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Soil Mapping and Advisory Services Botswana

Soils of The Diphuduhudu Remote Area Dwellers Settlement

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by

T. D. Mafoko
Soil Surveyor - Gaborone

and

T. Van der Sluis
Land Use Officer - Kweneng

Food and Agricultural Organization of the United Nations
United Nations Development
Republic of Botswana

Gaborone, June 1989

CONTENTS

Introduction

Conclusions and Recommendations

Contents

1	General Aspects	1
1.1	Location, Population and Communications	1
1.1.1	Location	1
1.1.2	Population and future development	1
1.1.3	Communications, infrastructure	1
1.2	Climate	3
1.2.1	Introduction	3
1.2.2	Rainfall and Potential Evapotranspiration	3
1.2.3	Temperature	7
1.2.4	Soil Climate	9
1.2.5	Conclusion	9
1.3	Hydrology	10
1.4	Geology and Geomorphology	10
1.5	Vegetation	11
1.6	Land Use	12
1.6.1	General Aspects	12
1.6.2	Wildlife	13
2	Soils	15
2.1	Soil Surveys methods	15
2.2	Soil Classification	15
2.3	Soil Legend	15
2.3.1	Main Units	15
2.3.2	Soil Units	16
2.4	Conclusion	18
3	Physiographic Units	19
3.1	Flat featureless Sandplain	19

3.2	Barchan dune depressions	19
3.3	River valleys	19
4	Land evaluation	21
4.1	Introduction	21
4.2	Discussion	21
4.3	Conclusion	23

References

Appendix 1 : Typifying Soil Profiles in Diphuduhudu area

Appendix 2 : Land suitability classification for rainfed sorghum under a system of improved traditional farming.

List of Tables

Table 1 : Mean monthly and annual rainfall and potential evapotranspiration at Letlhakeng.

Table 2 : Mean monthly minimum and maximum temperatures at Gaborone.

List of Figures

Figure 1 : Location of Diphuduhudu study area

Figure 2 : Rainfall versus potential evapotranspiration at Letlhakeng

Figure 3 : Types of growing period

Figure 4 : Agro-climatic zones in Botswana

ABSTRACT

This report describes the environment of the Diphuduhudu area and gives particular attention to the soils and climate prevailing in this zone. A land evaluation for rainfed sorghum is carried out and a soil map at 1:50 000 scale is attached.

INTRODUCTION

Diphuduhudu is an area set aside for RAD's. It is situated 80km north of Molepolole.

In 1978 the Diphuduhudu river valley was zoned communal, with a 4km broad zone of sandveld on each side of the river valley. This zoning practice was derived from the common tswana - kgalagadi practice of ploughing in the valleys and grazing cattle in the sandveld (Lupag, 1978).

In the same year a consultation tour was carried out to survey land use in the proposed second development area. At that time already many RAD's (Remote Area Dwellers) showed interest to settle at Diphuduhudu, provided facilities like water, school and health care, would be available. Diphuduhudu was by then surrounded by SDA (Second Development Area) ranches. Later ranches in the periphery were dezoned leaving those in the north. Diphuduhudu was now to be developed as a service centre that would compensate people who were previously hunting and gathering in the SDA and as a result a Soil Survey was requested with the aim of:

- Assessing the agricultural potential of the area, and
- To determine the location of areas suitable for dryland arable farming at a traditional management level

This survey was undertaken on request from the Kweneng District Land use Planning Unit, and took place in January 1989.

CONCLUSIONS AND RECOMMENDATIONS

In the surveyed area there are four major land units occurring:

1/ On the channel sides, land unit A40 (Haplic Arenosols) is the main soil type occurring. These are deep soils which are comparatively the best in this area with a suitability assessment of S3m (Marginally suitable with moisture availability as the main limiting factor)

2/ On the channel floor, the main land units occurring are A21 (Calcic Arenosols) and A21a (Petrocalcic Arenosols) both with a suitability assessment of S4t (very marginally suitable). The main problem with these soils is a very high calcium carbonate toxicity.

3/ On the flat to almost flat sandplain KS3 (Ferralic Arenosols) with a suitability assessment of N2 (permanent unsuitable) is the dominant soil unit. Moisture availability is the main limiting factor.

4/ KS6a and KS5a, which both are Luvic Arenosols, form an association with KS3, KS6a and KS5a occupying the lower areas in the landscape. The soils key out as S4m, a class better than KS5 because they are in slightly water receiving sites.

Recommendations:

- The only area recommended for sorghum under dryland farming is a thin strip of relatively better soils occurring along river valley sides.
- The rest of the area should be avoided since it is either not suitable or very marginally suitable.
- The possibility of introducing millet as the main crop should be considered as it is more drought resistant than sorghum.
- The alternatives for the above land use are livestock rearing (goats), hunting/gathering and preparation of derived products in home industries.

1 GENERAL ASPECTS

1.1 Location, Population and Communications

1.1.1 Location

Diphuduhudu is an area in Kweneng North. It is situated 20 km north of Ngware or 80 km north of Molepolole.

On the 9th April 1981, 40 000 ha of land (Diphuduhudu) was officially allocated to the RAD's. The corners were demarcated by cutting notches on big trees (Lupag, 1981). At present no one is sure of the boundary. The location, with tentative boundaries is presented in Figure 1.

1.1.2 Population and Future Development

In the past some 27 people were living at Diphuduhudu. According to the 1981 population census the number of compounds at Diphuduhudu was 1, Seisante: 1, Tshwantshwe: 12, Matsane: 16. In 1978 it was reported that the area Diphuduhudu might be used by the following people:

Semi permanently by Sarwa	±	260 people
Seasonally used by Sarwa	±	120 people
Semi permanently by Bakgalagadi	±	100 people

This makes a total of about 480 people. The groups coming from Diphuduhudu/Mmamosore/Mokgalawane/Gue, Lekoje, Tshwantshwe, Tlhgoyagaotlolong and Tamoo (see Appendix 3) (H. Bierick S. Kramer, 1978)

In the most recent report from MLGL 1079 people are mentioned, coming from 60 km away from 12 different 'settlements' or feeding points (C.M.J. Petje, 1987). However, it is doubtful that the resource base is such that it can sustain so many people.

1.1.3 Communications, Infrastructure

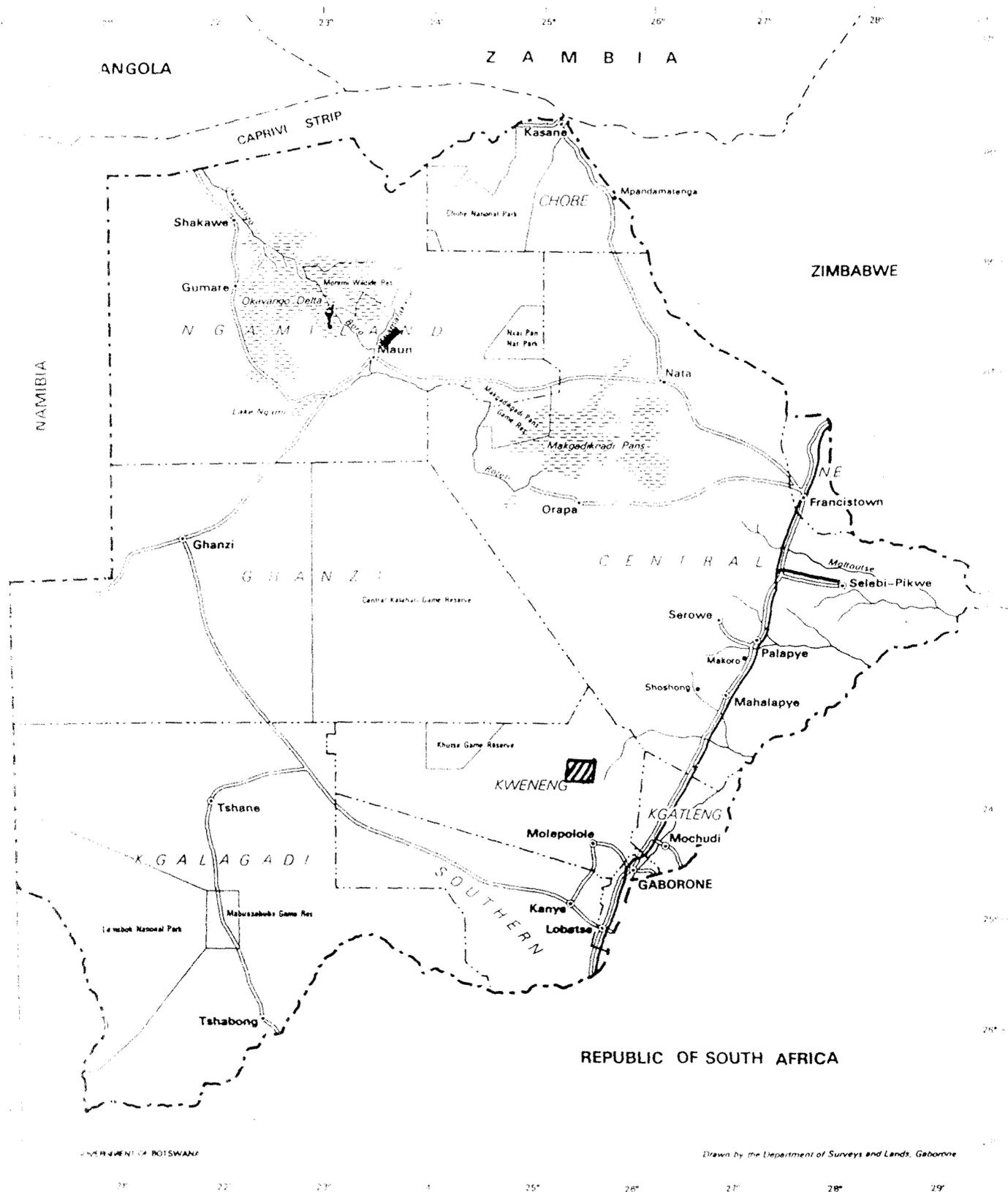
Secondary roads in the area are: from Diphuduhudu along the Dikogonnye fossil river, and another going around the selected area from Diphuduhudu round through Seisante, Lekoje Pan, round and back to Diphuduhudu. There is no infrastructure existing in the area.

REPUBLIC OF BOTSWANA

Fig. 1 LOCATION MAP

- SURVEYED AREA 
- Road 
- Railway 
- District Boundary 
- National Park 
- River 

0 100 200 Kilometres



GOVERNMENT OF BOTSWANA

Drawn by the Department of Surveys and Lands, Gaborone

Figure 1 : Location map.

1.2 Climate

1.2.1 Introduction

There are no long term climatic data available for the area. Hence for rainfall assumptions had to be made based on observations in Letlhakeng. For temperature data and potential evapotranspiration, assumption had to be based on a rather far away located synoptic station (Gaborone).

1.2.2 Rainfall and Potential Evapotranspiration

The mean total annual rainfall for Letlhakeng is about 420 mm (Table 1). The coefficient of variation of this annual rainfall is between 30 and 35%, according to Bhalotra (1984).

The distribution of the rainfall throughout the year indicates that more than 90% of the total is concentrated in the spring and summer months from October to March/April. The precipitation during winter and autumn is negligible. January is, in general, the wettest month of the year.

In summer the potential evapotranspiration is highest and reaches values in the range of 155 to 165 mm, hence the relatively low rainfall is concentrated in the season where its effectiveness is further diminished.

Based on the mean monthly and annual rainfall, and the potential evapotranspiration, the humidity regime of the area could be described as monsoon semi arid. This regime is characterized by an absence of humid months and only one or two months wherein, as an average, the rainfall exceeds half the potential evapotranspiration, while the rainy season occurs in summer (Papdakis, 1970).

The distribution of the rains within the rainy season is very variable from year to year. This is illustrated in Figure 2 where rainfall is compared to half and full PET.

FAO (1978) estimates that, as a rule, the rainy season and the growing period starts when rainfall (P) exceeds half the PET. A humid period occurs when P exceeds full PET, while the rainy season ends when P falls again below half PET. Taking into account a maximum of 100 mm stored soil moisture, the growing period ends when the soil is completely dry (Figure 3).

The results for twenty three growing seasons are summarized as follows:

- In two years out of twenty three (9%) no growing season occurred, in other words, in about one year out of ten did the rainfall not exceed half the potential evapotranspiration, and crops are bound to fail under rainfed conditions.

Table 1

Mean monthly and annual rainfall and potential evapotranspiration at Letlhakeng

	J	F	M	A	M	J	J	A	S	O	N	D	Annu
P	80	58	46	50	10	3	1	3	8	29	61	71	420
PET ^{1/}	161	131	124	86	63	39	43	82	123	158	156	165	1331

1/ Based on Gaborone climatic station, calculated with Penman equation

Table 2

Mean monthly minimum and maximum temperatures at Gaborone (°C)

	J	F	M	A	M	J	J	A	S	O	N	D	Annu
Mean	19.7	19.0	18.0	13.1	7.6	4.0	3.6	6.5	11.9	15.5	17.5	18.4	12.9
Min													
Mean	32.6	31.2	31.1	27.2	24.6	22.2	22.3	25.5	29.1	30.7	31.2	32.1	28.3
Max													

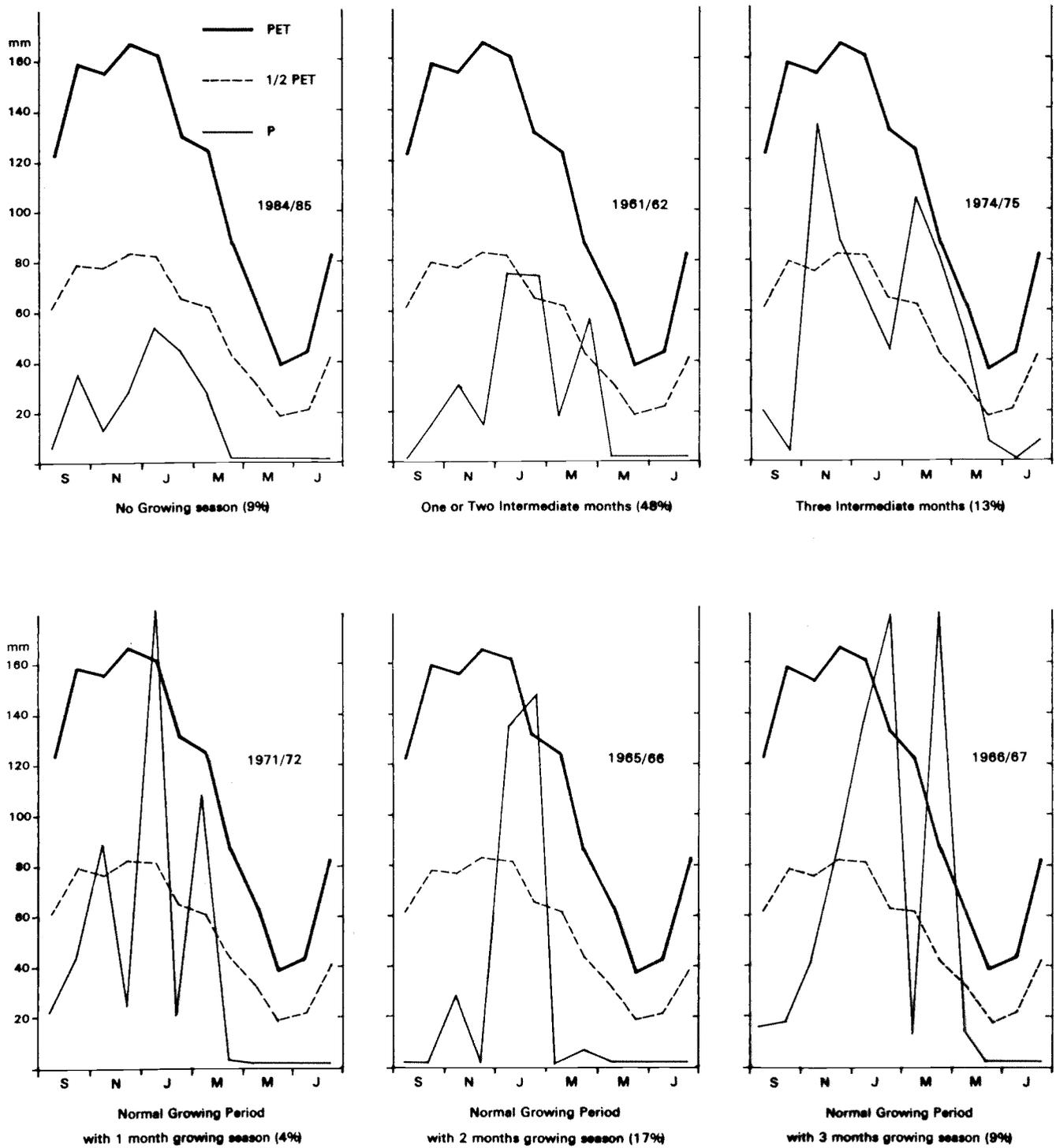
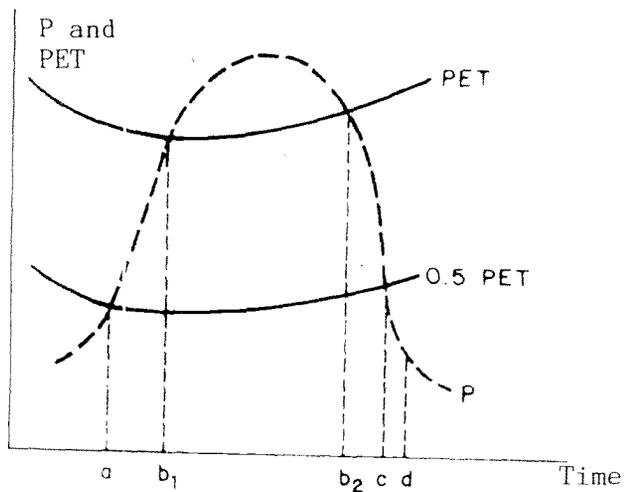
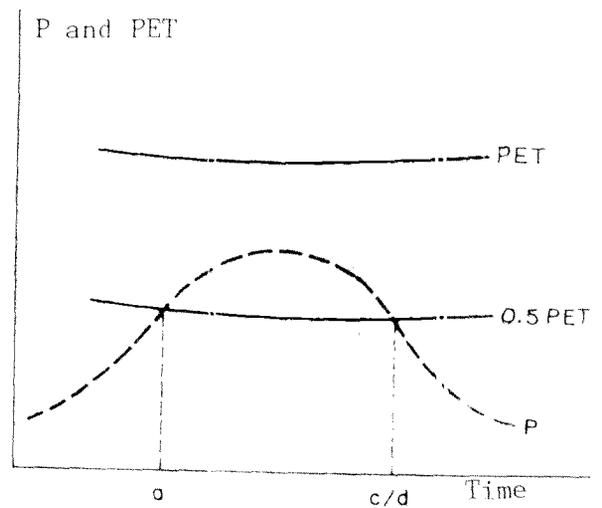


Figure 2: Rainfall versus Potential Evapotranspiration in Letlhakeng

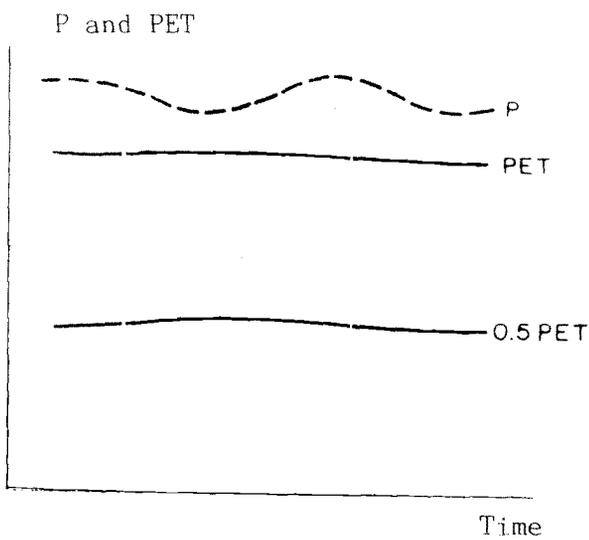
1. Normal



2. Intermediate



3. Humid throughout the year



4. Dry throughout the year

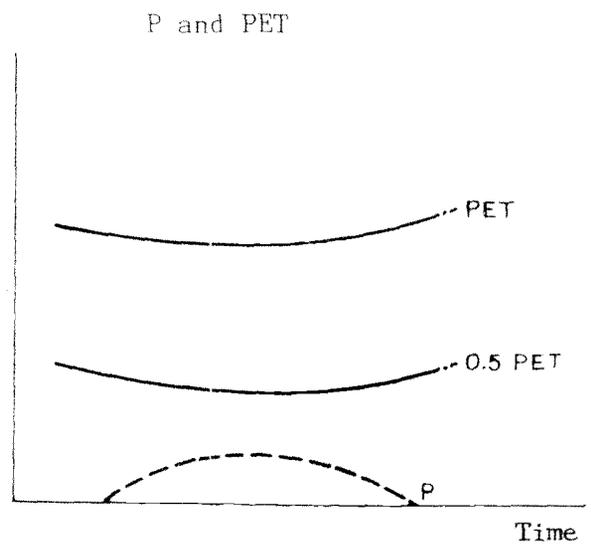


Figure 3: : Examples of the four types of growing period (FAO, 1978)

a : Start of the rainy season and
of the growing period

d : End of the growing period

P : Rainfall

b1 and b2: Start and end of humid period

PET: Potential Evapotranspiration

c : End of the rainy season.

- In seven years out of twenty three (30%) one or two humid months occurred during the growing season. This humid month could occur as early as December (1973/74 season) or as late as April (1960/61 and 1966/67 seasons)

- The length of uninterrupted normal growing period in Letlhakeng varies between thirty and about hundred and twenty days, but uninterrupted normal seasons of ninety days or more (taken as the lower limit for rainfed farming) occur only in five years out of twenty three, in other words, only in one year out of five is the rainfall distribution such that normal crop growth can be expected.

- In fourteen years out of twenty three (61%) one or more intermediate months occur, separated or not by dry months; under these conditions crops are submitted to a severe moisture stress and yields are bound to be marginal under rainfed conditions.

- The onset date of the growing season is very variable and may be as early as October (1982/83 season) or as late as March (1959/60 season)

From this analysis it follows that rainfed agriculture in this area is bound to be a risky and marginal enterprise as normal growing period of sufficient length only occur in one year out of five, while the additional problem of the variability of the onset dates of the growing season makes the planning of agriculture activities even more difficult.

The above analysis was confirmed by the general study of Dambe (1987) on growing periods in Botswana (Figure 4). The study area falls in zone 2D3 and is located near zone 3B3, with an expected length of the growing season of between eighty and a hundred days in the former but with an important number of dry days within the season (31-40). The length of the humid period does, in general, not exceed forty days.

1.2.3 Temperature

The mean monthly minimum and maximum temperatures for the Gaborone climatic station are presented in Table 2. The mean maximum temperature ranges from a low in June (22.2°C) to a high in January (32.6°C). The mean minimum temperature ranges from a low in July (3.6°C) to a high in January (19.7°C). Frost may occur from April to September. Extreme minimum temperature measured was -6.5°C

Based on the summer and winter temperatures, the temperature regime can be described as "subtropical", with relatively cool winters and warm summers (Papdakis, 1970). This temperature regime is suitable for a wide range of crops, including winter and summer cereals, but excluding equatorial crops, coffee, tea and frost sensitive perennials such as sugarcane.



Length of Season		Number of Dry Days within the Season	Length of Humid Period	
Duration (days)	Frequency (%)		Duration (days)	Frequency (%)
1 101-120	75-100	A 0-10	1 41-60	75-100
2 81-100	75-100	B 11-20	2 20-40	50-74
3 61-80	75-100	C 21-30	3 20-40	25-49
4 41-60	75-100	D 31-40	4 20-40	<25
5 41-60	50-74	E 41-50		

Figure 4 : Agro - climatic zones in Botswana

1.2.4 Soil Climate

Climatic parameters are considered in soil classification, particularly in the Soil Taxonomy (Soil Survey Staff, 1987).

The soil moisture regime of the area is considered as transitional between ustic and aridic. This implies that in most years the soil is dry in some or all parts for 90 or more cumulative days and is moist in some parts for more than 180 cumulative days. In some years the latter is probably not true and the moisture regimes become aridic. For soil classification purposes, the soil moisture regime is considered to be ustic.

The soil temperature regime is Hyperthermic, with a mean annual soil temperature higher than 22°C and with a difference of more than 5°C between the winter and summer soil temperatures.

1.2.5 Conclusion

The study area can be classified as a Low Tierra Fria climate with cool winters and warm to relatively hot summers, the rainy season occurs in summer and in only two months the rainfall exceeds half the potential evapotranspiration.

Although the temperature regime of the area is suitable for a large range of crops, the rainfall analysis indicates that drought years occur in one year out of ten, while good rainfall conditions occur only in one year out of five. In most years the length of the normal growing period does not exceed 90 days, while its onset dates are variable and may be as early as October or as late as March. Rainfed agriculture in the area is bound to be a risky enterprise, given these rainfall characteristics.

1.3 Hydrology

Boreholes are at Diphuduhudu, Tshwantshwe and Dinonyane. The borehole at Dinonyane and Diphuduhudu are from the council. In the past, the old borehole at Diphuduhudu was brought from a private owner. J.C. Louw. The yield was very low and pipes were blocked by mud. Many attempts were made to drill a new borehole, most recently in December by Water Affairs, again resulting in 3 blanks. In January the council tried and was this time finally successful. Two good yielding boreholes were found at about 620m depth. No pumping test has been made yet. At Dinonyane the yield is 30l/s (fair).

The groundwater flow is directed north.

The groundwater development prospects are uniformly poor. Productive aquifers are in Basalt from the stormberg lava group (GSD 1988)

Surface water is hardly available as the sand leaves little or no run off. The fossil, Dikogonnye river valley is draining into the Mmone valley, which once emptied in the Makgadikgadi depression in the north. Some water is available at wells and pans at Lekoje. This only for a limited number of months.

1.4 Geology and Geomorphology

The surveyed area is part of a vast flat to gently undulating plain of thick aeolian Kalahari sands, deposited during the tertiary and quarternary period. A few isolated barchan dunes do occur, breaking the otherwise uniform Kalahari sandplains. The fossil infilled Dikogonnye river channel which is evidence of a more humid past climate in the Kalahari crosses the area from north to Diphuduhudu in the south. Pans have developed along this channel in the north towards Seisante. Their formation has been due to deflationary action over the thick layer of calcrete which has been deposited in this channel

1.5 Vegetation

Twenty kilometres to the south close to Ngware, is the Matlolakgang research station from the Animal Production Research Unit (APRU). Here also some pasture monitoring is done, the vegetation here is as follows:

GRASSES Species	No in Diphuduhudu		Trees and shrubs Sp
<i>Urochlea sp.</i>	5		
<i>Stipagrotis uniplumis</i>	2		
<i>Antephora pubescens</i>	4	x	<i>Acacia giraffae</i> 50
<i>Bracharia sp</i>	3		<i>Boscia albitrunca</i> 3
<i>Klyonerus argentus</i>	2		<i>Combretum hereroense</i> 3
<i>Eragrostis rigidior</i>	1	x	<i>Dichrostachys cinerea</i> 47
<i>Mogaloprotachne albescens</i>	92		<i>Grewia sp</i> 20
<i>Pogonathria squarrosa</i>	1	x	Total Trees & Shrubs 129
<i>Schmidtia Uniplumis</i>	2		
Total grass sp.	112		
% annuals	82		
Total Woody Sp.	7		
Total Herb Sp.	62	(Source: DI, Field 1977)	

Grasses found in Diphuduhudu are of good quality. Besides above mentioned species, *Digitaria milianjana*, *cymbopogon plurinodis* and *Aristida congesta* are found.

The estimated carrying capacity calculated as a result from clipping studies is 8ha/LSU. The recommended stocking rates is 12ha/LSU (Hendzel 1980)

Outside the Research Station, the natural vegetation structure of the area is as follows:

Sandplains: open low shrub savanna of *Grewia flava*, *Terminalia sericia* and *Dichrostachys cinerea*.

Interdunal depressions: open low shrub savanna of *Grewia flava*, *Acacia mellifera* and *Terminalia sericea*.

Valley sides: open low shrub savanna of *Grewia flava*, *Acacia erioloba* and *Dichrostachys cinerea*

Valley bottom: open low shrub savanna of *Acacia mellifera* and *Grewia flava*.

Pans: devoid of vegetation.

1.6 Land Use

1.6.1 General Aspects

The people may move seasonally, but they have lived in this area for generations.

In 1977, the number of Basarwa using the area was about 263 permanently and 120 seasonally (Vierrich and Kramer, 1978)

The land use was two-fold:

- Raising of agricultural products in summer in the river valleys by both Bakgalagadi and Basarwa (as well as grazing of goats and donkeys)
- Full time hunting and gathering.

In Tshwantswe/Molongwane, groups of Bakgalagadi and Basarwa co-operated (LUPAG, 1978). Basarwa helped ploughing so several of them have this skill. Some two families were ploughing at Diphuduhudu (LUPAG, 1982).

Nowadays people are ploughing in Dikogonnye river valleys from Dinonyane up to 4km south of Diphuduhudu. Besides still 2 families are ploughing 2km northwest of Diphuduhudu. At Seisante a number of people are ploughing, they were allocated lands by Land Board in 1982.

Still some hunting and gathering is taking place, but is unknown to what extent this is practiced at present. The valley is extremely productive of veld foods, more than 100 plants were used in the Ngwane area (Vierrich, 1981).

An average household in Kweneng might plough some 6 ha of land. This can give an indication of the number of people that might depend on this resource. For hunting and gathering, the area required per person might be a bit less than 1500 ha, as the area is very rich in veld products. This applies when no development of cattle and husbandry takes place as they might destroy this resource, as happened in Tshwantswe (project memo-service center, 1978)

The Basarwa moved out from Tshwantswe. The borehole owner refused to let them drink from his borehole, while his cattle have destroyed their natural water source, Tshwantswe pan. That borehole was developed in 1963.

The Basarwa moved out from Tshwantswe. The borehole owner refused to let them drink from his borehole while his cattle have destroyed their original water source, Tshwantswe pan. That borehole was developed in 1973.

1.6.2 Wildlife

We recorded many steenbok and ostriches in Diphuduhudu. We also found dung of gemsbok at Masipakhukama pan (translated: M= dung of Gemsbok -) and tracks of hyena.

In the WMA more wildlife might be present, as it is adjoining the CKGR. Just inside the CKGR, a substantial number of giraffe was recorded at the end of November, 1988 (N. Rozemeyer, DOL; pers. Comm.)

This area with east Kweneng forms hunting area 33. In 1987 the following animals were culled:

Hartebeest	54
Ostrich	45
Kudu	35
Warthog	5
Gemsbok	42

For RAD's registered as hunter-gatherer, special licenses are given out for free. No further quantitative information is available on people using their rights

In an aerial survey the following animals were counted (Table 1)

TABLE 1

WILDLIFE PRESENT IN DIPHUDUHUDU AND ADJOURNING AREAS
(Source: Wildlife Department Aerial Survey Sept, 1987)

Species	Population Estimate	Population Density	% 95% confidence Limit	% standard
Cattle	11 540	1.60	73%	28.29
Horse	200	0.03	163%	63.00
Donkey	400	0.06	113%	43.75
Goats	1 400	0.19	17%	12.14
Duiker	260	0.04	125%	48.46
Eland	20	0.00	250%	97.45
Ostrich	560	0.08	187%	72.86
Steenbok	220	0.03	124%	48.18

This study area was measuring some 37 x 60km or 222 000ha, five and half times the size of Diphuduhudu. The cattle and other domestic animals counted are from neighbouring boreholes and settlements. Within Diphuduhudu virtually no cattle is present.

For the Ngware area, Vierrich (1981) mentions common antelope species like Kudu, Gemsbok Hartebeest, Duiker and Steenbok. Wildebeest visits occasionally, velvet monkey lived in upper Dikgonnye, but now only occurs in Lephephe area, Morula forest. Giraffe are rarely seen south of Masiphakukama pan and are not common until Taame, 50km to the north. Leopards are common, even near Bakgalagadi settlements (Vierrich, 1981).

Porcupines are very common, as are squirrels and hares. Aardwolves are very rare. Bat-eared fox are fairly frequent, as is the honey badger. There are numerous black backed jackals, brown hyena's and wild dogs. Caracal cats are seen only occasionally. Mongoose, striped genets and civet cats are common, as are Zorillas.

2 SOILS

2.1 Soil Survey Methods

Mapping was done with the aid of 1:50 000 aerial photographs (1982) combined with field work. The photographs were also used as a base map.

Detailed soil profile descriptions and chemical analysis of 13 pits were done following the Botswana soil Database Guidelines for Soil Profile descriptions (Rommelzwaal and Waveren, 1988), and Botswana Soil Testing Procedures for Soil Survey (Breitbart, 1988).

2.2 Soil Classification

Classification of soils has been done following the General Soil Legend of Botswana (Rommelzwaal, 1988). This system is based on the soil map of the world legend (FAO-Unesco, 1974) with modifications to suit Botswana conditions. The Soil Taxonomy classification (Soil Survey Staff, 1975, 1987) is used as a second classification system.

Recently an updated Legend of FAO/Unesco/ISRIC, 1988 was introduced. A correlation with this system has been included.

2.3 Soil Legend

2.3.1 Main Units

The legend consists of two components, Main Units and Soil Units. For the Diphuduhudu area, the following main units are recognized:

- A: Soil on alluvial deposits : exclusive of lacustrine sediments, but includes deltaic deposits, as well as colluvium of mixed origin.

- C: Soils on highly calcareous rocks and materials: contains all highly calcareous materials such as calcrete and calcareous nodules as well as limestone and dolomite which have CaCo₃ content of 40% or more at a depth of less than 50cm from the surface.

- KS: Soils on coarse grained sedimentary rocks; the sediments consists of unmixed Kalahari sand. The texture of the soil is loamy sand or coarser to a depth of fifty centimeters from the surface and not finer than fine sandy loam at 100cm.

2.3.2 Soil Units

Soil units recognized in the survey area and represented on the map are listed below. Details are given on occurrence, soil characteristics and vegetation. Selected typifying pedons are presented in Appendix 1, with standard analytical results. All other profiles described in the area are available in the Botswana Soil Database (Area code : KU), at the Ministry of Agriculture.

- A40** **FAO:** Eutric Arenosols (1975)
Haplic Eutric Arenosols (1988)
ST : Typic Ustipsamment
Description: Deep to very deep, moderately well to well drained, brown to white sands to loamy sands
Topography: Flat to gently undulating. Normal site.
Profiles: KU108, KU109.
Characteristics: Very weak structure. Very deep fine sands with calcrete nodules at 140cm.
Occurrence: On the upper river channel sides.
Vegetation: Open shrub savanna of Acacia mellifera, Acacia erioloba and Grewia flava.
- A21** **FAO:** Calcic Arenosol (1974)
Calcic Arenosol (1978)
ST : Typic Ustochrept
Description: Moderately deep to very deep, moderately well to well drained, dark grayish brown to yellowish brown, sands to loamy sands
Topography: Flat to gently undulating. Normal site.
Profiles: KU105, KU112, KU113.
Characteristics: Weak fine to medium subangular blocky structure with calcrete nodules occurring within 125cm.
Occurrence: On channel sides.
Vegetation: Open low shrub savanna of Grewia flava, Acacia erioloba and Dichrostachys cinerea.
- A21a** **FAO:** Petrocalcic Arenosols (1974)
Petri- Calcic Arenosols (1988)
ST : Petrocalcic Ustochrept
Description: Moderately deep to very deep, moderately well to well drained, dark grayish brown to yellowish brown, sands. Have a petrocalcic horizon with 125cm.
Topography: Flat to undulating.
Profiles: KU 107
Characteristics: Have a very weak fine structure. The soils are moderately deep.
Occurrence: On the channel bottom.
Vegetation: Open low shrub savanna of Acacia mellifera and Grewia flava. The typical grass is Cymbopogon purinoids.

- C1** **FAO:** Lithosols (1974)
 Calci-Lithic Leptosol (1988)
ST : Lithic Ustorthent
Description: Very shallow (less than 10cm), moderately well to well drained, dark grayish brown to brown, loamy sands to clayloam.
Topography: Flat to undulating.
Profile: None
Characteristics: In some areas there is no topsoil at all but strongly cemented calcrete.
Occurrence: In the pans
Vegetation: Devoid of vegetation.
- KS3** **FAO:** Ferralic Arenosol (1974, 1988)
ST : Ustic Quartzipsamment
Description: Deep to very deep, well to somewhat excessively drained, yellowish brown (with chroma fo 5 or more) to yellowish red, fine and fine medium sand.
Topography: Flat.
Profiles: KU100, KU102, 104, 106, and 111.
Characteristics: Very weak medium subangular blocky structure. Mainly fine sand throughout. The pH varies from 5.6 to 6.0 in the topsoil, and from 5.2 to 6.8 in the subsoil. Organic carbon content is low with values between 0.3 and 0.5 in the topsoil. The cation exchange capacity is low and remains less than 4meq/100g soil throughout.
Occurrence: These are dominant soils occurring on flat to almost flat sandplains. They occur in association with KS5 but differ from them by their high chroma (>5) and redder hue (7.5YR).
Vegetation: Open low shrub savanna of Grewia flava, Terminalia sericea and Dichrostachys cinerea.
- KS6a** **FAO:** Ferralic Arenosols (1974)
 Lamelli-Luvic Arenosol (1988)
ST : Typic Ustipsamment
Description: Deep to very deep, somewhat excessively to excessively drained, yellowish brown to red, fine sand and fine to medium sand to loamy fine - sand. Showing lamellae of clay accumulation.
Topography: Flat situated in depressions amid undulating dunes.
Profile: KU 103
Characteristics: Very deep sands, somewhat excessively drained. Very weak coarse to massive structure.
Occurrence: On interdunal depressions of scattered isolated lingoid dunes.
Vegetation: Open low shrub savanna of Grewia flava, Acacia mellifera and Terminalia sericea.

2.4 Conclusion

Soils show little variation with the exception of those along the Dikogonnye fossil river channel.

Dominant soils are very deep sands which differ according to position on the landscape. Those in the interdunal depression (Luvic Arenosol) have an accumulation of clay and sesquioxides in the form of lamellae at some depth whilst those on a flat to almost flat position do not this clay migration, and are Ferralic Arenosols.

The second category of soils are those along the river channel, where different soils are also found according to their position along the channel. Within the channel, soils range from very shallow (Lithosols, C1) in the pans, with calcrete almost exposed at the surface, to moderately deep sands overlying calcrete. On both sides of the channel very deep sands, which are calcareous to strongly calcareous from 80cm and deeper, occur.

3 PHYSIOGRAPHIC UNITS

In the Diphuduhudu area following main physiographic units can be distinguished (see Figure 5):

- 1 Flat featureless Sandplain
- 2 Barchan dune depressions
- 3 (Fossil) river valleys

3.1 Flat featureless Sandplain

Occurs as dominant physiographic unit forming part of the vast Kalahari aeolian sand.

3.2 Barchan dune depressions

They are part of the Kalahari occurring in between isolated clusters of crescent shaped dunes with horns pointing downwind. This feature is more prominent in the west of the surveyed area.

3.3 River valleys

Occurs along the fossil Dikgonnye river channel as alluvium and windblown sands on calcrete.

PHYSIOGRAPHIC MAP OF DIPHUDUHUDU AREA

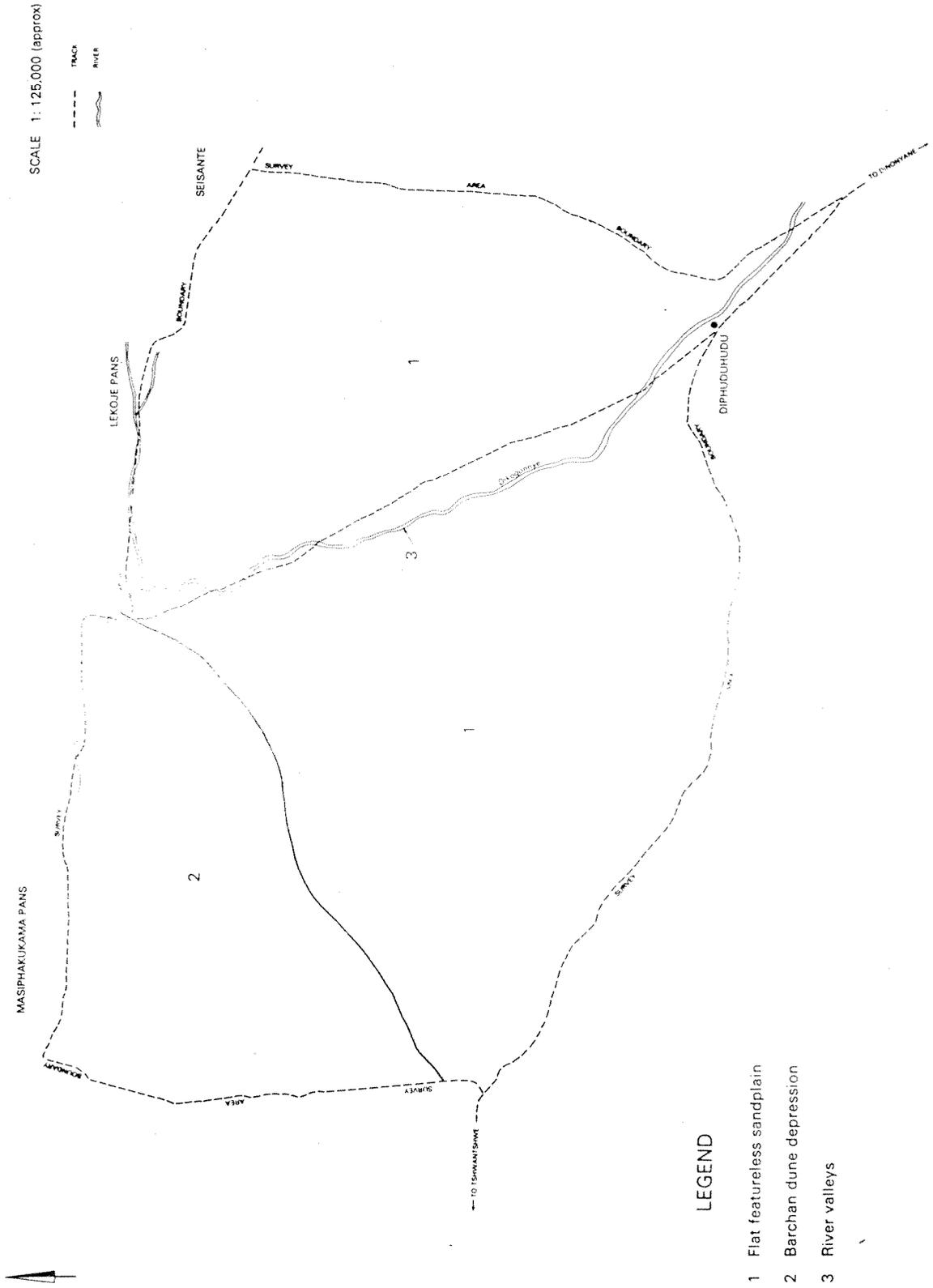


Figure 5 : Physiographic units in the Diphuduhudu area

4 LAND EVALUATION

4.1 Introduction

The request for the land evaluation of the study area specified that emphasis should be put on the possibilities for improved traditional dryland farming with sorghum as the main crop.

The general methodology, developed particularly for a land evaluation exercise at reconnaissance level, by Rhebergen (1988) was followed. In this methodology several land qualities such as accessibility, moisture availability, absence of floods, foothold for roots etc.. are matched with specific crop requirements in this respect.

The results for the six typifying pedons are presented in Appendix 2.

It was not possible at this stage to include an evaluation for rangeland suitability, because the evaluation system is still being developed.

4.2 Discussion

Accessibility : the area is rather isolated and no major roads service occurs in this zone. Infrastructural improvements will be required. The low population combined with the lack of infrastructure results in anticipated market problems, while inputs also will increase in cost.

Temperature regime : the optimum temperature regime for sorghum is characterized by following parameters during the growing season: mean temperature in the range of 22°C to 20°C, mean maximum less than 36°C and a mean minimum temperature higher than 18°C (Nachtergaele, 1988). Temperature conditions are ideal during the period November to March, and hence no temperature limitation exists in the zone.

Resistance to erosion : the resistance of the soil to erosion is a function of its texture, its structure, organic matter and silt content and its depth. The slope length and its steepness play also a role. Soils in the area are low in silt, low in organic matter and most are deep to very deep (with the exception of the (C1 unit). The resistance of the Ferralic Arenosols and the Calcic Arenosols is moderate, while the resistance of the Petrocalcic Arenosols is low.

The slope factor plays a less important role as the area is flat to gently undulating. The high infiltration rate is also a plus for the soils resistance to water erosion. Wind erosion might be as important as water erosion in this semi arid areas. The sandy textures in the soil indicate a moderate resistance to wind erosion.

- Absence of damaging flood : No floods are expected in most of the area. In the channel an occasional flood risk is present, though.
- Adequacy of conditions for germination : No surface crust, surface stones and gravel occur, hence no adverse conditions for germination exist in the soils of the area.
- Moisture availability : This is the most limiting land quality for rainfed agriculture. The combination of an unreliable short growing season with sandy soils with a low water holding capacity makes the land at most marginally suitable for rainfed sorghum.
- Nutrient availability : This is the second most limiting land quality, as soils are very sandy and have a low cation exchange capacity (<4meq per 100 g of soil); they are low in organic carbon content also, and for good yields fertilizers are required. However, given the low CEC, response to fertilizer may be limited, while in addition, the permeable soils might diminish the effectiveness of the fertilizer application through leaching. Please note that a development plan based on fertilizer input alone is bound to fail if the more limiting moisture stress limitation is not cured first.
- Oxygen availability : These soils have high porosity and are not affected by groundwater hence no problems with oxygen availability are expected for most soils. The soils on water receiving sites or in intermediate positions (A19, A21) might develop a slight limitation in this respect.
- Foothold for roots : With the exception of the Lithosol (C1). All the soils in area are deep to very deep and soil depth is no limitation for sorghum.
- Absence of toxic : There are no apparent salinity or sodicity problems in the area, nor has gypsum been observed. The only toxic substance is calcium carbonate. The relatively high CaCO₃ content in the Calcic Arenosol might be a moderate limitation, whilst in the Petrocalcic Arenosol (A21) it constitutes a severe limitation.
- Workability : For traditional farming practices there is no problem to work these soils, except in the C1 unit where a petrocalcic horizon occurs close to the surface.

4.3 Conclusions

In the major lands of the survey area, two main limitations for the production of rainfed sorghum are present. The most severe one is the restricted water availability for crops, which is due to the rather low and unreliable rainfall pattern, aggravated by the low water holding capacity of these sandy soils. The second severe limitation that occurs is the limited nutrient retention of the soils. In some soils a calcic and/or petrocalcic horizon has developed and depending on its depth may limit crop production due to a toxicity problem.

The relatively better soils occur in the fossil river valleys on sites which receive additional water. The yields will be slightly better but are expected to remain marginal in four years out of five.

Attention could be paid to the introduction of more drought resistant crops such as millet which are expected to give moderate yields in most years.

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Appendix 1 : TYPIFYING SOIL PROFILES IN DIPHUDUHUDU AREA

Symbol	Soil Unit	FAO Classification (1974)
KU 108	A40	Ferralic Arenosol
KU 113	A21	Calcic Arenosol
KU 107	A21a	Petrocalcic Arenosol
KU 100	KS3	Ferralic Arenosol
KU 106	KS5	Ferralic Arenosol
KU 110	KS5a	Lamelli-luvic Arenosol
KU 103	KS6a	Lamelli-luvic Arenosol

SOIL PROFILE DESCRIPTION

Profile: KU 0108 Unit: A40 Status: 2

SHEET :
LOCATION : Upper valley slope (5km West of Lekoje pan).
AUTHOR(S) : T.D.Mafoko
CLASSIFICATION FAO: Haplic Arenosol(1988) Eutric Arenosol (1974)
ST : Typic Ustipsamment
LANDFORM : alluvial plain
TOPOGRAPHY: gently undulating
SURF. CHAR: moderate sealing, no cracks, nil evidence of salt,
LAND USE: traditional grazing
SPECIES : Trees -
: Shrubs - Acacia mellifera (dom.) Acacia erioloba Grewia flava
: Grasses/forbs- Eragrostis rigidior (dom)
PARENT MATERIAL: alluvium
MOIST. COND: moist 0 - 140 cm
SURF.STONES: none
EROSION : moderate wind erosion/deposition and moderate sheet erosion

REMARKS: Water receiving.Coordinates to nearest minute.

SAMPLES: A: 0 - 15 B: 30 - 50 C: 80 - 100

- A 0 - 15 cm 10YR 3/2 (moist), fine sand, very weak fine and medium subangular blocky structure, friable, non calcareous, many fine and medium roots, gradual smooth boundary.
- B1 15 - 55 cm 10YR 4/2 (moist), fine sand, very weak medium and coarse subangular blocky structure, friable, non calcareous, few termite/ant activity, common fine and medium roots, diffuse smooth boundary.
- B2 55 - 140 cm 10YR 4/2 (moist), fine sand, very weak medium and coarse subangular blocky structure, friable, very few fine irregular soft calcareous white soft segregations, non calcareous, few termite/ant activity, common fine and medium roots, abrupt smooth boundary.
- Ck 140 cm + dominant medium irregular hard calcareous white concretions, extremely calcareous,

GRID : - - -
COORD: 23-35-00-S 25-16-00-E
DATE : 18/09/89
LAND ELEMENT : not applicable
MICRO TOPOGRAPHY: low hummocks
VEGETATION: open low shrub savanna
AGRO CLIM.ZONE: 2D3
ELEVATION : 1060 m
SMR: ustic to aridic
POSITION: upper slope
SLOPE : 2 - 3% convex
GRASSCOVER: 30 - 70 %
ROCK TYPE:
ROCK OUTCROP: none
GEOL.UNIT: Kalahari beds
DRAINAGE : well drained
HUMAN INF: nil

Soil Survey of Botswana FAO/BOT/85/011

print date: 03/05/89

STANDARD SOIL ANALYSIS RESULTS

PROFILE: KU 0108

SAMPLE	DEPTH	pH	EC	P	C	CEC	Ca	Mg	K	Na	PBS	Particle size (weight %)						CECclay	METH	PRETR			
		H2O	CaCL2	mS/cm	ppm	weight %	meq/100gr soil	meq/100gr soil	meq/100gr soil	meq/100gr soil	%	vcS	cS	mS	fS	vFS	cSi	fSi	Clay	meq/100gr			
A	0 15	6.9	6.0	0.0	2	0.4	2.9	3.6	0.1	0.2	0.0	>100	0	1	9	70	14	2	5	0	0	H	
B	30 50	6.9	6.1	0.0	2	0.4	3.3	3.8	0.3	0.1	0.1	>100	0	1	9	68	14	2	3	3	0	H	
C	80 100	7.4	7.0	0.1	1	0.3	4.6	5.6	0.3	0.1	0.0	>100	0	1	9	67	14	2	3	6	58	H	

Soil Survey of Botswana FAO/BOT/85/011

Print date: 02/05/89

PART-SIZE DETERMINATION METHOD: H = Hydrometer Method, P = Pipette Method, * = Not Known
 PRETREATMENT: O = Organic Matter, F = Free Iron Oxides, C = Carbonates, S = Soluble Salts N = None

SOIL PROFILE DESCRIPTION

Profile: KU 0113 Unit: A21 Status: 2

SHEET :
LOCATION : Just East of Lekoje pan.
AUTHOR(S) : T.D.Mafoko
CLASSIFICATION FAO: Calcic Arenosol(1988) Calcic Arenosol (1974)
ST : Typic Ustochrept
LANDFORM : sand plain
TOPOGRAPHY: undulating
SURF. CHAR: moderate sealing, no cracks, nil evidence of salt,
LAND USE:
SPECIES : Trees - *Boscia albitrunca* (dom.)
: Shrubs - *Grewia flava* (dom.)
: Grasses/forbs- *Stipachrostis uniplumis* (dom)
PARENT MATERIAL: aeolian sand
MOIST. COND: moist 0 - 120 cm
SURF. STONES: none
EROSION : moderate wind erosion/deposition

REMARKS: Coordinates to nearest minute.

SAMPLES: A: 0 - 20 B: 30 - 0 C: 100 - 120

- A 0 - 20 cm 10YR 5/2.5 (moist), fine sand, weak fine and medium subangular blocky moderate structure, soft, non calcareous, many fine and medium roots, gradual smooth boundary.
- B 20 - 110 cm 10YR 4/2 (moist), loamy fine sand, weak medium and coarse subangular blocky moderate structure, friable, non calcareous, common fine and medium roots, clear smooth boundary.
- Ck 110 - 120 cm 10YR 3/3 (moist), loamy fine sand to fine sandy loam, weak medium and coarse subangular blocky moderate structure, friable, frequent fine irregular soft calcareous white soft segregations, strongly calcareous, very few fine and medium roots,

Soil Survey of Botswana FAO/BOT/85/011

print date: 03/05/89

GRID :
COORD : 23-35-00-S 25-17-00-E
DATE : 19/01/89
LAND ELEMENT : not applicable
MICRO TOPOGRAPHY: low hummocks
VEGETATION:
ROCK TYPE:
ROCK OUTCROP: none
AGRO CLIM.ZONE: 2D3
ELEVATION : 1060 m
SNR: ustic to aridic
POSITION: upper slope
SLOPE : - 3 % straight
GRASSCOVER: 30 - 70 %
GEOL.UNIT: Kalahari beds
DRAINAGE : moderately well drained
HUMAN INF: nil

STANDARD SOIL ANALYSIS RESULTS

PROFILE: KU 0113

SAMPLE	DEPTH	pH	EC	P	C	CEC	Ca	Mg	K	Na	PBS	Particle size (weight %)					CECclay	METH	PRETR				
		H2O	mS/cm	ppm	weight %	meq/100gr soil	%	vcS	cS	mS	fS	vfS	cSi	fSi	Clay	meq/100gr							
A	0	7.1	6.2	0.0	0	0.4	3.1	3.2	0.2	0.2	0.0	>100	0	0	8	70	14	3	2	2	0		H
B	30	7.5	6.7	0.0	1	0.5	5.1	3.6	0.3	0.2	0.1	82	0	0	9	69	13	3	2	5	0		H
C	100	8.7	8.0	0.1	1	0.4	5.5	27.4	0.6	0.1	0.1	>100	0	0	0	73	13	3	2	9	43		H

Soil Survey of Botswana FAO/BCI/85/011

Print date: 02/05/89

METHOD: H = Hydrometer Method, P = Pipette Method, * = Not Known
 PRETREATMENT: O = Organic Matter, F = Free Iron Oxides, C = Carbonates, S = Soluble Salts N = None

SOIL PROFILE DESCRIPTION

Profile: XU 0107 Unit: A21a Status: 2

SHEET :
LOCATION : On the valley bottom 5km West of Lekoje pan§.
AUTHOR(S) : T.D.Mafoko
CLASSIFICATION FAO: Petri-Calcic Arenosol(1988) Petrocalcic Arenosol (1974)
ST : Petrocalcic Ustochrept
LANDFORM : alluvial plain
TOPOGRAPHY: flat
SURF. CHAR: strong sealing, no cracks, nil evidence of salt,
LAND USE: traditional grazing
SPECIES : Trees - *Boscia albitrunca* (dom.) *Grewia flava*
: Shrubs - *Acacia mellifera* (dom.)
: Grasses/forbs- *Cymbopogon plurinodis*
PARENT MATERIAL: alluvium
MOIST. COND: moist 0 - 50 cm
SURF. STONES: none
EROSION : strong sheet erosion

GRID : - - -
COORD: 25-35-00-S 25-16-99-E
DATE : 18/01/89
LAND ELEMENT : valley floor
MICRO TOPOGRAPHY:
VEGETATION: open low shrub savanna

AGRO CLIM. ZONE: 2D3
ELEVATION : 1060 m
SMR: ustic to aridic
POSITION: intermediate part
SLOPE : - 1 % straight
GRASSCOVER: > 70 %

ROCK TYPE:
ROCK OUTCROP: none

GEOLOG. UNIT: Kalahari beds
DRAINAGE : well drained
HUMAN INF: nil

REMARKS: Can be in associated with C3B /water relieving.Coordinates to nearest minute.

SAMPLES: A: 0 - 10 B: 30 - 50

A1 0 - 10 cm 10YR 3/2 (moist), fine sand, weak fine subangular blocky structure, slightly calcareous, many fine and medium roots, diffuse smooth boundary.
Ak 10 - 50 cm 10YR 3/2 (moist), fine sand, very weak fine subangular blocky structure, strongly calcareous, many fine and medium roots, abrupt smooth boundary.
Ck 50 cm + dominant coarse irregular hard calcareous white concretions, extremely calcareous,

Soil Survey of Botswana FAO/BOT/85/011

print date: 03/05/89

STANDARD SOIL ANALYSIS RESULTS

PROFILE: KU 0107

SAMPLE	DEPTH	pH	EC	P	C	CEC	Ca	Mg	K	Na	PBS	Particle size (weight %)					CECclay	METH	PRETR				
		H2O	mS/cm	ppm	weight %	meq/100gr soil	%	vcS	cS	mS	fS	vfS	cSi	fSi	Clay	meq/100gr							
A	0 10	7.3	6.7	0.1	1	0.6	2.9	2.9	0.2	0.2	0.0	>100	0	0	6	69	15	3	2	5	0	H	
B	30 50	8.4	7.7	0.1	3	0.4	3.3	7.5	0.2	0.1	0.1	>100	0	0	5	65	15	1	3	11	15	H	

Soil Survey of Botswana FAO/BOT/85/011

Print date: 02/05/89

PART-SIZE DETERMINATION METHOD: H = Hydrometer Method, P = Pipette Method, * = Not Known
 PRETREATMENT: O = Organic Matter, F = Free Iron Oxides, C = Carbonates, S = Soluble Salts N = None

SOIL PROFILE DESCRIPTION

Profile: KU 0100 Unit: KS03 Status: 2

SHEET :
 LOCATION : 3.5km West of Diphuduhudu along the Tswantswe road.
 AUTHOR(S) : T.D.Mafoko
 CLASSIFICATION FAO: Ferralic Arenosol(1988) Ferralic Arenosol (1974)
 ST : Ustic Quartzipsamment
 LANDFORM : sand plain
 TOPOGRAPHY: flat
 SURF. CHAR: slight sealing, no cracks, nil evidence of salt,
 LAND USE: traditional grazing
 SPECIES : Trees - Acacia luederitzii var.luederitzii (dom.)
 : Shrubs - Grewia flava (dom.) Terminalia sericea Dichrostachys cinerea
 : Grasses/forbs- Eragrostis rigidior (dom)
 PARENT MATERIAL: aeolian sand
 MOIST. COND: moist 0 - 120 cm
 SURF.STONES: none
 EROSION : moderate wind erosion/deposition

GRID : - -
 COORD: 23-42-00-S 25-17-00-E
 DATE : 17/01/89
 LAND ELEMENT : not applicable
 MICRO TOPOGRAPHY: low hummocks
 VEGETATION: open tree savanna
 ROCK TYPE:
 ROCK OUTCROP: none

AGRO CLIM.ZONE: 2D3
 ELEVATION : 1060 m
 SMR: ustic to aridic
 POSITION: intermediate part
 SLOPE : - 1 % straight
 GRASSCOVER: 30 - 70 %
 GEOL.UNIT: Kalahari beds
 DRAINAGE : somewhat excessively drained
 HUMAN INF: nil

REMARKS: Normal site.Coordinates to nearest minute.

SAMPLES: A: 0 - 20 B: 30 - 50 C: 80 - 100

A 0 - 25 cm 10YR 4/4 (moist), fine sand, very weak fine subangular blocky structure, friable, non calcareous, many fine and medium roots, clear smooth boundary.
 B 25 - 120 cm 7.5YR 5/6 (moist), fine sand, very weak medium subangular blocky structure, friable, non calcareous, common fine and medium roots,

Soil Survey of Botswana FAO/BOT/85/011

print date: 03/05/89

STANDARD SOIL ANALYSIS RESULTS

PROFILE: KU 0100

SAMPLE DEPTH	pH	EC	P	C	Ca	Mg	K	Na	PBS	Particle size (weight %)					CECclay	METH	PRETR				
	H2O CaCL2	mS/cm	ppm	weight %	meq/100gr soil	meq/100gr soil	meq/100gr soil	meq/100gr soil	%	vcS	cS	mS	fS	vfS	cSi	fSi	Clay	meq/100gr			
A 0 20	5.7 4.8	0.0	2	0.3	2.1	1.3	0.1	0.1	0.0	71	0	0	7	71	16	1	2	2	0	H	
B 30 50	5.6 4.5	0.0	2	0.3	2.0	1.3	0.1	0.1	0.0	75	0	0	9	71	15	1	4	1	0	H	
C 80 100	6.2 5.4	0.0	1	0.2	2.3	1.9	0.1	0.1	0.0	91	0	0	8	70	15	2	1	5	0	H	

Soil Survey of Botswana FAO/BOT/85/011

Print date: 02/05/89

PART-SIZE DETERMINATION METHOD: H = Hydrometer Method, P = Pipette Method, * = Not Known
 PRETREATMENT: O = Organic Matter, F = Free Iron Oxides, C = Carbonates, S = Soluble Salts N = None

Profile: KU 0106 Unit: KS05 Status: 2

SOIL PROFILE DESCRIPTION

SHEET :
LOCATION : 4.75km North of KU0105.
AUTHOR(S) : T.D.Mafoko
CLASSIFICATION FAO: Ferralic Arenosol(1988) Ferralic Arenosol (1974)
ST : Ustic Quartzipsamment
LANDFORM : sand plain
TOPOGRAPHY: flat
SURF. CHAR: slight sealing, no cracks, nil evidence of salt,
LAND USE: traditional grazing
SPECIES : Trees -
 : Shrubs - Grexia flava
 : Grasses/forbs-
PARENT MATERIAL: aeolian sand
MOIST. COND: moist 0 - 120 cm
SURF. STONES: none
EROSION : moderate wind erosion/deposition

GRID : - - -
COORD: 25-39-00-S 25-16-00-E
DATE : 18/01/89
LAND ELEMENT : not applicable
MICRO TOPOGRAPHY: low hummocks
VEGETATION: open low shrub savanna

AGRO CLIM.ZONE: 2D3
ELEVATION : 1060 m
SMR: ustic to aridic
POSITION: intermediate part
SLOPE : - 1 % straight
GRASSCOVER: 30 - 70 %

ROCK TYPE:
ROCK OUTCROP: none

GEOLOGICAL UNIT: Kalahari beds
DRAINAGE : somewhat excessively drained
HUMAN INF: nil

REMARKS: Normal site.Coordinates to nearest minute.

SAMPLES: A: 0 - 20 B: 30 - 50 C: 80 - 100

- A 0 - 20 cm 10YR 4/4 (moist), fine sand, very weak fine subangular blocky falling apart into single grain structure, friable, non calcareous, many fine and medium roots, gradual smooth boundary.
- B 20 - 120 cm 7.5YR 5/4 (moist), fine sand, very weak fine and medium subangular blocky structure, very friable, non calcareous, common fine and medium roots,

Soil Survey of Botswana FAO/BOT/85/011

print date: 03/05/89

STANDARD SOIL ANALYSIS RESULTS

PROFILE: KU 0106

SAMPLE DEPTH	pH	CaCl2	EC	P	C	CEC	Ca	Mg	K	Na	PBS	Particle size (weight %)					CECclay	METH	PRETR							
		H2O	mS/cm	ppm	weight %	meq/100gr soil	%	vsS	cS	mS	fS	vfS	cSi	fSi	Clay	meq/100gr										
A	0	20	5.6	4.4	0.0	1	0.3	1.3	0.9	0.0	0.1	0.0	0.0	77	0	0	12	72	12	3	1	0	0	0	H	
B	30	50	5.4	4.2	0.0	2	0.2	1.1	1.1	0.0	0.0	0.0	100	0	0	11	73	12	3	1	0	0	0	0	H	
C	80	100	5.7	4.6	0.0	1	0.1	1.0	1.2	0.8	0.0	0.2	>100	0	0	10	75	12	1	1	1	1	0	0	H	

Soil Survey of Botswana FAO/BOT/85/011

Print date: 02/05/89

METHOD: H = Hydrometer Method, P = Pipette Method, * = Not Known
 PRETREATMENT: O = Organic Matter, F = Free Iron Oxides, C = Carbonates, S = Soluble Salts N = None

SOIL PROFILE DESCRIPTION

SHEET :
 LOCATION : Along the road Diphuduhudu-Seisante, 7km..
 AUTHOR(S) : T.D.Mafoko
 CLASSIFICATION FAO: Lamelli-Luvic Arenosol (1988) Luvic Arenosol (1974)
 ST : Ustalfic Quartzipsamment
 LANDFORM : sand plain
 TOPOGRAPHY: flat
 SURF. CHAR: moderate sealing, no cracks, nil evidence of salt,
 LAND USE: traditional grazing
 SPECIES : Trees -
 : Shrubs - Terminalia sericea (dom.) Grewia flava
 : Grasses/Forbs- Eragrostis rigidior (dom)
 PARENT MATERIAL: aeolian sand
 MOIST. COND: moist 0 - 85 cm
 SURF. STONES: none
 EROSION :

GRID : - -
 COORD: 23-41-00-S 25-20-00-E
 DATE : 19/01/89
 LAND ELEMENT : not applicable
 MICRO TOPOGRAPHY:
 VEGETATION: open low shrub savanna
 ROCK TYPE:
 ROCK OUTCROP: none

AGRO CLIM.ZONE: 2D3
 ELEVATION : 1060 m
 SMR: ustic to aridic
 POSITION: intermediate part
 SLOPE : - 1 % straight
 GRASSCOVER: 30 - 70 %
 GEOL.UNIT: Kalahari beds
 DRAINAGE : somewhat excessively drained
 HUMAN INF: nil

REMARKS: Roots go only as deep as 85cm, then the horizon becomes compacted/water receiving.Coordinates to the nearest minute.

SAMPLES: A: 0 - 20 B: 30 - 50 C: 90 - 110

- A 0 - 35 cm 7.5YR 4/6 (moist), fine sand, very weak fine and medium subangular blocky structure, very friable, non calcareous, many fine and medium roots, gradual smooth boundary.
- B1 30 - 85 cm 7.5YR 5/6 (moist), fine sand, very weak medium and coarse subangular blocky structure, very friable, non calcareous, common fine and medium roots, abrupt smooth boundary.
- Bt2 85 - 120 cm 7.5YR 5/6 (moist) and 7.5YR 6/6 (dry), fine sand, very weak medium and coarse angular blocky structure, hard, continuous thin clay and sesquioxides lamellae, non calcareous,

STANDARD SOIL ANALYSIS RESULTS

PROFILE: KU 0110

SAMPLE DEPTH	pH	EC	P	C	CEC	Ca	Mg	K	Na	PBS	Particle size (weight %)						CECclay	METH	PRETR									
											H2O	CaCl2	ms/cm	ppm	weight %	meq/100gr soil				%	vcS	cS	mS	fS	vfS	cSi	fSi	Clay
A	0	20	7.0	4.8	0.0	1	0.4	1.7	2.8	0.1	0.1	0.1	0.0	0.0	>100	0	0	9	73	13	1	2	2	0	0	H		
B	30	50	5.9	4.9	0.0	2	0.3	1.5	3.0	0.1	0.1	0.1	0.0	0.0	>100	0	0	10	73	12	3	3	0	0	0	0	H	
C	90	110	6.0	5.2	0.0	1	0.3	1.5	0.9	0.1	0.1	0.1	0.0	0.0	73	0	0	8	71	16	2	1	3	0	0	0	H	

Soil Survey of Botswana IAO/BOT/85/011

Print date: 02/05/89

PART-SIZE DETERMINATION METHOD: H = Hydrometer Method, P = Pipette Method, * = Not Known
 PRETREATMENT: O = Organic Matter, F = Free Iron Oxides, C = Carbonates, S = Soluble Salts N = None

SOIL PROFILE DESCRIPTION

SHEET :
LOCATION : 16km West of Diphuduhudu, +5East of Tshwantse.
AUTHOR(S) : T.D.Mafoko
CLASSIFICATION FAO: Lamelli-Luvic Arenosol(1988) Luvic Arenosol (1974)
ST : Ustalfic Quartzipsamment

LANDFORM : dune field
TOPOGRAPHY: flat
SURF. CHAR: slight sealing, no cracks, nil evidence of salt,
LAND USE: traditional grazing
SPECIES : Trees - Acacia erioloba (dom.)
: Shrubs - Grewia flava (dom.) Acacia mellifera Terminalia sericea
PARENT MATERIAL: aeolian sand
MOIST. COND: moist 0 - 120 cm
SURF. STONES: none
EROSION : moderate wind erosion/deposition

REMARKS: Water receiving.Coordinates to the nearest minute.

SAMPLES: A: 0 - 20 B: 30 - 50 C: 80 - 100

- A 0 - 20 cm 10YR 5/4 (moist), fine sand, very weak fine and medium subangular blocky structure, friable, non calcareous, many fine and medium roots, gradual smooth boundary.
- B1 20 - 80 cm 7.5YR 5.5/6 (moist), fine sand, very weak medium and coarse subangular blocky structure, friable, non calcareous, common fine and medium roots, clear smooth boundary.
- Bt2 80 - 120 cm 7.5YR 5/6 (moist), fine sand, very weak medium and coarse subangular blocky structure, friable, continuous thin clay lamellae, non calcareous, few fine and medium roots,

Soil Survey of Botswana FAO/BOT/85/011

print date: 03/05/89

Profile: KU 0103 Unit: KS06a Status: 2

GRID : - - -
COORD: 23-31-00-S 25-11-00-E
DATE : 17/01/89
LAND ELEMENT : interdunal depression
MICRO TOPOGRAPHY: low hummocks
VEGETATION: open low shrub savanna
AGRO CLIM.ZONE: 2D3
ELEVATION : 1060 m
SMR: ustic to aridic
POSITION: lower slope
SLOPE : - 1 % straight
GRASSCOVER: 30 - 70 %
ROCK TYPE:
ROCK OUTCROP: none
GEOLOGICAL UNIT: Kalahari beds
DRAINAGE : somewhat excessively drained
HUMAN INT: nil

STANDARD SOIL ANALYSIS RESULTS

PROFILE: KU 0103

SAMPLE DEPTH	pH	EC	P	C	CEC	Ca	Mg	K	Na	PBS	Particle size (weight %)					CECclay	METH	PRETR				
	H2O CaCl2	mS/cm	ppm	weight %	meq/100gr soil	%	vcS	cS	mS	fS	vfS	cSi	fSi	Clay	meq/100gr							
A 0 20	6.1	5.3	0.0	1	0.6	1.6	1.0	0.1	0.1	0.1	81	0	0	9	69	13	3	0	5	8	H	
B 30 50	6.1	5.0	0.0	1	0.3	2.0	1.2	0.1	0.1	0.0	70	0	0	12	74	10	1	2	2	0	H	
C 80 100	5.8	4.8	0.0	1	0.2	2.0	1.5	0.1	0.1	0.0	85	0	0	11	72	12	1	2	2	0	H	

Soil Survey of Botswana FAO/BOT/85/011

Print date: 02/05/89

PART-SIZE DETERMINATION METHOD: H = Hydrometer Method, P = Pipette Method, * = Not Known
 PRETREATMENT: O = Organic Matter, F = Free Iron Oxides, C = Carbonates, S = Soluble Salts N = None

APPENDIX 2 : LAND SUITABILITY CLASSIFICATION FOR RAINFED
SORGHUM UNDER A SYSTEM OF IMPROVED TRADITIONAL FARMING

LAND SUITABILITY CLASSIFICATION SHEET SOIL SURVEY BOTSWANA FAO/BOT/85/011

location :

sheet:

date:

agro-climatic zone: 2d3

mapping unit: KS3

author: T. D. Mafoko

site characteristics: water receiving

remarks: moisture rating upgraded
because it is a water receiving site

LAND QUALITY	CDE	RTNG	LAND USE TYPE Improved trad dryland farming			LAND USE TYPE			LAND USE TYP		
			Sorg								
accessibility	a	2	S1								
correct temp. regime	c	1	S1								
soil drainability	d	-	-								
resistance to erosion	e	2	S2								
absence of dmgng floods	f	1	S1								
conditions for germin.	g	1	S1								
moisture availability	m	4	S4								
nutrient availability	n	3	S2								
oxygen availability	o	1	S1								
absence of psts & dses	p	1	S1								
avail water good qual.	q	-	-								
foothold for roots	r	1	S1								
absence of toxiz subs.	t	1	S1								
workability	w	1	S1								
adequacy of topo.	x1 x11 x111	-	-								
adequacy of flooding	y	-	-								
land drainability	z	-	-								
current land suitab.			S4m								

Recommended improvements

Potential land suitab.

LAND SUITABILITY CLASSIFICATION SHEET SOIL SURVEY BOTSWANA FAO/BOT/85/011

location : sheet: date:
 agro-climatic zone: 2d3 mapping unit: A21a
 author: T. D. Mafoko site characteristics: Water receiving
 remarks: calcium toxicity high

LAND QUALITY	CDE	RTNG	LAND USE TYPE Improved trad dryland farming			LAND USE TYPE			LAND USE TYP		
			Sorg								
accessibility	a	2	S1								
correct temp. regime	c	1	S1								
soil drainability	d	-	-								
resistance to erosion	e	2	S2								
absence of dmgng floods	f	3	S3								
conditions for germin.	g	3	S3								
moisture availability	m	3	S3								
nutrient availability	n	3	S2								
oxygen availability	o	3	S2								
absence of psts & dses	p	1	S1								
avail water good qual.	q	-	-								
foothold for roots	r	2	S1								
absence of toxiz subs.	t	4	S4								
workability	w	1	S1								
adequacy of topo.	x1 x11 x111	-	-								
adequacy of flooding	y	-									
land drainability	z	-									
current land suitab.			S4t								

Recommended improvements

Potential land suitab.											
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LAND SUITABILITY CLASSIFICATION SHEET SOIL SURVEY BOTSWANA FAO BOT/85/011

location :

sheet:

date:

agro-climatic zone: 2d3

mapping unit: KS3

author: T. D. Mafoko

site characteristics: Normal site

remarks: not suitable because of moisture
influenced by position on the
landscape

LAND QUALITY	CDE	RTNG	LAND USE TYPE Improved trad dryland farming			LAND USE TYPE			LAND USE TYP		
			Sorg								
accessibility	a	2	S1								
correct temp. regime	c	1	S1								
soil drainability	d	-	-								
resistance to erosion	e	2	S2								
absence of dmgng floods	f	1	S1								
conditions for germin.	g	1	S1								
moisture availability	m	5	N2								
nutrient availability	n	3	S2								
oxygen availability	o	1	S1								
absence of psts & dses	p	1	S1								
avail water good qual.	q	-	-								
foothold for roots	r	1	S1								
absence of toxiz subs.	t	1	S1								
workability	w	1	S1								
adequacy of topo.	x1 x11 x111	-	-								
adequacy of flooding	y	-	-								
land drainability	z	-	-								
current land suitab.			N2								

Recommended improvements

Potential land suitab.

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LAND SUITABILITY CLASSIFICATION SHEET SOIL SURVEY BOTSWANA FAO BOT/85/011

location :

sheet:

date:

agro-climatic zone: 2d3

mapping unit: A40

author: T. D. Mafoko

site characteristics: Intermediate

remarks:

LAND QUALITY	CDE	RTNG	LAND USE TYPE Improved trad dryland farming			LAND USE TYPE			LAND USE TYP		
			Sorg								
accessibility	a	2	S1								
correct temp. regime	c	1	S1								
soil drainability	d	-	-								
resistance to erosion	e	2	S2								
absence of dmngng floods	f	2	S2								
conditions for germin.	g	2	S2								
moisture availability	m	3	S3								
nutrient availability	n	3	S3								
oxygen availability	o	3	S2								
absence of psts & dses	p	1	S1								
avail water good qual.	q	-	-								
foothold for roots	r	1	S1								
absence of toxiz subs.	t	1	S1								
workability	w	1	S1								
adequacy of topo.	x1 x11 x111										
adequacy of flooding	y										
land drainability	z										
current land suitab.			S3m								

Recommended improvements

Potential land suitab.

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LAND SUITABILITY CLASSIFICATION SHEET SOIL SURVEY BOTSWANA FAO BOT/85/011

location : sheet: date:
 agro-climatic zone: 2d3 mapping unit: A21
 author: T. D. Mafoko site characteristics: water receiving
 remarks: calcium toxocity high

LAND QUALITY	CDE	RTNG	LAND USE TYPE Improved trad dryland farming			LAND USE TYPE			LAND USE TYP		
			Sorg								
accessibility	a	2	S1								
correct temp. regime	c	1	S1								
soil drainability	d	-	-								
resistance to erosion	e	2	S2								
absence of dmngng floods	f	3	S3								
conditions for germin.	g	3	S3								
moisture availability	m	3	S3								
nutrient availability	n	3	S2								
oxygen availability	o	3	S2								
absence of psts & dses	p	1	S1								
avail water good qual.	q	-	-								
foothold for roots	r	2	S1								
absence of toxiz subs.	t	4	S4								
workability	w	1	S1								
adequacy of topo.	x1 x11 x111	-	-								
adequacy of flooding	y	-									
land drainability	z	-									
current land suitab.			S4t								

Recommended improvements

Potential land suitab.											
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location :

sheet:

date:

agro-climatic zone: 2d3

mapping unit: A21

author: T. D. Mafoko

site characteristics: water receiving

remarks: nutrients low because of high pH
in subsoil

LAND QUALITY	CDE	RTNG	LAND USE TYPE Improved trad dryland farming			LAND USE TYPE			LAND USE TYP		
			Sorg								
accessibility	a	2	S1								
correct temp. regime	c	1	S1								
soil drainability	d	-	-								
resistance to erosion	e	2	S2								
absence of dmngng floods	f	2	S2								
conditions for germin.	g	1	S1								
moisture availability	m	3	S3								
nutrient availability	n	4	S3								
oxygen availability	o	1	S1								
absence of psts & dses	p	1	S1								
avail water good qual.	q	-	-								
foothold for roots	r	2	S1								
absence of toxiz subs.	t	4	S4								
workability	w	1	S1								
adequacy of topo.	x1 x11 x111	-	-								
adequacy of flooding	y	-	-								
land drainability	z	-	-								
current land suitab.			S4t								

Recommended improvements

Potential land suitab.

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