivation of the remaining portions of fields. Households reported to only cultivate 30-50% of their field in the 1994-95 crop season. The main reasons for not cultivating the total area is lack of labour and draught power or engagement in other activities. If the existence of a short term fallow in the field is a common trend, this might be an opportunity to introduce an improved short term fallow system as part of a 3-course crop rotation. In order for the project to be viable, it requires that farmers are able to control livestock movements in their field (see section 5.3).

4.1.2.2 Improved soil management.

The fertility maintenance should be improved, with frequent and sufficient application of manure or compost, ploughing in of crop residues, use of chemical fertilizer, adoption of agro-forestry practices. This will improve the soil in many ways (nutrient level, organic matter content, structure, water holding capacity). A high proportion of farmers are already using kraal manure, which increases the potential adoption of the recommendation since transport does not appear to be a problem, contrary to the situation in many other extension areas in the country. The present application rates are low and infrequent.

The use of old or composted kraal manure is recommended, since seeds have already germinated and died and the organic matter is decomposed to a stage that accelerates incorporation into the soil.

Gully erosion should be reduced by improved water conservation and soil conservation practices. Surface run-off should be reduced by slowing down water movement through tied bunding of fields, adoption of conservation crop management (ploughing across the slope, incorporate organic matter into the soil, agro-forestry practices). Farmers could plant strips of grass at edges of fields, on bunds, or even in the field (permanent or as part of the 3-course crop rotation described in section 5.3), to slow surface run-off and thus diminish erosion. Table 4.1 lists grass species which are well suited for either thatching or fodder.

Table 4.1 Thatching and fodder grass species

Use of grass	Scientific name	setswana name
Thatching	*Aristida meridionalis*	seri sa tau
	Eragrostis pallens	motsikiri
	Heteropogon contortus	seloka
	Stipagrostis uniplumis	tshikitsane
Fodder	*Panicum maximum*	?
	Scmidtia sp.	?
	Eragrostis sp.	?
	Cenchrus ciliaris	Modikangwetsi

The first three species listed as potential fodder grass species are already found in the area, and have proven well-adapted to the environment.

Farmers could harvest the grass strips (several times) during the rainy season to make hay of high nutritional value.

Farmers appeared positive towards the idea of introducing strips of grass in fields in erosion prone areas, especially economically valuable or fodder species. They indicated that the following points would need attention to ensure adoption by farmers:

1) seeds must be available. If the introduction of grass strips is viable, the Ministry of Agriculture should be responsible for the supply of seeds for the initial introduction.

2) Information on management techniques must be provided. Farmers should be assisted with information on 1) crop rotation, 2) hay cutting and storage, 3) "green manure" techniques and 4) crop husbandry of fodder crops.

4.1.2.3 Improved crop management

The adoption of improved crop management practices, including rowplanting, timely ploughing, efficient weeding, proper plant densities and improved pest and disease control should be stressed. The effect of these recommendations are analyzed in detail in section 5.1.

Increase motivation and knowledge

Many of the recommendations are well-known to farmers and extension staff. The reasons for the continued low levels of adoption and absence of positive effects in terms of increased crop yields are complex and involve many of the issues discussed in this chapter. It is likely that improved extension input will be beneficial. Frequent and continued communication with farmers, targeting of extension recommendations to different resource levels, creation of confidence and motivation and prompt response to requests are some keywords which characterize improved extension input.

Decentralization appears to be a central issue. If technical expertise and material was available at the extension area level, quicker and efficient response to pest and disease outbreaks, soil nutrient deficiencies could be provided. This means that Ads and/or farmers should be better trained and have access to equipment.

The courses already offered at Southern Rural Training Centre (SRTC) at Pelotshetla are very important for informing farmers of improved crop management techniques. Pamphlets regarding fertilizer dosages for specific combinations of soil type and crop management systems should be produced and available at BAMB and other outlets for fertilizer. Information about seed availability of alternative crops, fertilizer and other agro-chemical inputs (outlets, prices) should be broadcast over the radio and in other types of media. Pesticides should be available in smaller dosages than the two liter containers to allow more farmers to buy them. Alternatively, farmers should be encouraged to buy pesticides as a group, to allow them to purchase the two liter containers.

Introduce alternative crops

Some crops which are not currently cultivated widely in the area, but which may be alternative crops to those already known are listed in table 4.2. The use of a legumes/crop rotation would improve the fertility status of soil, provide crop with increased nutritional value and cash crop potential (cowpeas and other legumes) (see also section 5.3).

The crops listed in table 4.2 are crops which have a low (400-500 mm) to moderate (500-600mm) total rainfall requirement during the growing season, which makes them suited for Moshupa South AEA. The yields are estimated using "CYSLAMB reference crops" with similar growth requirements, which are the five crops presently included in the CYSLAMB dataset. The yields reflect the dependable yield which can be expected in 75% of all years considering the physical environment of Moshupa South AEA (see also section 6.2.3 of LUPSAD, 1995b).

4.1.2.4 Improved income generating opportunities

The problem of labour shortage and decline in the number of young people in general in the area is difficult to address at the extension area level. It is a traditional aspect of Motswana culture to spend even long periods away from the area of origin (ie. as a migrant worker in the mines in RSA). However, the present trend appears different in that the traditional agricultural sector has become so non-competitive compared to other sectors of the economy. The most promising option is to increase the economic returns from agricultural enterprises, which might encourage young people to stay in the area and not look for employment elsewhere. The adoption of improved crop management practices, new crops (see section 6.1.2 for a gross margin analysis of alternative crops) and the creation of small scale agricultural enterprises (horticulture, poultry) under the AE10 subsidy programme are therefore options which should receive high priority.

A suggested option is the construction of a poultry project which would enable poor households to generate an income. The project is described in section 5.3

4.1.2.5 Improved institutional support

Redirection of drought relief funds

The present drought relief program is open to abuse. It is considered by some individuals as a sort of social program in the rural area which is open for anyone.

Funds used for providing ploughing subsidies should be redirected into programmes aimed at higher production or investment in agricultural development. The present system only awards the initial part of crop production - ploughing and planting. An improved subsidy scheme would support the households during the entire crop production cycle, by attaching conditions of proper crop husbandry before the release of the subsidy, by awarding farmers who actually harvest produce

Table 4.2 Alternative crops for crop production

Name of crop	Main uses	Expected average yields (kg/ha) (g)reen or (h)ay	Comments
Bulrush millet (Pennisetum typhoides)	Food (grain) Fodder	400-700	well-drained, medium and light-textured soils, drought resistant
Castor (seed)[1] (Ricinus communis)	Industry (oil)	110-240	drought resistant, shortlived perennial, also windbreak, poisonous when green, harvest labour intensive
Lablab bean (Dolichos Lablab)	Fodder Green manure Food (dried seeds)	(h) 0.8-1.7 Tons/ha	yield with fertilizer. Drought resistant. Fodder: 2-4 T/ha
Sesame (Sesamum indicum)	Food (oil) Food (dried seeds)	90-190	drought resistant after seedling. Deep soils, labour intensive
Buffel grass (Cenchrus ciliaris)	Forage (grass)	?	drought resistant, requires deep soils, establishes well in old arable areas
Sunflower (Helianthus annuus)	Food (oil) Food (dried seeds)	170-370	moderate water requirements, prefers deep soils
Cluster bean (Cyamopsis tetragonolobe)	Industry (oil) Fodder Food (green pods) Green manure	170-370 8-10 T/ha(g)	drought resistant, prefers deep soils
Jugo bean (Vigna subterranea)	Food (oil) Food (dried seeds)	150-320	drought resistant, good for intercropping with grains, deep soils
Moth bean (Phaseolus aconitifolius)	Fodder Green manure Food (dried seeds) Food (green pods)	400	drought resistant, likes sandier soils
Tepary bean (Phaseolus acutifolius)	Fodder Food (dried seeds)	5-10 (h) Tons/ha 150-320	fairly hardy, harvest is labour intensive
Mung bean (Vigna radiata	Fodder Food (green pods) Food (dried seeds Green manure	230-260	requires early planting
Pigeon pea (Cajanus cajan)	Fodder Food (green pods) Food (dried seeds) Green manure	130-280	drought resistant, annual or short-lived perennial, good for intercropping with grains, deeper soils

[1] Castor cultivation requires very specialized knowledge and/or increased use of inputs. It is therefore not recommended on a general level but only to farmers with sufficient level of knowledge and capital.

Source: Sims (1981) and LUPSAD (1995b).

or by subventioning price of produce which was produced (or attempted produced) using correct crop husbandry. A fertilizer subvention program could be designed, in which the maximum hectarage subventioned is limited to three instead of the present five ha (totalling 360 P instead of 600 P. The money normally awarded for the remaining two ha (140 P) should instead be provided in the form of Single Superphosphate (or other appropriate) fertilizer which should be used on (part of) the three ha.

This program would circumvent the present situation, where fields in some cases are being ploughed apparently without the intention to do proper crop husbandry. This sort of abuse increases the work load of the AD, since everyone can apply for ploughing subsidy funds, whether they are full-time serious farmers or not. Cases exist where relatives living far away from the extension area will plough a portion of a field in the extension area in order to collect the subsidy, but never intended to continue cultivation.

Subsidy schemes in general should be avoided. They tend to make people dependent on/ expecting assistance rather than being self-reliant. A commercially oriented assistance program (drought insurance fund, credit schemes, etc.) might provide a better incentive to farmers.

Improvement of the agricultural extension service.

The AD should be allowed more time to concentrate on extension work instead of drought relief administration. Logistic support, especially in the form of transport is essential. A proper hand over procedure should be designed for transfer of AD's, to allow the incoming AD to gain as much as possible from the experience of the outgoing AD.

The division of Moshupa South AEA into two separate extension areas should be considered, as the extension worker to farmer ratio is high (estimated at 1:400) and many farmers have none or very infrequent direct contact with the Agricultural Demonstrator.

A baseline survey of farming systems, household composition, draught power situation, crop yields, other economic activities should be carried out every two to three years to update information on current farming condition and farming household grouping (see annex B). This information will assist the AD in targeting extension recommendations to relevant farmer groups.

Increased prices on agricultural products.

Higher prices would stimulate farmers to concentrate on crop production and not give priority to other activities. Having said this, it must be realized that price setting of agricultural products has to be coordinated with other sectors of the economy. At present, income from arable subsistence production is basically not competitive with income opportunities from other sectors. Although subsistence farmers operate on a different financial basis than commercially oriented households, this is nevertheless an important consideration, when households decide to engage in other activities, such as drought relief activities, which can earn a person 90 P/month.

Reschedule Drought relief activities.

Farmers should not be deprived of the opportunity of participation in drought relief activities. However, they should not interfere with the agricultural season but be limited to other periods to avoid competition for scarce labour and time. Furthermore, drought relief activities should only be initiated after feasibility studies have been carried out to avoid waste of public funds. As a minimum, small dam and drift fence construction needs proper assessment of location, size, analysis of possible conflict with other land uses and consultation with the community before construction starts.

Prompt processing of ALDEP applications

The support provided by the Government of Botswana to households lacking farming implements is a very important programme. Every effort should therefore be made to process applications for farming implements (ploughs and planters) and fencing material as prompt as possible. This would motivate farmers when they feel their applications and interest in improving their production system are being taken serious. A concern was raised by farmers, that the applications sometimes are handled by the temporarily engaged Field Assistants and not the Agricultural Demonstrator. This should be avoided, since the AD is the proper authority at that level.

Review conditions for provision of donkey carts under the ALDEP program

The provision of donkey carts is a program much appreciated by all farmers. It should be considered to change the condition concerning possession of other types of implements before donkey carts can be provided, since they also could improve the management system (especially for application of kraal manure) for farmers without ploughs and planters.

Replacement of "Zimbabwe" planters

Farmers frequently complain about the performance of the "Zimbabwe" planters provided under the ALDEP programme. They have a tendency to crush or scar the seeds when they drop through the seeding plate, which may lead to low and uneven plant densities as well as discourage farmers from rowplanting. It should be considered to discontinue the supply of these planters, if that is still the case, and to replace the planters already provided to farmers.

4.2 LAND DEGRADATION.

4.2.1 The problem

The steep slopes on the side of the escarpment and the more moderate slopes in the plain towards the major streams are subject to water erosion in the form of sheet and gully erosion. Affected areas are shown in figure 2.3. These areas cover approximately 12% of the Moshupa South AEA.

Farmers threatened by gully erosion used to plough diversion channels to stop the gully development, but complain that their efforts were futile. Previous constructions have either been destroyed by rain or poor maintenance. It appears as if conservation work is regarded as the responsibility of Government bodies and no longer concerns the farmer. This attitude towards soil conservation may also be linked to the past farming conditions in Botswana, under which population pressure was much lower than today, and it was easier to move to a new site when an old field was no longer productive due to low fertility status or erosion.

4.2.2 Suggested options

4.2.2.1 Re-establish vegetative cover

Some options which can help improve affected soil on the farm level have been suggested in sections 4.1.2.2 and 4.1.2.3. Areas severely affected by sheet erosion should be fenced off to prevent further removal of the vegetation by livestock. The construction of diversions and stone barriers or mats of sticks and branches at gullyheads may be necessary locally to stop further gully formation. Planting of fast growing tree and grass species should be considered in less severely affected areas, where controlled grazing may still be allowed.

Farmers appear reluctant to the idea of fencing of severely affected areas. They state that almost all the non-cultivated areas are claimed by individuals and fear that the ownership status of the area may change and/or they will lose grazing area which is already limited. However, they realize that the situation is getting worse and that action must be taken to conserve the soil and vegetative resources. They highlighted the following points concerning soil conservation measures:

1) Farmers do not have resources to combat erosion. This argument is quite typical and reflects the impression by the rural population that Government is responsible for land management, creating water resources and providing economic opportunities in the rural areas. On the other hand farmers feel that land tenure should remain unaffected and Government (and other "outside" agents) should not be able to dictate land management practices.

2) The community affected must be properly consulted. This point remains a central issue to any initiatives which affects land tenure and management. The population concerned must agree to the

measures suggested (if possible, it should be involved already at the early stages of formulation) and must become responsible for the activities.

If fencing is found viable, a demonstration plot could be established to allow the community to form their own opinion about the project. If possible, the management of the plot should be entrusted to a well-defined user group (ie. the farmers committee).

Farmers indicate that they are used to throwing branches and dead trees in gullies which indicates that they are aware of the problem and have an idea of means to combat gully spreading. This may help the introduction of more organized and coordinated incentives.

4.3 LACK OF FIREWOOD AND CONSTRUCTION MATERIALS

4.3.1 Constraint

The firewood demand in the areas surrounding Moshupa is expected to rise tremendously with an estimated population increase in Moshupa village from about 15.000 in 1995 to 38.000 in 2012 (DSL, 1991). Similar increases in demand for thatching material and poles for construction are expected. A proportion of the increased demand must be collected in Moshupa South AEA.

Potential firewood requirements in Botswana, based on figures used by Wijesuriya et al (1995) amount to 1.7 tonnes biomass per capita per year. The annual incremental production of the woody vegetation in the planning area is estimated at 5613 tonnes (or 0.44 kg/ha) per year. This production is only sufficient to meet the requirements of approximately 3300 persons. The implications are:

1) The present firewood production (based on annual increment in woody biomass) is presently sufficient to meet the requirements of the population of Moshupa South AEA (estimated at 2100 persons in 1995). However, it has already been established that firewood form the area is also being collected by outsiders or exported by local households to the neighbouring villages.

2) The present firewood production will not meet the requirements of the population of Moshupa South AEA in 2012 (estimated at 3575 persons).

It is evident that the firewood requirement is reaching the sustainable production capacity within the next decade or so, if an optimistic view is used. However, it is very likely that this limit has already been exceeded, given the considerable population increase in the surrounding major settlements and firewood collection from outsiders.

4.3.2 Suggested options

4.3.2.1. Establishment of woodlots

In order to supply the increasing population in Moshupa South AEA and in neighbouring Moshupa with fuelwood and poles for fencing and construction, it will be necessary to increase the tree biomass in the vicinity of Moshupa (a 10 km radius is used to delimit the area used for firewood collection). Woodlots or agroforestry projects may provide a solution. They have several advantages:

- if established on slopes and eroded areas, they may diminish erosion levels also in neighbouring fields. This could be an idea for fields next to the Polokwe escarpment, where farmers are already complaining about erosion and harassment by baboons, etc. Perhaps that could motivate the households to shift from crop to tree farming.

- they could provide an opportunity to use the abandoned fields productively, instead of laying idle (a certain biomass is already established in these fields, but not optimal!) This seems possible, as there is no production at present, and farmers would not have to totally shift from crops to trees, but merely establish woodlots.

- they could provide fodder for livestock, if properly managed, thus improving nutritional status of animals, and compensating for grazing area loss. If properly managed, animals need not be excluded from the area, but could actually graze in the forested area, thus eliminating the need for fencing

- they could provide an income to farmers through firewood sale. Typical annual incomes reported at present vary from 480 to 1200 Pula.

- If a mixed variety of species are planted (fruittrees, good firewood species, trees for construction purposes (*Eucalyptus sp.)*), they may provide additional income/improve nutrition. This additional advantage may prove to be too ambitious.

The establishment of woodlots will be evaluated in chapter 5.

4.4 LOW LIVESTOCK PRODUCTIVITY

4.4.1 Constraint

Households indicate that the grazing has become very scarce over the past decades and that livestock numbers exceed the carrying capacity of the area. This problem is accentuated by the fact that the grazing area is shared with households from neighbouring villages, such as Ranaka and Kanye, and it is therefore difficult to control cattle grazing.

Off-take from livestock production is low and most households operate on a subsistence strategy without commercial orientation. As such, livestock is only sold occasionally to meet cash needs. The management of herds is limited to kraaling and watering of animals.

4.4.2 Suggested options

4.4.2.1 Fencing of the grazing area

Farmers spend up to several weeks each year looking for stray cattle. This affects crucial arable farming operations, such as timely ploughing, planting and weeding. The grazing area is almost completely fenced off from the Lands area. If the remaining 29 km would be fenced, farmers could more easily find their cattle and control grazing in the area. Any other additional improvements in the grazing area are more apt to be adopted by farmers, if they can control the access to the area and feel they do not have to share the improvements with outsiders. A fence will preserve exclusive usership of the area. The issue would need to be discussed with neighbouring farmers who also use (parts of) the area for grazing. The Sobe sub-extension area reportedly do not share their grazing area with other farmers. In a fenced grazing area, the incentive to improve the use of the area, through paddocking and rotational grazing would also be higher.

4.4.2.2 Improving grazing quality

The quality of cattle fodder can be improved by the introduction of high quality species such as Siratro (*Macroptilium atropurpureum*). The introduction would be done by seeding small areas on the hill. The cattle would ingest seeds which would then spread by natural processes.

4.4.2.3 Improving the quality of crop residue

Grazing of arable residues is an important cattle grazing supplement to natural vegetation. The cattle are normally allowed in to the Lands area after harvest in June/July and exploit crops residues left in the field for a period. If crop residues were collected and kept nearby the kraal by the homestead, dry season feeding could be more easily regulated and residues would not be destroyed so easily by termites and fouling on the ground. The protein content could be improved if the residues are ammonified using a mixture of urea and water at a 10% concentration. This forage could be fed to selected animals during periods when grazing is scarce.

CHAPTER 5

LAND EVALUATION

Land evaluation is a method to estimate the production levels which can be achieved on different land units under different production systems. The results of the land evaluation can be used to:

- identify which production system is the most suitable for a given area and
- which recommendations can improve existing production systems.

In the semi-arid conditions of Botswana there are large differences in annual rainfall amounts, which has a major impact on crop yields. Land evaluation for crop production systems which assumes an average set of environmental conditions therefore has limited value. A new land evaluation system has been developed for Botswana, the Crop Yield Simulation and Land Assessment Model for Botswana (CYSLAMB), which takes the dynamic nature of rainfall patterns into account, by modelling crop production year by year using historic rainfall data (see annex A for details on CYSLAMB).

The same climatic conditions affect land evaluation for livestock production. A similar land evaluation system has therefore been developed for Botswana, the Animal Production Simulation and Range Assessment Model for Botswana (APSRAMB), which models rangeland biomass production and livestock carrying capacity year by year using historic rainfall data.

5.1 EVALUATION OF RAINFED CROP PRODUCTION

This section deals with the potential for rainfed crop production in the Moshupa South AEA. It is based on CYSLAMB simulations of different crop production systems on the most common soils in the area.

The yield calculated by CYSLAMB summarizes the production obtained on the specified soil type under historic climatic condition over a period of years. In the case of Moshupa South AEA, the model used data for a period of 30 years, from 1959 to 1989. The results are analyzed statistically and give an estimate of the *dependable* yield which is surpassed in 75% of all years.

The yield is calculated on the basis of the entire field (or holding). CYSLAMB assumes that draught power is only able to plough and plant an area of 2-3 ha at each planting opportunity ("dekad" or ten day period). Therefore, depending on the size of the field, a farmer may require between one and three (or more) occasion(s) for the ploughing and planting of the total area of his field. In years when not enough planting opportunities occur, due to insufficient rainfall, only a portion of the field can be ploughed and planted. The yield reflects the greater risk, and consequently lower aggregated production, experienced by farmers who depend on multiple planting opportunities. The number of planting opportunities required is specified in the *crop management system* which is one of the inputs used by CYSLAMB.

5.1.1 Yield index calculation

To begin with, CYSLAMB was run for the five most important crops in Botswana for which the necessary physiological information is available. These crops are sorghum, maize, millet, groundnut and cowpea. CYSLAMB was run for all soil units found in Moshupa South AEA which can sustain crop growth. This means that the shallow lithic Leptosols (LPe) (depth: maximum 10 cm) are excluded from the analysis, as they are unable to sustain crop growth (see table 2.4 for details on soil properties). The production systems simulated are based on a standard management system which was used to prepare the National Land Suitability Map of Botswana (Radcliffe, et al, 1992). This management system can be described as "improved traditional management" and it assumes that the standard recommendations of the agricultural extension service with respect to land preparation, rowplanting, plant spacing and weeding are adopted. No use of fertilizer is simulated. The characteristics of the management system are as follows:

Constant factors

Irrigation capacity/frequency:	0 mm/ 0/dekad
Degree of weed infestation:	0% of maximum
Period when early planting can occur:	SEP3-NOV1
Soil moisture requirement for early ploughing:	30 mm
Number of planting opportunities used:	1
Period when planting can occur:	DEC1-FEB2
Soil moisture requirement for planting:	30 mm
Effective rainfall requirement for planting:	30 mm
Fertilizer use:	0

Variable factors

Plant density:
- Sorghum (var. Segaolane): 50 000 plants/ha
- Maize (var. Kalahari Early Pearl): 15 000 plants/ha
- Millet, Cowpea and Groundnut: 50 000 plants/ha

Soil type:
- Ferralic arenosol (Aro)
- Luvic Arenosol (ARl)
- Ferric luvisol (LVf)
- Calcic Luvisol (LVk)
- Chromic luvisol (LVx)
- Stagnic Luvisol (LVj)
- Haplic Luvisol (LVh)
- Eutric Regosol (RGe)

A *yield index* was calculated to determine the **general** suitability of different soil units for crop production, based on the combined yield estimated from the five crops. (see annex A for a description of the yield index calculation).

Table 5.1 Dependable yield and yield index for Moshupa South AEA

	Dependable crop yield (kg/ha)					Index 75	Yield class
SOIL TYPES	Sorghum	Maize	Millet	Cowpea	Groundnut	(0-1000)	
ARo	1120	910	820	290	830	575	C
ARl	750	660	520	230	650	419	D
LVf	1600	1500	1150	340	980	769	B
LVk	1040	1030	700	240	680	515	D
LVx	1600	1500	1150	340	980	769	B
LVj	680	560	460	210	620	381	E
LVh	1040	1030	700	240	690	517	D
RGe	730	510	430	210	660	384	E
Ymax	2140	2070	1560	430	1160		

The yield index compares the dependable yield achieved on each soil unit in Moshupa South AEA with the highest yields achieved in Botswana using the same management system and displays the result on a scale from 0 (lowest) to 1000 (highest)(see table 5.1).

The most suited soil types are the deep Luvisols which have no limitations in terms of soil depth and available water holding capacity and possess a reasonable level of nutrient availability. These soils have a yield index of 769, which places them in the suitability category of B, moderately high.

The intermediate soils for crop production are soils with moderate constraints in terms of less nutrient availability (2-3 ppm phosphorus) or less Water Holding Capacity (70 mm per m). These soils have a yield index score of 515-575 which places them in the suitability categories of C and D, moderate to moderately low.

The least favorable soils for crop production are the soils with severe limitations caused by one or several restrictions, such as low Water Holding Capacity (70 mm per m) and low nutrient availability (2-3 ppm Phosphor). These soils with a yield index score of 380-420 are categorized as belonging to group E, low.

The general suitability of the land units in Moshupa South AEA for crop production has been calculated, based on the aggregated yield index values of the individual soiltypes contained in each land unit. Since most soil units could not be separated during the soil mapping, the land units often consist of soils with different suitability for crop production. In table 5.2 the average yield index for each land unit is displayed, by assigning a weighted value to the yield index value of each soil type according to its relative importance in the land unit.

It appears from table 5.2 that the land units with large proportions of fertile and deep Luvisols are the best land units for crop production, while the areas with mostly sandy soils (Ferralic or Luvic arenosols: ARo and ARl), stoney or poor unstructured soils (Eutric Regosols: RGe) are the least favorable.

Table 5.2 Yield index for land units in Moshupa South extension area

Land unit (LU)	area (ha)	Yield index	Yield Class(es)
LU1	13583	n/a	n/a
LU2	1046	542	C-D
LU3	3667	620	B-E
LU4	6384	492	B-E
LU5	142	384	E
LU6	807	592	B-D
TOTAL	25629		

5.1.2 Management systems

After the general assessment of the suitability of different land units for crop production, a more detailed analysis was carried out, with the following objectives:

- to estimate crop yields for five crops under the present crop management systems
- to indicate the scope for improvement of crop management systems
- to prepare yield data which may be used for comparison of gross margins of different crop management systems

In this analysis, Cyslamb was run for three types of scenarios: baseline scenario, intermediate scenario and optimal scenario.

The baseline scenario uses parameters which reflect the present farming situation in Moshupa South AEA, and is characterized by the absence of capital investment. The intermediate scenario simulates the yields which can be achieved by improved crop husbandry and small to medium level investments. The optimal scenario is based on high standards of crop husbandry and medium to high level of investments. The three scenarios consist of four management systems, each with different levels of draughtpower and labour resource availability. The four management systems are based on the farming household classification in section 3.3.3. The differences between the management systems are reflected in the number of planting occasions needed to plant the whole field and the timeliness of planting as follows:

Management system 1: The households following this management system plant early, as soon as possible after the first planting rains (November 11 is used as an average starting date for the rainy season) and are able to plant the whole area at once. This corresponds to households with access to sufficient draught power and labour, for example the R2 households.

Management system 2: Households following management system 2 also plant early, but are forced to use three planting opportunities to plant the whole area. In some cases, the last planting takes place in February. The households following this system are slightly restrained by draught power or labour availability, and correspond to R1 and W1 or W2 households.

Management system 3: These households plant late (after New Year) but are able to finish ploughing and planting at once. These households may have to wait for a draught span or a tractor to be available and do not possess sufficient draught power alone, which corresponds to P2 and some W1 or W2 households. The area cultivated may be smaller than for the households following management system 4, or the labour/and or draught power availability is greater.

management system 4: The households following this management system also plants late and have to use three planting opportunities to plant the whole area. In some years, there are no second or third planting opportunities, which decreases the average yield for this group of households. These households are seriously restrained by lack of draught power and belong to the P1 households.

Most households in Moshupa South extension area were forced to follow management system 3 or 4 in the 1994-95 crop season, as the first planting opportunity only occurred after a rainfall around New Year. However, during the farming household survey, many declared that they usually would plough and broadcast seeds during November or December, which means that they would follow management systems 1 or 2

Table 5.3 Characteristics of traditional management systems analyzed with CYSLAMB

Code	Period of planting	no of planting occasions used	P (according to table 2.4) (ppm)	Weed cover	Weeding (days after planting)	Target plant densities (pl/ha)
Bs1	11 Nov - 1 Mar	1	2,4 or 5	80	50 and 30	15000
Bs2	11 Nov - 1 Mar	3	2,4 or 5	80	50 and 30	15000
Bs3	1 Jan - 1 Mar	1	2,4 or 5	80	50 and 30	15000
Bs4	1 Jan - 1 Mar	3	2,4 or 5	80	50 and 30	15000

5.1.2.1 Baseline scenario

This scenario reflects the traditional management systems in the area, practiced by farmers who (often) have a shortage of draughtpower and follow sub-optimal crop husbandry practices without fertilizer application. The characteristics of the management systems are listed in table 5.3. The only improvement which is simulated at this level is a more timely weeding operation (30 instead of 50 days). This improvement is expected to be without extra costs to most households as it only entails a change in the timing of operations and no additional external inputs. In some cases, where labour constraints are important, earlier weeding may require hiring of labour to ensure timely operations.

The results of CYSLAMB simulations for the management systems in the baseline scenario are listed in table 5.4.

The following conclusions may be drawn from the analysis:

Soil type and crop yields

In general, two main groups can be separated.

1. The most suitable soil types for crop production in terms of yields are in most cases the medium-textured Luvisols and the light-textured Ferrallic Arenosol. These soils (LVf, LVx and ARo) produce the highest yields for most crops, using one or three planting occasions.

The Luvisols have high waterholding capacities and moderately high nutrient levels which are the main characteristics determining the high yields on these soils.

In relatively dry years lighter textured soils, such as the Ferralic arenosol may perform as well or even better than medium textured soils such as Ferric or Chromic Luvisols. Although the latter soils can contain more total moisture in the top soil (high AWC) the amount of water retained at suction values close to the Permanent Wilting Point (PWP) is higher in medium textured soils than in lighter textured soils and consequently, in relatively dry years the amount of water available for plant growth in medium textured soils is more difficult to extract.

2. Low to intermediary yields may be obtained on the remaining group of soils which exhibit some constraints to agricultural production in terms of AWC, soil structure or nutrient content. In this case, this correlates to the Luvic Arenosol (ARl) which has a coarse texture, low waterholding capacity and a low nutrient level. The Stagnic, Calcic and Haplic Luvisols are also constrained by a low P-content in the top-soil. This is also true for the Eutric Regosols.

Planting period and number of opportunities used and crop yields

The choice of management system has a very big impact on crop yields. The following conclusions can be drawn from the analysis.

1. The highest yields are always obtained by early planting and using one planting opportunity (management system 1). Although evapotranspiration values are highest around November-December, and the plants water requirements therefore are at a peak, early planting means that in total more moisture will be available during the crop season. This fact outweighs the negative effects of high evaporation demands.

2. Intermediary yields were obtained if planting starts before New Year and three planting opportunities are used.

3. For all crops except maize, it appears that planting after New Year, using only one planting opportunity, may also produce reasonable yields. In the case of sorghum, they are significantly[6] below yields obtained when planting starts before New Year, whereas for millet, cowpeas and groundnuts the yield is comparable to those obtained by early planting and using three planting opportunities.

[6] A yield difference of more than 20% is considered significant

4. Spreading planting over several opportunities generally reduces yields, as compared to only using one planting opportunity.

5. Maize is very sensitive to the timing of planting, and virtually no dependable yield can be expected in the baseline scenarios in case of late planting (after New Year).

6. Very low yields are expected for all crops when planting occurs after New Year using three planting opportunities.

weeding dates and crop yields

Weeds compete with crops for water, nutrients and sunlight. Excessive weedgrowth therefore reduces the amount of vital resources available for crop growth. It was therefore decided to examine the effect of earlier weeding on crop yields, as this might prove a (relatively) low cost extension recommendation that could improve yields.

In 33% of the various combinations of soiltype and management systems, the early weeding option (weeding after 30 days instead of 50 days) resulted in significantly higher yields. The yield increases were generally higher for maize than for other crops. This implies that earlier weeding alone does not have a positive effect on crop yields in a majority of cases in the baseline scenario.

Table 5.4 Dependable yields for baseline scenario (kg/ha)

crops		sorghum		maize		millet		cowpea		groundnut	
mana	soil	days to weeding		days to weeding		days to weeding		days to weeding		days to weeding	
syst.	type	50	30	50	30	50	30	50	30	50	30
Bs1	ARo	780	870	650	810	550	630	190	220	509	543
	ARl	570	640	450	580	390	450	150	180	402	422
	LVf	790	1050	640	1120	490	640	180	230	516	576
	LVk	560	740	430	750	340	440	140	170	382	429
	LVx	790	1050	640	1120	490	640	180	230	516	576
	LVj	570	630	420	510	360	400	140	170	395	415
	LVh	550	740	390	750	320	430	140	170	382	429
	RGe	630	630	450	450	340	400	140	170	429	442
Bs2	ARo	540	600	280	380	310	360	130	160	429	456
	ARl	380	440	200	260	230	250	100	130	335	362
	LVf	560	610	330	500	310	380	140	170	449	476
	LVk	390	430	220	270	210	240	100	120	335	348
	LVx	560	610	330	500	310	380	140	170	449	476
	LVj	360	430	200	240	220	250	100	130	328	355
	LVh	390	420	220	330	200	260	100	120	335	348
	RGe	380	440	170	200	240	270	110	140	355	375
Bs3	ARo	420	480	0	30	280	340	150	160	402	415
	ARl	300	340	0	0	190	230	110	130	315	328
	LVf	480	540	10	120	310	380	160	170	429	449
	LVk	310	350	0	20	200	230	120	130	315	335
	LVx	480	540	10	120	310	380	160	170	429	449
	LVj	300	340	0	0	170	210	110	120	308	328
	LVh	310	350	0	20	190	230	120	130	315	335
	RGe	340	370	0	0	190	230	120	130	342	362
Bs4	ARo	180	180	0	10	90	110	50	50	147	147
	ARl	130	130	0	0	60	80	40	40	114	114
	LVf	160	190	0	40	110	130	50	60	147	154
	LVk	110	130	0	10	70	80	40	40	107	114
	LVx	160	190	0	40	110	130	50	60	147	154
	LVj	130	130	0	0	60	70	40	40	114	114
	LVh	100	130	0	10	70	80	40	40	107	114
	RGe	160	160	0	0	60	80	40	40	127	127

groundnut yield calculated using shelling factor of 0.67

5.1.2.2 Intermediate scenario

The intermediate scenario is based on an improvement of the traditional management systems evaluated in section 5.1.2.1. The improvements concern plant population (increased from 15.000 to 30.000 plants/ha, weeding dates and fertilizer use (see table 5.5). The increase in plant population is assumed to follow from correct ploughing and planting depths as well as the higher nutrient status of the topsoil, which increases the survival rate of seedlings (Bekker, 1995). It could also be related to a shift in planting technique from broadcasting to rowplanting, which allows better control with seeding rates. Two levels of investment are simulated: 1) no use of Single Superphosphate (SSP) fertilizer (no costs) and 2) the use of 100 kg SSP/ha corresponding to an expense of approximately 50 Pula/ha for each household (BAMB, 1994). It is assumed that sufficient labour is available to carry out a second weeding operation, which is necessary due to increased weed growth.

Table 5.5 Characteristics of improved management systems analyzed with CYSLAMB

Code	Time of planting	no of planting occasions used	Amount of SSP fertilizer added	P (ppm)	Weed cover	Weeding (days after planting)	Target plant densities (pl/ha)
Is1	11 Nov - 1 Mar	1	0 and 100 kg/ha	5,7 or 9	80	30	30000
Is2	11 Nov - 1 Mar	3	0 and 100 kg/ha	5,7 or 9	80	30	30000
Is3	1 Jan - 1 Mar	1	0 and 100 kg/ha	5,7 or 9	80	30	30000
Is4	1 Jan - 1 Mar	3	0 and 100 kg/ha	5,7 or 9	80	30	30000

Table 5.6 Dependable yields for improved scenario (kg/ha)

crops		sorghum		maize		millet		cowpea		groundnut	
mana	soil	use of fertilizer		use of fertilizer		use of fertilizer		use of fertilizer		use of fertilizer	
syst.	type	0	100 kg	0	100 kg	0	100 kg	0	100 kg	0	100 kg
Is1	ARo	950	1140	770	990	640	810	220	260	543	630
	ARl	670	1000	500	840	450	700	180	240	422	570
	LVf	1150	1300	1120	1310	680	770	230	250	576	637
	LVk	770	1150	700	1120	420	690	170	230	429	576
	LVx	1150	1350	1120	1360	680	800	230	260	576	657
	LVj	650	970	420	750	380	620	170	220	415	556
	LVh	770	1150	700	1120	410	680	170	230	429	576
	RGe	660	940	350	590	370	570	170	220	442	563
Is2	ARo	640	770	370	450	340	440	160	190	456	529
	ARl	430	670	250	400	220	380	130	170	362	482
	LVf	640	730	470	560	390	460	170	180	476	523
	LVk	430	660	240	380	200	350	120	170	348	476
	LVx	640	760	470	590	390	470	170	190	476	543
	LVj	420	660	220	360	210	370	130	170	355	476
	LVh	420	640	250	470	240	390	120	170	348	476
	RGe	420	620	170	260	240	360	140	170	375	476
Is3	ARo	450	590	0	0	280	380	160	190	415	482
	ARl	300	500	0	0	150	320	130	170	328	436
	LVf	540	620	0	0	340	410	170	190	449	496
	LVk	320	540	0	0	170	340	130	170	335	449
	LVx	540	660	0	10	340	450	170	200	449	509
	LVj	300	500	0	0	140	300	120	170	328	436
	LVh	320	540	0	0	170	340	130	170	335	449
	RGe	330	500	0	0	170	310	130	170	362	462
Is4	ARo	180	230	0	0	90	130	50	60	147	168
	ARl	120	200	0	0	50	110	40	60	114	154
	LVf	190	220	0	0	110	140	60	70	154	168
	LVk	110	190	0	0	60	110	40	60	114	147
	LVx	190	230	0	0	110	150	60	70	154	174
	LVj	120	200	0	0	50	100	40	60	114	154
	LVh	120	190	0	0	60	110	40	60	114	154
	RGe	160	230	0	0	60	100	40	60	127	168

The dependable yields obtained in the improved scenario are listed in table 5.6.

higher plant population (30.000 plants/ha) and crop yields

The results of this analysis are only relevant for the grain crops (maize, sorghum and millet) as CYSLAMB is not yet validated for different plant population sizes for groundnut and cowpea. A higher plant population (30.000 plants instead of 15.000 plants per ha) does not seem to augment crop yields considerably if weeding takes place after 30 days. In fact, a higher plant population may actually reduce crop yields for certain crops (maize and millet) if it is not combined with other improvements. However, the **combined** effect of higher plant population and earlier weeding result in considerably higher yields when compared to the basescenario where weeding takes place after 50 days and the plant population is only 15.000 plants per ha.

Use of 100 kg Single Superphosphate fertilizer and crop yields

The soils found in the Moshupa area are generally poor in nutrients, with phosphorus (P) deficiency being a major reason for low yields. Raising the P-level of the topsoil from the original level of 2-5 ppm with 100 kg of SSP to 5-8 ppm has positive effects on most management systems except for maize, where planting after New Year still results in zero yields. In other cases, the use of 100 kg SSP fertilizer increases yields with 25% (groundnut) to 60% (millet) compared to a situation with similar plant population but no fertilizer. The yield increases are generally highest on the soils with lowest P-values to start with.

5.1.2.3 Optimal scenario

The optimal scenario reflects the highest yielding crop management systems in the area and illustrates the scope of improvement which exists in Moshupa South AEA. While not all farmers will be able to adopt the recommendations, which besides a medium to high investment level also requires high standards of crop husbandry, they can be adopted by households with above average resource levels, for example those belonging to the R1 and R2 groups. Two weeding session are necessary due to increased weed pressure resulting from the improved fertility status of the topsoil.

In the optimal scenario, all households apply Single Superphosphate (SSP) fertilizer to raise the P-level in the top soil. Two levels of fertilizer use is simulated: 1) 100 kg of SSP and 2) raising the P-level to 10 ppm, which is the level which has been found to reflect the economic optimum for many agro-ecological zones in Botswana and beyond which further fertilizer application does not increase crop yields significantly (De Wit, 1992)[7]. The plant population has also been increased from 30.000 to 50.000 plants/ha which reflects high standards of crop husbandry, good germination rates, efficient birdscaring and weeding. The characteristics of the management systems are listed in table 5.7.

Table 5.7 Characteristics of optimal management systems analyzed with CYSLAMB

Code	Time of planting	no of planting occasions used	Amount of SSP fertilizer added (according to table 2.4) (kg/ha)	P (ppm)	Weed cover	Weeding (days after planting)	Target plant densities (pl/ha)
Os1	11 Nov - 1 Mar	1	100 and 175-280	7-10	80	30	50000
Os2	11 Nov - 1 Mar	3	100 and 175-280	7-10	80	30	50000
Os3	1 Jan - 1 Mar	1	100 and 175-280	7-10	80	30	50000
Os4	1 Jan - 1 Mar	3	100 and 175-280	7-10	80	30	50000

The dependable yields obtained in the optimal scenario are listed in table 5.8.

[7] It requires 35 kg/ha of SSP to raise the P-level in the topsoil 1 ppm (De Wit, 1992)

Optimal plant population and 100 kg SSP fertilizer and crop yields

For the same reason as stated before, the results of this scenario can only be interpreted for the grain crops. A relatively small increase (3-16%) is observed when the plant population is increased with the same fertilizer level as in the improved scenario, when planting takes place before New Year for sorghum and millet. However, for maize small decreases are actually observed on some soil types for the management systems planting before New Year. The number of cases where reductions in crop yields occur increases if planting takes place after New Year for all three grain crops.

Optimal plant population and 175-280 kg SSP fertilizer/ha and crop yields

If the P-level is raised to 10 ppm in the topsoil, further increases are estimated for all five crops. The yield increases are largest on the soil types with low P-values to start with, where they may reach four times the yield level of the base scenario. Maize is the only crop where no yield is predicted when planting occurs after New Year.

Table 5.8 Dependable yields for optimal scenario (kg/ha)

crops		sorghum		maize		millet		cowpea		groundnut	
mana	soil	use of fertilizer		use of fertilizer		use of fertilizer		use of fertilizer		use of fertilizer	
syst.	type	100 kg	10 PPM	100 kg	10 PPM	100 kg	10 PPM	100 kg	10 PPM	100 kg	10 PPM
Os1	ARo	1300	1490	1090	1300	860	1030	260	290	637	704
	ARl	1140	1490	910	1300	750	1030	240	290	583	704
	LVf	1460	1660	1370	1620	870	1040	250	280	650	717
	LVk	1300	1690	1160	1620	750	1040	230	290	590	717
	LVx	1560	1660	1420	1620	930	1040	260	280	670	717
	LVj	1110	1450	710	1080	640	920	230	280	556	683
	LVh	1280	1660	1160	1620	750	1040	230	280	590	717
	RGe	1040	1290	540	770	610	770	220	250	563	650
Os2	ARo	870	1010	470	560	490	580	190	210	529	590
	ARl	750	1010	400	560	400	580	170	210	482	590
	LVf	840	960	530	660	490	570	190	200	523	583
	LVk	720	960	400	550	370	530	170	200	476	583
	LVx	880	960	570	660	520	570	190	200	543	583
	LVj	690	950	390	540	370	540	170	210	482	590
	LVh	720	960	420	660	400	570	170	200	476	583
	RGe	650	830	240	330	380	480	180	210	482	563
Os3	ARo	590	680	0	0	350	430	190	210	482	536
	ARl	490	680	0	0	260	430	170	210	436	536
	LVf	620	740	0	0	420	510	190	210	496	549
	LVk	510	740	0	0	310	510	170	210	449	549
	LVx	670	740	0	0	430	510	200	210	509	549
	LVj	440	660	0	0	230	420	170	200	436	536
	LVh	510	740	0	0	310	510	170	210	449	549
	RGe	490	660	0	0	280	420	180	200	462	536
Os4	ARo	250	300	0	0	120	140	60	70	174	188
	ARl	220	300	0	0	90	140	60	70	154	188
	LVf	220	270	0	0	140	180	70	70	168	188
	LVk	190	270	0	0	100	170	60	70	154	188
	LVx	240	270	0	0	160	180	70	70	174	188
	LVj	220	300	0	0	80	140	60	70	154	188
	LVh	190	270	0	0	100	180	60	70	154	188
	RGe	240	300	0	0	90	140	60	70	168	188

5.2 EVALUATION OF IRRIGATED CROP PRODUCTION SYSTEMS

Irrigated crop production is not presently practiced in Moshupa South AEA.

Small-scale irrigated crop production is reported to have taken place in one location by the Sobe stream by one household a number of years ago. The water source apparently became insufficient after the period of droughts in the 1980s and no production has taken place since then.

Since there are no perennial streams in the Moshupa South AEA, irrigated crop production would depend on:

1) non-perennial dams and wells
2) boreholes.

The more than 30 small dams in the area are not perennial and can not support commercial, large-scale horticultural production. They would be more suited for small-scale domestic production of vegetables (cabbage, onions, carrots) if sufficient water is available during the growing season. Borehole drilling is extremely costly and is unlikely to feasible for horticultural production alone. The two boreholes (BH1 and BH2 in fig.2.5) are presently not in use, but could possibly be used for horticultural production, preferably in connection with another project, such as agro-forestry. A preliminary investigation suggests that the yield from BH2 may be sufficient to irrigate a one ha horticultural plot (see table 5.9). A proper feasibility study should be carried out by irrigation specialists before a project is designed, notably concerning borehole yield during peak requirement periods.

Although the yield of borehole B1 is insufficient to sustain vegetable production, it should be considered to utilize the borehole for supplementary watering of crops. Suggested crops are fodder crops (Siratro, Buffel grass, Alfalfa) or a small-scale woodlot with fruit tree species.

Horticultural production may conflict with other activities (rainfed crop production, livestock production) for land, water and labour. In addition, horticultural projects requires certain capital investments (seeds, irrigation system, pesticides) and knowledge which may limit the number of farmers capable of implementing such projects. There are funds available through the FAP and AE10 subsidy programmes which could be of interest. However, water availability remains the crucial parameter.

Table 5.9 Identification of potential irrigated crop production system

Water source	Water yield (m^3/ month)[1]	Water quality (estimate)	Land suitability	Markets	Enterprise (crops)	Irrigation scheme	Size of scheme	Production system symbol	Feasibility (Preliminary assessment)
DAM1 Thlok-wane	?	good	medium-deep sandy-loamy soils	20 km	?	?	?	D1	?
BH1	360	good	deep sandy soils	20 km	Alfalfa, Siratro, Buffel grass, Woodlot	sprinkler	very small (<1 ha)	BH1	?[3]
BH2	3240	good	deep sandy soils	20 km	tomatoes and onions	sprinkler	small (1-2 ha)	BH2	good

[1] Based on drillers report. Yield based on 24 hour continuous delivery. Seasonal fluctuations not known.
[2] Kanye, Moshupa, Ranaka, dirt track for 10 km.
[3] Borehole yield too low to sustain vegetable production, but may sustain fodder or tree crops.

The financial feasibility of an irrigated vegetable production project at borehole BH2 is discussed in section 6.2.

5.3 EVALUATION OF EXTENSIVE LIVESTOCK PRODUCTION SYSTEM

5.3.1 Present carrying capacity

The grazing availability and carrying capacity of the planning area was analyzed through the use of the APSRAMB program. The first step in the analysis used the information about species composition and percentage cover along with figures on digestibility of various herbaceous species in each vegetation unit, together with soil and meteorological data to assess the biomass production and grazing capacity per vegetation unit (see table 5.10).

Table 5.10 grazing availability in vegetation units in planning area

Vegetation unit[1]	soiltypes	area (ha)	Biomass production (kg/ha)[2]	No. hectares for one LSU	No. of LSU in unit
H1	ARo-RGe-LPe	5001	216	14.8	335
H2	ARo-RGe-LPe	3732	419	7.6	486
H3	ARo-RGe-LPe	692	253	12.8	54
H4	RGE	394	719	5.5	72
H5	RGe	1677	356	11	152
H6	ARo-RGe-LPe	2087	439	7.3	285
RIV	LVk-LVf-LVh	807	228	8.8	91
FAL	LVx-LVh-LVf-ARo-RGe	3225	397	7.6	424
UNC	LVx-LVh-LVf-ARo-RGe	7922	681	4.4	1782
ROK	LPe-RGe	92	26	131	0.7
Crop residues		1542	720	11	138.5
TOTAL					3821

[1] See section 2.5.3 and annex F for a detailed description
[2] Average for whole unit, based on biomass production in each soil/vegetation sub-unit

The production of herbaceous biomass (see rows "Herbunder Aerial" and "Herbaway Aerial" in annex F) was calculated per vegetation/soil unit in much the same way the CYSLAMB program simulates crop yields. Similarly to CYSLAMB, a dependable biomass production (achieved in 75% of all years) was calculated. A "proper use" factor of 70% was applied to this figure and through division by the Dry Matter Intake (DMI) for a livestock unit, defined as 2.5% of bodyweight, the number of grazing days (ie. the number of days the unit can support 1 LSU) was calculated. The biomass production per vegetation/soil unit was aggregated, according to the area they represent in each vegetation unit, to calculate the total carrying capacity of each vegetation unit (ie. the number of ha required to support one LSU and the total number LSU which can be supported in the unit).

In addition to forage found in the vegetation units described above, crop residues constitute an important fodder resource when livestock in the beginning of July is let into the fields. The biomass of the crop residues amount to 720 kg/ha on average[8]. Assuming that 50% is wasted to soiling and termites, it appears that the arable residues can provide fodder for an additional 138.5 LSU. Forage from browse, which is particularly important for smallstock, is not included in the calculation.

[8] Based on CYSLAMB calculation of maize and sorghum yields under a traditional management system

Based on this calculation, it appears that average biomass production per ha is 441 kg/ha with a corresponding overall stocking rate of 6.7 ha/LSU. It follows that the planning area as a whole (grazing area and Moshupa South AEA) presently can produce forage for 3821 LSU. Comparing this figure with the livestock figure of 5529 LSU in the planning area, this implies that the area as a whole is overstocked by 1708 LSU.

It appears that the overstocking is found both in the Polokwe hills area and in the Moshupa South AEA. The available grazing resource is compared with the present demand in Table 5.11, separating the vegetation units in the grazing area, which are predominately grazed by adult cattle and the uncultivated areas in Moshupa South AEA (the uncultivated areas between fields, the short-term fallow portion within the Lands area, the river valley floor and the rock outcrops). These units are mainly grazed by smallstock, calves and donkeys. The extra grazing resource represented by the crop residues has been added to the vegetation units in the hills, since this forage is mostly reserved for cattle.

Table 5.11 stocking rates in planning area

Vegetation units	animal species	Present no. of LSU	Sustainable stocking rate (LSU)	overstocking (LSU)
H1-H6, Crop residues	adult cattle	2697	1523	1174
UNC,FAL,RIV,ROK	calves, smallstock, donkeys	2832	2298	534

5.3.2 Improved cattle grazing system

The present grazing availability could be increased in a number of ways.

1) reduction of livestock numbers. The overstocking could be diminished if restrictions on the number of livestock in the area were imposed. The level should reflect the dependable biomass production level in order to be sustainable. The new driftfence which is near completion will allow control with livestock movement into the Moshupa South AEA. The completion of fencing of the remaining 29 km would allow farmers in Moshupa South AEA exclusive use of the grazing resource, thus allowing households to profit from improvements introduced in the Polokwe hills, such as paddocking and rotational grazing schemes.

2) improve forage availability. The introduction of a fodder/legume crop in the crop production system would increase the available fodder

The adoption of a 3-course crop rotation scheme would increase fodder supplied by vegetation unit FAL (fallow plots in fields) in the Moshupa South AEA. It would at the same time improve soil fertility and crop yields.

The three-course rotation would consist of the present crop plot (50-70% of the field) and a fodder mixture of Buffel grass (also called African Foxtail) (*Cenchrus ciliaris*) and a companion legume Siratro (*Macroptilium atropurpureum*) which establishes well with Buffel grass and yields well even in lower rainfall areas. Half of the area not sown to crops (15-25% of the field) would be sown to the fodder mixture in Year 1 and cattle and smallstock kept out until June the following year at the earliest. This will give the forage crop time to establish and set seeds. In Year 2 the remaining 15-25% of the fallow area is sown down to the forage crop and excluded until June while animals are allowed to graze the forage crop in the plot established the previous year. Single Superphosphate fertilizer (SSP) should be applied to the forage crop in Year 1 and would have a positive residual effect on the "normal" arable crop which would follow in Year 3. Improved crop yields are expected due to increased phosphate levels, increased nitrogen fixation by the Siratro legume and increased organic carbon levels in the top soil if the forage crop established in Year 1 is ploughed under as a green manure in Year 3, followed by normal crop production.

The adoption of the improved crop management methods described in section 5.1 would increase crop yields and hence the biomass available as crop residue.

The ammonification of crop residue would further increase the nutritional level.

Further measures could include the introduction of high quality fodder species such as Siratro in the grazing area. It is not possible to quantify the extra fodder resource made available by this measure.

The reasonable offtake of livestock to keep the herd size within the bounds of the available forage would be within the control of individual farmers or farmer groups. Improved grazing would lead to increased weight gains and thus earlier marketing. Conserved fodder allows control of the marketing period to take advantage of the higher prices available during the October to December period.

5.3.3 Improved smallstock production systems.

The following section is a shortened version of Wijesurya, et al (1995). Readers are referred to this report for full details.

3) Establishment of feed gardens. The grazing situation and productivity of smallstock could be improved by the establishment of feedgardens next to the homesteads, where a combination of *Leucaena leucocephala* and Siratro in a 0.5 hectare area is cultivated. This has been proved in other countries and, in conjunction with a campaign to dip against ectoparasites on a monthly basis considerable improvements in goat production could be achieved. The feed gardens would need to be established as part of a credit programme, to allow households to raise sufficient capital for the initial investments.

Smallstock would be supplemented by production from the feed gardens and the fencing of the badly eroded areas would reduce erosion.

5.3.4 Improved poultry production system

Initial recommendations centre on the introduction, to more advanced farmers, of a livestock credit package for the production of broilers. Initial implementation of the credit package would be, once again, on a pilot basis. This is a higher cost package, designed to lift the able farmers out of the poverty trap and, in conjunction with a full investment project would provide a number of jobs in the abattoir. Although in principle six batches of broilers can be processed through the housing under experienced management, the projections envisage only four batches. This allows time to sterilize the building and litter and is less likely to result in disease. As management becomes more experienced there is no reason to assume that the number of batches put through the facility cannot be increased.

Normally each batch of chicks would be grown out for eight weeks and then the sterilization of the houses would take place in the next two to three days. Under the system envisaged the broilers can be grown out over a slightly longer period (though this increases costs) and there is time enough for catching and sales without disrupting the whole system should this become necessary. In addition the production of only four tranches instead of the possible five or six depresses returns and thus shows, in the financial projections, a more conservative estimate of the farmer's potential benefits.

Once again there would be a need for government to provide the basic infrastructure and extension support until such time as the full project was implemented.

Specialist services such as the supply of day old chicks and poultry equipment should be handled through a professional commercial poultry supply company.

The poultry abattoir needs initial government support in conjunction with private enterprise. The future funding is envisaged as being based on a co-operative system with the farmers buying in to the co-op by foregoing some returns on their products. The management, through the co-op, should initially be by an existing competent commercial company.

5.4 EVALUATION OF VELD PRODUCT PRODUCTION SYSTEMS

Veld product collection is no longer an important activity in the Moshupa South AEA. It is currently mainly limited to collection of wood for firewood and construction purposes and thatching grass while a few households collect herbs and grasses for medicinal purposes. In the Moshupa South AEA itself the continued cultivation of most of the land units 1, 2 and 4 has changed the species composition to predominantly invader species such as *Acacia tortilis*, *Acacia sp.*, and *Euclea undulata*. *Combretum sp.*, *Peltophorum africanum* and *Aloe sp.* are other common tree and shrub species in the area. These species are only used for the purposes mentioned above. A more varied and undisturbed species composition is found in the Polokwe hills, which is mainly used as grazing area for the community in Moshupa South AEA. Exploitable species, such as *Grewia sp.* (Moretlwa), are found throughout the area. In spite of this it appears that veld product collection is a negligible activity at present, which is not reported to contribute to annual income in any significant way. The feasibility of *Aloe sp.* as an ingredient in pharmaceutical and cosmetical products should be investigated, as it is used for these purposes in other parts of the world.

5.5 EVALUATION OF WILDLIFE PRODUCTION SYSTEMS

The Moshupa south AEA is a densely populated area with virtually no virgin land and natural habitats. It is intensively used for rainfed crop production, homesteads are located at fields throughout the area and many paths and trails traverse the area. The original wildlife mammal population is now limited to jackals, baboons, foxes and occasional antelopes (the presence of Kudu has been reported) which live in the surrounding Polokwe hills. There is no scope for wildlife utilization types based on existing wildlife population (hunting, photo safari) due to low population figures, small area, economically uninteresting species and the proximity to human dwellings and activities. Other types of wildlife utilization (game ranching, ostrich farming) would require major investments as no infrastructure, tradition for or knowledge of these land uses exists at present. Rodgers (1991) indicates that new game ranches are seldom profitable if they are not integrated into existing farms where use can be made of existing infrastructures (paddocks, fencing, watersupply). The potential for such projects is therefore considered very marginal.

5.6 EVALUATION OF AGROFORESTRY PROJECTS

An urgent need exists to plan for the anticipated increase in firewood demand, as indicated in section 4.3.

The establishment of woodlots and other agroforestry projects was discussed with the farmer committees in Moshupa South AEA. They indicate that it may be a problem to find vacant plots, as it is difficult to find unclaimed land. However, this statement was given during a initial presentation of the topic where no concrete suggestions regarding size and location were discussed. When more detailed discussions are held, farmers may be convinced that the relatively small areas involved (1-5 ha) can actually be accommodated within the area. The following points should be taken into consideration when designing woodlots:

1) Motivation of farmers. Information about the importance of woodlots and other afforestation projects in Botswana is already promoted through kgotla meetings, VDC meetings, agricultural shows, demonstration plots and public announcements. It has nevertheless been seen in other woodlot projects, that farmers often show great interest in the early stages, but that enthusiasm may diminish when daily routines need labour or other contributions which are already scarce. A great effort must be invested in motivating farmers and making them feel that their input is worthwhile. It might be investigated to what extent the local population could be allowed to control

all the aspects of natural resource management, with technical assistance from the Ministry of Agriculture.

2) Water availability. This crucial factor is the single most important factor for the choice of location. Due to the relatively large amounts of water needed for the establishment of trees, the ideal location is close to perennial water sources. The following waterpoints (boreholes, springs, large dams) seem most promising (see also figure 2.5):

a) D1, Tlhokwane dam in Polokwe
b) S1, Spring in Sobe/Pyetle grazing area
c) BH1 and BH2, Government boreholes in Sobe

Preliminary discussions with the Irrigation Section in Southern Agricultural Region indicate that the BH2 borehole could irrigate a woodlot measuring three ha (pers. comm., 1995).

In case of very small areas (0-0.5 ha), smaller water points may be sufficient to provide water. In this case, many of the small dams in Polokwe seem promising:

d) D11-D33

4) Location and access. Ideally, woodlots should be located close to the users. The relatively small area of the Moshupa South AEA and easy access routes in all of the extension area makes it generally uniformly suited for woodlots.

5) costs and labour requirements. A project proposal for the Forestry Extension Programme in Pitsane (FEPP) in 1989 details the costs of a 13.5 ha agroforestry project as follows (1989 prices):

- Fencing:	P 4603.55
- Seedlings and amendments:	P 12287.80

Although this project incorporates horticultural activities and is at a more commercial scale than what may be relevant for Moshupa South AEA, the figure nevertheless gives an impression of the costs involved with the establishment of woodlots. The big amounts needed can be subsidized by Government or donor programmes. The EU-sponsored "Forestry Protection and Development" project at the Ministry of Agriculture has expressed a strong interest in this recommendation, and assistance is likely to be available provided swift action is taken. o

Major labour inputs are required for fencing, ground preparation, planting, watering, termite control. It is expected that each planted tree will require watering with approximately 10 liters (1 bucket) twice a week for the first two growing seasons (dry periods).

6) Provide economic incentive. Financial assistance can be provided under the AE10 programme to farmers willing to start community woodlots. Under this programme, the households can be supplied with materials (seedlings, fencing material, standpipes). The VDC for Polokwe/Kgotla sub-extension areas indicated that if labour is employed, they may be paid by VDC funds. It may be desirable if the subsidies could be staggered, so that a significant portion is given to establish woodlots and the rest is given when woodlot/trees are well-established after a couple of years.

It should be assured that the financial benefits (if any) proceeding from the sale of firewood and poles go to the community managing the resource. Retrieval of firewood etc. by outsiders should therefore be controlled.

7) Provide technical support. Farmers will need technical input from the Forestry Section to ensure success of projects. The EU-sponsored "Forestry Protection and Development project" has expressed a strong interest in this recommendation and assistance is likely to be available if a request is formulated soon.

8) Land tenure. Land board should be involved to assure that land can be allocated for woodlots in the area.

It should be noted that woodlots seem to pose particular management problems when it comes to community or group managed woodlots. Several factors probably come into play, such as:

- the long term planning aspect. The 8-10 year it takes for trees to reach a harvestable age is too long to sustain group interest in woodlots. A combination with other products may sustain motivation during this period.
- the economic management. The sharing of cost and profits has proven to be very difficult for many woodlot groups.
- conflict with other interests. Realizing that rural households are engaged in many activities, a woodlot may cause conflict with crop production, livestock rearing, drought relief activities etc. in terms of time, capital, labour and motivation.

A special conflict is posed by the fact that farmers generally disfavor trees in the vicinity of the lands area, since they provide nesting places for birds which may diminish yields. Farmers may also fear that predators such as foxes, jackals and baboons may hide in wooded areas and attack smallstock and damage crops. However, the felling of trees around fields increases wind and water erosion and will eventually decrease crop yields. This (perhaps irreversible) environmental damage is much more important for agricultural production in the long term than the questionable crop damage by wildlife and birds from trees. Unfortunately this point is not always appreciated by farmers, who usually plan for a more limited period.

A proper feasibility study will be necessary to investigate these issues and to propose woodlot options to the community. The following items require investigation (the term "woodlot" is used in a broad sense, including small to large size agro-forestry projects).

1) costs of woodlots
2) water need of woodlots
3) identification of suitable sites and/or priority areas
4) populations opinion about woodlots
5) possible financial subsidy schemes to establish woodlots
6) land tenure conditions for woodlot establishment
7) management options for different types of woodlot

It would probably be necessary to develop several types of woodlot projects, to cater for water availability and land resources. As mentioned earlier, small (up to 1 ha) and large (1-5 ha) woodlots are possible alternatives.

It appears that the physical conditions are suitable for the establishment of a woodlot at borehole BH2. Furthermore, the positive interest expressed by the EU-sponsored "Forestry Protection and Development project" indicates that assistance is likely to be available.

CHAPTER 6

APPRAISAL OF ALTERNATIVES

6.1 GROSS MARGIN ANALYSIS OF RAINFED ARABLE PRODUCTION SYSTEMS

6.1.1 CYSLAMB crops

The financial performance of the production systems in the three scenarios have been calculated in terms of gross margins, based on cost figures and sales value from BAMB (BAMB, 1994) as indicated in section 3.8.

No fixed costs have been considered and no labour costs included since they in most cases only concern family labour. This means that costs of weeding, birdscaring and for shelling of groundnuts are **not** included in the calculation. The effect of pest and diseases in the baseline scenario has been simulated by reducing yields and consequently the value of produce with 20%. In the other scenarios, the costs of efficient plant protection, using Alphametrin at a dosage of 10 % has been deducted from the value of the produce.

A residual effect of the Single Superphosphate fertilizer application for three years is assumed, based on the findings of M.J. Jones which are reported in De Wit (1992). The residual effect is taken into account by dividing the fertilizer cost by three, simulating a fertilizer application every four years.

The combination of costs used in the gross margin calculations are listed in table 6.1.

Table 6.1 Production costs for CYSLAMB scenarios (Pula/ha)

Management systems	seed cost	fertilizer cost	plant protection cost	Total costs
Baseline scenarios	2.5	none	none	2.5
improved scenarios	2.5	0 or 18[1]	20	22.5 - 40.5
optimal scenario	5	18 or 31 to 50[2]	20	43 - 75

[1] No SSP fertilizer and 100 kg/ha respectively (see table 6.3)
[2] 100 kg/ha or 175 to 280 kg/ha SSP respectively (see table 6.4)

It must be remembered, when interpreting the results of the financial analysis, that the figures are **indicative** of the **potential** profit that can be derived from different crop production systems. The CYSLAMB program does not account for all factors which may decrease crop yields, and the figures should be used to compare the potential benefit of different crop production systems with that in mind.

The results are presented in tables 6.2, 6.3 and 6.4. Each table details the potential profit from the crop production systems in the three scenarios simulated in section 5.1.

The following key will assist in interpretation of the tables:

389 — The figures shown in **light shade** indicate the most profitable soil units for a given production system.

402 — The figures shown in **light shade** and with a **thick outline** indicate the most profitable combination of a soil unit and a production system for a specific crop.

531 — The figures shown in **dark shade** and with a **thick outline** indicate the most profitable combination of a soil unit and a crop production systems for the given scenario.

Table 6.2 Gross-margin analysis of baseline scenario (Pula/ha)

crops		sorghum		maize		millet		cowpea		groundnut	
mana.	soil	days to weeding		days to weeding		days to weeding		days to weeding		days to weeding	
syst.	type	50	30	50	30	50	30	50	30	50	30
Bs1	ARo	183	205	148	185	128	147	77	90	300	320
	ARl	133	150	101	131	90	105	61	73	237	249
	LVf	186	247	145	256	114	150	73	94	304	340
	LVk	131	174	97	171	78	102	56	69	225	253
	LVx	186	247	145	256	114	150	73	94	304	340
	LVj	133	147	95	115	83	93	56	69	233	245
	LVh	128	174	88	171	74	100	56	69	225	253
	RGe	147	147	101	101	78	93	56	69	253	261
Bs2	ARo	126	140	62	85	71	83	52	65	253	269
	ARl	88	102	44	58	52	57	40	52	197	213
	LVf	131	143	74	113	71	88	56	69	265	281
	LVk	90	100	48	60	47	55	40	48	197	205
	LVx	131	143	74	113	71	88	56	69	265	281
	LVj	83	100	44	53	50	57	40	52	193	209
	LVh	90	97	48	74	45	59	40	48	197	205
	RGe	88	102	37	44	55	62	44	56	209	221
Bs3	ARo	97	112	-2.5	4	64	78	61	65	237	245
	ARl	69	78	-2.5	-2.5	43	52	44	52	185	193
	LVf	112	126	-0.2	25	71	88	65	69	253	265
	LVk	71	81	-2.5	2	45	52	48	52	185	197
	LVx	112	126	-0.2	25	71	88	65	69	253	265
	LVj	69	78	-2.5	-2.5	38	47	44	48	181	193
	LVh	71	81	-2.5	2	43	52	48	52	185	197
	RGe	78	86	-2.5	-2.5	43	52	48	52	201	213
Bs4	ARo	40	40	-2.5	-0.2	19	24	19	19	85	85
	ARl	28	28	-2.5	-2.5	12	17	14	14	65	65
	LVf	36	43	-2.5	7	24	28	19	23	85	89
	LVk	24	28	-2.5	-0.2	14	17	14	14	61	65
	LVx	36	43	-2.5	7	24	28	19	23	85	89
	LVj	28	28	-2.5	-2.5	12	14	14	14	65	65
	LVh	21	28	-2.5	-0.2	14	17	14	14	61	65
	RGe	36	36	-2.5	-2.5	12	17	14	14	73	73

Table 6.3 Gross-margin analysis of improved scenario (Pula/ha)

crops		sorghum		maize		millet		cowpea		groundnut	
mana.	soil	use of fertilizer		use of fertilizer		use of fertilizer		use of fertilizer		use of fertilizer	
syst.	type	0	100 kg	0	100 kg	0	100 kg	0	100 kg	0	100 kg
Is1	ARo	301	347	232	286	195	235	110	115	439	494
	ARl	205	299	143	236	131	197	86	103	336	443
	LVf	369	401	347	391	209	221	116	109	467	500
	LVk	239	350	209	329	120	194	80	97	342	449
	LVx	369	418	347	408	209	231	116	115	467	517
	LVj	199	289	116	207	107	170	80	91	331	432
	LVh	239	350	209	329	117	190	80	97	342	449
	RGe	202	279	93	154	103	153	80	91	353	438
Is2	ARo	195	221	100	108	93	109	74	73	365	409
	ARl	124	187	60	91	52	88	56	61	285	369
	LVf	195	207	133	144	110	116	80	67	382	403
	LVk	124	184	57	85	46	78	50	61	274	364
	LVx	195	218	133	154	110	119	80	73	382	420
	LVj	120	184	50	78	49	85	56	61	279	364
	LVh	120	177	60	114	59	92	50	61	274	364
	RGe	120	170	34	45	59	82	62	61	296	364
Is3	ARo	131	160	−22.5	−41	73	88	74	73	331	369
	ARl	80	129	−22.5	−41	29	68	56	61	257	329
	LVf	161	170	−22.5	−41	93	99	80	73	359	381
	LVk	86	143	−22.5	−41	35	75	56	61	262	341
	LVx	161	184	−22.5	−38	93	112	80	79	359	392
	LVj	80	129	−22.5	−41	25	61	50	61	257	329
	LVh	86	143	−22.5	−41	35	75	56	61	262	341
	RGe	90	129	−22.5	−41	35	65	56	61	285	352
Is4	ARo	39	37	−22.5	−41	8	3	8	−5	103	102
	ARl	18	27	−22.5	−41	−6	−3	2	−5	74	90
	LVf	42	34	−22.5	−41	15	7	14	1	108	102
	LVk	15	24	−22.5	−41	−2	−3	2	−5	74	84
	LVx	42	37	−22.5	−41	15	10	14	1	108	107
	LVj	18	27	−22.5	−41	−6	−7	2	−5	74	90
	LVh	18	24	−22.5	−41	−2	−3	2	−5	74	90
	RGe	32	37	−22.5	−41	−2	−7	2	−5	86	102

The following conclusions can be drawn from the analysis:

The most profitable crop production system

The overall most profitable crop production system is the production of groundnuts on a Ferric or Chromic Luvisol using an optimal crop management system which includes the use of 175 kg of SSP fertilizer to raise the P-level in the topsoil to 10 PPM. The profit margin is 548 P/ha. This profit will be reduced if the cost of groundnut shelling is taken into consideration. However, assuming that this will not exceed 45 Pula/ha, this production remains the most profitable.

The most profitable soil type

The soil units showing the highest gross margins in general are the Chromic and Ferric Luvisols.

Table 6.4 Gross-margin analysis of optimal scenario (Pula/ha)

crops		sorghum		maize		millet		cowpea		groundnut	
mana. syst.	soil type	use of fertilizer		use of fertilizer		use of fertilizer		use of fertilizer		use of fertilizer	
		100 kg	10 PPM	100 kg	10 PPM	100 kg	10 PPM	100 kg	10 PPM	100 kg	10 PPM
Os1	ARo	399	438	327	373	249	281	113	105	498	529
	ARl	344	423	266	358	212	267	101	90	452	514
	LVf	453	503	422	489	252	292	107	106	509	548
	LVk	399	491	351	467	212	270	95	90	458	526
	LVx	487	503	439	489	273	292	113	106	526	548
	LVj	334	409	198	284	174	229	95	84	429	497
	LVh	392	481	351	467	212	270	95	84	458	526
	RGe	310	362	140	185	164	185	89	74	435	476
Os2	ARo	252	274	116	121	123	128	71	57	407	432
	ARl	212	260	93	107	93	114	59	42	367	417
	LVf	242	265	137	163	123	132	71	58	401	434
	LVk	201	243	93	103	82	97	59	36	361	412
	LVx	256	265	150	163	133	132	71	58	418	434
	LVj	191	239	89	100	82	100	59	42	367	417
	LVh	201	243	99	141	93	110	59	36	361	412
	RGe	178	206	38	36	86	87	65	50	367	402
Os3	ARo	157	162	-43	-69	76	77	71	57	367	387
	ARl	123	148	-43	-84	45	63	59	42	327	372
	LVf	167	190	-43	-62	99	112	71	64	378	405
	LVk	130	168	-43	-84	62	90	59	42	338	383
	LVx	184	190	-43	-62	103	112	77	64	389	405
	LVj	106	141	-43	-84	35	59	59	36	327	372
	LVh	130	168	-43	-84	62	90	59	42	338	383
	RGe	123	148	-43	-76	52	66	65	44	350	379
Os4	ARo	42	33	-43	-69	-3	-21	-7	-27	105	90
	ARl	31	18	-43	-84	-13	-36	-7	-42	88	76
	LVf	31	30	-43	-62	4	-0	-1	-20	99	98
	LVk	21	8	-43	-84	-9	-26	-7	-42	88	76
	LVx	38	30	-43	-62	11	-0	-1	-20	105	98
	LVj	31	18	-43	-84	-16	-36	-7	-42	88	76
	LVh	21	8	-43	-84	-9	-22	-7	-42	88	76
	RGe	38	26	-43	-76	-13	-29	-7	-34	99	83

The most profitable management system

The most profitable management systems (for all scenarios) are those which rely on early planting and the use of one planting opportunity (Management system number 1). The maximum profits (calculated on a chromic Luvisol) are summarized in table 6.5 for the five crops included in the simulation.

Table 6.5 Optimal gross margin on a Chromic Luvisol

Management systems Bs1-Os1	Sorghum	Maize	Millet	Cowpea	Groundnut
Range in profit (On a Chromic Luvisol)	247-503	256-489	150-292	94-116	340-548

Management systems relying on late planting (after New Year) and the use of more planting opportunities are not profitable in a number of cases (negative gross margins). Cultivation of maize is always seen to be unprofitable when planting occurs late. This is also true for millet and cowpea following an improved management system with fertilizer use on most soiltypes. With higher levels of inputs (optimal scenario), the cultivation of most crops is unprofitable if SSP fertilizer is added to reach a level of 10 ppm P in the topsoil for management systems relying on late planting and the use of three planting opportunities (except for sorghum and groundnuts). It is generally not profitable to use such high fertilizer doses for cowpeas, regardless of the management system used.

The most profitable crop production system for grain crops

Amongst the grain crops sorghum appears to be the most profitable crop in the baseline scenario on most soil types and under most management systems. On the most suitable soils, the Chromic and Ferric Luvisol, maize will give higher returns under management system 1 when weeding occurs after 30 days instead of 50 days. In the improved and optimal scenarios, sorghum is always the most profitable grain crop, regardless of soil type.

Profitability of baseline scenarios

In the baseline scenario, weeding after 30 instead of 50 days is found to be most profitable management system. Increases in profits obtained by earlier weeding average 18%. They are generally higher the earlier planting takes place, and are highest for maize and millet, lowest for groundnut.

Profitability of improved scenarios

In the improved scenario, the use of a 100 kg/ha SSP fertilizer application is found to be profitable in 75% of all cases. In these cases, an average increase of the gross margin of 31% can be expected. Fertilizer application is not profitable in many cases where management systems rely on late planting (IS3 and IS4). Fertilizer application shows a particularly bad response in the gross margin for cowpea, where it is less profitable than cultivation without fertilizer in 50% of all cases.

Profitability of optimal scenarios

In the optimal scenario, gross margins are generally found to be higher when the P-level is raised to 10 ppm, except in cases where planting occurs late and requires three planting opportunities (OS4). As in the other scenarios, maize is found to be unprofitable if planting occurs late. The average increase in gross margins under maximum fertilizer dosage is 17%. The high dosage of fertilizer gives negative financial returns for cowpea under all management systems.

An increase in plant density alone from 30.000 to 50.000 plants/ha is found to result in an increased financial return for sorghum and millet when planting takes place before New Year (management systems Os1 and Os2).

More modest increases are expected for maize and only if planting takes place before New Year, using one planting occasion (management system Os1). Under other management systems, the increase in plant density alone will result in a decrease in profitability.

Since CYSLAMB does not simulate the effect of different plant densities for groundnut and cowpea, the results of different plant densities for these crops cannot be interpreted.

Table 6.6 The most profitable management systems

Crop	Management system	Soil type	Gross margin (Pula/ha)
Sorghum	OS1	LVf, LVx	503
Maize	OS1	LVf, LVx	489
Millet	OS1	LVf, LVx	292
Cowpea	IS1	LVf, LVx	116[1]
Groundnut	OS1	LVf, LVx	548

[1] No use of fertilizer

6.1.1.1. Market analysis

Before a large-scale effort is launched to promote groundnut cultivation amongst households in Moshupa South AEA, a survey should be undertaken, to identify possible bottlenecks in the production system. Groundnuts are presently not widely cultivated and farmers complain that it is labour-demanding and "takes space away from sorghum". Particular topics to research are:

- does groundnut production compete with other crops and activities for scarce resources? If farmers are not interested in groundnut production due to high labour demand or general hesitant towards new crops, programs must be designed to alleviate these constraints.

- how can shelling be done most efficient? (A promising solution is the newly developed groundnut shelling machine which is being developed at RIIC in Kanye. Still at the prototype stage, this machine could be installed at a central location, and used by farmers against a fee).

- can a reliable and profitable production circuit be established (at local or other level) to ensure market for products.

- what employment opportunities are available within groundnut production in the area. The potential for employment of hired labour at farm level (maybe subventioned by a financial "soft loan" scheme), labour in product processing (deshelling, oil pressing) should receive attention.

Many of these topics are also relevant for the introduction of alternative crops mentioned in the following section.

6.1.2 Alternative crops

Very limited information is available concerning the market value of the alternative crops which were presented in table 4.2. The available information is presented in table 6.7.

Table 6.7 Gross margin for some alternative crops

Name of crop	Expected average yields (kg/ha)[1]	Value of produce (Pula/ha)	Gross margin (pula/ha)[2]
Sunflower (Helianthus annuus)	170-370	100-220	60-180
Jugo bean (Vigna subterranea)	150-320	100-200	60-160
Tepary bean (Phaseolus acutifolius)	150-320	76-200	40-160

[1] Based on comparison with a CYSLAMB reference crop (see also table 4.2)
[2] Based on improved scenario costs (use of Alphametrin and 100 kg SSP (see also table 6.1)

Source: Sims (1981) and LUPSAD (1995b).

This information indicates that alternative crops may be profitable in Moshupa South AEA. The gross margins which can be expected equal those of most crops currently cultivated in the area assuming similar costs of production as indicated in table 6.1 for the improved scenarios.

6.2 GROSS MARGIN ANALYSIS OF IRRIGATED ARABLE PRODUCTION SYSTEMS

In the following, it is attempted to calculate the gross margin and the net farm income for an irrigation project at BH2.

The information presented in table 6.8 and 6.9 is based on estimated production costs and prices in Central Agricultural Region (LUPSAD, 1995b). They indicate that a double-cropping irrigation project at BH2 is financially attractive, providing a gross margin of 17 458 P for a 1 ha project.

The net farm income for the project is presented in table 6.8, in which the fixed costs have been deducted from the gross margin. A net farm income of 16 228 P/year is expected, provided all production factors are optimal (good soils and fair yield, double cropping, excellent market and good management.

Table 6.8 Net farm income for irrigation project BH2 (Pula)

Perimeter fence (materials and labour)	1500
Pump, reservoir, hose, fittings, sprinklers	10000
plot preparation (destumping and ploughing)	300
tools	500
total fixed costs	12300
total fixed costs (per year)[1]	1230
total variable costs (per year)	17458
total costs (per year)[2]	18688
net farm income	16228

[1] a 10% depreciation per year is expected
[2] only costs of hired labour is included, not of owner himself/herself

Source: LUPSAD (1995b)

Table 6.9 displays the break-down of the gross-margin calculation and the financial variables at the basis of the calculations.

An irrigated horticultural project appears to be a very promising option based on this analysis. However, the gross margins estimated are much higher than any presently realized in Southern Region. It is likely that the actual feasibility of a project may be lower, viewed against experiences with present projects.

Table 6.9 Gross margin calculation for irrigation project BH2

		Oct-Feb (135 days)	Mar-Sep (180 days)	Year total 1 ha
Value of produce	Crop	Tomato	Onion	
	Yield (kg/ha)	20 000	25 000	
	Price (P/kg)	1	0.8	
	Value	20 000	20 000	40 000
Variable costs	Seed (type)	seedbed	direct seed	
	Quantity (kg/ha)	0.4	10	
	Price (P/ha)	150	100	
	Cost/seeds	-60	-1000	-1060
	Fertilizer (type 1)	compound	compound	
	Quantity (kg/ha)	500	500	
	Price (P/kg)	0.59	0.59	
	Fertilizer (type 2)	amm.sulph.[2]	amm.sulph.[2]	
	Quantity (kg/ha)	200	300	
	Price (P/kg)	0.76	0.76	
	Cost/fertilizer	-447	-523	-970
	Pesticides (type)	various	various	
	Cost/agro-chemicals	-250	-250	-500
	Marketing containers	boxes	bags	
	Quantity	2500	3200	
	Price (P/each)	1.3	0.35	
	Cost/containers	-3250	-1120	-4370
	Fuel (type)	diesel	diesel	
	Quantity (l/ha)	450	550	
	Price (P/l)	1.08	1.08	
	Cost/fuel	-488	-594	-1080
	Hired labour (type)	unskilled	unskilled	
	Hired labour (mandays/ha)	540	720	
	Price (P/day)[1]	8	8	
	Cost/hired labour	-4320	-5760	-10080
	Transport to market	hired	hired	
	Distance to market (km)	20	20	
	Number of roundtrips	65	70	
	Cost (P/km)	0.83	0.83	
	Cost/transport	-2158	-2324	-4482
Gross margin		9029	8429	17458

[1] Days of 6 hours. Wage level is higher than wages paid at Drought Relief Projects (which is 6 P/day in 1995-96 season)
[2] ammonium sulphate fertilizer

Source: LUPSAD (1995b)

CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS

The main land use problems in Moshupa South AEA arise from an increasing population attempting to extract a living from an area which is of limited size and thereby putting the land under increasing pressure for arable land, grazing, firewood and other veld products. Many households in Moshupa South AEA are poor and have little or difficult access to basic agricultural resources, such as labour and draught power. The presentation of land use problems in chapter 4 showed how the present constraints to crop and livestock production are interlinked and need comprehensive planning to improve the living condition of the population in the planning area.

7.1 INCREASE CROP YIELDS

The adoption of improved management systems is likely to increase crop yields substantially. Extension recommendations should be targeted to different farming household groups.

Poor households with low labour and draught power availability (P1, P2, W1) should be motivated to improve the quality of existing crop management system, especially with regard to timing of planting and weeding. Households should strive to utilize the first planting rains, and should consider reducing areas cultivated to increase total yields. This should be done in accordance with household requirements, although they are normally not met by crop production in the first place. Draught power arrangements could be organized ahead of the onset of the ploughing season to allow the most efficient use of existing draught power in the extension area. This might include supplementary feeding of animals to enable a more powerful resource at the onset of the season. Weeding should be carried out after 30 days to improve crop yields. Households should be informed of existing opportunities for draught power assistance (ALDEP). Redirection of ploughing subsidy funds into financial schemes ("soft loans") could be considered to these households, for hire of draught power and labour to adopt recommendations.

Households faced with less serious constraints (W1, W2) regarding draught power and labour availability should consider the use of 100 kg/ha Single Superphosphate fertilizer and increasing plant densities in addition to the general recommendations regarding improved crop husbandry. The timely use of pest control inputs is also likely to increase crop yields. The use of drought relief funds for agro-chemical inputs might be useful. This would require an adjustment of the present drought relief policy by MoA.

Rich households (W2, R1, R2) with high labour and draught power availability should consider the use of higher levels of fertilizer and may raise plant population levels higher.

All households should consider to diversify crops grown by introducing alternative crops such as fodder crops (buffel grass: *Cenchrus ciliaris* and siratro: *Macroptilium atropurpureum*), legumes, cash crops (groundnuts, sunflower, sesame). This recommendation must receive strong input from extension staff.

A three course rotation involving two years fodder fallow on 1/3 of the area, recent fodder fallow (1 year old) on 1/3 of the area and food and cash crops on the remaining 1/3 of the area would be an efficient way to introduce many of the recommendations listed:

improved soil fertility:	residual effect of SSP fertilizer and nitrogen fixation as well as increased organic matter content of top soil
reduced erosion:	permanent vegetation cover in 1/3 of the field during dry season
improved grazing resource:	fodder crop and storage of crop residues

improved income: sale of groundnut (and other crops), hay if surplus, better quality livestock products

7.2 IMPROVE LAND UTILIZATION

Owners of abandoned fields should be urged to cultivate their fields or initiate agro-forestry, foddercrop or other projects. When no cultivation is likely to take place, fields should be repossessed and allocated to motivated farmers. Land Board should start with fields that have been abandoned for the longest period first and those which have no known owner. The move to motivate farmers to start cultivating abandoned fields may inspire others so that Land Board is not forced to repossess recently abandoned fields.

7.3 IMPROVE SOIL MANAGEMENT

Soil fertility should be increased by recycling of nutrients, in the form of crop residue or manure or use of chemical fertilizer. Farmers should be encouraged to adopt soil conservation practices (ploughing across the slope, construction of diversional channels and bunds) to reduce surface run-off. Areas with severe sheetwash erosion should be fenced off to allow regeneration of plant cover. Grazing in areas with moderate soil erosion should be controlled to avoid further deterioration.

7.4 INCREASE FUEL WOOD RESOURCE

Woodlots and other agroforestry projects should receive high priority, to meet future demands. The use of borehole no 7006 is very promising in that respect. Woodlot projects should be designed on different scales to cater for different levels of resources, ranging from windbreaks and small orchards to community-based woodlot production of firewood and other commercially utilizable species.

7.5 INCREASE LIVESTOCK PRODUCTION

Improved herd management in the grazing area will reduce time farmers spend looking for stray cattle. A fence surrounding the grazing area in the Polokwe hills completely will allow rational use of the grazing resource and motivate farmers to look after improvements. A high-quality fodder species should be introduced to increase grazing quality.

Fodder crop species (*Cenchrus ciliaris* and *Macroptilium atropurpureum*) should be introduced in a 3-course rotation in the short-term fallow portions in farmers fields, to increase forage availability during the dry season. Crop residues should be collected and stored near homesteads to increase quality. If feasible, they can be treated with urea to increase protein content.

Feed gardens should be established close to homesteads to increase fodder availability for smallstock.

7.6 INCREASE INCOME GENERATING ACTIVITIES

A poultry abattoir should be constructed to increase job opportunities, increase value of products and motivate young people to stay in the area. The borehole no. 7006 might be used for a horticultural project which serves the same purposes.

Groundnut production has a promising potential an important cash crop in the area. The existing ADF-trials should receive high priority, and bottle-necks in the production of groundnuts should be identified.

7.7 RECOMMENDED LAND USE

The suggested land use plan is outlined in table 7.1.

Table 7.1 Recommended land use

Land unit	area (ha)	Present land use	Recommended land use	Remarks	relevant sections in report
1	13572	Extensive cattle grazing, veld product collection	improved herd management, improved grazing availability,	Seeding of Siratro plots, controlled cattle numbers, drinking water reticulation at Sobe wells site.	2.7.2, 3.3.2, 4.4, 5.3
2	1046	Traditional rainfed crop production	Improved traditional crop production, smallstock fodder gardens, woodlot, horticultural project[1]	3-course crop rotation, groundnut production, conservation farming, limited SSP fertilizer use, alternative crops	2.7, 3.3.1, 3.3.3, 4.1, 5.1
3	3667	as above	as above	as above and closure of strongly eroded areas	as above
4	6384	as above	as above	closure of strongly eroded areas, water catchment projects	as above
5	142	smallstock grazing, veld product collection,	as present	monitor erosion, smallstock grazing and firewood depletion	2.4.1, 2.5, 4.3, 5.3
6	807	smallstock grazing and watering, veld product collection	wells, grazing	as above	2.6 and as above

[1] woodlot and horticultural project at BH2 (Borehole no. 7006) by Sobe wellsite.

CHAPTER 8

PLAN OF IMPLEMENTATION

It is felt that it would be easier for staff involved in the implementation of the land use plan for Moshupa South AEA if a diagram was prepared which shows which inputs are required from different actors as well as the phasing of different activities. The diagram lists the input required for one year, assuming that all activities are initiated at the same time. Most of the activities can take place independently of each other, and it is therefore possible to prioritize between activities according to annual plans, funding, policy priorities, etc.

It is realized that funds and planning priorities may not permit the implementation of the agricultural land use plan with all its details. Two different options for implementation have therefore been prepared. The first option ("increased input") assumes all the recommendations can be implemented immediately whereas option two ("status quo") is based on a more limited set of activities being initiated.

8.1 OPTION ONE: "INCREASED INPUT"

This option reflects the optimal situation where the recommendations outlined in the agricultural land use plan are implemented in their totality. It relies on increased funding to the extension service (no. of AD's, transport) and maximum involvement of technical support staff at the Regional level.

At the extension area level, the four farmer committees will be responsible for the organizing of work groups, motivation of fellow-farmers and maintenance of structures. The DAO will introduce the land use activities and provide support through the AD. The farming community will provide labour for land use activities (construction of anti-erosion structures, seeding in grazing area, fencing of degraded areas) and identify 32 households for croptrials. It is advisable to increase the number of ADs, as outlined in section 4.1.2.5, to meet the increase in land use activities, notably the monitoring of trials and the construction of various anti-erosion structures (see table 7.2). The ADs are keyplayers since they constitute the link between extension service and the farming community and will be responsible for the daily monitoring of activities and projects. The technical officers in Southern Region will all be required to design and supervise projects within their areas of expertise. The Regional agricultural officer will play a vital role in allocating resources, request services from central level (request the use of borehole no. 7006) and assigning technical officers to support the land use activities. The RAO will coordinate crop production activities with livestock related activities through the Senior Veterinary Officer. The Senior Veterinary Officer (SVO) will be responsible for the preparation of the activity consisting of 3-course crop rotation, which involves fodder crops, in collaboration with the AD and Southern Rural Training Centre as well as seeding of Siratro seeds in the grazing area. The SVO will also supervise the establishment of feed gardens for smallstock on an experimental basis. Finally, he/she will be responsible for the preparation and implementation of management plans for the use of the new livestock watering reservoir in Polokwe as well as overall stocking rates for the planning area. Many of these activities will be monitored in the field by the Veterinary Assistant, who will liaise closely with the AD.

The Moshupa Sub-land board also has an important role, as it must act on the issue of abandoned fields and allocate land for land use activities (woodlot). Other players are the Southern Rural Training Centre, which must hold courses for 32 farming households conducting crop trials and Sebele which must provide seeds and do research into the suitability of alternative crops in the area. Finally, The Government of Botswana, through the Ministry of Agriculture, must create an enabling environment as far as funds, support programmes and legislation is concerned. The suggested plan of implementation is summarized in table 8.1.

Table 8.1 Implementation of Moshupa South AEA land use plan: Increased input

Level	Major player	April to September 1996	October 1996 to March 1997
Moshupa South AEA	Farming household	8 R2 households trained in 3-course crop rotation, ammonification of crop residue 8 W2 households trained in production of groundnut, sesame, sunflower 8 P1 households trained in improved crop management, draught power arrangements and storage of crop residue at kraal 8 households with gulley formation in fields trained in grass strip planting	8 R2 households to adopt 3-course crop rotation 8 W2 households to cultivate 0.25 ha plots of groundnut, sesame, sunflower 8 P1 households to improve crop management, make draught power arrangements, store crop residue at kraal 8 households with gulley formation in fields to plant grass strips
	Farmers commitee	to be briefed about land use plan to identify site for siratro seeding in grazing area to identify 4 areas to fence off to allow regeneration of vegetative cover to identify 4 areas for construction of gully structures	to organize workgroup to distribute seeds in grazing area to organize workgroup to fence off moderately eroded areas to organize workgroup to make gulley structures in uncultivated areas
	Agricultural demonstrator(s)	to identify 32 farming households for improved crop husbandry demonstrations to brief farmers commitees/farmers/kgosi/councilers about land use plan at Kgotla meeting to facilitate draughtpower arrangements for 4 P1 households	to supervise 32 households with crop trials and grass strip cultivation to follow up on draught power arrangements
	veterinary assistant	to collect information on herd composition to organize farmers for distribution of Siratro seeds to identify 4 W1 households for establishment of smallstock feed gardens to supervise use of new livestock watering reservoir in Polokwe	to supervise preparation of herd management plans to supervise Siratro seeding in grazing area to monitor feed gardens to identify possible water sites in grazing area
Ngwaketse North District	District agricultural officer	brief farmers commitees/farmers/kgosi/councilers about land use plan at Kgotla meeting	to monitor progress of all land use activities to coordinate land use activities with Moshupa L.B and DAHP to process applications for AE10, ALDEP support to land use activities promptly
Southern Agri. Region	Irrigation officer	to design construction of woodlot/agroforestry project for borehole 7006, and small dams in AEA	to supervise construction of woodlot/agroforestry project for borehole 7006 dams and the spring in Sobe grazing area
	Soil conservation officer	to assist in identification and assessement of eroded areas to design 4 structures for protection of fields	to supervise construction of 4 structures for protection of fields
	Marketing officer	to analyze feasibility of introduction of new crops to identify site for groundnut sheller, design terms of use	to process application/supervise construction for groundnut sheller
	Water development officer	to identify 4 households and design water harvesting structures to identify sites for 4 small dams	to supervise construction of 4 water harvesting projects to supervise construction of 4 small dams
	Forestry officer(s) (district/regional)	to design a 3 ha woodlot by bh no. 7006 to design different types of agro-forestry projects	to arrange for seedlings and other materials to monitor 3 ha woodlot and other agro-forestry projects
	Crop production officer	to plan crop trials	to support all crop-related activities (inputs, know-how)
	Range ecology officer	to make detailed vegetation survey in grazing area to plan paddocking in grazing arae	to monitor range conditions in grazing area to monitor smallstock grazing habits/damage in lands area
	Land use officer	to supervise first phase of implementation of land use plan	to monitor progress of all land use activities to inform RAO and other staff of progress
	Poultry officer	to identify site for poultry abbatoir	to process application/supervise construction for poultry abbatoir
	Regional acricultural officer	to request the use of borehole 7006 from DWA to post one more AD and a vehicle for land use activities in Moshupa South AEA	to coordinate activities with DAHP
	Senior veterinary officer	to organize buffel grass and siratro seeds for 3-course rotation to organize supply of Siratro seeds for grazing area to organize establishment of smallstock feed gardens to monitor use of new livestock watering reservoir in Polokwe	to coordinate activities with DCPF
Others	Southern Rural Training Centre	to train 32 households in improved crop production practices to train work groups in construction of anti-erosion structures, fencing, seeding in grazing area	
	Moshupa Sub-Land board	to approach owners of fields abandonded >20 years to make lease agreements with farmers willing to do so to allocate land for woodlot	to repossess fields with no owners
	Sebele	to issue buffel grass and siratro seeds for 3-course rotation	to prepare recommendations for alternative crops
	Department of Water affairs	to allow the use of borehole 7006	
	Ministry of agriculture	reformulate ploughing subsidy policy increase extension area funds (number of AD's, transport) prepare financial assistance (soft loans, credits)	implement new subsidy policy (include fertilizer) offer financial assistance (soft loans, credits)

8.2 OPTION TWO: "STATUS QUO INPUT"

The second option presents a more limited set of activities which is more likely to be implemented given the present set of circumstances for the agricultural extension service in Moshupa South AEA.

The main differences between the two option are as follows:

- The number of supervised farming households is reduced. Instead of identifying 32 households, the total number of households is limited to 16 (12 implementing crop trials and 4 engaged in anti-erosion grass strip cultivation). This allows the supervision to be carried out by one AD.

- The present number of AD's is maintained. It might not be possible to increase the number of AD's in the area from one to two. The status quo input option is therefore based on the present situation.

- No extra transport is available. Similarly to the last condition, it is assumed that the existing transport situation will be maintained. This will not allow the AD to supervise as many crop trials and land use activities as scheduled under the increased input option.

The suggested plan of implementation under the status quo input option is summarized in table 8.2.

The activities presented in the diagrams must be accompanied by management plans which ensure that livestock numbers are limited to a sustainable level which falls within the carrying capacity of the area, and that herd management is improved to utilize the existing resources optimally. Although the management plans should be implemented by the community of Moshupa South AEA, technical assistance and supervision should be given by officers from DAHP, notably the SVO and VA.

Table 8.2 Implementation of Moshupa South AEA land use plan: status quo input

Level	Major player	April to September 1996	October 1996 to March 1997
Moshupa South AEA	Farming household	4 R2 households trained in 3–course crop rotation, ammonification of crop residue 4 W2 households trained in production of groundnut, sesame, sunflower 4 P1 households trained in improved crop management, draught power arrangements and storage of crop residue at kraal 4 households with gulley formation in fields trained in grass strip planting	4 R2 households to adopt 3–course crop rotation 4 W2 households to cultivate 0.25 ha plots of groundnut, sesame, sunflower 4 P1 households to cultivate smaller area, make draught power arrangements, store crop residue at kraal 4 households with gulley formation in fields to plant grass strips
	Farmers commitee	to be briefed about land use plan to identify site for siratro seeding in grazing area to identify 4 areas to fence off to allow regeneration of vegetative cover to identify 4 areas for construction of gully structures	to organize workgroup to distribute seeds in grazing area to organize workgroup to fence off moderately eroded areas to organize workgroup to make gulley structures in uncultivated areas
	Agricultural demonstrator	to identify 16 farming households for improved crop husbandry demonstrations to brief farmers commitees/farmers/kgosi/councilers about land use plan at Kgotla meeting to facilitate draughtpower arrangements for 4 P1 households	to supervise 16 households with crop trials and grass strip cultivation to follow up on draught power arrangements
	veterinary assistant	to collect information on herd composition to organize farmers for distribution of Siratro seeds to identify 4 W1 households for establishment of smallstock feed gardens to supervise use of new livestock watering reservoir in Polokwe	to supervise preparation of herd management plans to supervise Siratro seeding in grazing area to monitor feed gardens to identify possible water sites in grazing area
Ngwaketse North District	District agricultural officer	brief farmers commitees/farmers/kgosi/counciliers about land use plan at Kgotla meeting	to monitor progress of all land use activities to coordinate land use activities with Moshupa L.B and DAHP to process applications for AE10, ALDEP support to land use activities promptly
Southern Agri. Region	Irrigation officer	to design construction of woodlot/agroforestry project for borehole 7006, and small dams in AEA	to supervise construction of woodlot/agroforestry project for borehole 7006 dams and the spring in Sobe grazing area
	Soil conservation officer	to assist in identification and assessement of eroded areas to design 4 structures for protection of fields	to supervise construction of 4 structures for protection of fields
	Marketing officer	to analyze feasibility of introduction of new crops to identify site for groundnut sheller, design terms of use	to process application/supervise construction for groundnut sheller
	Water development officer	to identify 4 households and design water harvesting structures to identify sites for 4 small dams	to supervise construction of 4 water harvesting projects to supervise construction of 4 small dams
	Forestry officer(s) (district/regional)	to design a 3 ha woodlot by bh no. 7006 to design different types of agro–forestry projects	to arrange for seedlings and other materials to monitor 3 ha woodlot and other agro–forestry projects
	Crop production officer	to plan crop trials	to support all crop–related activities (inputs, know–how)
	Range ecology officer	to make detailed vegetation survey in grazing area to plan paddocking in grazing arae	to monitor range conditions in grazing area to monitor smallstock grazing habits/damage in lands area
	Land use officer	to supervise first phase of implementation of land use plan	to monitor progress of all land use activities to inform RAO and other staff of progress
	Poultry officer	to identify site for poultry abbatoir	to process application/supervise construction for poultry abbatoir
	Regional acricultural officer	to request the use of borehole 7006 from DWA	to coordinate activities with DAHP
	Senior veterinary officer	to organize buffel grass and siratro seeds for 3–course rotation to organize supply of Siratro seeds for grazing area to organize establishment of smallstock feed gardens to monitor use of new livestock watering reservoir in Polokwe	to coordinate activities with DCPF
Others	Southern Rural Training Centre	to train 16 households in improved crop production practices to train work groups in construction of anti–erosion structures, fencing, seeding in grazing area	
	Moshupa Sub–Land board	to approach owners of fields abandonded >20 years to make lease agreements with farmers willing to do so to allocate land for woodlot	to repossess fields with no owners
	Sebele	to issue buffel grass and siratro seeds for 3–course rotation	to prepare recommendations for alternative crops
	Department of Water affairs	to allow the use of borehole 7006	
	Ministry of agriculture	reformulate ploughing subsidy policy prepare financial assistance (soft loans, credits)	implement new subsidy policy (include fertilizer) offer financial assistance (soft loans, credits)

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ANNEX A THE CYSLAMB PROGRAMME

The CYSLAMB program models the performance of a selected crop under a predefined management system on a particular land unit. A land unit is typified by its soil and climatic characteristics, using actual effective rainfall figures for individual years. The results of a simulation are expressed in quantitative terms (kg/ha) and yield levels that are exceeded in a certain proportion of years (the yield probability) can be estimated, as well as the risk of crop failure.

For details on the scientific background and the operation of the program, reference is made to CYSLAMB Part I Theory and Validation (De Wit *et al.*, 1994), CYSLAMB Part II User Manual (Radcliffe *et al.*, 1995) and Applications for Agricultural Land Use Planning and Extension in Botswana, Guidelines for the Use of *CYSLAMB* (Bekker, R.P., et al, 1994).

Structure and operation of the program

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 year required by the run.

CYSLAMB first calculates what would be the maximum possible biomass production for the crop under the specified management conditions if there were no constraints due to soils or rainfall. This theoretical maximum is determined by solar radiation and temperature. The model then calculates a moisture balance from the first dekad (10 day period) of each hydrological year (1st - 10th September, "SEP1", 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 production. The moisture limited production is then adjusted to take account of the effects of drainage conditions, nutrient supply and toxicities. The amount of produce is derived by multiplying the resulting net biomass production by the harvest index and applying a moisture correction factor.

In the Botswana dataset released with CYSLAMB version 2.0, five crops (i.e. maize, sorghum, millet, cowpea and groundnut) are included.

Presentation of results

The results of CYSLAMB reflect the production on the specified soil type under the climatic conditions prevailing in a particular year. The yields calculated by CYSLAMB are *potential* yields which represent management situations without yield reductions due to pests, diseases and other adversities.

If the model is run over a number of years the outputs can be analyzed statistically to give estimates of the yield exceeded at stated levels of probability and the risks of crop failure.

The CYSLAMB program offers the user a complete series of yield statistics for simulation runs consisting of more than five years.

The individual annual yields predicted by CYSLAMB do not follow a normal statistical distribution but are skewed by years of crop failure, particularly in the drier areas of the country. The average yield does not have much meaning under these circumstances, and the results have therefore been grouped into *quartiles* to form a basis for the expression of yields in terms of probabilities. The limits between the quartiles represent the
minimum potential yields the farmer can expect in the following numbers of years:

- i) in 75% of years (lower quartile)
- ii) in 50% of years (median)
- iii) in 25% of years (upper quartile)

The lower quartile yield is the most relevant figure to traditional farmers. It is related to yields expected in years with low rainfall or more. This yield is called *dependable yield*, since the farmer can rely on it for his/her food security. Supposedly a small surplus can be build up in 75% of the years. This surplus alleviates the grain shortage occurring in one out of four years, caused by an extremely low yield or a crop failure, due to adverse rainfall. The *median yield* is achieved in 50% of the years, i.e. years with average or high rainfall.

Only advanced or commercial farmers can sustain the financial risks associated with management systems, that aim for these higher production levels. The *upper quartile yield* can only be achieved in years of above average rainfall (25% of the years).

Combining production systems: Productivity Indices

When land suitability for a number of crop production systems is evaluated, consideration must be given to the efficiency and clarity with which the results are presented. The option exists to present the results separately as single crop (or production system) suitability maps, but such a presentation can be costly and can result in a large number of maps, possibly posing practical handling problems in the field. Conversely, a single map presenting the results of several evaluations can be unintelligible unless the legend is carefully designed.

The National Land Suitability Map (De Wit, 1992) has a detailed legend in which the potential dependable and median yields of the five crops evaluated are listed for each land mapping unit. This ensures the inclusion of all the important information resulting from the evaluation. As it is not practical to present all this information on the map, yields are grouped into classes which are color coded for ease of presentation. So that the classes are not biased to any of the individual crops evaluated, a non-crop specific comparator, the *yield index*, is derived to reflect general suitability for rainfed crop production. The yield index is rated on a scale from 0 to 1000 and is calculated from proportionately weighted yields averaged over the five crops as shown in Equation (1). Separate indices are derived for dependable and median yields (INDEX_25 and INDEX_50 respectively).

$$INDEX = 1000 \times \sum_{n}^{1} \left(\frac{Y_a - Y_{min}}{Y_{max}} \right) \div n \quad (1)$$

where:

Y_a = simulated crop yield
Y_{min} = minimum simulated yield of an individual crop (over range of mapping units)
Y_{max} = maximum simulated yield of an individual crop (over range of mapping units)
n = number of crops

The dependable yield index is used as the primary criterion for separating classes of potential yield. Figure 5 shows the distribution of *INDEX_25* values and the selection of class limits. Classes *B* to *F* and *U* are then further subdivided according to the proportion of productive land within the mapping unit.

Name of enumerator:________________ Date:______________

Name of farmer:____________________ Village/location:______________

2. land tenure situation

TENURE TYPE	TOTAL HA.
Owned and registered	
Owned, not regist.	
Borrowed expense:	
Hired expense:	

When did you first cultivate field:__________

Did you clear the field: __________

Do you stay some other place part of the year (where):__________

1. Household composition

	POSITION in household	Sex: M/F	AGE/ year	PRES./ ABS.	OCCUPATION	HELP IN FIELD: doing what?
a.						
b.						
c.						
d.						
e.						
f.						
g.						
h.						
i.						
j.						

3. Sources of income.

SOURCE OF INCOME	average income (Pula/year)
Cash remittance from relatives	
Wage labour	
Sale of crops	
Sale of cattle: smallstock:	
Sale of firewood	
Other	

4. Water situation

Where do you get water for domestic use:

____

Where do you get water for livestock:

____

Is water source reliable all year round:

____

If no: where else do you fetch water:

____

5. Livestock/small stock ownership. (write numbers)

LOCA TION	CATTLE	CALVES	DONKEYS	SMALL DONK.	GOATS	KIDS
At cattle post						
at Lands						
in village						
in Mafisa						

6. Draught power situation.

DRAUGHT POWER	NUMBER OF OXEN	NUMBER OF DONKEYS	TRACTOR		
			year of purchase	price	income from ploughing
Owned					
Borrowed					
Hired expense:					
Other:					
no. of animals lost in drought					
year of drought					

Write any major changes in draught power situation within last 5 years, except drought and give reasons (example: bought tractor):

____

7. Inputs used.

INPUTS	obtained from	amount (unit?)	applied to which crops	expense	reasons for non-use
Fertilizer:			1. 2. 3.		
Kraal manure			1. 2. 3.		
Other:			1. 2. 3.		

8. Crops grown.

CROPS	Variety	approx. area grown (ha): 93-94	94-95	Yield 1993-94/ last harvest (bags or kg/ha)	Problems encountered during season (pests, lack of labour, weeds, etc)	Action taken (hire draught power, labour, etc)
Maize						
Sorghum						
Mixed (which)						
Total area cultivated						

If area cultivated 1994-95 is less than area of field: give reason: ______________________________

____

____

9. Crop husbandry

Do you ever do early ploughing:______________

When did you carry out the following operations:

operation	1993-94	1994-95	normally
plough			
plant			

(dates or approximate dates (eg. "end of october") or (eg. "end of october - end of November").

When were you last self-sufficient in maize/sorghum?:___________

How many bags did you produce that year: ma.:_______ so.:_______

When did you last sell maize/sorghum from your field:_________

How many bags:___________ What did you earn:_____________

When did you last hire labour to help in field:_______________

If yes: to do what, when, how many for what expense (also absent relatives):

____

____

____

____

____

10. Farming implements. Do you use the following implements? (only list implements which work!!)

	rowplanter	harrow	scofolo	plough s.furrow	plough d.furrow	scotch-cart
always						
most years						
50% of years						
seldom						
never (give reason)						
quantity						
source - (ALDEP, gift from son, borrow)						

if you rowplant crops: which crops:____________________

if yes: what might prevent you from rowplanting (lack of time, labour, broken planter, etc):

____

____

____

10. Why did you choose to plough right here:______________________

____

____

____

ANNEX C SUMMARY OF INTERVIEWS WITH 40 FARMING HOUSEHOLDS IN MOSHUPA SOUTH AEA

Reg no.	Head of household: gender	genname	age	location	Household composition, no. of labour units in different age classes/gender: RSA Mine	de facto fhh	no. A.M. P	no. A.M. A	no A.F. P	no A.F. A	no M.M. P	no. M.M. A	no M.F. P	no M.F. A	no. <10yrs	no. 10–14	no. 15–17	no. >18yrs	Total L.U.	Total P	Total A	Total HH	Land data: Land owned	Reg Y/N 1/0	year field cleared	year hh cultivate	Household income (Pula), sources, importance: income per year	source of income: cattle	smallstock	crops	dr.relief
1	F	K. MOKOTEDI	53	POLOKWE	1	0	1	3	2	0	0	2	0	0	4	0	0	3	3	3	5	8	10	0			1800	0	600	0	0
2	F	B.POGISO	36	POLOKWE	1	1	0	1	1	1	0	3	0	0	2	0	0	1	1	1	5	6		0			4900	0	100	0	0
3	F	B.BONTLOGILE	30	POLOKWE	1	1	0	1	1	0	1	0	0	1	2	1	0	1	1.2	2	2	4		1			5040	0	240	0	0
4	F	K. MAGANG	48	POLOKWE	0	1	0	3	1	1	0	0	0	0	0	0	0	1	1	1	4	5	9.5	0	1967	1968	12850	0	200	60	0
5	F	C. KEMOKGATLA	28	POLOKWE	1	1	0	1	1	0	0	0	0	0	4	0	0	1	1	1	1	2		1	1989	1990	2565	0	165	0	0
6	F	B. MAROGWE	38	POLOKWE	0	0	1	0	1	1	2	0	2	0	0	2	2	2	3.4	6	1	7	10	0	1976	1977	1300	0	200	0	0
7	F	G.MONAGENG	46	POLOKWE	0	1	0	2	2	1	0	3	0	1	3	0	0	2	2	2	7	9		0	1990	1991	1200	0	100	0	0
8	M	T.MABOANG	67	POLOKWE	0	0	1	0	2	0	0	0	0	0	4	0	0	3	3	3	0	3	12	0	1959	1960	1545	0	300	45	0
9	F	M.OTUKILE	62	POLOKWE	0	0	1	1	1	2	0	0	0	0	0	0	0	2	2	2	3	5	10	0	1960	1961	600	0	240	0	0
10	F	S.OSUPENG	70	POLOKWE	0	0	1	0	1	4	0	0	0	0	14	0	0	2	2	2	4	6	15	0	1955	1956	6300	1000	0	300	0
11	M	S.LEKOBE	43	KGOTLA	0	0	2	1	1	0	1	0	0	1	4	0	1	3	3.5	4	2	6		0	INHERITED	1979	1260	0	260	0	360
12	F	L.BAKANYI	38	KGOTLA	0	1	1	0	2	0	1	1	0	0	0	1	0	3	3.2	4	1	5	20	1	1955	?	1760	0	200	60	360
13	F	T.NTEBOGANG	38	KGOTLA	0	0	1	0	1	0	0	0	0	0	4	0	0	2	2	2	0	2	3	0	1993	1994	910	250	300	0	360
14	M	S. MAJAFE	43	KGOTLA	0	0	1	0	1	0	1	0	0	1	4	1	0	2	2.2	3	1	4	10	0	INHERITED	1982	1360	400	600	0	360
15	M	K.NKGE	58	KGOTLA	0	0	1	2	2	1	0	0	0	2	1	0	0	3	3	3	5	8	3.8	0	1980	1982	1800	300	300	0	0
16	F	P.ITEBOGENG	41	KGOTLA	1	1	0	2	1	1	0	2	0	1	1	0	0	1	1	1	6	7	3	1	1977	1978	2760	0	0	0	360
17	F	N. ITEBOGENG	43	KGOTLA	0 ?		0	2	2	0	0	2	0	1	1	0	0	2	2	2	5	7	10	0	1972	1973	3000	0	0	0	0
18	F	K.SEIKANO	38	KGOTLA	0 ?		1	1	1	0	0	2	0	1	2	0	0	2	2	2	4	6	5	0	1979	1980	2000	0	200	0	0
19	M	K.RAMATHLO	55	KGOTLA	0	0	3	2	2	1	0	1	0	2	2	0	0	5	5	5	5	10	15	0	1970	1971	4900	1500	400	0	0
20	F	S.LEKOBE	50	KGOTLA	0	1	2	2	1	1	0	0	0	1	1	0	0	3	3	3	4	7	6	0	INHERITED	1974	2340	300	0	0	0
21	M	N.KOFI	54	SOBE	0	0	2	0	2	0	2	0	2	0	2	2	2	4	5.4	8	0	8	10	0	1988	1989	860	0	300	0	0
22	M	M.ALMARUMO	55	SOBE	0	0	2	1	1	3	0	0	1	1	1	0	1	3	3.5	4	5	9	5	0	1970	1971	2300	0	200	0	0
23	F	K.KGALADUA	61	SOBE	1	0	1	2	1	3	0	0	0	0	0	0	0	2	2	2	5	7	10	1	INHERITED	1987	4600	0	400	0	0
24	M	L.SEBOLAO	45	SOBE	0	0	2	1	1	0	0	0	0	0	0	0	0	3	3	3	1	4	6	1	1968	1969	660	0	300	0	0
25	F	P.SELEBATSO	38	SOBE	0	0	1	0	1	2	1	1	0	0	3	1	0	2	2.2	3	3	6	4.5	0	INHERITED	1987	860	0	500	0	360
26	M	M.NKUTWANG	47	SOBE	0	0	1	0	1	1	0	0	0	1	2	0	0	2	2	2	2	4	5	1	1975	1976	2000	850	600	0	0
27	F	S.OAGENG	33	SOBE	0	0	1	0	1	0	0	0	0	1	2	0	0	2	2	2	1	3	5	0	1987	1988	1570	850	360	0	360
28	F	B.SEKHOBE	58	SOBE	0	0	1	2	1	6	1	1	0	0	0	0	1	2	2.5	3	9	12	10	0	1962	1963	3440	0	200	0	0
29	M	R.KEMONEILWE	66	SOBE	1	0	1	3	1	1	0	2	0	0	2	0	0	2	2	2	6	8	8	0	1962	1963	2700	0	200	0	0
30	F	B.MOKGADINYANA	57	SOBE	0	0	2	2	2	2	0	0	0	0	3	0	0	4	4	4	4	8	8	0	1974	1975	3550	1700	300	0	0
31	M	S.GOLEKANYE	63	MATIHAKOLA	0	0	3	5	1	3	0	0	0	0	0	0	0	4	4	4	8	12	10	0	1946	1947	3800	0	200	0	0
32	M	B.MATSOLO	74	MATIHAKOLA	0	0	1	1	1	0	0	0	0	0	0	0	0	2	2	2	1	3	8	0	1951	1952	1750	150	400	0	0
33	F	M. OKATSWA	66	MATIHAKOLA	0	0	1	4	2	6	0	1	0	1	0	0	0	3	3	3	12	15	12	0	1959	1960	2500	0	400	0	0
34	M	K.MATHIAKOTSA	56	MATIHAKOLA	0	0	1	3	1	3	0	1	0	1	2	0	0	2	2	2	8	10	5	0	1967	1968	3120	0	120	0	0
35	M	M.MATHIAOKOTSA	94	MATIHAKOLA	0	0	3	3	4	0	0	0	0	0	0	0	0	7	7	7	3	10	6.5	0	1953	1954	3160	0	200	0	0
36	F	G.MODIAKGOTLA	52	MATIHAKOLA	1	1	0	3	2	0	0	1	0	2	0	0	0	2	2	2	6	8	10	0	1988	1989	3300	0	300	0	0
37	F	K.DINGALO	60	MATIHAKOLA	1	1	1	1	2	0	0	0	0	0	0	0	0	3	3	3	1	4	5	0	1953	1954	3060	0	300	0	360
38	M	M.LETIHATSHANE	64	MATIHAKOLA	0	0	2	2	2	3	0	0	0	0	4	0	0	4	4	4	5	9	10	0	1958	1959	3210	150	300	0	360
39	F	K.SEJABOSIGO	59	MATIHAKOLA	1	0	1	3	3	3	0	0	0	0	7	0	0	4	4	4	6	10	7.5	0	INHERITED	1952	4860	0	360	0	0
40	F	B.KESELWE	49	MATIHAKOLA	0	0	2	0	2	4	0	1	0	1	1	0	0	4	4	4	6	10	8	0	INHERITED	1971	2910	0	150	0	360
Average			52		0	0	1	2	1	1	0	1	0	1		0	0	3		3	4	7	8	0			2860	186	262	12	90
Sum of sample																															
Sum for Moshupa South AEA ("Sum" x 10)																															

F= female
M= male

does hh have absent relative working in RSA mine (y/n) (1/0)?

is household de facto femaleheaded (y/n) (1/0)?

A.M.= Adult male (>18 years)
A.F.= Adult female (>18 years)
M.M.= Minor male (10–18 years)
M.F.= Minor female (>10–18 years)
P= Present in household
A=Absent from household

Household composition per age group

No of Labour units present in hh.

Total persons (P)resent and A(bsent) in hh.

Estimate of total area of field

is field registered w. L.B.?

Reg no.	other	remittances	rem/income (%)	Livestock production system (herd composition) cattle bulls	cattle bulls/i.	cattle cows	cattle heifers	cattle oxen	cattle tollies	cattle adults	calves male	calves female	calves total	cattle calves	donkeys adults	donkeys foals	total donkeys	goats br.male	goats br.fema	goats adults	kids m:.5–1	kids f:.5–1	kids m:0–.5	kids f:0–.5	kids total	total goats	goat capital	animal capital	time used for cattle	time used for s.stock	average prices cattle	average prices s.stock
1	0	1200	67	14						14	0		0	14	6		6	20		20					0	20	3	17				
2	0	4800	98	0						0	0		0	0			0	15		15					0	15	3	3				
3	0	4800	95	0						0	0		0	0			0	15		15					0	15	3	3				
4	0	12300	96	0	1	4	3	0	1	9	0	0	0	9	9	2	11	1	15	16	9	3	10	9	31	47	8	17	2.5	2.5	530	151.3
5	0	2400	94	3						3	0		0	3	4	0	4	23		23	29				29	52	9	12				
6	0	1100	85	0	0	2	0	1	0	3	0	0	0	3	0	0	0	0	4	4	3	1	2	0	6	10	2	5	2.5	2.5	700	
7	0	1100	92	0	0	8	1	0	13	22	3	3	6	28	2	0	2	1	18	19	4	9	10	11	34	53	9	37	3	2.5	710	
8	0	1200	78	0	0	10	0	2	10	22	0	5	5	27	10	7	17	1	31	32	13	12	9	7	41	73	12	39		3		
9	0	360	60	0						0	0		0	0	0	0	0	8		8	0				0	8	1	1				
10	0	5000	79	0	1	3	1	0	1	6	0	3	3	9	5	3	8	0	12	12	4	4	5	6	19	31	5	14	3.5	4.5	800	70
11	640	0	0	1	0	3	2	1	0	7	1	1	2	9	5	0	5	1	12	13	7	5	4	4	20	33	6	15	3.5	2		60
12	0	1200	68	0	0	2	1	8	1	12	0	0	0	12	3	1	4	0	11	11	0	0	5	4	9	20	3	15	2	2		
13	0	0	0	3						3	1		1	4	0	0	0	15		15	3				3	18	3	7				
14	0	0	0	0	1	2	1	0	0	4	2	0	2	6	6	1	7	0	6	6	1	5	4	2	12	18	3	9	2.5	3	900	
15	0	1200	67	0	0	5	1	2	1	9	0	4	4	13	10	4	14	1	10	11	5	7	7	4	23	34	6	19	3.5	3.5	700	124
16	0	2400	87	0	0	3	1	5	0	9	2	1	3	12	11	3	14	0	9	9	5	7	1	6	19	28	5	17	3.5	2.5		120
17	0	3000	100	0						0	0		0	0	8	2	10	9		9	3				3	12	2	2				
18	0	1800	90	0	0	3	0	0	0	3	1	1	2	5	6	2	8	0	7	7	2	1	1	2	6	13	2	7	3.5	3		100
19	0	3000	61	1	0	7	0	4	0	12	2	2	4	16	6	2	8	0	16	16	10	9	4	5	28	44	7	23	4	3	700	
20	0	2040	87	0	0	2	0	0	0	2	0	2	2	4	2	1	3	0	5	5	2	3	3	2	10	15	3	7	4	3		105
21	500	0	0	0	0	6	0	0	0	6	1	5	6	12	2	1	3	0	6	6	0	0	7	2	9	15	3	15	3	2.5	500	50
22	1200	900	39	0	0	3	0	3	0	6	3	1	4	10	7	2	9	0	1	1	0	1	6	5	12	13	2	12	3.5	2.5		80
23	0	4200	91	0						0	0		0	0	6	2	8	20		20	14				14	34	6	6				
24	0	360	55	0	0	7	0	0	0	7	3	4	7	14	2	1	3	0	2	2	2	0	5	10	17	19	3	17	3	3	680	
25	0	0	0	0	0	2	0	1	0	3	1	1	2	5	0	0	0	0	3	3	5	0	1	11	17	20	3	8	2.5	2.5		90
26	550	0	0	0	1	3	4	0	4	12	1	1	2	14	10	4	14	0	8	8	4	7	5	10	26	34	6	20	3	2.5	700	121.3
27	0	0	0	0	1	8	0	2	0	11	1	1	2	13	5	2	7	1	7	8	15	3	6	8	32	40	7	20	3.5	2.5	775	80
28	0	3240	94	0	0	1	1	0	0	2	2	0	2	4	2		2	0	5	5	5	2	2	7	16	21	4	8	2	3	700	100
29	0	2500	93	0	0	2	1	0	1	4	0	0	0	4	2	0	2	0	1	1	0	0	2	3	5	6	1	5	2.5	3		
30	0	1550	44	0	0	5	5	2	0	12	2	2	4	16	0	0	0	0	7	7	5	8	3	6	22	29	5	21	3.5	2.5	810	
31	480	3120	82	1	0	7	0	3	0	11	3	3	6	17	3	0	3	0	4	4	5	0	3	5	13	17	3	20	4	3	799.4	100
32	0	1200	69	1	0	5	1	1	1	9	3	2	5	14	16	3	19	1	12	13	9	4	20	6	39	52	9	23	3	1.5	600	110
33	0	2100	84	0	0	8	3	0	3	14	3	3	6	20	15	0	15	0	30	30	18	16	30	23	87	117	20	40	3	1.5	875	100
34	0	3000	96	0	0	5	0	0	0	5	2	3	5	10	0	0	0	0	0	0	0	0	2	9	11	11	2	12	3.5	2		
35	0	2960	94	0	0	1	1	0	1	3	0	0	0	3	3	1	4	0	1	1	3	1	0	4	8	9	2	5	3.5	2		
36	0	3000	91	0	0	3	0	0	0	3	0	1	1	4	7	2	9	1	22	23	2	8	11	20	41	64	11	15	2	1.5		117.7
37	0	2400	78	0	0	3	1	4	0	8	1	3	4	12	4	1	5	1	7	8	6	7	4	5	22	30	5	17	7	2	298	83.33
38	0	2400	75	1	0	3	0	5	0	9	3	2	5	14	7	2	9	0	20	20	10	15	40	41	106	126	21	35	7	2	633.3	115
39	0	4500	93	0	0	3	1	3	0	7	1	1	2	9	8	3	11	0	28	28	15	17	7	5	44	72	12	21	2	2.5	401.7	107
40	0	2400	82	0	0	0	2	1	0	3	0	0	0	3	10	3	13	0	10	10	3	7	6	3	19	29	5	8	2	3.5	650	100
	84	2218	67	1	0	4	1	2	1	7	1	2	2	9	5	2	6			12					21	33		15	3	3	673	99
				25	5	129	31	48	37	275	42	55	97	372	202	55	257			464					853	1317						
				250	50	1290	310	480	370	2750	420	550	970	3720	2020	550	2570			4640					8530	13170						

remittances as percentage of annual hh. income

Information about livestock comes from survey May–June 1995

goat capital: no. of goats/6
animal capital: no. of cattle + goat capital

Reg no.	buyer cattle	s.stock	salt source	salt amount	salt price	bonemeal source	bonemeal amount	bonemeal price	t.mycin source	t.mycin amount	t.mycin price	t.grease source	t.grease amount	t.grease price	other source	other amount	other price	total cattle	Draught power 0=D,1=O,2=T	H/B/S/O (0/1/2/3)	Inputs fertilizer	kraal manure	amount manure applied	area	rate pr ha	year	Area cultivated 93–94	Area cultivated 94–95	planting dekad 93–94	planting dekad 94–95	last harvest
1																			1	3		1	4	2.5	1.6			2.51	DEC	DEC3	91
2																			1	0	0	0	0	0		0		1.71		JAN3	
3																			1	0	0	0	0	0		0		1.13	JAN1	JAN1	
4		2	1	50	9.6				1	100	10.4	1	1500	10.29				30.29	1	0	0	1	5	5	1.0	1986		2.42	JAN1	JAN3	94
5																			1	1	0	0	0	0		0		1.22	DEC2	JAN2	
6									2	100	8.97	3	500	5				13.97	2	0	0	1	21	5	4.2	1991		4.97	DEC3	JAN1	
7			2	100	16	3	70	21	1	100	10.4	2	500	54.95			38	119.4	1	3	0	1	0	0		0	2.83	2.83	JAN1	JAN1	
8																		0	2	0	1	1	4	6	0.7	1971		5.28	JAN1	JAN1	
9																		0	2	0	0	1	12	5	2.4	1987		5	JAN1	JAN1	94
10			1	50	7	2	25	8.7	2	100	10.4	2	1000	77.75				95.15	2	0	0	0	0	0		0		5.54	DEC3	JAN2	
11												1	500	5				5	0	2	0	1	4	5	0.8	1994	5*	4.48	JAN1	JAN2	92
12			1	100	20	4	140	20				1	500	5				25	1	3	0	1	20	10	2.0	1987		2.79	JAN1	JAN2	92
13																		0	1	2	0	0	0	0		0		0.62	FEB1	JAN2	
14			1	50	11				1	200	20.8	1	500	5				36.8	0	3	0	0	12	5	2.4	1989		1.73	DEC2	JAN2	
15			1	100	21.6	1	140	42	1		42	1	500	5			18	86.6	1	3	0	1	20	4	5.0	1988		2.56	JAN2	JAN1	92
16			1	50	10	1	70	21	1	100	10.4	1	200	31.99			10	62.39	0	3	0	1	7	3	2.3	1991		2.1	JAN1	JAN3	94
17																		0	0	3	0	1	10	5	2.0	1986	4	0.62	JAN1	JAN3	
18			1	50	11				1	100	10.4	1	500	5				26.4	0	3	0	1	6	2.5	2.4	1991	2.5	1.6	JAN1	JAN2	91
19			1	150	30	1	70	21	1	100	10.4	1	500	15				55.4	1	3	0	1	8	4	2.0	1989	5	5.21	JAN1	DEC3	
20		2				1	25	8.7				1	500	5				5	1	2	0	1	6	3	2.0	1992	4	2.06	JAN1	DEC3	
21		2							1	100	10.4	1	25	1				11.4	1	2	0	0	0	0		0	5.5	4.99	JAN1	JAN3	
22		2	1	50	10	1	70	19.8	1	100	10.4	1	1000	13		70	10	43.4	1	2	0	1	2	2.5	0.8	1982	3	4.25	NOV1	JAN1	
23																		0	0	3	0	1	7	5	1.4	1993	5.5	5	DEC1	DEC3	89
24									1	50	6.5	1	500	5				11.5	1	3	0	0	0	0	0.0	0	3	4.46	DEC1	JAN1	91
25		3	1	50	10	1	70	21	1	100	10.4							20.4	1	2	0	0	0	0		0	4.5	4.16	DEC2	JAN1	89
26	2	2	1	100	20				1	100	10.4	1	5000	75		50	68	173.4	0	3	0	1	3	2.5	1.2	1982	5	5	JAN1	DEC3	90
27		2	1	50	10.6	1	70	21	1	1100	49.4	1		22		70	38	120	0	3	0	1	3	5	0.6	1993	3.5	1.94	JAN2	JAN2	94
28		3	1	50	10	1	70	21	1	100	10.4	1	550	17				37.4	0	2	0	1	10	5	2.0	1991	2	0.89	JAN1	FEB1	
29									1	100	10.4	1	500	5				15.4	1	0	0	0	4	6	0.7	1968	5	1.82	JAN1	JAN1	
30			1	50	10.6				1	100	10.4	1	500	5				26	1	3	0	1	27*	4	0.0	1980	4	4.21	NOV3	DEC3	
31		3	1	50	10.6				1	100	10.4	3	2000	2				23	1	3	0	1	3	5	0.6	1992	10	4.3	NOV3	JAN2	90
32		2	1	100	22	1	70	21	1	100	10.4	1	500	15				47.4	0	3	0	1	5	4	1.3	1994	2.5	4.14	DEC3	JAN1	
33		2	1	50	11	1	70	21	1	100	10.4	1	500	5		70	10	36.4	0	3	0	1	8	6	1.3	1994	4.5	3.26	NOV3	JAN1	90
34			1	50	10	3	50	30	1	40	6.05	1	50	1				17.05	1	2	1	1	8	2.5	3.2	1994	4	4.68	JAN1	JAN1	91
35									1	80	12.1	1	100	10.8				22.9	1	2	1	1	3	3.25	0.9	1994	6.5	2.05	JAN1	JAN1	
36		4	1	50	10.6							1		4				14.6	0	3	1	1	4	5	0.8	1994	5	4.35	DEC1	JAN1	90
37			1	50	10							1	100	10.8				20.8	1	1	0	1	6	2.5	2.4	1994	5	4.45	NOV2	DEC3	94
38			1	100	20				1	320	24.82		100	10.8				55.62	0	3	1	1	4	5	0.8	1993	10	6.63	OCT1	DEC3	94
39	1	3	1	50	10.6	5	70	18.5	1	100	10.4	1		9				30	1	3	1	1	12	3.75	3.2	1993	5	3.25	JAN1	JAN1	90
40		3										1	0.25	0.25				0.25	0	3	0	1	12	4	3.0	1994	5	2.34	NOV3	DEC2	
					14			21			14			15			27	36	1	2	0	1					4	3			
																												132.55			
																												1325.5			

origin of buyers:
1:bmc 3:Moshupa/Manyana
2:local 4:Moa

source of inputs:
1:coop 3: store 5:bmc
2:lac 4:unknown

bonemeal — terramycin — tick grease

0=Donkeys
1=Oxen
2=Tractor

0=hire
1=borrow
2=supplement
3=own

no of donkeycarts

according to AD's ploughing subsidy records

Reg no.	last sale	Implements owned: Planter	Cultivators	plough s.f.	plough d.f	scotch cart	does hh. rowplant? Y/N (1/0)	Description of household
1	0	0	0	1	0	1	0	couple + one daughter and 4 small children, medium herd, uses oxen as dr.power, 20 SMALLSTOCK, son in RSA, remittances
2	0	0	0	1	0	0	0	f.hh, young household, RSA husband, hire dr.p.
3	0	1	0	1	0	1	0	f.hh, young household, RSA husband, hire dr.p.
4	1977	1	0	1	1	1	1	f.hh., husband died, large pension, children away, 30 cattle died 92, has/uses planter, sells crop
5	0	0	0	1	0	0	0	f.hh, young household, RSA ex-husband, borrow dr.p., 52 SMALLSTOCK!, 4 small children. new field, recently divorced.
6	0	0	0	1	1	1	0	many kids at home but labour shortage, lost cattle, hire tractor ploughing, remittances,
7	0	0	0	1	0	0	1	f.hh, no husband, children away, remittances, 34 SMALLSTOCK, borrows planter
8	1993	1	0	1	1	1	1	v. old couple + daughter, remittance, sell l.stock, crops, big size herd, 17 donkeys, 17 SMALL STOCK, has planter, tractor ploughed, labour short., bushmecanic
9	0	1	1	0	1	0	0	old couple alone, cattle died, no animals left, broken planter, big area must be due to 3 sons (not listed!)
10	1993	1	1	1	1	0	1	v. old couple alone, much from remittance, sell l.stock, sell crops, medium size herd, 11 donkeys, 36 SMALL STOCK, has planter
11	0	0	0	1	1	1	0	old couple + 4 big/adult children, some remittance, dr.relief, sell l.stock, small size herd, borrows 1 donkey to supplement 5 own as dr.power, 27 SMALL STOCK,
12	1992	0	0	1	1	1	0	f.hh, no husband, one son at home+ old mother, remittances, uses own oxen, small herd,
13	0	0	0	0	0	0	0	cattle died, no implements, young couple+4 small children, new small field
14	0	0	0	1	1	1	0	couple + one son and 4 small children, small herd, uses domkeys as dr.power, 22 SMALLSTOCK, dr.relief
15	1974	1	1	1	1	1	1	old couple + one daughter, remittances, small herd, dr.power is own oxen, 34 SMALLSTOCK!, uses planter, limited by labour
16	0	0	0	0	0	0	0	f.hh, husband in rsa, children away from home, remittances, dr relief, 11 donkeys, no plough
17	0	0	0	1	0	0	0	f.hh., absent husband, only daughter at home, cattle died, no rowplanter, plough, small area
18	0	1	1	1	1	1	1	f.hh, husband works away, alone w. son, remittances, only 4 cattle, uses donkeys as dr.p., 11 SMALLSTOCK, uses planter, lost 10 cattle
19	0	0	0	1	0	1	0	old couple + 3 adult children, remittance, sell l.stock, medium size herd, uses own oxen as dr.power, 32 SMALL STOCK, no planter
20	0	0	0	1	0	0	0	no husband, 2 sons present, remittances, small herd, small loss, last harvest 89-90, borrow dr.power to suppl. own dr.power
21	0	0	0	1	0	0	0	old couple + 6 big/adult children, no remittance, sell l.stock, small size herd, borrows 2 oxen to supplement own oxen as dr.power, 15 SMALL STOCK, no planter
22	0	1	0	1	1	1	1	old couple + daughter and son, remittances, very small herd, borrows dr.power to add to one oxen, planter broken, limited by labour
23	0	1	0	1	1	1	1	old couple alone, remittances, small herd, no cattle, dr.power is own donkeys, 34 SMALLSTOCK!, uses planter, limited by dr.power
24	0	0	0	1	0	0	0	couple + one son, small herd, uses oxen as dr.power, 15 SMALLSTOCK, dr.relief
25	0	0	0	1	0	0	0	only 1 son + parents, small herd, no remittances, last harvest: 89
26	1991	0	0	0	1	1	0	couple alone, children away, medium herd, 30 SMALLSTOCK,
27	0	0	0	1	0	1	0	couple alone, dr.relief, 25 SMALLSTOCK, donkeys as dr.power,
28	0	0	0	1	0	1	0	old couple, no kids at home, cattle died, remittances, small area
29	0	0	0	1	0	1	0	old couple, no kids at home, 12 cattle died, remittances, plough
30	0	0	0	1	0	0	0	old couple + son and daughter, little remittance, medium size herd, uses own oxen as dr.power, 24 SMALL STOCK, no planter
31	0	1	1	1	1	1	0	old couple + 2 sons, remittances, medium size herd, uses own oxen as dr.power, 24 SMALL STOCK, has planter but not used
32	1981	0	0	1	0	1	0	v. old couple alone, remittance, sell l.stock, medium size herd, 19 donkeys, lost 23 cattle, 46 SMALL STOCK, no planter
33	0	1	1	1	0	1	1	v. old couple + 1 daughter, remittance, sell l.stock, medium size herd, uses own donkeys as dr.power, 73 SMALL STOCK, has planter
34	0	0	0	1	0	1	0	old couple alone, remittances, small herd, lost cattle, supplement dr.power by borrowing, last harvest 91
35	0	0	0	1	0	1	0	94 yrs old farmer, 5 unmarried adult kids at home, remittances
36	0	0	0	1	0	1	0	f.hh, husband in rsa, alone w. daughter, remittances, only 3 cattle, uses donkeys as dr.p., 41 SMALLSTOCK!
37	0	0	0	1	0	1	0	old lady, no husband, only daughter + grandchild present. remittances from son-in-law. Only donkeys, hired dr.power (oxen).dr.relief. harvest 94 early ploughing
38	0	1	1	1	1	1	1	old couple + son and daughter, remittance, dr.relief, small herd, uses own donkeys as dr.power, 39 SMALL STOCK, uses planter
39	0	1	1	1	1	1	1	v. old couple + many children/ g. childre, remittance, sell l.stock, small size herd, uses own 4 oxen as dr.power, 57 SMALL STOCK, has planter
40	0	1	0	1	0	1	1	old couple + daughter and son, remittances, very small herd, uses own donkeys as dr.power, 49 SMALL STOCK, uses planter

s.f=single furrow
d.f=double furrow

ANNEX D LIST OF ABANDONED FIELDS IN MOSHUPA SOUTH AEA

SUMMARY OF ABANDONED FIELDS SURVEY IN MOSHUPA SOUTH AEA, MARCH 1995

Reasons for abandoning field:

0=not recorded/unknown
1=owner died
2=owner left the area
3=owner left the area to cultivate elsewhere
4=owner old/sick
5=poor soil/owner cultivate elsewhere
6=owner waiting to aquire draught power

Reasons for non-cultivation of field by present owner:

0=not recorded/unknown
1=owner waiting to aquire draught power
2=no present owner
3=owner not likely to start cultivation
(other interests, old,...)

Chance of re-cultivation:
0=likely with present ownership situation
1=unlikely with present ownership situation

reg nr	utm-x	utm-y	area (ha)	years abandoned	reason for abandoning	reason for non-cultivation	chance of recultivation
1	347527	7251596	7	8	1	1	0
2	347314	7252025	5	7	1	1	0
3	347226	7252227	5	9	1	1	0
4	347029	7252001	3.5	10	1	1	0
5	347005	7251979	8	11	3	1	0
6	346908	7251952	7	8	1	1	0
7	346578	7251662	5	4	1	1	0
8	346449	7252138	5	3	1	1	0
9	345971	7252644	5	4	4	0	1
10	346029	7252514	4.5	7	1	1	0
11	345740	7252757	5	3	1	1	0
12	346261	7253164	4	3	4	0	0
13	346279	7252968	5	7	3	1	0
14	346405	7252839	4	5	4	1	0
15	346462	7252744	10	17	3	1	0
16	345636	7250770	4.5	10	1	1	0
17	344497	7250682	8	8	0	1	0
18	344436	7250613	8	9	4	1	0
19	344489	7251359	10	18	1	1	0
20	345441	7251453	5	22	3	0	1
21	345517	7251449	3.5	15	5	0	1
22	345690	7251445	4	22	1	1	0
23	345635	7251434	5	15	3	0	1
24	347933	7252821	5	8	3	1	0
25	347955	7253132	5	5	3	1	0
26	347683	7253584	5	5	4	1	0
27	347632	7253801	14	12	1	1	0
28	348842	7252739	4	8	6	1	0
29	349001	7252874	8	24	1	0	1
30	351678	7253036	5	7	3	0	1
31	352099	7253358	4.5	15	4	0	1
32	352515	7253870	5	4	6	1	0
33	352851	7253858	6	12	3	1	0
34	351895	7254296	8	7	1	0	1
35	351059	7254028	3	23	1	0	1
36	349897	7253531	5	7	4	0	1
37	342026	7251349	7	11	1	1	0
38	341535	7251733	5	12	3	0	1
39	342117	7252186	5	25	3	0	1
40	342222	7252202	6	18	3	0	1
41	340241	7249876	7	6	4	1	0
42	340498	7249517	6	7	4	1	0
43	340741	7249507	10	11	2	2	1
44	340844	7249644	10	10	1	3	1
45	340945	7249974	7.5	12	1	0	1
46	341114	7250223	8	13	3	0	1
47	340966	7251296	2	16	1	3	1
48	340882	7250804	7	14	3	0	1
49	341154	7250973	12	21	3	0	1

SUMMARY OF ABANDONED FIELDS SURVEY IN MOSHUPA SOUTH AEA, MARCH 1995

Reasons for abandoning field:

0=not recorded/unknown
1=owner died
2=owner left the area
3=owner left the area to cultivate elsewhere
4=owner old/sick
5=poor soil/owner cultivate elsewhere
6=owner waiting to aquire draught power

Reasons for non-cultivation of field by present owner:

0=not recorded/unknown
1=owner waiting to aquire draught power
2=no present owner
3=owner not likely to start cultivation
(other interests, old,...)

Chance of re-cultivation:
0=likely with present ownership situation
1=unlikely with present ownership situation

reg nr	utm-x	utm-y	area (ha)	years abandoned	reason for abandoning	reason for non-cultivation	chance of recultivation
50	341272	7251382	5	26	5	0	1
51	341222	7251505	3	36	5	0	1
52	341589	7250920	6.5	17	2	0	1
53	342125	7250888	5	27	5	0	1
54	342166	7250411	3.5	22	4	0	1
55	342196	7250169	8	7	3	0	1
56	342018	7249842	8	15	1	3	1
57	342848	7249666	5	11	4	0	1
58	342809	7249789	4.5	14	2	0	1
59	342845	7250118	5	16	4	3	1
60	342147	7250074	6.5	13	4	3	1
61	343136	7250089	6	12	1	3	1
62	342893	7250453	8	17	2	0	1
63	343049	7250606	2.5	12	4	3	1
64	342939	7250942	3	17	1	3	1
65	342499	7252740	5	5	5	0	1
66	342997	7252061	5	5	6	1	0
67	342710	7252935	5	10	5	0	1
68	342820	7252893	6	2	1	1	0
69	342912	7253177	8	5	6	1	0
70	342618	7253218	10	50	3	2	1
71	348697	72521949	4.5	3	3	1	0
72	349335	7251814	6	4	4	1	0
73	349438	7252138	3	5	3	1	0
74	349406	7252493	5	11	1	1	0
75	349788	7252324	6	17	4	0	0
76	350055	7253012	10	8	3	1	0
77	350087	7252478	8	4	3	1	0
78	350673	7252566	15	18	3	1	0
79	351002	7252493	5	14	3	0	1
80	344739	7252334	5	7	3	1	0
81	335350	7246670	5	7	3	1	0
82	335537	7246607	6	4	1	1	0
83	336511	7246733	3.5	15	1	3	1
84	336555	7247092	3.5	21	5	0	1
85	337021	7247295	7	20	1	0	1
86	337175	7247396	5.5	23	3	1	0
87	337344	7247446	7	16	3	1	0
88	337436	7247537	6	15	5	3	1
89	337628	7247664	5	3	1	1	0
90	337858	7247842	5	34	3	2	1
91	338303	7248930	3.5	27	3	2	1
92	337877	7248908	3.5	30	2	2	1
93	337710	7248831	4	3	3	0	1
94	336052	7250971	3.5	25	5	0	1
95	334573	7249846	2.5	24	5	0	1
96	344772	7252317	7	10	1	1	1
97	344533	7252651	5	7	2	1	0
98	344889	7253316	5	6	1	1	0

ANNEX E LIST OF WATERPOINTS IN MOSHUPA SOUTH AEA

Name of waterpoint	UTM-coordinates X!	Y!	Location Sub-ext.area	Type of waterpoint	no. of users	duration of watersupply	no. of Cattle	goats	donkeys	remarks	Owner
D1	331923	7249477	Polokwe	Dam			428			Thlokwane dam	
WS1	332457	7248135		wellsite							
W4	334113	7248839		well							
WS2	335150	7249511		wellsite							
W5	335664	7248108		well							
D2	338286	7249322	Polokwe	Dam	not in use					Ditsobotlana dam	
D3	349211	7253773	Mathlakola	Dam	partly in use					Zambia/Setswamothlaba dam	
WS3-D4	335863	7247320	Polokwe	Dam						drought relief dam	
D5	340032	7249510	Kgotla	Dam	not in use					Black soil dam, broken in 1982	
D6	340330	7252663	Kgotla	Dam	many		250			built 1994, dr.relief, Rra Nkaelang dam	
D7	333753	7249142	Polokwe	Dam						small dam by kgopiso	
D8	351812	7250486	Mathlakola	Dam						Mabidijana/Mathlakola dam, in grazing area, for Pyetle+Mathlakola	
W6	351173	7250486	Mathlakola	well	?	1-2				depressions in rock collect rainwater+pond, livestock only	
WS7	345513	7255101	Mathlakola	wellsite		7-9				livestock+domestic,5 wells	
W8	350593	7257423	Mathlakola	well							
D9	351870	7254347	Mathlakola	Dam	1	3-4				s.stock+domestic	
D10	351173	7253505	Mathlakola	Dam	1	3-4				s.stock+domestic	
W10	345803	7253940	Mathlakola	well	8	7-9				s.stock+domestic	
WS11-D12	345745	7250341	Sobe	wellsite	80		500			SOBE WELLS+DR RELIEF DAM, 10 wells, each w.8 users	
WS12	339243	7250079	Kgotla	wellsite						KGOTLA WELLS	
WS9	343597	7255450	Mathlakola	wellsite	many	6-9				2 wells	
D11	350651	7253331	Mathlakola	Dam	1	4-5					
D12	335144	7248870	Polokwe	Dam	15	9-12		350	76	not for domestic use	Rra Usupeng Selotlego
D13	334141	7248857	Polokwe	Dam	1	12	20	40	16	not for domestic use	Rra T.Maboane
D14	333221	7249172	Polokwe	Dam	1	9-12				domestic use only	Rra Kokong Okatswa
D15	333412	7249008	Polokwe	Dam	1	7-10				domestic use only	Rra R. Rampotokwane
D16	332417	7248402	Polokwe	Dam	1	7-10				domestic use only	Rra Noko Sepapi
D17	332338	7248334	Polokwe	Dam	2	7-10				domestic use only	Sanyane Mothudi
D18	332431	7248183	Polokwe	Dam	1	7-10				domestic use only	T. Tsheko
D19	333430	7248592	Polokwe	Dam	1	7-10		36		s.stock mainly	M.Kgopiso
D20	333716	7247899	Polokwe	Dam	1	12				s.stock,donkeys+domestic	R.Marumo
D21	333786	7247838	Polokwe	Dam	1	7-10				s.stock+domestic	N.Ikeleng
D22	333852	7247714	Polokwe	Dam	1	7-10				domestic use only	Rantonoko Mathibidi
D23	333891	7247708	Polokwe	Dam	1	7-10				s.stock+domestic	M. Magolwane
D24	333927	7247612	Polokwe	Dam	1	7-10				s.stock,donkeys+domestic	G.Marumo
D25	334396	7250207	Polokwe	Dam	8	9-12	120	210	54	livestock	Maitshoko
D26	335386	7249776	Polokwe	Dam	1	7-10				s.stock,donkeys+domestic	Mogaetsho Tau
D27	335393	7249630	Polokwe	Dam	1	7-10				s.stock+domestic	Mpeo Kelobang
D28	335557	7249893	Polokwe	Dam	1	9-12				s.stock+domestic	Rra M. Tau
D29	335230	7248497	Polokwe	Dam	1	9-12				s.stock+domestic	Rra Poutona Majafe
D30	335434	7247319	Polokwe	Dam	1	7-10				s.stock+domestic	Mma Keitumetse
D31	335490	7247339	Polokwe	Dam	1	6-9				domestic use only	
D32	335623	7248143	Polokwe	Dam	1	12				s.stock+domestic	Rra Tshimologo Mathibidi
										s.stock	Rra Stinko

Name of waterpoint	UTM-coordinates X!	Y!	Location Sub-ext.area	Type of waterpoint	no. of users	duration of watersupply	no. of Cattle	goats	donkeys	remarks	Owner
D34	336749	7248543	Polokwe	Dam	1	6-9				domestic use only	?
D35	339134	7249453	Polokwe	Dam	?	9-12		75	17	s.stock+domestic	Rra Wantwa Marumo
WS13	336528	7249441	Polokwe	Wellsite	48					s.stock+domestic, 12 wells, Maiphitihwane river	
D36	347442	7251527	Sobe	Dam	1					livestock+domestic	Rra Smuts Kgopana
BH1	346232	7251031	Sobe	Borehole	not in use					Borehole no.7175	
BH2	345517	7250099	Sobe	Borehole	not in use					Borehole no.7006	
S1	346806	7248880	Sobe/Pyetle	Spring		12					
D38	341737	7252319	Kgotla	Dam	1	7-9				livestock+domestic	Rra Motshegare
D39	341402	7252788	Kgotla	Dam	1	7-9				livestock+domestic	Rra Bagwera
D40	340743	7252652	Kgotla	Dam	1	9-12				livestock+domestic	Rra Mokwere
D41	340399	7250703	Kgotla	Dam	1	7-9				s.stock,donkeys+domestic	Rra Nkge
W14	339811	7250714	Kgotla	Well	1	9-12				s.stock+domestic	Patricia
W15	341482	7252523	Kgotla	Well	1	9-12				domestic use only	
BH3	334764	7247376	Polokwe	Borehole							
BH4	332721	7239381	Mmakgodumo	Borehole	not in use					Will be used for livestock watering in grazing area (not in ILWIS)	
R1	333524	7242024	Grazing area	Reservoir	50					Will be used for livestock watering, water from BH4 for 50 farmers	
TOTAL					241		1318	711	163		

ANNEX F VEGETATION UNITS

Table I Major tree species identified in vegetation units

Vegetation units	H1	H2	H3	H4	H5	H6	ROK	FAL	UNC	RIV
Acacia caffra				X						
Acacia erubescens									X	
Acacia fleckii	X								X	
Acacia karro										X
Acacia tortilis				X				X	X	X
Boscia albitrunca			X							
Burkea africana	X	X		X					X	
Croton gratissimus							X			
Croton zambesicus	X	X	X							
Combretum apiculatum		X	X		X		X	X	X	
Combretum molle		X	X		X	X				
Combretum zeyheri			X			X				
Dichrostacys cinerea					X			X	X	
Euclea undulata								X		
Gardinea spatuifolia			X							
Grewia species			X							
Ochna pulchra		X					X			
Ozorea paniculosa					X	X				
Pappea capensis			X	X			X			
Pelthophorum africanum	X	X	X	X		X		X	X	
Rhus lancea				X					X	
Sclerocarya caffra									X	
Spirostachys africana	X									
Terminalia sericea	X	X	X			X			X	
Ximenia cappra			X							
Ziziphus mucronata	X									

Table II Major grass species identified in vegetation units

Vegetation unit	H1	H2	H3	H4	H5	H6	ROK	FAL	UNC	RIV
Aristida congesta	X		X	X	X	X	X	X	X	
Aristida scrabrivalis					X					
Aristida stipitata	X	X	X	X			X	X	X	
Brachiaria nigropedata				X	X	X				
Chloris virgata				X	X					
Cynodon dactylon				X				X		X
Digitaria species			X		X					
Eragrostis bicolor								X		
Eragrostis lehmanniana				X	X	X		X	X	
Eragrostis rigidior			X	X	X	X	X	X	X	
Eragrostis superba			X							
Eragrostis species								X	X	X
Heteropogon contortus			X	X						
Oropetium capens					X					
Panicum maximum			X					X		X
Pogonarthria squarrosa				X						
Rhynchelytrium repens	X	X	X	X						
Schmidtia pappophoroides	X		X		X	X				
Setaria species					X					
Tragus berteronianus					X	X		X		
Urochloa mosambicencis					X					
Urochloa trichopus					X	X		X		X

Summary of biomass calculations for all soil/vegetation units
Grazing days based on herbaceous biomass only

Summary table of biomass calculations taking phosphate limitation and losses due to pests and diseases into account

Dataset: Moshupa
Synoptic station: Kanye
Rainfall station: Kanye
Soil unit: ARo
Vegetation type: H1 Area: 997
Number of seasons: 29

	100	75	50	25	0
Trees: Total	229	494	823	1090	1741
Trees: Stem	69	148	247	327	522
Trees: Leaves	133	287	477	632	1010
Trees: Roots	27	59	99	131	209
Upper Stratum: Total	90	195	324	429	686
Upper Stratum: Stem	27	58	97	129	206
Upper Stratum: Leaves	52	113	188	249	398
Upper Stratum: Roots	11	23	39	52	82
Lower Stratum: Total	159	345	574	760	1213
Lower Stratum: Stem	48	103	172	228	364
Lower Stratum: Leaves	92	200	333	441	704
Lower Stratum: Roots	19	41	69	91	146
Herbunder Total	144	230	381	482	782
Herbunder Aerial	98	168	299	416	644
Herbunder Roots	33	51	74	83	158
Herbaway Total	245	408	664	901	1355
Herbaway Aerial	171	311	526	728	1111
Herbaway Roots	60	95	134	153	276
proper use factor	70%	b.mass/hb.mass in unit			
Dry Matter Intake LSU/Day	11.25	269	268193		
Grazing Days	16.7	29.8	51.3	71.2	109.2
Hectares/LSU	21.81	12.25	7.11	5.13	3.34

Summary table of biomass calculations taking phosphate limitation and losses due to pests and diseases into account

Dataset: Moshupa
Synoptic station: Kanye
Rainfall station: Kanye
Soil unit: RGe
Vegetation type: H1 Area: 1993
Number of seasons: 29

	100	75	50	25	0
Trees: Total	251	506	845	1089	1711
Trees: Stem	75	152	254	327	513
Trees: Leaves	146	294	490	631	992
Trees: Roots	30	61	101	131	205
Upper Stratum: Total	99	199	333	429	674
Upper Stratum: Stem	30	60	100	129	202
Upper Stratum: Leaves	57	116	193	249	391
Upper Stratum: Roots	12	24	40	51	81
Lower Stratum: Total	175	353	589	759	1192
Lower Stratum: Stem	53	106	177	228	358
Lower Stratum: Leaves	102	205	342	440	692
Lower Stratum: Roots	21	42	71	91	143
Herbunder Total	159	275	433	532	922
Herbunder Aerial	109	199	339	460	735
Herbunder Roots	39	59	87	95	205
Herbaway Total	275	490	741	883	1358
Herbaway Aerial	191	359	583	731	1088
Herbaway Roots	66	110	149	169	305
proper use factor	70%	b.mass/hb.mass in unit			
Dry Matter Intake LSU/Day	11.25	300	597900		
Grazing Days	18.7	34.7	57.4	74.1	113.4
Hectares/LSU	19.55	10.51	6.36	4.93	3.22

w. biomass	w. biomass	grazing days		ha per LSU		LSU in unit		sum for unit H1 area:
430704	886885	29.80	34.72	12.25	10.51	81	190	88.0 grazing
								38.3 ha/lsu
								335.3 lsu in un
								1082442.00 total bior
								216.45 biomass

Summary table of biomass calculations taking phosphate limitation and losses due to pests and diseases into account

Dataset: Moshupa
Synoptic station: Kanye
Rainfall station: Kanye
Soil unit: LPe
Vegetation type: H1 Area: 997
Number of seasons: 29

	100	75	50	25	0
Trees: Total	96	177	383	538	872
Trees: Stem	29	53	115	161	262
Trees: Leaves	56	103	222	312	506
Trees: Roots	12	21	46	65	105
Upper Stratum: Total	38	70	151	212	344
Upper Stratum: Stem	11	21	45	64	103
Upper Stratum: Leaves	22	40	88	123	199
Upper Stratum: Roots	5	8	18	25	41
Lower Stratum: Total	67	123	267	375	608
Lower Stratum: Stem	20	37	80	112	182
Lower Stratum: Leaves	39	71	155	217	353
Lower Stratum: Roots	8	15	32	45	73
Herbunder Total	87	170	379	517	889
Herbunder Aerial	76	135	319	432	687
Herbunder Roots	7	36	59	78	203
Herbaway Total	160	299	618	922	1358
Herbaway Aerial	141	243	528	748	1062
Herbaway Roots	11	65	110	136	296
proper use factor	70%	b.mass/hb.mass in unit			
Dry Matter Intake LSU/Day	11.25	217	216349		
Grazing Days	13.5	23.5	52.7	73.4	108.8
Hectares/LSU	27.03	15.52	6.93	4.97	3.35

Summary table of biomass calculations taking phosphate limitation and losses due to pests and diseases into account

Dataset: Moshupa
Synoptic station: Kanye
Rainfall station: Kanye
Soil unit: ARo
Vegetation type: H2 Area: 743
Number of seasons: 29

	100	75	50	25	0
Trees: Total	117	253	421	558	891
Trees: Stem	35	76	126	168	267
Trees: Leaves	68	147	244	324	517
Trees: Roots	14	30	51	67	107
Upper Stratum: Total	110	237	395	523	836
Upper Stratum: Stem	33	71	119	157	251
Upper Stratum: Leaves	64	138	229	304	485
Upper Stratum: Roots	13	28	47	63	100
Lower Stratum: Total	161	348	579	766	1226
Lower Stratum: Stem	48	104	174	230	368
Lower Stratum: Leaves	93	202	336	445	711
Lower Stratum: Roots	19	42	70	92	147
Herbunder Total	144	230	381	482	782
Herbunder Aerial	98	168	299	416	644
Herbunder Roots	33	51	74	83	158
Herbaway Total	606	1007	1639	2222	3342
Herbaway Aerial	421	768	1297	1796	2740
Herbaway Roots	147	233	331	378	680
proper use factor	70%	b.mass/hb.mass in unit			
Dry Matter Intake LSU/Day	11.25	519	385617		
Grazing Days	32.3	58.2	99.3	137.6	210.6
Hectares/LSU	11.3	6.27	3.68	2.65	1.73

		grazing days		ha per LSU		LSU in unit		sum for unit H2 area:
154535	260793	23.52	58.24	15.52	6.27	64	119	171.5 grazing d
								19.7 ha/lsu
								486.3 lsu in unit
								1563272.00 total biom
								418.88 biomass/

Summary table of biomass calculations taking phosphate limitation and losses due to pests and diseases into account

Dataset: Moshupa
Synoptic station: Kanye
Rainfall station: Kanye
Soil unit: RGe
Vegetation type: H2 Area: 1486
Number of seasons: 29

	100	75	50	25	0
Trees: Total	129	259	433	558	876
Trees: Stem	39	78	130	167	263
Trees: Leaves	75	150	251	323	508
Trees: Roots	15	31	52	67	105
Upper Stratum: Total	121	243	406	523	821
Upper Stratum: Stem	36	73	122	157	246
Upper Stratum: Leaves	70	141	235	303	476
Upper Stratum: Roots	14	29	49	63	99
Lower Stratum: Total	177	356	595	770	1205
Lower Stratum: Stem	53	107	179	230	361
Lower Stratum: Leaves	103	207	345	445	699
Lower Stratum: Roots	21	43	71	92	145
Herbunder Total	159	275	433	532	922
Herbunder Aerial	109	199	339	460	735
Herbunder Roots	39	59	87	95	205
Herbaway Total	679	1210	1829	2177	3349
Herbaway Aerial	472	886	1438	1803	2684
Herbaway Roots	182	270	368	418	753
proper use factor	70%	b.mass/hb.mass in unit			
Dry Matter Intake LSU/Day	11.25	581	863366		
Grazing Days	36.2	67.5	110.6	140.8	212.7
Hectares/LSU	10.1	5.41	3.3	2.59	1.72

Summary table of biomass calculations taking phosphate limitation and losses due to pests and diseases into account

Dataset: Moshupa
Synoptic station: Kanye
Rainfall station: Kanye
Soil unit: LPe
Vegetation type: H2 Area: 743
Number of seasons: 34

	100	75	50	25	0
Trees: Total	49	91	196	275	447
Trees: Stem	15	27	59	83	134
Trees: Leaves	29	52	114	160	259
Trees: Roots	6	11	24	33	54
Upper Stratum: Total	46	85	184	258	419
Upper Stratum: Stem	14	25	55	77	126
Upper Stratum: Leaves	27	49	107	150	243
Upper Stratum: Roots	6	10	22	31	50
Lower Stratum: Total	58	124	270	379	614
Lower Stratum: Stem	20	37	81	114	184
Lower Stratum: Leaves	39	72	157	220	356
Lower Stratum: Roots	8	15	32	45	74
Herbunder Total	87	170	379	517	889
Herbunder Aerial	76	135	319	432	687
Herbunder Roots	7	36	59	78	203
Herbaway Total	396	737	1525	2274	3350
Herbaway Aerial	347	600	1302	1844	2619
Herbaway Roots	26	161	271	337	731
proper use factor	70%	b.mass/hb.mass in unit			
Dry Matter Intake LSU/Day	11.25	423	314289		
Grazing Days	26.3	45.7	100.9	141.6	205.7
Hectares/LSU	13.87	7.98	3.62	2.58	1.77

		grazing days		ha per LSU		LSU in unit	
536446	92875	67.51	45.73	5.41	7.98	275	93

Summary table of biomass calculations taking phosphate limitation and losses due to pests and diseases into account

Dataset: Moshupa
Synoptic station: Kanye
Rainfall station: Kanye
Soil unit: ARo
Vegetation type: H3 Area: 138
Number of seasons: 29

	100	75	50	25	0
Trees: Total	163	353	588	778	1243
Trees: Stem	49	106	176	234	373
Trees: Leaves	95	205	341	451	721
Trees: Roots	20	42	71	93	149
Upper Stratum: Total	149	322	536	711	1135
Upper Stratum: Stem	45	97	161	213	340
Upper Stratum: Leaves	87	187	311	412	658
Upper Stratum: Roots	18	39	64	85	136
Lower Stratum: Total	121	261	434	575	919
Lower Stratum: Stem	36	78	130	173	276
Lower Stratum: Leaves	70	151	252	334	533
Lower Stratum: Roots	14	31	52	69	110
Herbunder Total	108	172	286	361	587
Herbunder Aerial	74	126	224	312	483
Herbunder Roots	24	38	56	62	118
Herbaway Total	345	572	930	1261	1897
Herbaway Aerial	239	436	736	1019	1555
Herbaway Roots	83	132	188	214	386
proper use factor	70%	b.mass/hb.mass in unit			
Dry Matter Intake LSU/Day	11.25	313	43194		
Grazing Days	19.5	35.0	59.7	82.8	126.8
Hectares/LSU	18.74	10.44	6.11	4.41	2.88

Summary table of biomass calculations taking phosphate limitation and losses due to pests and diseases into account

Dataset: Moshupa
Synoptic station: Kanye
Rainfall station: Kanye
Soil unit: LPe
Vegetation type: H3 Area: 138
Number of seasons: 29

	100	75	50	25	0
Trees: Total	69	126	274	384	623
Trees: Stem	21	38	82	115	187
Trees: Leaves	40	73	159	223	361
Trees: Roots	8	15	33	46	75
Upper Stratum: Total	63	115	250	351	569
Upper Stratum: Stem	19	35	75	105	171
Upper Stratum: Leaves	36	67	145	203	330
Upper Stratum: Roots	8	14	30	42	68
Lower Stratum: Total	51	93	202	284	460
Lower Stratum: Stem	15	28	61	85	138
Lower Stratum: Leaves	30	54	117	165	267
Lower Stratum: Roots	6	11	24	34	55
Herbunder Total	65	127	284	388	667
Herbunder Aerial	57	102	240	324	516
Herbunder Roots	5	27	44	58	152
Herbaway Total	225	418	866	1291	1901
Herbaway Aerial	197	341	739	1047	1486
Herbaway Roots	15	91	154	191	415
proper use factor	70%	b.mass/hb.mass in unit			
Dry Matter Intake LSU/Day	11.25	254	35052		
Grazing Days	15.8	27.6	60.9	85.3	124.5
Hectares/LSU	23.09	13.24	5.99	4.26	2.93

		grazing days		ha per LSU		LSU in unit		sum for unit H3 area: 69
54234	19458	34.97	27.56	10.44	13.24	13	10	103.2 grazing day
								32.7 ha/lsu
								54.5 lsu in unit
								175196.00 total biomas
								253.17 biomass/ha

Summary table of biomass calculations taking phosphate limitation

and losses due to pests and diseases into account
Dataset: Moshupa
Synoptic station: Kanye
Rainfall station: Kanye
Soil unit: RGe
Vegetation type: H3 Area: 277
Number of seasons: 29

	100	75	50	25	0
Trees: Total	179	361	603	777	1222
Trees: Stem	54	108	181	233	366
Trees: Leaves	104	210	350	451	708
Trees: Roots	22	43	72	93	147
Upper Stratum: Total	164	330	551	710	1115
Upper Stratum: Stem	49	99	165	213	335
Upper Stratum: Leaves	95	191	320	412	647
Upper Stratum: Roots	20	40	66	85	134
Lower Stratum: Total	133	267	446	575	903
Lower Stratum: Stem	40	80	134	172	271
Lower Stratum: Leaves	77	155	259	333	524
Lower Stratum: Roots	16	32	54	69	108
Herbunder Total	120	207	325	399	692
Herbunder Aerial	82	150	254	345	551
Herbunder Roots	29	44	65	71	154
Herbaway Total	385	687	1038	1236	1901
Herbaway Aerial	268	503	816	1023	1523
Herbaway Roots	92	153	209	237	428
proper use factor	70%	b.mass/hb.mass in unit			
Dry Matter Intake LSU/Day	11.25	350	96950		
Grazing Days	21.8	40.6	66.6	85.1	129.0
Hectares/LSU	16.76	8.98	5.48	4.29	2.83

	grazing days		ha per LSU		LSU in unit		
111354	0	40.63	0.00	8.98	0.00	31	0

Summary table of biomass calculations taking phosphate limitation and losses due to pests and diseases into account
Dataset: Moshupa
Synoptic station: Kanye
Rainfall station: Kanye
Soil unit: RGe
Vegetation type: H4 Area: 315
Number of seasons: 29

	100	75	50	25	0
Trees: Total	43	86	144	185	291
Trees: Stem	13	26	43	56	87
Trees: Leaves	25	50	83	107	169
Trees: Roots	5	10	17	22	35
Upper Stratum: Total	43	86	144	185	291
Upper Stratum: Stem	13	26	43	56	87
Upper Stratum: Leaves	25	50	83	107	169
Upper Stratum: Roots	5	10	17	22	35
Lower Stratum: Total	53	108	180	231	363
Lower Stratum: Stem	16	32	54	69	109
Lower Stratum: Leaves	31	62	104	134	211
Lower Stratum: Roots	6	13	22	28	44
Herbunder Total	80	138	216	266	461
Herbunder Aerial	55	100	169	230	367
Herbunder Roots	19	30	43	47	103
Herbaway Total	954	1700	2570	3060	4706
Herbaway Aerial	664	1245	2020	2534	3772
Herbaway Roots	228	380	517	587	1059
proper use factor	70%	b.mass/hb.mass in unit			
Dry Matter Intake LSU/Day	11.25	719	226485		
Grazing Days	44.7	83.7	136.2	172.0	257.5
Hectares/LSU	8.16	4.36	2.68	2.12	1.42

Summary table of biomass calculations taking phosphate limitation and losses due to pests and diseases into account
Dataset: Moshupa
Synoptic station: Kanye
Rainfall station: Kanye
Soil unit: RGe
Vegetation type: H5 Area: 1342
Number of seasons: 29

	100	75	50	25	0
Trees: Total	82	166	277	357	561
Trees: Stem	25	50	83	107	168
Trees: Leaves	48	96	161	207	325
Trees: Roots	10	20	33	43	67
Upper Stratum: Total	82	166	277	357	561
Upper Stratum: Stem	25	50	83	107	168
Upper Stratum: Leaves	48	96	161	207	325
Upper Stratum: Roots	10	20	33	43	67
Lower Stratum: Total	73	147	246	317	498
Lower Stratum: Stem	22	44	74	95	150
Lower Stratum: Leaves	42	86	143	184	289
Lower Stratum: Roots	9	18	30	38	60
Herbunder Total	90	155	243	299	519
Herbunder Aerial	62	112	191	258	413
Herbunder Roots	22	33	49	53	116
Herbaway Total	422	752	1137	1353	2082
Herbaway Aerial	294	551	894	1121	1668
Herbaway Roots	101	168	229	260	468
proper use factor	70%	b.mass/hb.mass in unit			
Dry Matter Intake LSU/Day	11.25	356	477752		
Grazing Days	22.2	41.3	67.5	85.8	129.5
Hectares/LSU	16.48	8.85	5.41	4.25	2.82

		grazing days		ha per LSU		LSU in unit		
36855	271084	83.69	41.25	4.36	8.85	72	152

Summary table of biomass calculations taking phosphate limitation and losses due to pests and diseases into account
Dataset: Moshupa
Synoptic station: Kanye
Rainfall station: Kanye
Soil unit: LPe
Vegetation type: H6 Area: 417
Number of seasons: 29

	100	75	50	25	0
Trees: Total	14	25	55	77	125
Trees: Stem	4	8	17	23	38
Trees: Leaves	8	15	32	45	73
Trees: Roots	2	3	7	9	15
Upper Stratum: Total	69	127	275	386	626
Upper Stratum: Stem	21	38	83	116	188
Upper Stratum: Leaves	40	74	160	224	363
Upper Stratum: Roots	8	15	33	46	75
Lower Stratum: Total	31	57	124	174	282
Lower Stratum: Stem	9	17	37	52	84
Lower Stratum: Leaves	18	33	72	101	163
Lower Stratum: Roots	4	7	15	21	34
Herbunder Total	87	170	379	517	889
Herbunder Aerial	76	135	319	432	687
Herbunder Roots	7	36	59	78	203
Herbaway Total	417	777	1608	2397	3531
Herbaway Aerial	365	633	1373	1944	2760
Herbaway Roots	28	170	286	355	770
proper use factor	70%	b.mass/hb.mass in unit			
Dry Matter Intake LSU/Day	11.25	441	183897		
Grazing Days	27.4	47.8	105.3	147.8	214.5
Hectares/LSU	13.3	7.64	3.47	2.47	1.7

Summary table of biomass calculations taking phosphate limitation and losses due to pests and diseases into account
Dataset: Moshupa
Synoptic station: Kanye
Rainfall station: Kanye
Soil unit: ARo
Vegetation type: H6 Area: 417
Number of seasons: 29

	100	75	50	25	0
Trees: Total	33	71	118	156	250
Trees: Stem	10	21	35	47	75
Trees: Leaves	19	41	68	91	145
Trees: Roots	4	9	14	19	30
Upper Stratum: Total	164	355	590	782	1249
Upper Stratum: Stem	49	106	177	235	375
Upper Stratum: Leaves	95	206	342	454	724
Upper Stratum: Roots	20	43	71	94	150
Lower Stratum: Total	74	160	266	352	562
Lower Stratum: Stem	22	48	80	106	169
Lower Stratum: Leaves	43	93	154	204	326
Lower Stratum: Roots	9	19	32	42	67
Herbunder Total	144	230	381	482	782
Herbunder Aerial	98	168	299	416	644
Herbunder Roots	33	51	74	83	158
Herbaway Total	541	1062	1727	2342	3522
Herbaway Aerial	444	809	1367	1893	2888
Herbaway Roots	155	246	349	398	717
proper use factor	70%	b.mass/hb.mass in unit			
Dry Matter Intake LSU/Day	11.25	542	226014		
Grazing Days	33.7	60.8	103.7	143.7	219.8
Hectares/LSU	10.82	6	3.52	2.54	1.66

		grazing days		ha per LSU		LSU in unit			sum for unit H6 area: 2'
36696	102582	47.79	60.79	7.64	6.00	55	70		179.1 grazing d

18.8 ha/lsu
285.3 lsu in unit
916756.00 total biom
439.27 biomass/

Summary table of biomass calculations taking phosphate limitation and losses due to pests and diseases into account
Dataset: Moshupa
Synoptic station: Kanye
Rainfall station: Kanye
Soil unit: RGE
Vegetation type: H6 Area: 835
Number of seasons: 29

	100	75	50	25	0
Trees: Total	36	73	121	156	245
Trees: Stem	11	22	36	47	74
Trees: Leaves	21	42	70	91	142
Trees: Roots	4	9	15	19	29
Upper Stratum: Total	180	363	606	781	1227
Upper Stratum: Stem	54	109	182	234	368
Upper Stratum: Leaves	104	211	352	453	712
Upper Stratum: Roots	22	44	73	94	147
Lower Stratum: Total	81	163	273	351	552
Lower Stratum: Stem	24	49	82	105	166
Lower Stratum: Leaves	47	95	158	204	320
Lower Stratum: Roots	10	20	33	42	66
Herbunder Total	159	275	433	532	922
Herbunder Aerial	109	199	339	460	735
Herbunder Roots	39	59	87	95	205
Herbaway Total	715	1275	1928	2295	3530
Herbaway Aerial	498	934	1515	1900	2829
Herbaway Roots	171	285	367	440	794
proper use factor	70%	b.mass/hb.mass in unit			
Dry Matter Intake LSU/Day	11.25	607	506845		
Grazing Days	37.8	70.5	115.4	146.8	221.8
Hectares/LSU	9.66	5.18	3.16	2.49	1.65

Summary table of biomass calculations taking phosphate limitation and losses due to pests and diseases into account
Dataset: Moshupa
Synoptic station: Kanye
Rainfall station: Kanye
Soil unit: LVK
Vegetation type: RIV Area: 404
Number of seasons: 35

	100	75	50	25	0
Trees: Total	50	107	219	358	677
Trees: Stem	15	32	66	107	203
Trees: Leaves	29	62	127	208	393
Trees: Roots	6	13	26	43	81
Upper Stratum: Total	90	194	397	649	1228
Upper Stratum: Stem	27	58	119	195	368
Upper Stratum: Leaves	52	113	230	376	712
Upper Stratum: Roots	11	23	48	78	147
Lower Stratum: Total	78	167	342	559	1058
Lower Stratum: Stem	23	50	103	168	317
Lower Stratum: Leaves	45	97	199	324	614
Lower Stratum: Roots	9	20	41	67	127
Herbunder Total	136	315	645	862	1465
Herbunder Aerial	94	245	540	719	1139
Herbunder Roots	16	53	107	131	337
Herbaway Total	209	546	933	1137	1855
Herbaway Aerial	145	416	780	973	1452
Herbaway Roots	26	89	181	196	402
proper use factor	70%	b.mass/hb.mass in unit			
Dry Matter Intake LSU/Day	11.25	239	96556		
Grazing Days	14.9	41.1	82.1	105.3	161.2
Hectares/LSU	24.54	8.87	4.44	3.47	2.26

		grazing days		ha per LSU		LSU in unit			sum for unit RIV area:
211255	79184	70.50	41.13	5.18	8.87	161	46		121.7 grazing d

27.1 ha/lsu
90.8 lsu in unit
184267.00 total biom
228.34 biomass/

Summary table of biomass calculations taking phosphate limitation and losses due to pests and diseases into account
Dataset: Moshupa
Synoptic station: Kanye
Rainfall station: Kanye
Soil unit: LVF
Vegetation type: RIV Area: 242
Number of seasons: 29

	100	75	50	25	0

Summary table of biomass calculations taking phosphate limitation and losses due to pests and diseases into account
Dataset: Moshupa
Synoptic station: Kanye
Rainfall station: Kanye
Soil unit: LVh
Vegetation type: RIV Area: 161
Number of seasons: 29

	100	75	50	25	0

		grazing days		ha per LSU		LSU in unit		
50578	25599	43.80	36.77	8.33	9.93	29	16

Trees: Total	53	114	233	381	721
Trees: Stem	16	34	70	114	216
Trees: Leaves	31	66	135	221	418
Trees: Roots	6	14	28	46	87
Upper Stratum: Total	96	207	423	691	1308
Upper Stratum: Stem	29	62	127	207	392
Upper Stratum: Leaves	56	120	245	401	758
Upper Stratum: Roots	12	25	51	83	157
Lower Stratum: Total	83	178	365	596	1127
Lower Stratum: Stem	25	53	109	179	338
Lower Stratum: Leaves	48	103	212	345	654
Lower Stratum: Roots	10	21	44	71	135
Herbunder Total	145	335	687	918	1560
Herbunder Aerial	100	261	575	765	1214
Herbunder Roots	17	56	113	139	359
Herbaway Total	222	582	993	1211	1975
Herbaway Aerial	154	443	831	1036	1547
Herbaway Roots	28	94	171	211	429

proper use factor	70% b.mass/hb.mass in unit				
Dry Matter Intake LSU/Day	11.25	254	61468		
Grazing Days	15.8	43.8	87.5	112.1	171.8
Hectares/LSU	23.09	8.33	4.17	3.26	2.12

Trees: Total	39	87	199	319	609
Trees: Stem	12	26	60	96	183
Trees: Leaves	22	51	116	185	353
Trees: Roots	5	10	24	38	73
Upper Stratum: Total	70	158	361	578	1104
Upper Stratum: Stem	21	47	108	173	331
Upper Stratum: Leaves	41	92	209	335	640
Upper Stratum: Roots	8	19	43	69	132
Lower Stratum: Total	61	136	311	498	951
Lower Stratum: Stem	18	41	93	149	285
Lower Stratum: Leaves	35	79	180	289	552
Lower Stratum: Roots	7	16	37	60	114
Herbunder Total	98	260	598	746	1569
Herbunder Aerial	67	216	497	611	1218
Herbunder Roots	12	43	97	116	350
Herbaway Total	139	440	899	1076	1855
Herbaway Aerial	96	375	756	919	1460
Herbaway Roots	20	71	144	190	395

proper use factor	70% b.mass/hb.mass in unit				
Dry Matter Intake LSU/Day	11.25	163	26243		
Grazing Days	10.1	36.8	78.0	95.2	156.6
Hectares/LSU	35.99	9.93	4.68	3.83	2.19

Summary table of biomass calculations taking phosphate limitation and losses due to pests and diseases into account

Dataset: Moshupa
Synoptic station: Kanye
Rainfall station: Kanye
Soil unit: LVx
Vegetation type: FAL   Area: 481
Number of seasons: 29

	100	75	50	25	0
Trees: Total	94	154	216	280	428
Trees: Stem	28	46	65	84	128
Trees: Leaves	55	90	125	162	248
Trees: Roots	11	19	26	34	51
Upper Stratum: Total	148	243	339	440	672
Upper Stratum: Stem	44	73	102	132	202
Upper Stratum: Leaves	86	141	197	255	390
Upper Stratum: Roots	18	29	41	53	81
Lower Stratum: Total	242	397	555	720	1100
Lower Stratum: Stem	73	119	166	216	330
Lower Stratum: Leaves	141	230	322	418	638
Lower Stratum: Roots	29	48	67	86	132
Herbunder Total	328	514	739	847	1195
Herbunder Aerial	237	405	573	670	961
Herbunder Roots	75	105	146	166	261
Herbaway Total	1090	1362	1781	2029	2541
Herbaway Aerial	795	1069	1425	1625	2000
Herbaway Roots	231	326	374	404	544

proper use factor	70% b.mass/hb.mass in unit				
Dry Matter Intake LSU/Day	11.25	1032	496392		
Grazing Days	64.2	91.7	124.3	142.8	184.2
Hectares/LSU	5.66	3.98	2.94	2.56	1.98

Summary table of biomass calculations taking phosphate limitation and losses due to pests and diseases into account

Dataset: Moshupa
Synoptic station: Kanye
Rainfall station: Kanye
Soil unit: LVh
Vegetation type: FAL   Area: 641
Number of seasons: 29

	100	75	50	25	0
Trees: Total	20	46	105	168	321
Trees: Stem	6	14	32	50	96
Trees: Leaves	12	27	61	98	186
Trees: Roots	2	6	13	20	39
Upper Stratum: Total	32	72	165	264	505
Upper Stratum: Stem	10	22	50	79	151
Upper Stratum: Leaves	19	42	96	153	293
Upper Stratum: Roots	4	9	20	32	61
Lower Stratum: Total	53	118	270	432	826
Lower Stratum: Stem	16	35	81	130	248
Lower Stratum: Leaves	31	69	157	251	479
Lower Stratum: Roots	6	14	32	52	99
Herbunder Total	58	154	354	441	927
Herbunder Aerial	40	128	294	361	720
Herbunder Roots	7	26	57	69	207
Herbaway Total	160	506	1034	1238	2133
Herbaway Aerial	110	431	869	1057	1679
Herbaway Roots	23	82	165	218	454

proper use factor	70% b.mass/hb.mass in unit				
Dry Matter Intake LSU/Day	11.25	150	96150		
Grazing Days	9.3	34.8	72.4	88.2	149.3
Hectares/LSU	39.11	10.49	5.04	4.14	2.45

		grazing days		ha per LSU		LSU in unit		sum for unit FAL area:
160654	64100	91.72	34.78	3.98	10.49	121	61	250.3 grazing
								41.1 ha/lsu
								424.4 lsu in un
								1283326.00 total bio
								397.93 biomass

Summary table of biomass calculations taking phosphate limitation and losses due to pests and diseases into account

Dataset: Moshupa
Synoptic station: Kanye
Rainfall station: Kanye
Soil unit: ARo
Vegetation type: FAL   Area: 321
Number of seasons: 29

	100	75	50	25	0
Trees: Total	54	118	196	259	414
Trees: Stem	16	35	59	78	124
Trees: Leaves	32	68	113	150	240
Trees: Roots	7	14	23	31	50
Upper Stratum: Total	86	185	308	407	650
Upper Stratum: Stem	26	55	92	122	195
Upper Stratum: Leaves	50	107	178	236	377
Upper Stratum: Roots	10	22	37	49	78
Lower Stratum: Total	140	302	503	667	1064
Lower Stratum: Stem	42	91	151	200	319
Lower Stratum: Leaves	81	175	292	387	617
Lower Stratum: Roots	17	36	60	80	128
Herbunder Total	117	186	310	392	635
Herbunder Aerial	80	136	243	338	523
Herbunder Roots	26	42	61	67	128
Herbaway Total	378	626	1019	1381	2077
Herbaway Aerial	262	477	806	1116	1703
Herbaway Roots	91	145	206	235	423

proper use factor	70% b.mass/hb.mass in unit				
Dry Matter Intake LSU/Day	11.25	342	109782		
Grazing Days	21.3	38.1	65.3	90.5	138.5
Hectares/LSU	17.15	9.57	5.59	4.03	2.64

Summary table of biomass calculations taking phosphate limitation and losses due to pests and diseases into account

Dataset: Moshupa
Synoptic station: Kanye
Rainfall station: Kanye
Soil unit: RGe
Vegetation type: FAL   Area: 1122
Number of seasons: 29

	100	75	50	25	0
Trees: Total	60	120	201	259	407
Trees: Stem	18	36	60	78	122
Trees: Leaves	35	70	117	150	236
Trees: Roots	7	14	24	31	49
Upper Stratum: Total	94	189	316	407	639
Upper Stratum: Stem	28	57	95	122	192
Upper Stratum: Leaves	54	110	183	236	371
Upper Stratum: Roots	11	23	38	49	77
Lower Stratum: Total	154	310	517	666	1046
Lower Stratum: Stem	46	93	155	200	314
Lower Stratum: Leaves	89	180	300	386	607
Lower Stratum: Roots	18	37	62	80	126
Herbunder Total	130	224	352	432	749
Herbunder Aerial	89	162	275	373	597
Herbunder Roots	31	48	70	77	167
Herbaway Total	422	752	1137	1353	2082
Herbaway Aerial	294	551	894	1121	1668
Herbaway Roots	101	168	229	260	468

proper use factor	70% b.mass/hb.mass in unit				
Dry Matter Intake LSU/Day	11.25	383	429726		
Grazing Days	23.8	44.4	72.7	93.0	140.9
Hectares/LSU	15.32	8.23	5.02	3.93	2.59

		grazing days		ha per LSU		LSU in unit	
81213	291720	38.14	44.36	9.57	8.23	34	136

Summary table of biomass calculations taking phosphate limitation and losses due to pests and diseases into account

Dataset: Moshupa
Synoptic station: Kanye
Rainfall station: Kanye
Soil unit: LVf
Vegetation type: FAL   Area: 641
Number of seasons: 29

	100	75	50	25	0
Trees: Total	28	60	123	201	381
Trees: Stem	8	18	37	60	114
Trees: Leaves	16	35	71	117	221
Trees: Roots	3	7	15	24	46
Upper Stratum: Total	44	95	193	316	598
Upper Stratum: Stem	13	28	58	95	179
Upper Stratum: Leaves	26	55	112	183	347
Upper Stratum: Roots	5	11	23	38	72
Lower Stratum: Total	72	155	317	517	979
Lower Stratum: Stem	22	46	95	155	294
Lower Stratum: Leaves	42	90	184	300	568
Lower Stratum: Roots	9	19	38	62	117
Herbunder Total	86	198	406	542	922
Herbunder Aerial	59	154	340	452	717
Herbunder Roots	10	33	67	82	212
Herbaway Total	256	669	1142	1393	2272
Herbaway Aerial	177	510	956	1191	1779
Herbaway Roots	32	109	197	243	493

proper use factor	70% b.mass/hb.mass in unit				
Dry Matter Intake LSU/Day	11.25	236	151276		
Grazing Days	14.7	41.3	80.6	102.2	155.3
Hectares/LSU	24.86	8.83	4.53	3.57	2.35

Summary table of biomass calculations taking phosphate limitation and losses due to pests and diseases into account

Dataset: Moshupa
Synoptic station: Kanye
Rainfall station: Kanye
Soil unit: LVx
Vegetation type: UNC   Area: 1186
Number of seasons: 29

	100	75	50	25	0
Trees: Total	132	216	301	391	597
Trees: Stem	39	65	90	117	179
Trees: Leaves	76	125	175	227	347
Trees: Roots	16	26	36	47	72
Upper Stratum: Total	132	216	301	391	597
Upper Stratum: Stem	39	65	90	117	179
Upper Stratum: Leaves	76	125	175	227	347
Upper Stratum: Roots	16	26	36	47	72
Lower Stratum: Total	190	311	435	565	863
Lower Stratum: Stem	57	93	131	170	259
Lower Stratum: Leaves	110	181	252	326	501
Lower Stratum: Roots	23	37	52	68	104
Herbunder Total	428	672	966	1108	1563
Herbunder Aerial	310	530	749	877	1257
Herbunder Roots	98	138	190	217	341
Herbaway Total	1990	2487	3252	3705	4640
Herbaway Aerial	1451	1952	2603	2967	3652
Herbaway Roots	421	595	684	738	994

proper use factor	70% b.mass/hb.mass in unit				
Dry Matter Intake LSU/Day	11.25	1761	2086546		
Grazing Days	109.6	154.4	208.6	239.2	305.4
Hectares/LSU	3.33	2.36	1.75	1.53	1.19

		grazing days		ha per LSU		LSU in unit		sum for unit UNC area: 7
82689	370032	41.32	154.44	8.83	2.36	73	503	425.4 grazing d
								24.1 ha/lsu
								1782.4 lsu in unit
								5394707.00 total bion
								680.98 biomass/

Summary table of biomass calculations taking phosphate limitation and losses due to pests and diseases into account

Dataset: Moshupa
Synoptic station: Kanye
Rainfall station: Kanye
Soil unit: LVh
Vegetation type: UNC   Area: 1582
Number of seasons: 29

	100	75	50	25	0
Trees: Total	29	64	147	235	449
Trees: Stem	9	19	44	70	135
Trees: Leaves	17	37	85	136	260
Trees: Roots	3	8	18	28	54
Upper Stratum: Total	29	64	147	235	449
Upper Stratum: Stem	9	19	44	70	135
Upper Stratum: Leaves	17	37	85	136	260
Upper Stratum: Roots	3	8	18	28	54
Lower Stratum: Total	41	93	212	339	648
Lower Stratum: Stem	12	28	64	102	194

Summary table of biomass calculations taking phosphate limitation and losses due to pests and diseases into account

Dataset: Moshupa
Synoptic station: Kanye
Rainfall station: Kanye
Soil unit: ARo
Vegetation type: UNC   AREA 791
Number of seasons: 29

	100	75	50	25	0
Trees: Total	76	164	273	362	578
Trees: Stem	23	49	82	109	173
Trees: Leaves	44	95	159	210	335
Trees: Roots	9	20	33	43	69
Upper Stratum: Total	76	164	273	362	578
Upper Stratum: Stem	23	49	82	109	173
Upper Stratum: Leaves	44	95	159	210	335
Upper Stratum: Roots	9	20	33	43	69
Lower Stratum: Total	110	237	395	523	835
Lower Stratum: Stem	33	71	118	157	251

		grazing days		ha per LSU		LSU in unit	
147126	187467	59.36	65.33	6.15	5.59	257	142

Lower Stratum: Leaves	24	54	123	197	376
Lower Stratum: Roots	5	11	25	41	78
Herbunder Total	76	201	462	576	1212
Herbunder Aerial	52	167	384	472	941
Herbunder Roots	9	33	75	90	271
Herbaway Total	292	925	1888	2260	3896
Herbaway Aerial	202	787	1587	1930	3067
Herbaway Roots	42	149	302	398	829

proper use factor	70% b.mass/hb.mass in unit				
Dry Matter Intake LSU/Day	11.25	254	401828		
Grazing Days	15.8	59.4	122.6	149.5	249.4
Hectare/LSU	23.09	6.15	2.98	2.44	1.46

Summary table of biomass calculations taking phosphate limitation and losses due to pests and diseases into account

Dataset:	Moshupa				
Synoptic station	Kanye				
Rainfall station	Kanye				
Soil unit	RGe				
Vegetation type	UNC		Area:		2773
Number of seasons		29			
	100	75	50	25	0
Trees: Total	83	168	281	362	568
Trees: Stem	25	50	84	108	170
Trees: Leaves	48	98	163	210	330
Trees: Roots	10	20	34	43	68
Upper Stratum: Total	83	168	281	362	568
Upper Stratum: Stem	25	50	84	108	170
Upper Stratum: Leaves	48	98	163	210	330
Upper Stratum: Roots	10	20	34	43	68
Lower Stratum: Total	121	243	406	522	821
Lower Stratum: Stem	36	73	122	157	246
Lower Stratum: Leaves	70	141	235	303	476
Lower Stratum: Roots	14	29	49	63	98
Herbunder Total	169	293	460	565	980
Herbunder Aerial	116	212	360	488	781
Herbunder Roots	41	63	92	101	218
Herbaway Total	771	1373	2076	2471	3801
Herbaway Aerial	536	1006	1632	2047	3046
Herbaway Roots	184	307	417	474	855

proper use factor	70% b.mass/hb.mass in unit				
Dry Matter Intake LSU/Day	11.25	652	1807996		
Grazing Days	40.6	75.8	123.9	157.7	238.1
Hectare/LSU	9	4.82	2.94	2.31	1.53

Summary table of biomass calculations taking phosphate limitation and losses due to pests and diseases into account

Dataset:	Moshupa				
Synoptic station	Kanye				
Rainfall station	Kanye				
Soil unit	RGe				
Vegetation type	ROK		Area:		9
Number of seasons		29			
	100	75	50	25	0
Trees: Total	59	120	200	258	405
Trees: Stem	18	36	60	77	121
Trees: Leaves	34	69	116	149	235
Trees: Roots	7	14	24	31	49
Upper Stratum: Total	172	347	580	747	1174
Upper Stratum: Stem	52	104	174	224	352
Upper Stratum: Leaves	100	202	337	433	681
Upper Stratum: Roots	21	42	70	90	141
Lower Stratum: Total	65	132	220	283	445
Lower Stratum: Stem	20	40	66	85	134
Lower Stratum: Leaves	38	76	128	164	258
Lower Stratum: Roots	8	16	26	34	53
Herbunder Total	30	52	81	100	173
Herbunder Aerial	21	37	64	86	138
Herbunder Roots	7	11	16	18	39
Herbaway Total	128	229	346	412	634
Herbaway Aerial	89	168	272	341	508
Herbaway Roots	31	51	70	79	143

proper use factor	70% b.mass/hb.mass in unit				
Dry Matter Intake LSU/Day	11.25	110	990		
Grazing Days	6.8	12.8	20.9	26.5	40.2
Hectare/LSU	53.33	28.61	17.46	13.74	9.08

Lower Stratum: Leaves	64	138	229	303	484
Lower Stratum: Roots	13	28	47	63	100
Herbunder Total	153	244	405	512	831
Herbunder Aerial	105	178	317	442	684
Herbunder Roots	35	54	79	88	168
Herbaway Total	690	1143	1860	2522	3793
Herbaway Aerial	478	872	1472	2038	3110
Herbaway Roots	167	265	376	429	772

proper use factor	70% b.mass/hb.mass in unit				
Dry Matter Intake LSU/Day	11.25	583	461153		
Grazing Days	36.3	65.3	111.3	154.3	236.1
Hectare/LSU	10.06	5.59	3.28	2.37	1.55

Summary table of biomass calculations taking phosphate limitation and losses due to pests and diseases into account

Dataset:	Moshupa				
Synoptic station	Kanye				
Rainfall station	Kanye				
Soil unit	LVf				
Vegetation type	UNC		AREA		1584
Number of seasons		29			
	100	75	50	25	0
Trees: Total	39	84	172	281	532
Trees: Stem	12	25	52	84	159
Trees: Leaves	23	49	100	163	308
Trees: Roots	5	10	21	34	64
Upper Stratum: Total	39	84	172	281	532
Upper Stratum: Stem	12	25	52	84	159
Upper Stratum: Leaves	23	49	100	163	308
Upper Stratum: Roots	5	10	21	34	64
Lower Stratum: Total	57	121	248	406	768
Lower Stratum: Stem	17	36	75	122	230
Lower Stratum: Leaves	33	70	144	235	445
Lower Stratum: Roots	7	15	30	49	92
Herbunder Total	112	259	531	709	1206
Herbunder Aerial	77	202	444	591	938
Herbunder Roots	13	43	88	108	277
Herbaway Total	467	1222	2086	2543	4148
Herbaway Aerial	324	931	1745	2176	3248
Herbaway Roots	59	198	359	444	900

proper use factor	70% b.mass/hb.mass in unit				
Dry Matter Intake LSU/Day	11.25	401	635184		
Grazing Days	25.0	70.5	136.2	172.2	260.5
Hectare/LSU	14.63	5.18	2.68	2.12	1.4

Summary table of biomass calculations taking phosphate limitation and losses due to pests and diseases into account

Dataset:	Moshupa				
Synoptic station	Kanye				
Rainfall station	Kanye				
Soil unit	LPe				
Vegetation type	ROK		AREA		18
Number of seasons		29			
	100	75	50	25	0
Trees: Total	23	42	91	127	206
Trees: Stem	7	13	27	38	62
Trees: Leaves	13	24	53	74	120
Trees: Roots	3	5	11	15	25
Upper Stratum: Total	66	121	263	369	599
Upper Stratum: Stem	20	36	79	111	180
Upper Stratum: Leaves	38	70	153	214	347
Upper Stratum: Roots	8	15	32	44	72
Lower Stratum: Total	25	46	100	140	227
Lower Stratum: Stem	8	14	30	42	68
Lower Stratum: Leaves	15	27	58	81	132
Lower Stratum: Roots	3	6	12	17	27
Herbunder Total	16	32	71	97	167
Herbunder Aerial	14	25	60	81	129
Herbunder Roots	1	7	11	15	38
Herbaway Total	75	139	289	430	634
Herbaway Aerial	66	114	246	349	495
Herbaway Roots	5	30	51	64	138

proper use factor	70% b.mass/hb.mass in unit				
Dry Matter Intake LSU/Day	11.25	80	1440		
Grazing Days	5.0	8.5	19.0	26.8	38.8
Hectare/LSU	73.33	42.2	19.17	13.64	9.4

		grazing days		ha per LSU		LSU in unit		
671066	191664	75.79	70.50	4.82	5.18	575	306	

		grazing days		ha per LSU		LSU in unit		sum for unit ROK	
								area:	9
2268	1602	12.76	8.65	28.61	42.20	0	0		21.4 grazing day
									70.8 ha/lsu
									0.7 lsu in unit
									2430.00 total biomass
									26.41 biomass/ha

Moshupa S. AEA
pop:2100 in 1995
pop:3575 in 2012

			total grazing days		total ha per LSU		total LSU in unit	
sum of columns Q and P	2757673	2845045	761.3	724.3	140.1	145.7	1841	1842
Total woody biomass (tonnes)	5612.718						3684	
Woody biomass kg/ha	0.218999							
Woody biomass per capita (1995 pop. figures)	2.672723							
total LSU in H1–H6	1385							
total LSU in RIV,FAL,UNC	2298							

ANNEX G DESCRIPTION OF FARMING HOUSEHOLDS IN MOSHUPA SOUTH AEA

Table III Characteristics of farming households in Moshupa South AEA

Subject	Parameter	number	%
gender of head of household	number of male headed hh. number of female headed hh.:	28 12	70 30
rowplanting	number of household using rowplanter number of household not using rowplanter	13 27	32.5 67.5
manure	no. of hh. using manure no. of hh. not using manure	30 10	75 25
draught power type	no. of hh. using oxen as draughtpower no. of hh. using donkeys as draught power no. of hh. using tractor as draughtpower	22 14 4	55 35 10
draught power ownership	no. of hh. owning their draughtpower no. of hh. borrowing their draughtpower no. of hh. owning/borrowing their draughtpower no. of hh. hiring their draughtpower	21 2 9 8	52.5 5 22.5 20
relative working in mines in RSA	no of hh. with RSA relative no of hh. with no RSA relative	10 30	25 75
Land Board certificate	no of hh. with Land Board certificate no of hh. with no Land Board certificate	7 33	17.5 82.5
age of field	no of hh. cultivating field > 10 years no of hh. cultivating field < 10 years	32 8	80 20
annual income	no of hh. with annual income of 0 - 1000 P no of hh. with annual income of 1000 - 2000 P no of hh. with annual income of 2000 - 3000 P no of hh. with annual income of 3000 - 4000 P no of hh. with annual income of 4000 - 5000 P no of hh. with annual income of > 5000 P	5 12 8 8 3 4	12.5 30 20 20 7.5 10
remittance	no of hh. with no remittance from relatives no of hh. with remittance > 75 of annual income	8 23	20 57.5
cattle ownership	no of hh. with no cattle/calves no of hh. with 1-5 cattle/calves no of hh. with 6-10 cattle/calves no of hh. with > 10 cattle/calves	6 16 4 14	15 40 10 35
donkey ownership	no of hh. with no donkeys no of hh. with 1-5 donkeys no of hh. with 6-10 donkeys no of hh. with > 10 donkeys	8 12 9 11	20 30 22.5 27.5
smallstock ownership	no of hh. with no s.stock no of hh. with 1-10 s.stock no of hh. with 11-20 s.stock no of hh. with 21-30 s.stock no of hh. with 31-40 s.stock no of hh. with > 40 s.stock	0 4 15 5 6 10	0 10 37.5 12.5 15 25
fertilizer	no. of hh. that has used fertilizer at least once	6	15
area cultivated 1994-95	no. of hh. cultivating 0-2 ha no. of hh. cultivating 2-3 ha no. of hh. cultivating >3 ha	8 23 7	20 57.5 17.5