AG : BOT/85/011
FIELD DOCUMENT 2

Soil Mapping and Advisory Services

Botswana

SOILS AND LAND SUITABILITY OF THE CHOBE ENCLAVE

FOOD & AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

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REPUBLIC OF BOTSWANA

GABORONE, 1988

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SOILS AND LAND SUITABILITY

OF THE CHOBE ENCLAVE

BY

G. Baert

APO Soil Survey

Food and Agriculture Organization of the United Nations

United Nations Development Programme

Republic of Botswana

Gaborone, 1989

The conclusions given in this report are those considered appropriate at the time of its preparation.
They may be modified in the light of further knowledge gained at subsequent stages of this project.

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ABSTRACT

This report describes the soils and physiography of the Chobe enclave and is accompanied by a semi-detailed soil map at a scale 1:100 000. The soil survey was carried out in 1987. The soil map served as a basis for a land evaluation exercise for large scale irrigation schemes and traditional molapo farming.

SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

- The major soils in the higher positions are generally very sandy and have a low inherent fertility level, the main soils in the intermediate positions are characterized by high alkalinity, while in the lower positions soils with impeded drainage occur. Strongly calcareous soils occur in the high and intermediate positions, while salinity and sodicity problems is noted in specific soil units.

- It is concluded that the current suitability of the Chobe floodplain for commercial irrigated farming is only very marginal. The main restriction is the possibility for very high floods which may inundate the lower and intermediate parts once every ten years.

- Flood protection may improve the suitability in the intermediate parts, but limited soil drainability will remain a restriction in the lower lying areas.

- Other severe limitations occur, mainly low fertility level, and locally high salinity and sodicity levels.

- The soils in the lower lying areas are expected to yield well under flood recession farming, due to their high fertility level and high water holding capacity.

- The sandy soils on the higher parts are only very marginally suitable due their low inherent fertility and their low water holding capacity.

- It is recommended to carry out further studies to complement the soil characterization by determining soil physical properties; a detailed hydrological study has to be carried out to determine the quantity and quality and the movement of the groundwater in space and time, and more information is required on the frequency, the duration and the extents of the floods.

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1. General Description of the Area

1.1. Location

The Chobe enclave is located in the northern part of Botswana. It is situated between the Caprivi strip to the north ,the Chobe national park to the southwest, and the Chobe forest reserve to the southeast. Lake Lyambezi and the Chobe and Linyanti rivers form the international boundary with Namibia.

The Chobe enclave consists of the Chobe flats (roughly west of longitude 24o17'E) and the Chobe floodplain. The survey area covers the whole floodplain up to Kavimba and part of the Chobe flats, and occupies an area of approximately 120,000 hectares.

The main villages in the area are Satau and Parakarungu, both situated on sand ridges in the floodplain, and Kachikau and Kavimba, both on the upland.

Accessibility is good during the dry season. It becomes less during the rainy season, mainly in the lower parts, and is very difficult to impossible during high floods.

The enclave is connected by a good gravel road to Kasane. The area can also be reached from Maun, via the Mababe depression.

(Figure 1)

1.2. Climate

1.2.1. Climatic Data

The climate of the Chobe enclave can be considered as similar to that of Kasane, where rainfall data of the last 65 years are available. However, the other basic climatic data, necessary for the calculation of the PET, are only available for the last 3-5 years after a synoptic station was installed in 1981. These data are presented in table 1. Average rainfall data of the last three years are also given. Comparison can be made with the climatic record of Victoria Falls, which covers a period of more than 10 years.

The mean annual rainfall over the last 65 years is 668 mm, which is the highest in Botswana. The rainy season starts in November (few showers may occur in October) and ends in March. The variation, both monthly and annually, is very large. Comparison of the monthly rainfall during the rainy season over a period of 65 years , gives a coefficient of variation ranging from 50 to 80 %. Rains usually occur in short but intense showers. Dry spells of several weeks may occur during the rainy season.

The relatively low rainfall over the last 3 years (see table 1, 1983-86) is reflected by the higher PET (see further). The mean annual rainfall (hydrological years) over this period is only 550 mm. A very low rainfall was observed in 1981-82 (300 mm).

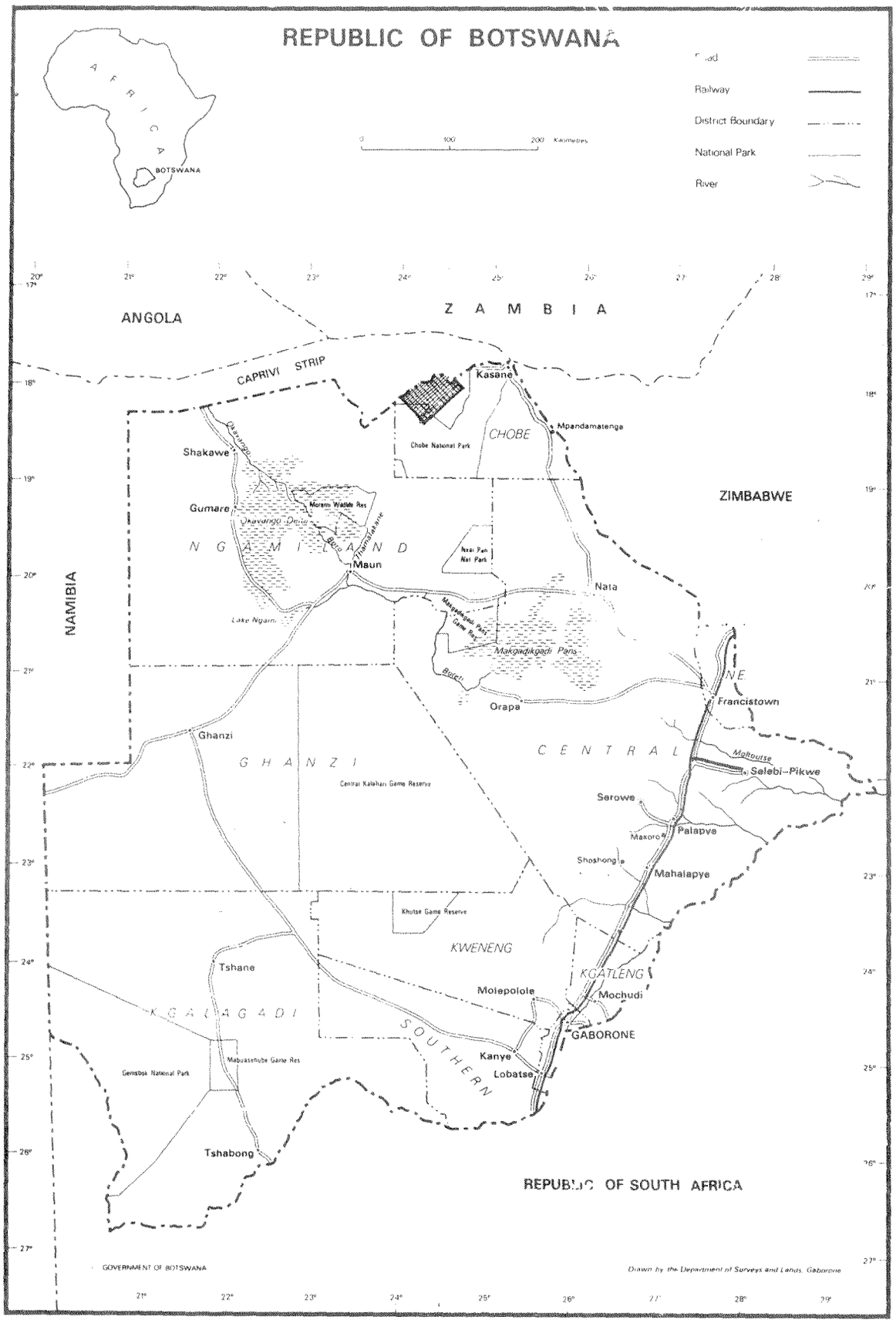

Figure 1 : Location of Chobe enclave

TABLE 1 : CLIMATE DATA FOR KASANE (1983-86)

PET according to modified Penman Method (1984)

No. of Values		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
2-4	PET (mm)	187,9	185,0	224,1	203,2	157,9	136,0	145,4	183,5	224,5	278,9	211,3	195,1	2332,8
2-4	EFWS (mm)	224,4	218,9	253,0	228,9	177,2	149,2	159,1	200,8	245,4	301,1	240,3	226,4	2624,7
3-5	Max. Temp	31,0	31,1	31,3	30,0	28,9	26,8	26,3	28,6	33,5	33,6	32,7	31,5	30,4
3-5	Min. Temp	20,0	19,3	19,2	17,3	15,1	11,7	11,2	13,0	17,3	20,2	20,2	20,0	17,0
3-5	Rel. Humid (%)	65,2	66,8	63,6	57,4	47,0	42,1	38,2	31,4	26,9	36,6	49,4	63,1	49,0
4-5	V.P. Deficit	25,3	8,0	11,7	12,5	14,1	10,4	13,4	16,9	23,9	22,6	12,7	12,3	15,3
2-4	SSS (%)	51,5	62,1	57,7	73,4	81,8	81,4	82,6	86,1	83,3	63,6	55,8	46,6	68,8
2-4	Sol. Rad (mm)	9,2	9,6	8,5	8,6	7,7	7,0	7,4	8,6	9,8	9,4	9,3	8,8	8,7
4-5	Wind Ratio	2,0	2,0	2,0	2,0	2,0	2,0	2,0	2,0	2,0	2,0	2,0	2,0	2,0
3-5	W Speed (m/s)	1,24	1,39	1,44	1,66	2,00	1,87	2,11	2,3	2,5	2,33	1,66	1,47	1,83
YEAR														
'83-86	P (mm)	89,8	135,0	48,3	32,0	2,1	0,0	0,0	0,0	1,4	27,5	38,5	175,9	550,0
'22-86	P (mm)	161,4	136,0	96,1	24,9	3,7	1,5	0,0	0,2	1,6	21,3	70,5	150,5	667,7

(PET Values of March and April 20% too high)

TABLE 2 : CLIMATE DATA FOR VICTORIA FALLS (ZIMBABWE)

PET calculated according to original Penman (FAO '79), but converted to modified Penman ('84) using: - MODIFIED = 4,4166 (Penman '79)^{0,7604}

No of Values		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
10	P (mm)	186	138	91	21	2	1	0	0	1	25	72	179	716
10	PET (mm)	184	174	180	161	149	124	140	186	233	262	218	192	2203
10	Max Temp	28,7	28,6	29,0	28,4	26,9	24,2	24,8	27,5	31,2	33,2	31,3	29,4	28,6
10	Min Temp	18,3	17,8	17,0	14,1	9,7	5,8	6,0	8,8	13,0	17,6	18,0	18,1	13,7
10	V.P. Deficit	20,8	20,2	18,9	15,8	11,2	8,4	8,0	8,1	8,8	12,2	16,8	19,5	14,1
10	SSS (%)	50	60	65	74	86	88	90	89	86	73	58	47	72
10	Sol. Rad	496	518	495	458	428	395	414	469	535	547	520	485	480

Solar Radiation given in Cal/cm^2/day

The mean monthly maximum temperatures vary between 26 oC in winter and 34 oC in summer. The highest temperarures are reached before the start of the rainy season (September and October) and remain above 30 oC till the end of the rains. The mean monthly minimum ranges from 20 oC in summer to approximately 10 oC in winter. These minimum temperatures are somewhat higher than in the other parts of the country. The average temperatures over a long period will probably be 1 to 2 oC lower.

The relative humidity varies between 30% in winter and 70% during the wet season.

The average annual PET (3 years period) is 2330 mm. This figure is not representative since the lower rainfall over the past years. The real PET will be lower, but will remain relatively high because of the relatively high wind speed in Kasane (average 1.83 m/s). The evaporation is high during the rainy season (highest in October). The mean monthly PET is always higher than the mean monthly rainfall.

1.2.2. Soil Temperature and Moisture Regime

No information is available on the pedoclimate. The mean annual soil temperature (MAST) is closely related to the mean annual air temperature. As the air temperature is only slightly different from Shakawe, comparison can be made with the data of the latter station. Since the MAST at 50 cm is higher than 22 oC and the difference between mean summer (MSST) and mean winter (MWST) is more than 5 oC, the soil temperature regime is Hyperthermic (USDA, 1975).

The soil moisture regime is Aquic for the lower parts of the Chobe floodplain, with impeded drainage. The higher, well drained, parts of the floodplain, the Chobe flats and the sandveldt have a Ustic soil moisture regime.

1.2.3. Agro-Climatic Zones

The FAO agro-climatic methodology, as described in the FAO Agro-Ecological Zones Project report (FAO, 1978), was used to establish the agro-climatic zones for Botswana. The method is developed for rainfed (dryland) agriculture, but may also be usefull in irrigation scheduling.

The climatic adaptability and distribution, both in space and time, of crops is maily governed by temperature and water availability from rainfall. Temperature determines the rate of growth and development.

The growing period is that part of the year when neither moisture availability nor temperature limit crop groth and yield formation. In Botswana, two types of growing periods are distinguished, which are determined by waterbalance approaches, as follows:

-Normal growing period: is the period (in days) during

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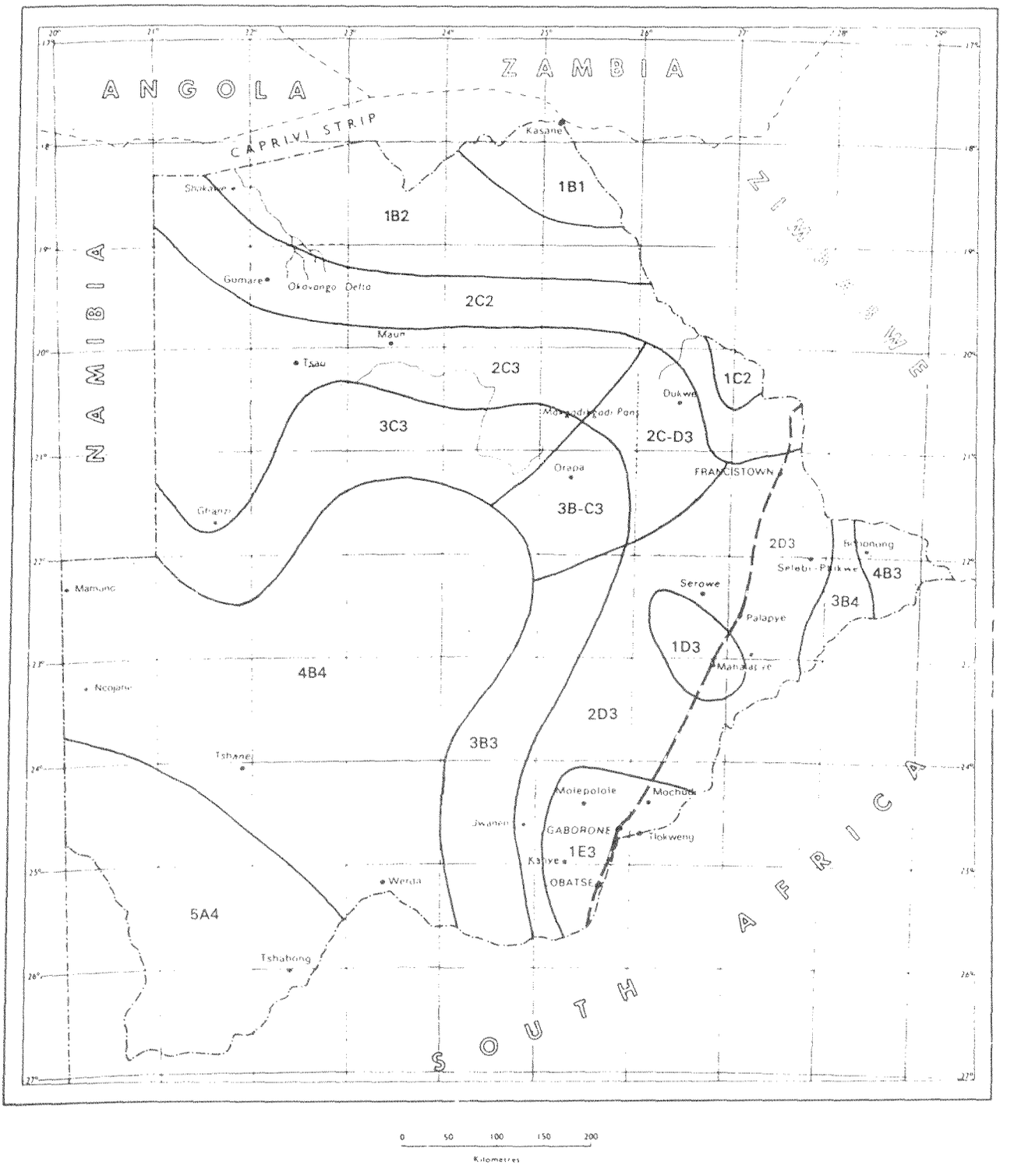

Fig. 2 AGRO-CLIMATIC ZONES OF BOTSWANA (Dambe, 1987)

a year which starts when the precipitation exceeds 40% of the potential evapotranspiration. The end of the growing period is assumed when the rainfall falls below 40% of the PET, plus a period to required to evaporate an assumed 100 mm of moisture reserve, from excess precipitation, when available. Therefore, a normal growing period must exhibit a 'humid period', i.e. when precipitation exceeds the PET.

- Intermediate growing period: does not have a humid period, thus no storage of water in the soil, and starts when rainfall exceeds 40% of the PET. The end is assumed when precipitation falls below 40% of the PET.

The PET is calculated according to the modified Penman method, as described in 'Crop Water Requirements', FAO 1984, as opposed to the former method, described in 'Agrometeorological Crop Monitoring and Forecasting, FAO 1979, used in Botswana. The modified method, developed for irrigated land in dry climates, mainly involves a revised wind function term, resulting in considerably higher PET values, on average 25-35%, than the '79 method.

Furthermore, 10 day periods (in 30 day totals), instead of average monthly data for the original method, were used. This methodology provides a better reflection of the large variation of the rainfall. This results in a considerable reduction of the length of the growing periods and humid periods. On the other hand, as the dry spells are better defined, the number of growth seasons and humid periods increases. The Total Growing Period equalls the total lengths of the different growing seasons.

As no PET data for Kasane were available,the PET values were obtained through correlation with meteorological stations in Zambia (Livingstone) and Zimbabwe (Victoria Falls and Hwange). The calculations were carried out at the Department of Meteorological Services in Gaborone.

The results are presented in fig. 2 The map is derived from the first and second growing season and the probality of a humid period.

The survey area is part of the 1b.1 unit, representing the best conditions for crop growth under rainfed conditions in Botswana. The Chobe enclave has (in most years) an adequate growing season length for basic crops as sorghum, maize and millet, as the probability is relatively high to have two growing seasons combined with a humid period. Under irrigation, the presence of a humid period may reduce the pumping costs considerably.

1.3. Geology

Three parallel fault lines are clearly visible on satellite imagery, having a northeast to southwest orientation and running parallel to the faults at the base of the Okavango delta, and can be considered as the extension of the Okavango graben

fault system.

The northern Linyanti fault line is probably an extension of the Gomare fault. The second fault line determines the southern boundary of Lake Lyambezi. The southern Chobe fault separates the sandveldt from the Chobe flats and floodplain (escarpment).

Very little information is available on the solid geology of the area. The rock probably consists of Mesozoic Karroo sediments (sandstones, shales and coal seams) overlain by the younger Karroo basalts of the Stormberg series, which are covered by thick Cainozoic alluvial and lacustrine deposits. These basalts outcrop as a low but distinct escarpment from Kavimba to Ngoma bridge. They are often associated with calcrete, probably a weathering product of basalt, which occur along the lower edge of the sandridge (escarpment).

The Karroo sediments are underlain by metasediments of the Ghantzi Formation (Precambrium - Proterozoic), comprising of slightly metamorphosed sandstones (quartzites), shales and limestones. Intrusive into these rocks are the porphyries of the Kgwebe Group.

South of the escarpment, the Karroo and pre-Karroo sediments are extensively overlain by unconsolidated red Kalahari sands of Tertiary to Quaternary age.

1.4. Geomorphology

A major distinction in the physiography can be made between the sandveldt, south of Kachikau, and the alluvial and lacustine deposits of the Chobe flats and floodplain, separated by a linear escarpment formed by geological faulting.

Within the survey area, the escarpment consists of basalt overlain by reddish fine sands (soil unit KS3). Calcrete (soil units A21a, C3) occurs at the base of the escarpment. The cliff rises up to 30 m above the present floodplain.

The sandveldt consists of aeolian Kalahari sand (soil ,units KS3-5). The sandveldt is undulating near the edge, but becomes rather flat further away from the escarpment. Few scattered pans occur. Two valleys, the Kataba and Ncarcangu valley (soil unit A19), drain into the floodplain, dissecting the escarpment.

The Chobe flats, separated from the Linyanti swamps by the Linyanti fault, consist of old alluvial deposits, characterized by old channel sediments as is typical in the present Okavango delta. Younger (fossil) channels are present in the southern part of the flats. They run parallel to the escarpment and form a connection between the Savuti channel and the Chobe floodplain. Pans commonly occur throughout the flats.

The Linyanti floodplain consists of an extensive swamp area, characterized by meandering channels, often resulting in the formation of ox-bow lakes in the plain.

Recent geomorphological studies (Shaw, 1986) indicate the Chobe floodplain as part of an extensive late Pleistocene lake at 936 m level, covering vast areas in the Caprivi strip and

therefore indicated as 'Lake Caprivi'. Landforms of lacustrine origin have been recognized in the floodplain. The most prominent evidence is the series of parallel ridges (LS17d), oriented north-south and stretching from Lake Lyambezi to the Chobe escarpment. The present ridges are not continuous over the whole length, but interrupted by several channels. The villages of Satau and Parakarungu, and several other settlements in the area, are situated on the ridges. Barometer measurements (Shaw, 1986) indicate an altitude of 936 m for the Satau and Parakarungu beach ridges, consistent with the ridges in Lake Ngami and the Mababe depression. The other ridges fall in the range of 932-936 m.

Another evidence of lacustrine origin is the presence of diatomaceous earth (soil units L38b and LA42b) on the western side of the Parakarungu beach ridge. Analysis indicate the presence of diatoms with abundant chrysophyte cysts and sponge spicules. The valves were badly broken, probably a result of alluvial reworking (Shaw, 1986, personal communication).

The lower parts of the floodplain occur mainly east of Satau at a level of approx. 928 m, consisting of a channel complex with a very irregular topography. The areas at intermediate level go up to 930 m and are very flat, but show in places an anthill microtopography (soil units L11, 38a and 43a).

1.5. Hydrology

1.5.1. General

The Chobe enclave is part of the Kwando-Linyanti-Chobe river system, the Kwando and Linyanti both referring to the upper reaches of the Chobe river, upstream of Lake Lyambezi.

The Kwando originates from the eastern slopes of the Angolan highlands. The flow of the Kwando-Linyanti-Chobe network is controlled by a series of parallel faultlines, running southwest-northeast. After flowing in a southerly direction (parallel to the Okavango river), the Kwando river enters an extensive swamp area and turns abruptly northeast. This Linyanti swamp is sharply confined by the Linyanti fault. Besides receiving water from the Kwando, the Linyanti swamps also receives water from the Okavango system, through the Magweqana or Selinda spillway, but only in years with very high floods. The Kwando river backflows into the Selinda spillway for a few km, as the gradient is to steep to allow further flow in opposite direction. In years of very high floods, part of the water travels down to the Savuti marsh through the Savuti channel.

East of Kweha, the river turns south again up to Kalunda lagoon, where it makes another sharp turn to the northeast to follow the second fault line. This fault also determines the southern boundary of Lake Lyambezi. The outflow of the lake, the Chobe river, flows southeast to the escarpment at Kavimba, where it makes a third sharp turn to the northeast. The Chobe river follows the escarpment northeastwards as far as Nanyanga, where it turns east to join the Zambezi at Kazungula.

However, the largest part of the Chobe water, flowing in the Zambezi, originates from the Zambezi itself, overflowing its southern bank. Downstream of Kavimba, the Chobe is mainly fed by floodwater from the Zambezi through drainage of the Caprivi swamp zone, east of Lake Lyambezi, via the Kasaiya channels and through backflow of the Zambezi river.

1.5.2. Water Sources

1.5.2.1. Surface Water

At the time of the survey, surface water only occurred in the Linyanti channel and associated lagoons, and in some pools in the Chobe riverbed. Lake Lyambezi was found dry. As observed in the past, the occurrence of very high floods, filling up Lake Lyambezi, is cyclical with a 10 years interval (1957, 1968, 1978). During these floods most of the floodplain is inundated, even the soils in the intermediate positions, or is at least subjected to a high water table.

No information was available on river water quality within the Chobe enclave. However, recent water analysis of the Chobe river in Kasane were obtained. It is likely that the quality of the river water in the Chobe enclave is similar to that at Kasane.

The analyses indicate very low electrical conductivity (ECw) and total dissolved solids (TDS), both indicators of water salinity. The SAR (sodium absorption ratio) was also very low (<0.2), which , combined with the very low salinity, adversely effects the infiltration rate when used as irrigation water. Very low salinity water tends to leach the soil from solubles, especially Ca, reducing the stability of the aggregates. Without salts and Ca, the soil disperses which results in a decrease of the infiltration and permeability rates.

No data are available on the in- and outflow in the area (water balance).

1.5.2.2. Groundwater

In order to determine the suitability for irrigation, it is essential to know the behaviour of the groundwater

Analysis of borehole water, from Satua, Parakarungu and Kachikau, indicate the presence of salts in the groundwater. The ECw varies between 1.0 and 4.0 mS/cm and the TDS ranges from 1,000 to 5,000 ppm. Furthermore, the groundwater has a high sodium content, between 180 and 300 ppm (Ca only up to 25 ppm), resulting in a very high SAR (up to 20). Unless adequate leaching takes place, a temperary high water table may cause severe salinity problems and may result in Na toxicity. The groundwater is not suitable for irrigation.

Since no data are available on the groundwater flow and fluctuations, a network of piezometers should be installed

allover the floodplain in order to follow the behaviour of the groundwater table, especially in years of high floods.

A hard, massive layer of loamy sand, underlain by loose sand (soil unit L43a), is commonly found throughout the floodplain. When reaching this layer, the groundwater will probably create an upward hydraulic pressure. It is important to find out the influence of this layer on the groundwater, and to determine the physical properties of this layer (hydraulic conductivity, bulk density etc.).

1.6. Vegetation

The vegetation is described according to its occurrence in the different physiographic units:

-Sandveldt (soil units KS3-5): open woodland with dense shrub undergrowth. Trees are mainly Baikiaea plurijuga (Rhodesian teak), Pterocarpus angolensis (mukwa), Burkea africana and Erythrophleum africanum. Shrubs are dominantly seedlings of the larger trees and Terminalia sericea, Grewia spp., Bauhinia macrantha, Ochna pulchra etc...
Common grass species are Digitaria spp., Eragrostis rigidor, Aristida spp., Schmidtia bulbosa, Panicum maximum etc...

-Valleys (channels) in sandtveldt (soil unit A19): dense shrub savanna, mainly Terminalia sericea, Baikiaea plurijuga, Grewia spp., few Baikiaea plurijuga trees. Grasses are similar as in the sandveldt.

-Transition from sandveldt to floodplain, colluvium (soil units A21, A21a and C3). Common shrubs are Terminalia sericea, Combretum hereroense, C. imberbe, Dichrostachys cinerea, Pelthophorum africanum, Acacia tortilis, A. erioloba and Lonchocarpus nelsii. Trees are mainly Lonchocarpus nelsii, Terminalia sericea and Adansonia digitata (Baobab).
The areas with shallow to moderately deep calcrete (soil units A21a and C3) carry an open tree savanna. Same species occur as on soil unit A21, but Adansonia digitata is not as common on this soils. Acacia tortilis is more common. Grassland is often encountered on the very shallow calcrete (soil unit C3).
On heavier soil, soil unit A9, mainly east of Kavimba, Colophospermum mopane occurs.
Main grasses are Digitaria spp., Eragrostis spp., Heteropogon spp. and Aristida spp..

-Chobe and Linyanti floodplain: mainly grassland.
  -Wettest areas, i.e. channels, lake bottoms and backwaters (soil units L37, 37a, 9; (L)A42, 42a, 42b, 31b; A24b and partly A40), support a dense sedge and reed vegetation. Common species are Phragmites mauritianus, Cyperus digitatus, C. articulatus, C. esculentus and Vetiveria migritama. Cyperus papyrus and

Salvinia auriculata were observed in the Linyanti swamps. Sorghum versicilliflorum and Sesbania sesban occur along the Chobe river.

-The intermediate, less frequently flooded areas (soil units L42, 38a, 38b, 43a and partly 31b) support a grassland with mainly CChloris gayana, Setaria sphacelata, Digitaria spp., Sporobolus spp., Cymbopogon spp. and Aristida spp.. Most grasses have a good forage value.
Scattered throughout the grassland, mainly in soil units L43a, 11 and 16, are many anthills which carry trees as Hyphaene ventricosa and Phoenix reclinata (palm trees), Lonchocarpus capassa, Kigelia africana, K. pinnata and Combretum imberbe.

-Beach ridges (soil unit LS17d) carry a dense shrub and tree savanna. Dominant shrubs are Terminalia sericea, Grewia spp., Dichrostachys cinerea, Acacia tortilis, Ximenia americana and Hyphaene ventricosa. Most common trees are Terminalia sericea, Hyphaene ventricosa, Combretum hereroense and Kigelia africana (on the edges). The most important grass species include Digitaria spp., Erachiariaspp., Cynodon dactylon, Chloris gayana, Schmidtia spp., Eragrostis spp. and Heteropogon contortus.

-West of the Parakarungu beach ridge, in the diatom area (soil units L38b and C2), very open tree savanna is encountered, mainly consisting of Combretum imberbe, C. hereroense and Lonchocarpus capassa.

- Chobe flats, on old alluvial deposits:

-A narrow belt of Riparian woodland occurs along the Linyanti (soil units A40, 9), which is mainly composed of Acacia erioloba, A. nigrescens, A. tortilis, A. albida, Lonchocarpus capassa, Croton megalobotrys, Garcinia livingstonei, Ficus capensis, Combretum imberbe mainly on soil unit A9, C. eleagnoides and occassionally Colophospermum mopane. Typical grasses are Oplismenus burmanii and Cymbosetaria sagittifolia.

-The loose sandy soils (soil unit A40) support a tree savanna. Common trees are Acacia erioloba, Terminalia sericea, Lonchocarpus nelsii and Colphospermum mopane. C. mopane shrubland, mixed with Lonchocarpus nelsii shrubs occurs on the more compact sandy soils (soil unit A40a).

-The vegetation on the calcrete ridges depends on the thickness of the sandcover: Terminalia sericea on deep sand and mainly C. mopane and Combretum imberbe on moderately deep to shallow calcrete.

-Pure stands of C. mopane trees occur on the Calcic Luvisol (soil units A9, 9a), spread all over the Chobe flats.

-C. mopane does not occur in the southern part of the Chobe flats, bordering the colluvium. The vegetation consists of an open tree savanna mainly composed of Combretum imberbe and C. hereroense. Terminalia sericea

becomes the dominant species on the loose sand.

-Most common grasses in the Chobe flats are Brachiaria spp., Eragrostis superba, E. rigidor, Schmidtia spp., Hyparrhenia spp., Heteropogon contortus and Cynodon dactylon.

The description of the vegetation is mainly based on 'An Ecological Survey of Northeastern Botswana' (Child, 1968) and on personal observations. The grass species are mainly derived from the range assessment study of the CFDA-Chobe (Kwerepe, 1984).

1.7. Land Use

The main land use in the floodplain is molapo farming, livestock and fishing. The Chobe flats are a hunting area (concession) and the sandveldt consists of the Chobe forest reserve, leased out to a timber company.

The cultivation fluctuates according to the flooding of the area. During floodless years or years with limited floods, crops are grown in the lower floodplains and dried up water ways (channels). In years of high floods, the sandy dryland is cultivated. Cultivation then concentrates at the foot of the escarpment. Arable land becomes gradually available with the recession of the floods. Maize, sorghum and millet are the main crops, intermixed with beans and cucurbits.

The farming is practized in combination with communal grazing. The cattle are kept close to the fields to be used as draught power.

The melapo are used as grazing land during the dry season. In the Kavimba-Kachikau area, the cattle are transferred to the upland during the rainy season to prevent damage to the crops grown in the melapo.

The sale of thatching grass from the enclave provides an extra source of income for the traditional farmers.

When flooded, Lake Lyambezi is a rich fishing ground. About 300 tons of fish, mainly bream and barbel used to be caught per year. At the moment, the fishing is restricted to the Chobe river, downstream Kavimba, and in a few scattered lagoons, associated with the lake and the Linyanti river.

More information on the land use of the Chobe enclave is available in 'Land use planning in the CFDA Chobe' (Gelmroth 1984).

2. Soil Survey Methods

2.1. Aerial Photography Interpretation and Fieldwork

Prior to the fieldwork, a preliminary satellite image (scale 1:250,000) and aerial photo interpretation on scale 1:50,000, was carried out to identify the main landforms. Landsat imagery

appeared to be very useful in delineating the different drainage classes of the floodplain.

The fieldwork was carried out at a detailed reconnaissance level, scale 1:100,000, following to the free survey method. The different physiographic units were checked by means of soil pits and augerings.

Photomaps at scale 1:100,000 (1824A and 1824B) were used as base for the soil map. Enlargements of this maps, scale 1:50,000, and aerial photographs, scale 1:50,000, were used in the field for orientation and location of the observations.

A total of 45 soil pits were dug, described, sampled and classified. Many augerings, mainly in the calcareous soils, were made to check boundaries. Also many hand dug wells, scattered over the floodplain, were checked.

The soil profiles were described following the FAO Guidelines for Soil Profile Descriptions (FAO, 1977).

The field data are available at the soil survey offices in Maun and Gaborone.

2.2. Laboratory Analysis

As the laboratory methods have already been described in other soil reports, only a summing up of the main determinations is given below:

- PH-H_2O and PH-$CaCl_2$ (1:2.5)
- Electrical conductivity (mS/cm)
- Extractable phosphorous (ppm), Bray and Kurtz method
- Organic carbon (weight %), Walkley and Black method
- CEC (meq/100g soil), ammonium acetate method at PH 7.0
- Exchangeable cations Ca, Mg, K, Na (meq/100g soil)
- Particle size: sand, silt and clay (weight %).

The determinations were carried out at the project soil laboratory in Sebele.

3. Soils

3.1. Soil Classification

The soils are classified following the FAO/UNESCO system (FAO-Legend of the Soil Map of the World, 1974), with amendments (as for Arenosols) made by the FAO Soil Mapping Project. Soil Taxonomy (USDA, 1975) is used as a second system. Reference is made to these publications for definitions of diagnostic horizons and criteria used. Following horizons are recognized as diagnostic in the survey area: Ochric A, Mollic A, Albic E, Cambic B, Argillic B, Natric B, Calcic and Petrocalcic.

Both soil classifications are given in the descriptions of the soil units and for the selected soil profile descriptions (see appendix 1)

The most common soil units in the floodplain are Arenosols

and Gleysols, usually having a calcic horizon in the subsoil, except in the lower, more regularly flooded areas (Mollic Gleysol, A42-42a).

In Lake Lyambezi, where very low PH values of 3-4 have been observed in the subsoil, the percentage of base saturation will be less than 50% in some part of the subsoil. Therefore, these soils are not classified according to Soil Taxonomy as Fluvaquentic Haplaquoll, soil units L37 and A42(a) ,but as Fluvaquentic Humaquept (soil unit L37a).

Very common in the somewhat higher areas in the floodplain is the presence of a very massive, hard layer of loamy sand, generally calcareous, overlain by light gray, loose fine sand. This overlying horizon qualifies for an Albic horizon which is probably formed under reductive conditions of a perched watertable on top of the massive layer, which is often sodic. These soils are classified as Arenic (Calcic) Albic Luvisol (soil unit L43a). If the massive layer is considered as a buried surface, the soil would classify as Eutric Arenosol (soil unit L16), since the non calcareous sand cover is usually more than 50 cm.

A natric horizon, with columnar structure and ESP>15, overlain by an albic horizon, was found between Satau and Parakarungu (soil unit L42). These soils, which also have a relatively high salt content are classified as Solodic Planosol.

The dominant soils of the Chobe flats are Eutric Arenosols (soil units A40-40a), with Calcic Luvisols (soil unit A9) in the lower parts. These areas are probably underlain by calcrete. Petrocalcic Arenosols (soil unit A21a) were encountered on the calcrete ridges occuring in the flats. Gleyic Solonetz (A5) mainly occurs in the northern part of the flats.

Calcrete is also found in the colluvial soils at the edge of the floodplain, bordering the escarpment This calcrete has probably formed on weathered basalt, which forms the basis of the escarpment. The Petrocalcic often occurs within 50 cm from the surface (soil unit C3).

The aeolian Kalahari sands of the sandveldt are classified as Ferralic Arenosols (soil units KS3-5).

3.2. The Soil Units

3.2.1. General

The General Soil Map Legend for Botswana, developed by the Soil Mapping Project, is used as the basic legend for the Chobe Enclave. Some new units were introduced.

Two levels are distinguished within the legend:

- -the Main Units, based on Parent Rock
- -the Soil Units, based on Pedological Criteria.

Four main units have been recognized in the survey area:

- -A unit: soils on alluvial deposits
- -C unit: soils on highly calcareous material

-L unit: soils on lacustrine deposits
-S unit: soils on coarse grained sedimentary rocks (aeolian sands).

The deposits of the Chobe flats are clearly alluvial (A), characterized by old channel sediments. Since the presence of beach ridges (soil unit LS17d) and diatomaceous earth, the deposits of the Chobe floodplain are considered of lacustrine origin. However, part of the area has been strongly alluvial reworked. Therefore, the latter mapping units are indicated as LA. The S unit is expressed as LS and KS. KS indicates the origin of the sands as Kalahari sands, while LS refers to sands of lacustrine origin but reworked by aeolian action.

The soils of the dry lagoons and lake bottoms (Lake Lyambezi and Lake Nangombe) are mapped as L (lacustrine environment), as well as the vast plaines, not disturbed by alluvial action (soil units L11a, L38a and L43a).

Due to the complexity of the area and the scale of the mapping, most of the soil mapping units consist of more than one soil unit, forming associations or complexes of soils.

3.2.2. Description of the Soil Units

3.2.2.1. A (or LA): Soils on Alluvial Deposits

A5 — **FAO: Gleyic Solonetz, partly saline**
ST : Typic Natraqualf

Deep to very deep imperfectly drained dark grayish brown to dark gray sandy clay loam to clay.
Flat to slightly undulating

Occurrence: mainly the northern part of the Chobe flats. Also occurs in the southern part of the flats but unit to small to be mapped (included in A9, sodic and saline phase). Associated with A9 and A40.

Characteristics: weak prismatic to massive structure. Patchy thin cutans in natric horizon. Calcic horizon (Ck) in subsoil, within 125 cm from the surface. Accumulation of salts in the subsoil.

Vegetation: tree savanna (C. mopane) to C. mopane woodland.

A7 — **FAO: Gleyic Luvisol, partly sodic**
ST : Mollic Ochraqualf

Deep to very deep poorly to imperfectly drained dark gray to grayish brown sandy clay loam to clay.
Flat to almost flat.

Occurrence: southern part of the floodplain, bordering the Chobe flats, in association with Calcic Luvisol (A9).

Characteristics: structure is massive weak very coarse prismatic, breaking into angular and suangular blocky. The Bt horizon is often underlain by fine sand. Patchy thin cutans. The subsoil may be sodic.

Vegetation: open shrub savanna to grassland.

A9 FAO: Calcic Luvisol, partly sodic partly saline
ST : Typic Haplustalf

Deep to very deep imperfectly to moderately well drained brown to dark grayish brown sandy clay loam to clay.
Flat to slightly undulating.

Occurrence: southern part of Chobe floodplain, associated with Gleyic Luvisol (A7), and scattered allover the Chobe flats, mainly in association with A40(a), A31b and A21a (on calcrete ridges). Associated with A5 in the northern part of the flats.

Characteristics: the structure ranges from moderate fine to medium angular blocky in highly calcareous soils (Btk) to very coarse prismatic or massive. The latter soils are only calcareous in the subsoil (Ck). Broken, thin cutans in well structured soils. The calcic horizon occurs within 125 cm from the surface. The subsoil may be sodic and saline.

Vegetation: open tree savanna (Combretum spp) to C. mopane woodland.

A19 FAO: Ferralic Arenosol
ST : Ustic Quartzipsamment

Deep to very deep well to somewhat excessively drained yellowish brown to yellowish red fine sands to loamy fine sands.
Flat to almost flat.

Occurrence: Kataba and Ncarcangu valley, in KS3-5 sandveldt.

Characteristics: structureless fine sands.

Vegetation: shrubsavanna.

A21 FAO: Calcic Arenosol
ST : Typic Ustochrept

Moderately deep to very deep moderately well to well drained very dark gray to yellowish brown fine sand to loamy fine sand, but having a calcic within 125 cm from the surface.
Flat to undulating.

Occurrence: -near the edge of the floodplain, Chobe flats, associated with A9 and A40(a)
-at the edge of the floodplain, colluvium, bordering the escarpment, together with A21a and C3.

Characteristics: topsoil has a weak subangular structure, subsoil is structureless with soft consistency. Calcic horizon within 125 cm from the surface. Probably underlain by calcrete (Petrocalcic).

Vegetation: shrubland to tree savanna

A21a FAO: Petrocalcic Arenosol
ST : Typic Ustochrept

As A21, but having a Petrocalcic horizon within 125 cm from the surface.
Flat to undulating (calcrete ridges).

Occurrence: on calcrete ridges in the Chobe flats, in association with A40(a) and A9, and on the transition to the escarpment, colluvium, together with A21 and C3. In the latter case, the calcrete is probably the weathering product of the basalt.

Characteristics: as A21, but over calcrete

Vegetation: C. mopane shrub savanna on the calcrete ridges, tree and shrub savanna on the colluvium.

A24b FAO: Eutric Fluvisol
ST : Mollic Haplaquept

Very deep poorly to imperfectly drained dark grayish brown to black loamy sand to sandy loam.
Flat (channels).

Occurrence: in the channels of the Chobe and the Linyanti floodplains, in association with (L)A42-42a. This unit indicates

the lowest (wet) areas of the floodplains.

Characteristics: loamy topsoil, high O.M. content, over structureless loamy sand to sandy loam, often sand in the subsoil.

Vegetation: reeds, papyrus or cultivation.

(L)A31b **FAO: Eutric Gleysol, partly sodic**
ST : Mollic Haplaquept

Deep to very deep poorly to imperfectly drained very dark gray to gray sandy loam to loam.
Flat (channels).

Occurrence: A31b occurs mainly in the channels in the eastern and southern part of the Chobe flats and at the edges of the Linyanti floodplain, usually in association with A40(a) and A42.
LA31b indicates the channels throughout the Chobe floodplain, together with L38a-38b and L11, mainly at the edges of the channels.

Characteristics: structure of the cambic is very weak prismatic to massive. The texture is often sandy in the subsoil. The Ah horizon does not qualify as mollic because of thickness. Channels with thick epipedon in the floodplain are classified as Mollic Gleysol. May be sodic in the subsoil.

Vegetation: grassland, reeds and sedges in lower parts.

A40 **FAO: Eutric Arenosol**
ST : Ustic Quartzipsamment

Deep to very deep moderately well to well drained white to brown sand to loamy sand.
Flat to undulating.

Occurrence: A40 covers the main part of the Chobe flats, in association with A40a, A9 and calcrete ridges (A21a). It occurs in the Linyanti floodplain with Mollic Gleysol (A42), also in some channels with A31b.

Characteristics: Structure of topsoil very weak subangular blocky. Structureless, loose fine sand in the subsoil.

Vegetation: tree savanna with dense shrub undergrowth

A40a

FAO: Eutric Arenosol
ST : Ustic Quartzipsamment

As A40 but massive.
Flat to slightly undulating.

Occurrence: mainly in the depressions in the Chobe flats, associated with A40 (higher parts), A9 and A21a. Also in the southern part of the Chobe flats, parallel to the escarpment, together with A7, A9 and A31b (channels).

Characteristics: massive structure in the subsoil, consistency hard to slightly hard when dry.

Vegetation: C. mopane shrub savanna in the depressions to open tree savanna.

(L)A42

FAO: (Vertic) Mollic Gleysol
ST : Fluvaquentic Haplaquoll

Deep to very deep poorly to imperfectly drained gray to black loam to clay.
Flat.

Occurrence:-A42 occurs in the Linyanti floodplain.
-LA42 covers the low areas of the Chobe floodplain, east and west of Satau, mainly in association with LA42a and A24b.

Characteristics: profile has a high silt content throughout. The Cambic has a weak subangular structure. Few lime nodules may occur. Often deep cracks at the surface (Vertic properties). Slight accumulation of salts.

Vegetation: reeds or cultivation.

(L)A42a

FAO: (Vertic) Mollic Gleysol
ST : Fluvaquentic Haplaquoll

As (L)A42, but overlying grayish brown to white fine sand within 100 cm from the surface.
Flat.

Occurrence:-A42a is present in the Linyanti floodplain.
-LA42a occurs at the edge of Lake Lyambezi, associated with L16 and A24b, and in the low areas east and west of Satau, in slightly higher positions than LA42.

Characteristics: structureless fine sand, overlain by loamy layers (Bw) with a weak subangular blocky to prismatic structure. Usually PH is neutral. However, very low (3-4) PH was found at the edge of Lake Lyambezi. Often cracking at the surface (Vertic properties). Slight accumulation of salts.

Vegetation: reeds or cultivation.

LA42b **FAO: Mollic Gleysol, partly sodic**
ST : Fluvaquentic Haplaquoll

As LA42a, but with diatomaceous earth in subsoil, within 50 cm from the surface.
Flat.

Occurrence: in Chobe floodplain, west of the Parakarungu beach ridge and up to the Lyambezi fault line. Occurs in alternation with L38b.

Characteristics: the diatomaceous deposits are massive, with slightly hard to hard consistency. Often, as in L38bG, a layer of silty clay occurs in between the diatom layers. The underlying fine sand is soft and structureless.In some cases, the base saturation percentage is less than 50% in some part of the subsoil (Fluvaquentic Humaquept), but as this soil unit does not cover large areas, it is not included in the soil map legend. Slight accumulation of salts. May be sodic in subsoil.

Vegetation: grassland.

3.2.2.2. C: Soils on Highly Calcareous Material (Calcrete), within 50 cm from the Surface.

C2 **FAO: Calcaric Regosol**
ST : Aridic Ustochrept

Very shallow to shallow imperfectly drained very dark gray to dark brown sandy loam to clay loam.
Undulating (ridges).

Occurrence: on calcrete ridges east of the Parakarungu beach ridge, mainly associated with L38b and LA42b (diatoms).

Characteristics: thin layer of loam on calcrete. Calcrete usually within 30 cm from the surface.

Vegetation: open tree savanna.

C3 FAO: Petrocalcic Arenosol
SL : Aridic Ustochrept

Very shallow to shallow moderately well to well drained very dark grayish brown to reddish brown sands to loamy sands.
Flat to undulating (ridges).
Occurrence: at the edge of the floodplain, bordering the escarpment, colluvium, (calcrete probably weathering product of basalt), and on the ridges in the southern part of the Chobe flats. The ridges are not indicated on the soil map as C3, but as A21a, since the calcrete generally occurs at more than 50 cm depth. C3 is associated with A21 and A21a.

Characteristics: loose, structureless to weak subangular, fine sand over calcrete.

Vegetation: tree and shrub savanna on the colluvium and C. mopane shrub savanna on the ridges.

3.2.2.3. L: Soils on Lacustrine Deposits

L9 FAO: Eutric Fluvisol
ST : Mollic Haplaquent

Very deep very poorly to poorly drained yellowish brown to olive gray to black stratified complexes of coarse sand to silt to clay.
Flat.

Occurrence: lower parts of lakes and lagoons, associated with L37.

Characteristics: high silt and organic matter content.

Vegetation: reeds, papyrus and Salvinia.

L11 FAO: Calcic Arenosol
ST : Typic Ustochrept

Deep to very deep moderately well to well drained very dark gray to yellowish brown fine sand to loamy fine sand, having a calcic horizon within 125 cm from the surface.
Flat to undulating.

Occurrence: all over the Chobe floodplain, mainly on the higher

parts east of Parakarungu and on the areas bordering the beach ridges (LS17d). Usually in association with L16, L38a and L43a.

Characteristics: topsoil has a weak subangular blocky structure. Subsoil is structureless or massive (hard consistency). White sand, often with irregular siliceous nodules, occurs in the subsoil. Calcareous within 50 cm from the surface.
Slight accumulation of salts.

Vegetation: grassland to open tree savanna, on scattered anthills.

L16 FAO: Eutric Arenosol
ST : Ustic Quartzipsamment

Deep to very deep well to somewhat excessively drained dark gray to pale brown fine sand to loamy fine sand, non calcareous between 0 and 100 cm from the surface.
Flat to undulating.

Occurance: mainly in the southern part of the Chobe floodplain, associated with L11 , and on the somewhat higher, isolated areas thoughout the plain.

Characteristics: Stucure of the topsoil is very weak subangular blocky. Strucureless loose sand in the subsoil.

Vegetation: open tree savanna (anthills).

L37 FAO: (Vertic) Mollic Gleysol
SL : Fluvaquentic Haplaquoll

Very deep poorly to imperfectly drained very dark gray to black loam to clay.
Flat.

Occurrence: in lakes and lagoons, dry at the time of the survey,but flooded regularly (Lake Lyambezi and Lake Nangombe). associated with L9.

Characteristics: as LA42/42a, but PH usually lower. Base saturation percentage higher than 50% throughout. Cracking when dry. Has a very low PH in subsoil, but a relatively high EC.

Vegetation: reeds or cultivation.

L37a

FAO: Mollic Gleysol
SL : Fluvaquentic Humaquept

As L37 but base saturation percentage less than 50% in some part of the subsoil.
Flat.

Occurrence: as L37.

Characteristics: as L37, except for base saturation.

Vegetation: reeds or cultivation.

L38a

FAO: Calcic Gleysol, partly sodic
ST : Aeric/Mollic Haplaquept

Deep to very deep poorly to imperfectly drained gray to very dark gray loam to clay, overlying grayish brown to white fine sand within 100 cm from the surface.
Flat.

Occurrence: in Chobe floodplain, mainly east of Parakarungu, associated with L11 and L43a, also at the edges of the beachridges (LS17d), though dominated by L11.

Characteristics weak subangular and angular blocky, sometimes prismatic structure in the cambic horizon, overlying soft, structureless fine sand. The Ah horizon often fulfills the requirements for Mollic except thickness. Hydromorphic properties within 50 cm from the surface. Calcic horizon occurs within 50 cm from the surface (higher areas), or calcareous between 0 and 50 cm (lower floodplains).Slight accumulation of salts.May be sodic.

Vegetation: grassland.

L38b

FAO: Calcic Gleysol, partly sodic
ST: Mollic Haplaquept

As L38a but overlying diatomaceous earth within 50 cm from the surface.
Flat.

Occurrence: west of Parakarungu beach ridge. Occurs in alternation with calcrete ridges (C2), and in association with LA42-42a and LA31b (channels).

Characteristics: massive deposits of, probably transported, diatomaceous earth. Often, a layer of silty clay occurs in

between the diatom layers. Usually fine sand in the subsoil. Calcic horizon within 125 cm from the surface, generally within 50 cm. Slight accumulation of salts. Usually sodic in subsoil.

Vegetation: grassland with few scattered trees.

L42 FAO: Solodic Planosol, partly saline
ST : Albic Natraqualf

Deep to very deep poorly to imperfectly drained dark grayish brown to very dark gray sandy clay loam to clay.
Flat to slightly undulating.

Occurrence: in lower areas, between Satau and Parakarungu, associated with L43a and L11.

Characteristics: columnar structure in the Bt horizon (natric), very hard consistency. High sodium and salt content. Patchy thin cutans. Calcareous in the subsoil. Abrupt boundary between E and Bt horizon. High sodium and salt content in subsoil.

Vegetation: open tree savanna, scattered anthills.

L43 FAO: (Arenic) Albic Luvisol
ST : Psammentic Haplustalf

Deep to very deep well to moderately well drained gray to light brownish gray fine sand over dark grayish brown to pale brown massive loamy sand to sandy loam.
Flat to slightly undulating.

Occurrence: west of the Parakarungu beach ridge, on the transition to the older alluvial deposits (Chobe flats), in association with A9 and A40a.

Characteristics: the structureless E horizon (Albic) is overlying a hard to very hard, massive argillic horizon, which is often underlain by loose fine sand. Claybands occur in the subsoil. Abrupt boundary between the E and Bt horizon.

Vegetation: open tree savanna.

L43a FAO: (Arenic) Calcic Albic Luvisol
partly sodic
ST : Psammentic Haplustalf

As L43, but having a calcic horizon within 125 cm from the surface and underlain by grayish brown to white fine sand in the subsoil.
Flat to slightly undulating.

Occurrence: common on the higher parts (intermediate areas) of the Chobe floodplain, mainly north and northeast of Satau and between the Satau and Parakarungu beach ridges. Usually associated with L38a ,L42 and L11.

Characteristics: the argillic horizon, loamy sand, is massive, very hard and often sodic. A calcic horizon or calcareous nodules are present within 125 cm from the surface, usually in the Bt horizon. These soils are characterized by many anthills.
Slight accumulation of salts.

Vegetation: grassland to open tree savanna (scattered anthills).

3.2.2.3. S (or KS, LS): Soils on Coarse Grained Sedimentary Rocks (Aeolian Sand).

KS3 — **FAO: Ferralic Arenosol**
SL : Ustic Quartzipsamment

Deep to very deep well to somewhat excessively drained yellowish brown to yellowish red fine sands.
Flat to undulating.

Occurrence: sandveldt south of Kachikau, associated with KS5.

Characteristics: structureless fine sands.

Vegetation: tree savanna to woodland.

KS5 — **FAO: Ferralic Arenosol**
SL : Ustic Quartzipsamment

As KS3 but fine sands to loamy fine sands.

Occurrence: sandveldt south of Kachikau, associated with KS3.

Characteristics: as KS3, structureless loamy sands.

Vegetation: as KS3.

LS17d FAO: Eutric Arenosol
ST : Ustic Quartzipsamment

Deep to very deep well to somewhat excessively drained light yellowish brown to dark grayish brown fine sands to loamy fine sands, non calcareous between 50 and 100 cm.
Undulating (beach ridges).

Occurrence: beach ridges in the Chobe floodplain, sometimes in association with L11.

Characteristics: structureless fine sands.

Vegetation: tree and shrub savanna.

3.2.3. Soil Sequence

The relative position of the different units in the Chobe floodplain is represented in fig. 3.

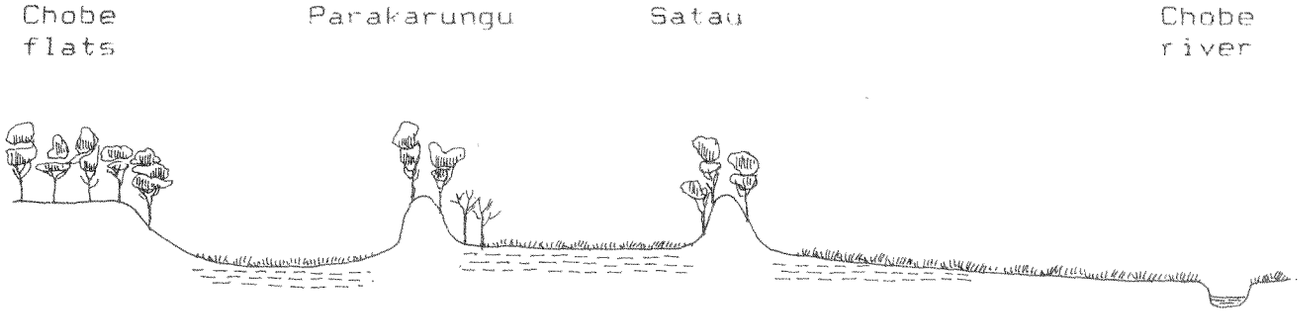

Fig. 3 E-W cross section through the Chobe floodplain

The soils in the high positions (Chobe flats,units A40 and A40a, and the beach ridges LS17d) are generally very sandy and have a low fertility related to the low CEC. The Calcic Luvisols (A9-9a) are strongly calcareous and often have a sodic and saline phase. The Gleyic Solonetz (A5) is also saline. The A21-21a units have a strongly calcareous subsoil and/or a petrocalcic horizon.

The soils in the intermediate positions (L42, 11, 38a/b and 43a) are characterized by a very alkaline pH. The pH ranges from 8-8.5 in the topsoil to 10 in the (strongly calcareous) subsoil. However, calcareous soils usually have a pH in the range of 7.5-8.5. The very high amount of calcium in the subsoil could

indicate another source of calcium other than CaCO3 (see further). A relatively high Mg content was observed in the analysis. As such MgCO3 may be present in the soil, raising the pH to 9.0 and higher. Also bicarbonates may be present. The sodium content was usually low (see further) and should thus not be the main cause of the high pH.

The electric conductivity (EC) generally remains below 4 mS/cm. The accumulation of salts is probably related to the groundwater table and to capillary rise. The latter is higher in heavy than in light textured soils. The Calcaric Gleysol (L38a/b), which occurs in somewhat lower positions, shows a slight accumulation of salts in the heavy topsoil (up to 5 mS/cm). On the other hand, the sandy soil units L11 and L43a have a higher EC (max. 3 mS/cm) in the subsoil (lower groundwater table, less capillary rise).

The high amount of free Ca usually coincides with a higher EC. Possibly, soluble Ca salts occur. Another source may be gypsum.

The soil unit L42 (Solodic Planosol) is both saline (EC up to 10 mS/cm) and very sodic (ESP up to 70!!). A sodic phase may also occur in the L38a/b but the ESP usually remains below 15 %. The hard layer in the subsoil of L43a is often sodic, characterized by the very massive structure caused by dispersion.

The O.C. content is very low (<0.5 %) in L42, L11 and L43a (sandy topsoil), also resulting in a very low phosphor content (less than 1 ppm). These values are somewhat higher for L38a/b, but remain very low (O.C. up to 1 % and P between 1 and 2 ppm).

The CEC is medium to high for the L38a/b units, ranging from 15 to 30 meq/100g soil, but is low to very low in the sandy topsoil of L11 and L43a.

As a conclusion, L11 and L43a have a very low fertility and will need large inputs of fertilizer to fullfil the needs of the crops. Furthermore, the high pH may result in nutrient deficiencies of Fe and other micronutrients. Also phosphorous fixation as calcium phosphate may be a problem. L38a/b have less nutrient constraints but its imperfect drainage may leed to accumulation of salts (if not properly drained).

The soil units (L)A42-42a-42b, in the lower positions, are poorly drained but generally have a relatively high fertility. However, the pH remains fairly high, varying between 5.5 and 8. The impeded drainage results in a slight accumulation of salts (EC up to 4.5 mS/cm), probably Ca and Mg salts (see SA 14). Sodium remains low throughout the profile for LA42-42a. LA42b may have a high sodium content in the subsoil.

These soils have a high O.C. and relatively high P values (10 ppm). The CEC is high. The complex is completely saturated due to the presence of soluble salts.

For Lake Lyambezi (L9-37-37a), the analysis indicate very low PH values (as low as 3.5) and the presence of salts (EC up to 3 mS/cm). This could indicate an actual or previous acid sulphate soil. However, no yellow mottles of jarosite, KFe3(OH)6(SO4)2, were observed. Further analysis should be carried out to check for sulphates and for free AL+++ (soluble at PH < 5). The high

free calcium content may indicate the presence of gypsum. Higher pH was observed in the other lagoons.

4. Land Evaluation

4.1. General

Land evaluation is the process whereby the suitability for a given land utilization type, in this case commercial irrigated farming, is assessed.

The land evaluation follows the methodology developed for Botswana (G. Rhebergen, 1987), which is based on 'A Framework for Land Evaluation' (FAO, 1976). For more information, reference is made to this publications.

Only the most restricting qualities are considered here:

- -d: Adequacy of drainage conditions, based on physical properties as infiltration, permeability, available water holding capacity (AWHC) and the depth of the groundwater table.
- -e: resistance to soil erosion by wind, mainly based on the topsoil texture, O.M. and structure.
- -n: nutrient availability, related to O.M., P, CEC and the bases Ca, Mg, K, Na. Corrected for PH, depending on the type of crop.
- -o: oxygen availability: fuction of the drainage.
- -p: absence of pests and deseases.
- -q: availability of water of good quality, mainly based on the salinity and sodicity of the water.
- -t: absence of toxic substances in the soil: salts, sodium and carbonates.
- -x: adequacy of topography: determines the possible field size.

Following suitability classes are considered:

- -S1: highly suitable: land which is expected to be highly productive for the defined use. High returns amply justify required imputs. No significant limitations.
- -S2: moderately suitable: land which is expected to be moderately productive for the defined use. Moderate returns justify required inputs. Limitations reduce crop yields 10-25% and/or increase recurrent costs for production and conservation.
- -S3: marginally suitable: land which is expected to have low productivity for the defined use. Yield benefits are just enough to justify required inputs. Limitations reduce crop yields 25-50% and/or considerably increase costs for production and conservation.
- -S4: very marginally suitable: land which is expected to have a very low productivity for the defined use. It is doubtful whether yield benifits alone justify inputs.

Severe limitations reduce crop yields with more than 50% and/or considerably increase costs for production and conservation.

-N1: currently non suitable: may be corrected and upgraded to S3-S4.

-N2: permanently unsuitable: may not be corrected.

The suitability is discussed for the dominant soil types in the Chobe floodplain and the Chobe flats. The Kalahari sands (KS3-5), the colluvium (A21-21a) and the beach ridges (LS17d) are not taken into account because of their distance to the watersource.

4.2. Land Quality Ratings

Since the lack of information, mainly soil physical and hydrological data, only a preliminary land evaluation can be made.

Adequacy of drainage conditions is the most restricting land quality, as it is related to the flooding conditions. This quality refers to the internal drainage of the soil and is mainly a function of available water holding capacity (AWHC), infiltration rate, permeability and depth of the watertable. However, most of these data are lacking. A high watertable generally coincides with high floods. As very high floods may occur in the floodplain, the suitability of the soils is only very marginal to NOT suitable, providing no floodprotection measures or adequate drainage works are carried out (current suitability). Nevertheless, the potential suitability will remain marginal to very marginal, due to other constraints.

Very high floods are cyclical with a 10 years interval (see hydrology) and will result in extensive inundated areas and/or a high (saline and sodic) watertable within rooting depth of the crops.

The first soils to be flooded are the units L9-37-37a, (L)A31b and A24b. With higher floods, the units (L)A42-42a-42b and even L38a are inundated or have a high watertable. Since their low position, these areas should be disregarded for commercial irrigated farming, but retained for traditional molapo farming.

When very high floods occur, even the soils in the intermediate positions (L11, 43a and 16) may get flooded. Furthermore, their sandy subsoil, which have a high hydraulic conductivity, will allow a fast vertical and lateral movement of the groundwater. Special attention must be given to the hard, massive layer in the subsoil of L43a. It is important to know the soil physical properties of this layer and its influence on the behaviour of the groundwater.

The sandy soils of the Chobe flats (A40-40a) are not subjected to flooding. However, they are only marginally suitable due to other constraints (see further). The A9 unit has an impeded drainage.

Nutrient availability has already been described in the soil chapter (see 3.2.3.).

The fertility is high in the heavy soils of the lower, more frequently flooded areas (LA42-42a). These soils have a high O.M. content and are relatively high in available phosphor. However, the PH may be relatively high in some parts (up to 8), coinciding with a slight accumulation of salts (saline phase).

The lake and lagoon bottoms are very high in O.M. but are acid to very acid (PH as low as 3.5). Al toxicity may occur.

The soils in the intermediate positions (L11-43a) have a very low fertility. Furthermore, the PH is alkaline to very alkaline, which may result in deficiencies of micronutrients. Under improved drainage and floodprotection measures, nutrient availability becomes the next most restricting factor.The fertility is somewhat better for the L38a unit which has a heavier topsoil, but the PH remains very high.

The nutrient availability is low for the A40-40a units in the Chobe flats, due to the very low O.M. and phosphor content and the low CEC. The PH is slightly acid.

Oxygen availability is related to the drainage. Drainage is poor to very poor in the L9-37-37a units and imperfect to poor for LA42-42a-42b. The drainage improves in the intermediate positions, being imperfect for L38a-38b and moderately well for L11. The massive layer in L43a will result in a more impeded drainage. Under years of high floods and/or a high watertable, oxygen availability will be poor in the intermediate positions as well. The oxygen availability is high for the well drained sandy soils in the Chobe flats.

Absence of pests and deseases is difficult to quantify and is not related to the soil units. Very important is the potential damage from large herbivores (now in Chobe flats), from locust and from quelea birds. A locust outbreak was reported during winter '86.

Availability of water of good quality may be limited in some years. As years of very high floods occur, also years of very low floods were reported, resulting in a limited supply of surface water (and related groundwater). Little information is available on the frequency, the extension and duration of the floods. Water quality is discussed in chapter 1 (hydrology). Irrigation with groundwater is not advisable due to its salinity and alkalinity, resulting in high leaching requirements.

Absence of toxic substances is the main limiting factor for unit L42. This quality mainly refers to salinity, sodicity and the presence of carbonates. Salts occur throughout the floodplain but the EC generally does not exceed 4mS/cm. The soils in the intermediate positions (L11a, 38a, 38b, 43a) may also have a sodic phase. Furthermore, these soils are strongly calcareous.

Their very high PH is probably due to the presence of MgCO3 and bicarbonates. L42 is both strongly saline and sodic. The A9-9a unit in the Chobe flats may be sodic and saline. The variation (in time) of the salinity and sodicity is unknown.

Adequacy of topography refers to the possible field size. The lower LA42-42a units consists of a channel complex with a very irregular topography. The L11-16-43a soil units are characterized by the presence of many anthills.

The results for the main soil units in the floodplain are given in tables 3-8 (see annex 2), assuming enough water of good quality is available throughout the year.

5. Conclusions and Recommendations

5.1. Conclusions

From the discussions above, it is obvious that the current suitability of the floodplain for commercial irrigated farming is only very marginal (S4) to not suitable (N1/N2). The main restriction is the possibility for very high floods (reflected in the drainability), which generally occur once in 10 years. During these very high floods most of the floodplain, even the intermediate positions, is inundated. After recession of the floods, a high groundwater table will be present for a considerable time. The overall low suitability is determined by these exceptional conditions. Flood protection measures may improve the suitability of the soils in the intermediate positions, but the soil drainability will remain the most limiting factor in years of very high floods.

Furthermore, other severe limitations occur, mainly fertility, salinity and sodicity, depending on the position in the landscape. Each of these land qualities can be improved individually at a very high cost. However the combination of these restrictions, together with the drainability, makes it doubtful whether all these investments are justified. The suitability of the intermediate areas will be very marginal to not suitable.

The soils in the lower areas (LA31b-42-42a, L7-37-37a and A24b) are more regularly flooded and for this reason can be disregarded for irrigated agriculture. However, due to their higher fertility and AWHC, these soils will give relatively high yields under flood recession farming.

The sandy soils in the Chobe flats (A40-40a) are only very marginally suitable due to their low fertility and low AWHC (very

high infiltration).

5.2. Recommendations

As the above conclusions are partly based on assumptions, it is advisable to carry out further studies.

No information is available on the soil physical properties as: -available water holding capacity (AWHC)
-bulk density
-infiltration rate
-permeabilty (hydraulic conductivity).
Special attention should be given to the massive layer in the subsoil of the L43a unit. The physical properties are important in determining the irrigation method (sprinkler, gravity etc.) considered.

A detailed hydrological study has to be carried out to determine the quantity, the quality (at different times of the year, depending on the level of the water table), the lateral movement and the fluctuations of the groundwater, this mainly in years of high floods. A network of piezometers has to be installed all over the floodplain, if possible in combination with observation wells. The common hand dug wells in the area may be useful, but not as reliable as the piezometer observations. The complete range of fluctuations should be established over a long period (at least a few years) by checking the groundwater levels at regular intervals.

As the groundwater table depends on the topography and on the distance to a permanent water source, the hydrological study should be combined with a topographical survey. Moreover, the precise elevations and locations of the piezometers and wells have to be known.

More information is required on the frequency, the duration and mainly the extension of the floods (hydrographical study). The maximum floodlevel has to be established and plotted out on the topographical maps. Satellite image interpretation may be very useful in this exercise. This information is very important in determining the floodprotection measures and drainage methods.

A water balance has to be made, calculating the in- and outflow of water through the Linyanti-Lyambezi-Chobe network, also considering the backflow from the Zambezi in the Chobe. The amount of available water, mainly in years of very low floods, has to be determined.

The fluctuation of saline and sodic groundwater will result in the precipitation and accumulation of salts and sodium somewhere in the soil, depending on the depth of the water table and on the capillary rise (related to texture). Therefore, in

combination with the hydrological study, the salt balance of the Chobe Enclave has to be established. Also further chemical analysis are required to determine the type of salts (possibly sulphates present).

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APPENDIX 1 SELECTED REPRESENTATIVE SOIL PROFILE DESCRIPTIONS AND ANALYTICAL DATA

Profile	Unit	FAO Classification
SA 0001	L38a	Calcic Gleysol
SA 0004	L16	Eutric Arenosol
SA 0011	L43a	Calcic albic Luvisol, sodic phase
SA 0015	LS17d	Eutric Regosol
SA 0017	LO6b	Calcic Gleysol, sodic phase
SA 0018	L43	Albic Luvisol
SA 0019	A21	Calcic Arenosol
SA 0020	A7	Gleyic Luvisol
SA 0031	A9	Calcic Luvisol
SA 0032	(L)A42a	Mollic Gleysol, sodic phase
SA 0038	A31b	Eutric Gleysol, sodic phase
SA 0039	A40	Eutric Arenosol
SA 0040	A5	Gleyic Solonetz, sodic phase
SA 0042	A19	Ferralic Arenosol
SA 0045	KS3	Ferralic Arenosol

Information on all other soil profiles is available from the Botswana Soil Database.

SOIL PROFILE DESCRIPTION — Profile: SA 0001 Unit: L38a Status: 2

SHEET : 1824A
LOCATION : 1.5km from Kachikau to Satau.
AUTHOR(S): G.Baert A.Remmelzwaal K.Verbeek T.D.Mafoko
CLASSIFICATION FAO: Calcic Gleysol (1974)
ST : Aeric Haplaquept
LANDFORM : alluvial plain
TOPOGRAPHY: almost flat
SURF. CHAR: no sealing, no cracks, nil evidence of salt,
LAND USE: no apparent management system
SPECIES : Trees -
: Shrubs -
: Grasses/forbs-
PARENT MATERIAL: lacustrine
MOIST. COND: dry 0 - 150 cm
SURF.STONES: none
EROSION : nil

GRID : KK-346-925
COORD: 18-08-32-S 24-29-30-E
DATE : 28/06/86

LAND ELEMENT : flood plain
MICRO TOPOGRAPHY: uneven

VEGETATION: grassland

ROCK TYPE:

ROCK OUTCROP: none

AGRO CLIM.ZONE: 1B1
ELEVATION :

SMR: aquic

POSITION: intermediate part
SLOPE : 1 - 2 %

GRASSCOVER:

GEOL.UNIT:
DRAINAGE : imperfectly drained

HUMAN INF: nil

REMARKS: Flooded about 1-4 times in 10 years. Pockets or lenses up to 20% volume of diatoms and pockets of sand in Ak horizon.

SAMPLES: A: 0 - 20 B: 20 - 38 C: 38 - 60 D: 60 - 90 E: 90 - 120 F: 120 - 150

A 0 - 20 cm 10YR 3/1 (moist) and 10YR 5/1 (dry), sandy clay loam, very weak very coarse subangular blocky structure, hard, few very fine and fine pores, very few fine soft calcareous white nodules, moderately calcareous, many burrows, common very fine and fine roots, clear wavy boundary.

Ak 20 - 38 cm 10YR 3/1.5 (moist) and 10YR 6/1 (dry), sandy clay loam, strongly coherent massive very coarse subangular blocky structure, slightly hard, many very fine and fine pores, few fine soft calcareous white nodules, strongly calcareous, common very fine and fine roots, clear wavy boundary.

2Cck 38 - 60 cm 2.5Y 6/2 (moist) and 2.5Y 7/1 (dry), fine sand, weakly coherent massive structure, soft to slightly hard, few very fine and fine pores, frequent fine soft calcareous white nodules, strongly calcareous, few burrows, common very fine and fine roots, clear wavy boundary.

2Ck 60 - 150 cm 2.5Y 7/2 (moist) and 2.5Y 8/1 (dry), fine sand, weakly coherent massive structure, soft, few very fine and fine pores, moderately calcareous, few burrows, few very fine roots,

STANDARD SOIL ANALYSIS RESULTS

PROFILE: SA 0001

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	8.2	7.4	0.2	2	1.0	12.2	34.8	3.0	0.5	0.1	>100	0	0	3	35	20	4	10	28	29		
B	20	38	8.4	7.7	0.3	1	0.5	8.0	39.6	2.6	0.4	0.1	>100	0	0	3	40	25	5	5	21	28		
C	38	60	9.0	7.9	0.2	1	0.1	2.2	21.2	0.9	0.0	0.1	>100	0	0	0	66	30	0	0	4	51		
D	60	90	9.2	8.1	0.2	1	0.0	1.6	14.1	0.5	0.0	0.1	>100	0	0	0	87	11	0	0	2	104		
E	90	120	9.3	8.1	0.2	1	0.0	1.3	17.2	0.7	0.0	0.1	>100	0	0	11	81	7	0	0	1	94		
F	120	150	9.4	8.4	0.1	1	0.0	1.1	13.5	0.5	0.0	0.1	>100	0	1	44	52	2	0	0	1	157		

Soil Survey of Botswana FAO/BOT/85/011

Print date: 29/11/88

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: SA 0004 Unit: L16 Status: 2

SHEET : 1824A
LOCATION : 1.1km from Kasitwane to Lake Nangobe.
AUTHOR(S): K.Verbeek G.Baert A.Remmelzwaal
CLASSIFICATION FAO: Eutric Arenosol (1974)
ST : Ustic Quartzipsamment
LANDFORM : lacustrine plain
TOPOGRAPHY: flat
SURF. CHAR: no sealing, no cracks, nil evidence of salt,
LAND USE: no apparent management system
SPECIES : Trees - Kigelia africana (dom.) Hyphaene ventricosa Phoenix redinata
: Shrubs -
: Grasses/forbs-
PARENT MATERIAL: lacustrine
MOIST. COND: dry 0 - 125 cm
SURF.STONES: none
EROSION : nil

GRID : KL-269-013
COORD: 18-03-47-S 24-25-10-E
DATE : 28/06/86

LAND ELEMENT :
MICRO TOPOGRAPHY: even

VEGETATION: open tree savanna

ROCK TYPE:

ROCK OUTCROP: none

AGRO CLIM.ZONE: 1B1
ELEVATION :

SMR: ustic

POSITION: intermediate part
SLOPE : 0 - 1 %

GRASSCOVER:

GEOL.UNIT:
DRAINAGE : moderately well drained

HUMAN INF: nil

REMARKS:

SAMPLES: A: 0 - 25 B: 25 - 50 C: 50 - 70 D: 70 - 100 E: 100 - 125

A1 0 - 25 cm 10YR 2/1.5 (moist) and 10YR 3/2 (dry), loamy fine sand to fine sandy loam, weak medium and coarse subangular blocky structure, soft, common fine and medium pores, non calcareous, common termite/ant activity, many very fine and fine roots, clear boundary.

A2 25 - 50 cm 10YR 2/1.5 (moist) and 10YR 3.5/2 (dry), loamy fine sand, weakly coherent massive structure, slightly hard, common fine and medium pores, non calcareous, common termite/ant activity, many very fine and fine roots, clear boundary.

C1 50 - 70 cm 10YR 3.5/2 (moist) and 10YR 5/2 (dry), fine sand, weakly coherent massive structure, slightly hard, few very fine and fine pores, non calcareous, common termite/ant activity, common very fine and fine roots, clear boundary.

C2 70 - 125 cm 10YR 7/1 (moist) and 10YR 8/1 (dry), fine sand, weakly coherent massive structure, soft to slightly hard, few very fine and fine pores, non calcareous, few very fine and fine roots,

STANDARD SOIL ANALYSIS RESULTS

PROFILE: SA 0004

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	25	7.0	6.6	0.2	1	0.5	4.0	4.1	0.7	0.2	0.0	>100	0	0	8	71	3	0	6	12	15		
B	25	50	7.2	7.1	0.2	1	0.1	2.3	3.7	0.5	0.2	0.0	>100	0	0	9	71	6	1	2	10	20		
C	50	70	7.4	7.3	0.3	1	0.1	1.0	1.9	0.3	0.1	0.0	>100	0	0	8	75	12	0	0	4	20		
D	70	100	8.5	7.6	0.3	1	0.0	0.9	0.9	0.2	0.0	0.0	>100	0	0	8	82	2	0	0	7	12		
E	100	125	8.8	8.0	0.3	1	0.0	1.5	2.1	0.2	0.0	0.0	>100	0	0	4	84	8	1	1	3	45		

Soil Survey of Botswana FAO/BOT/85/011

Print date: 29/11/88

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: SA 0011 Unit: L43a Status: 2

SHEET : 1824A
LOCATION : 3km from Satau to lake liambezi.
AUTHOR(S): G.Baert A.Remmelzwaal K.Verbeek
CLASSIFICATION FAO: Calcic Albic Luvisol (1974) sodic phase
ST : Psammentic Haplustalf
LANDFORM : lacustrine plain
TOPOGRAPHY: flat
SURF. CHAR: no sealing, no cracks, nil evidence of salt,
LAND USE:
SPECIES : Trees -
: Shrubs -
: Grasses/forbs-
PARENT MATERIAL: lacustrine
MOIST. COND: dry 0 - 125 cm
SURF.STONES: none
EROSION : nil

GRID : KL-227-091
COORD: - - 0-S - - 0-E
DATE : 20/06/86

LAND ELEMENT :
MICRO TOPOGRAPHY: even

VEGETATION: grassland

ROCK TYPE:

ROCK OUTCROP: none

AGRO CLIM.ZONE: 1B1
ELEVATION :

SMR: ustic

POSITION: intermediate part
SLOPE : - %

GRASSCOVER:

GEOL.UNIT:
DRAINAGE : imperfectly drained

HUMAN INF: nil

REMARKS:

SAMPLES: A: 0 - 15 B: 15 - 31 C: 31 - 57 D: 57 - 103 E: 103 - 125

A1 0 - 15 cm 10YR 3.5/1.5 (moist) and 10YR 6/1.5 (dry), fine sand, weak fine to coarse subangular blocky structure, slightly hard, few very fine and fine pores, non calcareous, common termite/ant activity, common fine and medium roots, clear wavy boundary.

A2 15 - 31 cm 10YR 3.5/1.5 (moist) and 10YR 6/1.5 (dry), fine sand, very weak subangular blocky structure, slightly hard, few very fine and fine pores, non calcareous, common termite/ant activity, common fine and medium roots, clear wavy boundary.

E 31 - 57 cm 10YR 6/2 (moist) and 10YR 7/2 (dry), fine sand, weakly coherent massive structure, soft to slightly hard, few very fine pores, non calcareous, common termite/ant activity, common very fine and fine roots, abrupt wavy boundary.

Btk 57 - 103 cm 10YR 4.5/2.5 (moist) and 10YR 5.5/2.5 (dry), fine sand to loamy fine sand, massive structure, hard, common very fine and fine pores, few fine soft calcareous white nodules, non calcareous, common termite/ant activity, very few fine roots, clear wavy boundary.

Ck 103 - 125 cm 10YR 5/2.5 (moist) and 10YR 6/2.5 (dry), fine sand, massive structure, hard, common very fine and fine pores, few fine soft calcareous white nodules, non calcareous, very few fine roots,

S T A N D A R D S O I L A N A L Y S I S R E S U L T S

PROFILE: SA 0011

SAMPLE	DEPTH		pH		EC	P	C	CEC	Ca	Mg	K	Na	PBS	Particle size (weight %)								CECclay	METH	PRETR
			H2O	CaCL2	mS/cm	ppm	weight %	ù----- meq/100gr soil -------ù					%	vcS	cS	mS	fS	vfS	cSi	fSi	Clay	meq/100gr		
A	0	15	6.2	5.8	0.3	2	0.2	2.0	1.5	0.6	0.1	0.1	>100	0	0	14	73	6	1	1	5	26		
B	15	31	7.2	6.3	0.3	2	0.2	1.9	1.6	0.5	0.1	0.0	>100	0	5	10	70	7	0	3	6	20		
C	31	57	7.4	6.7	0.2	1	0.1	0.9	0.8	0.3	0.0	0.1	>100	0	0	12	74	8	2	1	3	16		
D	57	103	8.8	7.5	3.1	2	0.1	4.9	6.5	1.6	0.3	3.6	>100	0	0	13	68	7	1	1	9	50		
E	103	125	9.1	7.7	1.6	2	0.0	2.7	5.5	1.0	0.2	1.4	>100	0	0	16	75	3	0	0	6	45		

Soil Survey of Botswana FAO/BOT/85/011

Print date: 08/03/89

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: SA 0015 Unit: LS17d Status: 2

SHEET : 1824A
LOCATION : Parakarungu.
AUTHOR(S): C.I.Ketlogetswe G.Baert K.Verbeek A.Remmelzwaal
CLASSIFICATION FAO: Eutric Arenosol (1974)
ST : Ustic Quartzipsamment
LANDFORM : lacustrine plain
TOPOGRAPHY: undulating
SURF. CHAR: no sealing, no cracks,
LAND USE: no apparent management system
SPECIES : Trees - Acacia fleckii (dom.) Terminalia sericea Grewia sp.
: Shrubs -
: Grasses/forbs-
PARENT MATERIAL: littoral
MOIST. COND: dry 0 - 130 cm
SURF.STONES: none
EROSION : nil

GRID : KL-161-032
COORD: 18-02-30-S 24-19-02-E
DATE : 30/06/86

LAND ELEMENT : beach ridge
MICRO TOPOGRAPHY: uneven

VEGETATION: dense savanna

ROCK TYPE:

ROCK OUTCROP: none

AGRO CLIM.ZONE: 1B1
ELEVATION : 935 m

SMR: ustic

POSITION: intermediate part
SLOPE : 0 - 1 %

GRASSCOVER:

GEOL.UNIT:
DRAINAGE : somewhat excessively drained

HUMAN INF: nil

REMARKS: Probable aeolian reworked material

SAMPLES: A: 0 - 25 B: 30 - 60 C: 100 - 130

A 0 - 25 cm 10YR 4.5/2 (moist) and 10YR 6/2 (dry), fine sand, very weak medium subangular blocky structure, soft, few very fine pores, non calcareous, many burrows, common fine and medium roots, clear smooth boundary.

C1 25 - 70 cm 10YR 6/3 (moist) and 10YR 7/2 (dry), fine sand, weakly coherent massive structure, soft, few very fine pores, non calcareous, few burrows, common fine and medium roots, diffuse smooth boundary.

C2 70 - 130 cm 10YR 6.5/3 (moist) and 10YR 8/2 (dry), fine sand, weakly coherent massive structure, soft, few very fine pores, non calcareous, few very fine and fine roots,

S T A N D A R D S O I L A N A L Y S I S R E S U L T S

PROFILE: SA 0015

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	25	6.5	5.6	0.0	3	0.1	1.7	1.3	0.2	0.1	0.0	95	0	0	7	69	22	0	0	1	151		
B	30	60	5.9	4.5	0.0	2	0.0	1.2	0.5	0.1	0.0	0.0	52	0	2	7	70	20	0	0	1	120		
C	100	130	6.0	4.9	0.0	1	0.0	1.1	0.4	0.1	0.1	0.0	57	0	1	9	70	19	0	0	1	162		

Soil Survey of Botswana FAO/BOT/85/011

Print date: 29/11/88

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: SA 0017 Unit: L06b Status: 2

SHEET : 1824A
LOCATION : 7km from Karoga to Kasinka.
AUTHOR(S): K.Verbeek A.Remmelzwaal G.Baert T.D.Mafoko
CLASSIFICATION FAO: Calcic Gleysol (1974) sodic phase
ST : Mollic Cryaquept
LANDFORM : lacustrine plain
TOPOGRAPHY: flat
SURF. CHAR: slight sealing, no cracks, nil evidence of salt,
LAND USE:
SPECIES : Trees -
: Shrubs -
: Grasses/forbs-
PARENT MATERIAL: lacustrine
MOIST. COND: dry 0 - 115 cm
SURF.STONES: none
EROSION : nil

GRID : KK-157-949
COORD: 18-07-05-S 24-13-45-E
DATE : 01/07/86

LAND ELEMENT :
MICRO TOPOGRAPHY: even

VEGETATION: grassland

ROCK TYPE:

ROCK OUTCROP: none

AGRO CLIM.ZONE: 1B1
ELEVATION :

SMR: aquic

POSITION:
SLOPE : 0 - 0.5%

GRASSCOVER:

GEOL.UNIT:
DRAINAGE : imperfectly drained

HUMAN INF: nil

REMARKS: C, 3C1 and 3C2 are diatom. earth layers. In 3C horizons, from 92 to 96cm more whitish diatom layer 10YR 8/90S/0, strongly calcareous.

SAMPLES: A: 0 - 21 B: 30 - 50 C: 60 - 80 D: 83 - 96 E: 96 - 115

A 0 - 21 cm 10YR 2.5/1 (moist) and 10YR 6/1 (dry), clay, weak fine subangular blocky structure, hard, common very fine and fine pores, non calcareous, few burrows, many very fine and fine roots, abrupt wavy boundary.

C 21 - 60 cm 2.5Y 6/2 (moist) and 10YR 8/1 (dry), strongly coherent massive structure, very hard, common very fine and fine pores, strongly calcareous, few burrows, very few very fine and fine roots, abrupt wavy boundary.

2C 60 - 83 cm 2.5Y 3/2 (moist) and 2.5Y 4/4 (dry), common coarse distinct clear brownish mottles, clay, massive structure, slightly hard to hard, common very fine and fine pores, frequent fine soft calcareous white nodules, strongly calcareous, few burrows, very few very fine and fine roots, clear wavy boundary.

3C1 83 - 96 cm 2.5Y 4/2 (moist) and 10YR 8/1 (dry), common coarse distinct clear brownish mottles, massive structure, hard, common very fine and fine pores, strongly calcareous, no roots, abrupt wavy boundary.

3C2 96 - 115 cm 10YR 3/2 (moist) and 10YR 8/1 (dry), massive structure, hard, common very fine and fine pores, very few fine soft calcareous white nodules, non calcareous, no roots,

S T A N D A R D S O I L A N A L Y S I S R E S U L T S

PROFILE: SA 0017

SAMPLE	DEPTH		pH		EC	P	C	CEC	Ca	Mg	K	Na	PBS	Particle size (weight %)								CECclay	METH	PRETR
			H2O	CaCL2	mS/cm	ppm	weight %	ù----- meq/100gr soil ------ù					%	vcS	cS	mS	fS	vfS	cSi	fSi	Clay	meq/100gr		
A	0	21	7.0	6.7	1.5	2	0.4	18.3	15.5	3.0	1.2	1.0	>100	0	0	1	18	13	8	16	44	38		
B	30	50	8.1	7.8	4.0	1	0.1	9.0	42.3	4.1	0.6	5.2	>100	1	5	4	9	9	7	17	50	18		
C	60	80	8.1	7.6	3.1	1	0.1	24.4	40.4	9.8	1.0	7.6	>100	2	2	2	10	12	7	15	52	47		
D	83	96	8.4	7.7	1.5	1	0.1	13.1	36.8	5.2	0.5	3.8	>100	5	6	4	7	9	7	16	46	28		
E	96	115	8.4	7.6	0.7	1	0.1	10.3	19.4	3.1	0.6	2.1	>100	4	6	4	7	8	5	17	50	20		

Soil Survey of Botswana FAO/BOT/85/011

Print date: 29/11/88

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: SA 0018 Unit: L43 Status: 2

SHEET : 1824A
LOCATION : 17km from Karoga to Kasinga.
AUTHOR(S): A.Remmelzwaal G.Baert R.Verbeek T.D.Mafoko
CLASSIFICATION FAO: Albic Luvisol (1974)
ST : Psammentic Haplustalf
LANDFORM : lacustrine plain
TOPOGRAPHY: flat
SURF. CHAR: slight sealing, no cracks,
LAND USE:
SPECIES : Trees - Combretum imberbe (dom.) Combretum hereroense Lonchocarpus nelsii
: Shrubs -
: Grasses/forbs-
PARENT MATERIAL: lacustrine
MOIST. COND: dry 0 - 65 , slightly moist 65 - 145 cm
SURF.STONES: none
EROSION : nil

GRID : KK-197-875
COORD: 18-11-02-S 24-21-10-E
DATE : 01/07/86

LAND ELEMENT :
MICRO TOPOGRAPHY: even

VEGETATION: open tree savanna

ROCK TYPE:

ROCK OUTCROP: none

AGRO CLIM.ZONE: 1B1
ELEVATION :

SMR: ustic

POSITION:
SLOPE : 0 - %

GRASSCOVER:

GEOL.UNIT:
DRAINAGE : imperfectly to moderately well drained

HUMAN INF: nil

REMARKS: 20cm into B hor. Interfingering of claybands about 5mm thick at 108, 115,125

SAMPLES: A: 0 - 30 B: 30 - 54 C: 54 - 65 D: 65 - 75 E: 75 - 95 F: 95 - 108 G: 125 - 145

A 0 - 30 cm 10YR 3.5/1.5 (moist) and 10YR 5/1 (dry), fine sand, very weak medium and coarse subangular and angular blocky structure, slightly hard, few very fine and fine pores, non calcareous, many very fine and fine roots, gradual smooth boundary.

E1 30 - 54 cm 10YR 5/1 (moist) and 10YR 6.5/1 (dry), fine sand, weakly coherent massive structure, slightly hard, few very fine and fine pores, non calcareous, few burrows and few termite/ant activity, common very fine and fine roots, gradual smooth boundary.

E2 54 - 65 cm 10YR 5/1 (moist) and 10YR 7/1 (dry), fine sand, weakly coherent massive structure, slightly hard, common very fine and fine pores, non calcareous, few burrows, common very fine and fine roots, abrupt wavy boundary.

Bt1 65 - 95 cm 10YR 4/2 (moist) and 10YR 5/1.5 (dry), loamy fine sand to fine sandy loam, massive structure, hard to very hard friable, patchy thin clay cutans, common very fine and fine pores, non calcareous, common burrows, few very fine and fine roots, clear wavy boundary.

Bt2 95 - 108 cm 10YR 5/2 (moist) and 10YR 6/2 (dry), fine sand, massive structure, hard friable, broken clay lamellae, few very fine and fine pores, non calcareous, common burrows, few very fine and fine roots, abrupt wavy boundary.

Bt2 108 - 145 cm 10YR 6/1.5 (moist) and 10YR 7/1 (dry), fine sand, single grain structure, loose, broken clay lamellae, few very fine pores, non calcareous, very few very fine and fine roots,

S T A N D A R D S O I L A N A L Y S I S R E S U L T S

PROFILE: SA 0018

SAMPLE	DEPTH		pH		EC	P	C	CEC	Ca	Mg	K	Na	PBS	Particle size (weight %)								CECclay	METH	PRETR
			H2O	CaCL2	mS/cm	ppm	weight %	ù----- meq/100gr soil ------ù					%	vcS	cS	mS	fS	vfS	cSi	fSi	Clay	meq/100gr		
A	0	30	6.5	5.8	0.0	1	0.1	3.3	2.4	0.7	0.1	0.0	98	0	1	16	48	14	4	10	8	36		
B	30	54	6.4	5.9	0.0	1	0.0	0.8	0.9	0.3	0.0	0.1	>100	0	0	14	50	19	5	7	5	16		
C	54	65	6.4	6.1	0.0	1	0.0	0.4	0.6	0.3	0.0	0.0	>100	0	0	14	51	22	5	4	5	8		
D	65	75	7.4	7.0	0.2	1	0.1	5.9	6.2	1.7	0.2	0.2	>100	0	0	12	44	19	7	5	14	40		
E	75	95	6.8	6.4	0.1	2	0.1	5.6	4.2	1.6	0.2	0.1	>100	0	0	11	48	23	4	4	10	50		
F	95	108	6.4	5.9	0.0	1	0.0	3.5	2.6	1.0	0.2	0.1	>100	0	0	15	59	15	2	2	7	48		
G	125	145	6.7	6.5	0.0	2	0.2	0.2	0.5	0.2	0.0	0.0	>100	0	0	26	69	2	1	2	0	0		

Soil Survey of Botswana FAO/BOT/85/011

Print date: 29/11/88

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: SA 0019 Unit: A21 Status: 2

SHEET : 1824A
LOCATION : 12.7km from Kachikau to Kasinka.
AUTHOR(S): G.Baert A.Remmelzwaal
CLASSIFICATION FAO: Calcic Arenosol (1974)
ST : Typic Ustochrept
LANDFORM : alluvial plain
TOPOGRAPHY: gently undulating
SURF. CHAR: no sealing, no cracks, nil evidence of salt,
LAND USE: no apparent management system
SPECIES : Trees - Terminalia sericea (dom.) Lonchocarpus nelsii Peltophorum africanum
: Shrubs - Terminalia sericea (dom.) Pappea capensis Lonchocarpus nelsii
: Grasses/forbs-
PARENT MATERIAL: alluvium
MOIST. COND: dry 0 - 130 cm
SURF.STONES: none
EROSION : nil

GRID : KK-242-876
COORD: 18-11-10-S 24-23-40-E
DATE : 01/07/86

LAND ELEMENT :
MICRO TOPOGRAPHY: even

VEGETATION: dense savanna

ROCK TYPE:

ROCK OUTCROP: none

AGRO CLIM.ZONE: 1B1
ELEVATION :

SMR: ustic

POSITION: higher part
SLOPE : - 2 %

GRASSCOVER:

GEOL.UNIT:
DRAINAGE : well drained

HUMAN INF: nil

REMARKS:

SAMPLES: A: 0 - 12 B: 12 - 44 C: 44 - 77 D: 77 - 112 E: 115 - 130

A1 0 - 12 cm 10YR 3.5/1.5 (moist) and 10YR 4.5/1.5 (dry), fine sand, weak medium and coarse subangular blocky structure, soft, common very fine and fine pores, non calcareous, common termite/ant activity and common burrows, many fine and medium roots, clear wavy boundary.

A2 12 - 44 cm 10YR 4.5/1.5 (moist) and 10YR 5.5/1.5 (dry), fine sand, weakly coherent massive structure, soft, few very fine and fine pores, few coarse soft calcareous white nodules, non calcareous, common termite/ant activity and common burrows, common very fine and fine roots, clear wavy boundary.

Ck1 44 - 77 cm 10YR 5/2 (moist) and 10YR 6.5/2.5 (dry), fine sand, weakly coherent massive structure, soft to slightly hard, few very fine and fine pores, few fine hard and soft calcareous white nodules, non calcareous, common termite/ant activity and common burrows, few very fine and fine roots, gradual smooth boundary.

Ck2 77 - 112 cm 10YR 6/4 (moist) and 10YR 7.5/2 (dry), loamy fine sand, weakly coherent massive structure, soft to slightly hard, common very fine and fine pores, very few fine hard and soft calcareous white nodules, strongly calcareous, common termite/ant activity, few very fine and fine roots, abrupt smooth boundary.

Cck 112 - 130 cm 10YR 6/4 (moist) and 10YR 7.5/2 (dry), loamy fine sand to fine sandy loam, weakly coherent massive structure, soft, frequent fine hard and soft calcareous white nodules and frequent coarse hard and soft calcareous white nodules, strongly calcareous, very few very fine and fine roots,

STANDARD SOIL ANALYSIS RESULTS

PROFILE: SA 0019

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	12	6.5	6.2	0.1	3	0.4	4.3	3.0	0.7	0.2	0.1	94	0	1	17	66	9	1	1	6	45		
B	12	44	7.9	7.2	0.1	3	0.2	4.7	8.7	0.5	0.2	0.2	>100	0	0	10	67	14	0	0	8	49		
C	44	77	8.4	7.6	0.1	2	0.1	4.0	27.1	0.8	0.1	0.2	>100	0	1	13	65	11	1	1	10	39		
D	77	112	8.4	7.7	0.1	1	0.0	4.6	33.7	1.2	0.2	0.2	>100	0	1	14	59	9	2	1	14	32		
E	115	130	8.3	7.7	0.1	2	0.1	6.4	33.8	1.9	0.6	0.2	>100	4	5	13	45	9	10	3	11	56		

Soil Survey of Botswana FAO/BOT/85/011 Print date: 29/11/88

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: SA 0020 Unit: A07 Status: 2

SHEET : 1824A
LOCATION : 10.6km from Kachikau to Kasinka.
AUTHOR(S): R.Breitbart A.Remmelzwaal K.Verbeek
CLASSIFICATION FAO: Gleyic Luvisol (1974)
ST : Mollic Ochraqualf
LANDFORM : alluvial plain
TOPOGRAPHY: almost flat
SURF. CHAR: no sealing, no cracks, nil evidence of salt,
LAND USE: no apparent management system
SPECIES : Trees -
: Shrubs - Combretum hereroense (dom.) Combretum imberbe Terminalia sericea
: Grasses/forbs-
PARENT MATERIAL: alluvium
MOIST. COND: dry 0 - 115 cm
SURF.STONES: none
EROSION : nil

GRID : KK-277-882
COORD: 18-11-10-S 24-24-40-E
DATE : 01/07/86

LAND ELEMENT :
MICRO TOPOGRAPHY: even

VEGETATION: open shrub savanna

ROCK TYPE:

ROCK OUTCROP: none

AGRO CLIM.ZONE: 1B1
ELEVATION :

SMR: aquic

POSITION: intermediate part
SLOPE : 0 - 1 %

GRASSCOVER:

GEOL.UNIT:
DRAINAGE : imperfectly drained

HUMAN INF: nil

REMARKS:

SAMPLES: A: 0 - 30 B: 35 - 55 C: 57 - 82 D: 90 - 115

A 0 - 30 cm 10YR 3.5/1 (moist) and 10YR 5/1 (dry), sandy loam to sandy clay loam, weak medium and coarse subangular blocky structure, hard, common very fine and fine pores, non calcareous, few termite/ant activity, few very fine and fine roots, gradual smooth boundary.

B 30 - 57 cm 10YR 3.5/1.5 (moist) and 10YR 5/1.5 (dry), sandy loam to sandy clay loam, strongly coherent massive structure, very hard very firm, common very fine and fine pores, non calcareous, few termite/ant activity, few very fine and fine roots, clear wavy boundary.

Bt 57 - 82 cm 10YR 3/1 (moist) and 10YR 5/1 (dry), sandy clay loam (30% clay), weak very coarse prismatic weak coarse and very coarse angular and subangular blocky structure, very hard very firm, patchy thin cutans, common very fine and fine pores, non calcareous, few termite/ant activity, few very fine and fine roots, abrupt wavy boundary.

2C 82 - 115 cm 10YR 5/2.5 (moist) and 10YR 6/2.5 (dry), fine sand, massive structure, hard, common very fine and fine pores, non calcareous, very few very fine and fine roots,

S T A N D A R D S O I L A N A L Y S I S R E S U L T S

PROFILE: SA 0020

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	30	6.6	5.4	0.1	2	0.8	11.1	7.6	1.7	0.3	0.2	89	0	1	14	34	12	5	9	25	31		
B	35	55	7.0	5.6	0.1	2	0.2	10.4	6.7	1.9	0.3	0.2	88	0	1	14	35	10	5	7	28	34		
C	57	82	7.0	5.8	0.1	2	0.1	13.2	8.3	2.4	0.4	0.2	86	0	1	17	31	11	4	8	29	44		
D	90	115	7.4	6.1	0.0	2	0.0	4.3	2.3	0.8	0.1	0.2	78	0	3	30	43	13	2	0	9	47		

Soil Survey of Botswana FAO/BOT/85/011

Print date: 29/11/88

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: SA 0031 Unit: A09 Status: 2

SHEET : 1824A
LOCATION : 14.6 km from Kachikau to Kasinka.
AUTHOR(S): G.Baert
CLASSIFICATION FAO: Calcic Luvisol (1974) sodic phase
ST : Typic Haplustalf
LANDFORM : alluvial plain
TOPOGRAPHY: flat
SURF. CHAR: slight sealing, no cracks, nil evidence of salt,
LAND USE: no apparent management system
SPECIES : Trees - Combretum hereroense Combretum imberbe
: Shrubs -
: Grasses/forbs-
PARENT MATERIAL: alluvium
MOIST. COND: dry 0 - 50 cm
SURF.STONES: none
EROSION : nil

GRID : KK-214-863
COORD: 18-11-48-S 24-22-00-E
DATE : 05/08/86

LAND ELEMENT : not applicable
MICRO TOPOGRAPHY: even

VEGETATION: open tree savanna

ROCK TYPE:

ROCK OUTCROP: none

AGRO CLIM.ZONE: 1B1
ELEVATION :

SMR: ustic

POSITION:
SLOPE : 0 - 1 %

GRASSCOVER:

GEOL.UNIT:
DRAINAGE : imperfectly drained

HUMAN INF: nil

REMARKS: Bt2 horizon too hard to dig. Solonetz?

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

A 0 - 10 cm 10YR 3.5/1 (moist) and 10YR 3/1 (dry), sandy loam to sandy clay loam, weak medium subangular and angular blocky structure, hard, common very fine and fine and few medium pores, non calcareous, many very fine and fine roots, clear wavy boundary.

Bt1 10 - 30 cm 10YR 3/1.5 (moist) and 10YR 4/1.5 (dry), sandy clay, weak medium and coarse subangular and angular blocky structure, hard, patchy thin cutans, common very fine and fine pores, few fine soft calcareous white nodules, moderately calcareous, few termite/ant activity, common very fine and fine roots, abrupt wavy boundary.

Bt2 30 - 50 cm 10YR 6/2 (moist) and 10YR 7/1 (dry), sandy clay, strongly coherent massive structure, extremely hard, weakly cemented, few very fine and fine pores, strongly calcareous, very few very fine and fine roots,

S T A N D A R D S O I L A N A L Y S I S R E S U L T S

PROFILE: SA 0031

SAMPLE	DEPTH		pH		EC	P	C	CEC	Ca	Mg	K	Na	PBS	Particle size (weight %)								CECclay	METH	PRETR
			H2O	CaCL2	mS/cm	ppm	weight %	ù----- meq/100gr soil ------ù					%	vcS	cS	mS	fS	vfS	cSi	fSi	Clay	meq/100gr		
A	0	10	7.4	7.0	0.2	2	0.8	8.5	6.4	1.9	0.6	0.1	>100	0	0	1	49	17	4	12	17	31		
B	10	30	7.8	7.3	0.2	1	0.6	8.8	22.1	3.1	0.9	0.0	>100	0	0	1	45	15	5	9	26	25		
C	30	50	8.7	7.6	0.2	1	0.6	6.1	37.1	3.1	1.0	0.6	>100	9	10	6	20	9	5	12	29	12		

Soil Survey of Botswana FAO/BOT/85/011

Print date: 29/11/88

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: SA 0032 Unit: LA42a Status: 2

SHEET : 1824A
LOCATION : 13km from Kachikau to Sedumelela.
AUTHOR(S): G.Baert
CLASSIFICATION FAO: Mollic Gleysol (1974) sodic phase
ST : Haplaquic Haplaquoll
LANDFORM : alluvial plain
TOPOGRAPHY: flat
SURF. CHAR: no sealing, no cracks, nil evidence of salt,
LAND USE:
SPECIES : Trees -
: Shrubs -
: Grasses/forbs-
PARENT MATERIAL: fluvial reworked lacustrine
MOIST. COND: moist 0 - 135 cm
SURF.STONES: none
EROSION : nil

GRID : KK-245-942
COORD: 18-07-30-S 24-23-50-E
DATE : 05/06/86

LAND ELEMENT : not applicable
MICRO TOPOGRAPHY: uneven

VEGETATION: grassland

ROCK TYPE:

ROCK OUTCROP: none

AGRO CLIM.ZONE: 1B1
ELEVATION :

SMR: aquic

POSITION: lower part
SLOPE : 0 - %

GRASSCOVER:

GEOL.UNIT:
DRAINAGE : poorly drained

HUMAN INF: nil

REMARKS: Structure difficult to see, profile too moist, will probably give Vc prismatic when drying up. Thin layer of white sand between Bw and 2C and pockets of white sand in both h-or. In 3C layers of sand mixed with O.M., in dark layer.

SAMPLES: A: 0 - 16 B: 16 - 45 C: 45 - 75 D: 75 - 103 E: 103 - 135

A1 0 - 16 cm 10YR 2/1- (moist), loamy sand, weak fine and medium subangular blocky structure, soft, common very fine and fine pores, non calcareous, few termite/ant activity, abundant very fine and fine roots, abrupt wavy boundary.

A2 16 - 45 cm 10YR 2/1- (moist), clay loam, weak very coarse prismatic structure, soft, common very fine and fine pores, non calcareous, many very fine and fine roots, abrupt wavy boundary.

Bw 45 - 75 cm 10YR 4/1 (moist), clay, weak very coarse angular and subangular blocky structure, hard, few very fine and fine pores, non calcareous, common very fine and fine roots, abrupt wavy boundary.

2C 75 - 103 cm 10YR 3/1 (moist), sandy loam, weakly coherent massive structure, soft, few very fine and fine pores, non calcareous, very few very fine and fine roots, abrupt smooth boundary.

3C 103 - 135 cm 10YR 6/2.5 (moist), fine sand, single grain structure, loose, few very fine and fine pores, non calcareous, no roots,

S T A N D A R D S O I L A N A L Y S I S R E S U L T S

PROFILE: SA 0032

SAMPLE	DEPTH		pH		EC	P	C	CEC	Ca	Mg	K	Na	PBS	Particle size (weight %)								CECclay	METH	PRETR
			H2O	CaCL2	mS/cm	ppm	weight %	ù----- meq/100gr soil ------ù					%	vcS	cS	mS	fS	vfS	cSi	fSi	Clay	meq/100gr		
A	0	16	7.5	7.3	1.7	2	2.2	24.1	52.4	9.0	1.4	2.0	>100	1	1	1	12	5	9	57	13	115		
B	16	45	7.9	7.6	1.1	3	1.9	18.3	37.6	6.7	1.0	1.2	>100	0	0	1	19	11	14	25	30	37		
C	45	75	8.4	7.8	1.5	2	0.5	5.8	21.0	3.1	0.9	1.3	>100	0	0	1	23	15	6	17	38	10		
D	75	103	8.8	7.8	0.2	1	0.0	4.9	11.1	2.5	0.3	0.5	>100	0	0	1	28	35	15	6	14	34		
E	103	135	9.1	8.1	0.2	1	0.1	5.8	1.2	0.5	0.1	0.2	34	0	0	6	54	36	1	0	1	469		

Soil Survey of Botswana FAO/BOT/85/011 Print date: 29/11/88

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: SA 0038 Unit: A31b Status: 2

SHEET : 1824A
LOCATION : 2.4km from Mabozu to Shaile.
AUTHOR(S): G.Baert
CLASSIFICATION FAO: Eutric Gleysol (1974) sodic phase
ST : Mollic Haplaquept
LANDFORM : alluvial plain
TOPOGRAPHY: flat
SURF. CHAR: slight sealing, no cracks, nil evidence of salt,
LAND USE: traditional Molapo farming
SPECIES : Trees -
: Shrubs -
: Grasses/forbs-
PARENT MATERIAL: alluvium
MOIST. COND: dry 0 - 120 cm
SURF.STONES: none
EROSION : nil

GRID : KL-087-008
COORD: 18-03-50-S 24-14-40-E
DATE : 07/08/86

LAND ELEMENT : not applicable
MICRO TOPOGRAPHY: even

VEGETATION: grassland

ROCK TYPE:

ROCK OUTCROP: none

AGRO CLIM.ZONE: 1B1
ELEVATION :

SMR: aquic

POSITION: lower part
SLOPE : 0 - %

GRASSCOVER:

GEOL.UNIT:
DRAINAGE : imperfectly to poorly drained

HUMAN INF: nil

REMARKS:

SAMPLES: A: 0 - 16 B: 16 - 55 C: 55 - 80 D: 85 - 115

A 0 - 16 cm 10YR 2/1- (moist) and 10YR 3.5/1 (dry), sandy clay loam, weak medium and coarse subangular blocky structure, slightly hard, common very fine and fine pores, non calcareous, abundant very fine and fine roots, abrupt wavy boundary.

Bw 16 - 55 cm 10YR 3/1 (moist) and 10YR 5.5/1 (dry), clay, very weak very coarse prismatic falling apart into very weak very coarse angular and subangular blocky structure, slightly hard to hard, few very fine and fine pores, non calcareous, few termite/ant activity and few burrows, common very fine and fine roots, abrupt smooth boundary.

2C1 55 - 84 cm 10YR 3/1 (moist) and 10YR 5/1 (dry), loamy sand, strongly coherent massive structure, very hard, few very fine and fine pores, non calcareous, few burrows, few very fine and fine roots, abrupt wavy boundary.

2C2 84 - 120 cm 10YR 4/1 (moist) and 10YR 5.5/1 (dry), sandy loam to loamy sand, massive structure, hard to very hard, few very fine and fine pores, non calcareous, very few very fine roots,

S T A N D A R D S O I L A N A L Y S I S R E S U L T S

PROFILE: SA 0038

SAMPLE	DEPTH		pH		EC	P	C	CEC	Ca	Mg	K	Na	PBS	Particle size (weight %)								CECclay	METH	PRETR
			H2O	CaCL2	mS/cm	ppm	weight %	ù----- meq/100gr soil ------ù					%	vcS	cS	mS	fS	vfS	cSi	fSi	Clay	meq/100gr		
A	0	16	7.5	7.2	0.3	2	5.4	22.1	45.7	3.9	2.8	0.3	>100	2	0	1	15	5	4	52	21	2		
B	16	55	7.7	7.3	0.2	2	2.5	22.0	26.3	2.6	1.3	0.4	>100	0	0	1	20	6	7	21	45	27		
C	55	80	7.9	7.3	0.2	2	0.3	7.7	4.6	0.8	0.4	0.3	79	0	0	3	69	9	2	3	14	48		
D	85	115	8.2	7.3	0.1	1	0.0	5.7	4.5	1.2	0.4	0.3	>100	0	0	3	70	8	2	2	16	37		

Soil Survey of Botswana FAO/BOT/85/011

Print date: 29/11/88

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: SA 0039 Unit: A40 Status: 2

SHEET : 1824A
LOCATION : 6km from Mabozu to Shaile.
AUTHOR(S): G.Baert
CLASSIFICATION FAO: Eutric Arenosol (1974)
ST : Ustic Quartzipsamment
LANDFORM : alluvial plain
TOPOGRAPHY: flat
SURF. CHAR: no sealing, no cracks, nil evidence of salt,
LAND USE: no apparent management system
SPECIES : Trees - Acacia erioloba Acacia tortilis subs. heterocantha Colophospermum mopane
: Shrubs -
: Grasses/forbs-
PARENT MATERIAL: alluvium
MOIST. COND: dry 0 - 130 cm
SURF.STONES: none
EROSION : nil

GRID : KL-054-004
COORD: 18-04-00-S 24-13-05-E
DATE : 07/08/86

LAND ELEMENT : not applicable
MICRO TOPOGRAPHY: uneven

VEGETATION: open tree savanna

ROCK TYPE:

ROCK OUTCROP: none

AGRO CLIM.ZONE: 1B1
ELEVATION :

SMR: ustic

POSITION:
SLOPE : 0 - 1 %

GRASSCOVER:

GEOL.UNIT:
DRAINAGE : well drained

HUMAN INF: nil

REMARKS:

SAMPLES: A: 0 - 16 B: 16 - 43 C: 45 - 80 D: 90 - 120

A 0 - 16 cm 10YR 3/2 (moist) and 10YR 3/1.5 (dry), fine sand, very weak medium and coarse subangular blocky structure, loose, common very fine and fine pores, non calcareous, many very fine and fine roots, clear smooth boundary.

C1 16 - 43 cm 10YR 4/2 (moist) and 10YR 5/1.5 (dry), fine sand, single grain structure, loose, few very fine and fine pores, non calcareous, common very fine and fine roots, gradual smooth boundary.

C2 43 - 80 cm 10YR 5/2 (moist) and 10YR 6/1 (dry), fine sand, single grain structure, loose, few very fine and fine pores, non calcareous, few burrows, few very fine and fine roots, diffuse smooth boundary.

C3 80 - 130 cm 10YR 6/2 (moist) and 10YR 7/1 (dry), fine sand, single grain structure, loose, few very fine and fine pores, non calcareous, few burrows, few very fine and fine roots,

S T A N D A R D S O I L A N A L Y S I S R E S U L T S

PROFILE: SA 0039

SAMPLE	DEPTH		pH		EC	P	C	CEC	Ca	Mg	K	Na	PBS	Particle size (weight %)								CECclay	METH	PRETR
			H2O	CaCL2	mS/cm	ppm	weight %	ù----- meq/100gr soil ------ù					%	vcS	cS	mS	fS	vfS	cSi	fSi	Clay	meq/100gr		
A	0	16	6.6	5.8	0.0	2	0.3	2.1	1.3	0.5	0.2	0.0	98	0	0	6	71	13	2	2	6	14		
B	16	43	6.6	6.0	0.0	2	0.1	1.8	1.4	0.5	0.2	0.1	>100	0	0	7	73	12	2	0	6	27		
C	45	80	6.7	6.4	0.0	2	0.0	1.9	1.0	0.5	0.2	0.1	95	0	0	7	71	13	2	2	4	42		
D	90	120	6.7	6.4	0.0	2	0.0	1.0	0.7	0.3	0.1	0.0	>100	0	0	7	72	13	2	2	3	29		

Soil Survey of Botswana FAO/BOT/85/011

Print date: 29/11/88

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: SA 0040 Unit: A05 Status: 2

SHEET : 1824A
LOCATION : 10km from Mabozu to Shaile.
AUTHOR(S): G.Baert
CLASSIFICATION FAO: Gleyic Solonetz (1974) sodic phase
ST : Typic Natraqualf
LANDFORM : plain
TOPOGRAPHY: flat
SURF. CHAR: slight sealing, no cracks, nil evidence of salt,
LAND USE: no apparent management system
SPECIES : Trees - Colophospermum mopane (dom.)
: Shrubs -
: Grasses/forbs-
PARENT MATERIAL: alluvium
MOIST. COND: dry 0 - 120 cm
SURF.STONES: none
EROSION : nil

GRID : KK-010-997
COORD: 18-04-20-S 24-10-30-E
DATE : 07/08/86

LAND ELEMENT : not applicable
MICRO TOPOGRAPHY: even

VEGETATION: woodland

ROCK TYPE:

ROCK OUTCROP: none

AGRO CLIM.ZONE: 1B1
ELEVATION :

SMR: aquic

POSITION: lower part
SLOPE : 0 - %

GRASSCOVER:

GEOL.UNIT:
DRAINAGE : imperfectly drained

HUMAN INF: nil

REMARKS:

SAMPLES: A: 0 - 15 B: 15 - 45 C: 50 - 85 D: 95 - 120

A 0 - 15 cm 10YR 3/1 (moist) and 10YR 4/1 (dry), fine sand, very weak very coarse subangular blocky structure, slightly hard, common very fine and fine pores, non calcareous, common very fine and fine roots, abrupt wavy boundary.

Btn 15 - 45 cm 10YR 5/1.5 (moist) and 10YR 6/1 (dry), sandy loam, very weak very coarse prismatic structure, very hard, patchy thin cutans, common very fine and fine pores, non calcareous, few very fine and fine roots, clear wavy boundary.

Btkn 45 - 90 cm 10YR 4/2 (moist) and 10YR 5/2 (dry), sandy clay loam, massive structure, slightly hard to hard, common very fine and fine pores, few fine hard and soft calcareous white nodules, non calcareous, few very fine and fine roots, gradual smooth boundary.

Ckn 90 - 120 cm 10YR 5/2 (moist) and 10YR 5/1.5 (dry), sandy clay loam, massive structure, slightly hard, many very fine and fine pores, frequent fine hard and soft calcareous white nodules, strongly calcareous, very few very fine and fine roots,

S T A N D A R D S O I L A N A L Y S I S R E S U L T S

PROFILE: SA 0040

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	15	6.4	5.3	0.0	3	0.3	2.7	1.5	0.5	0.3	0.2	91	0	0	7	72	13	3	2	3	60		
B	15	45	8.5	7.1	0.1	2	0.1	7.7	3.4	1.1	0.6	2.3	97	0	0	8	57	12	3	3	16	45		
C	50	85	9.5	8.1	0.4	2	0.0	12.0	8.8	1.3	0.9	9.2	>100	0	1	9	52	10	3	3	22	54		
D	95	120	10.5	10.1	1.8	3	0.0	16.1	8.0	0.6	1.5	19.5	>100	0	1	6	41	10	5	7	31	52		

Soil Survey of Botswana FAO/BOT/85/011

Print date: 29/11/88

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: SA 0042 Unit: A19 Status: 2

SHEET : 1824A
LOCATION : 9km from Kachikau to Gcoha hills.
AUTHOR(S): G.Baert
CLASSIFICATION FAO: Ferralic Arenosol (1974)
ST : Ustic Quartzipsamment
LANDFORM : valley
TOPOGRAPHY:
SURF. CHAR: no sealing, no cracks, nil evidence of salt,
LAND USE: no apparent management system
SPECIES : Trees -
: Shrubs - Terminalia sericea Grewia flava Baikiaea plurijuga
: Grasses/forbs-
PARENT MATERIAL: alluvium
MOIST. COND: dry 0 - 130 cm
SURF.STONES: none
EROSION : nil

GRID : KK-288-862
COORD: 18-11-55-S 24-26-05-E
DATE : 07/08/86

LAND ELEMENT : valley floor
MICRO TOPOGRAPHY: even

VEGETATION: dense shrub savanna

ROCK TYPE:

ROCK OUTCROP: none

AGRO CLIM.ZONE: 1B1
ELEVATION :

SMR: ustic

POSITION:
SLOPE : 0 - 0.5%

GRASSCOVER:

GEOL.UNIT:
DRAINAGE : well drained

HUMAN INF: nil

REMARKS:

SAMPLES: A: 0 - 25 B: 30 - 55 C: 80 - 110

A 0 - 25 cm 7.5Y 3/4 (moist) and 7.5Y 4/4 (dry), fine sand, very weak medium and coarse subangular blocky structure, soft, few very fine and fine pores, non calcareous, many very fine and fine roots, gradual smooth boundary.

C1 25 - 60 cm 7.5Y 4/4 (moist) and 7.5Y 5/4 (dry), fine sand, weakly coherent massive structure, soft, few very fine and fine pores, non calcareous, common very fine and fine roots, diffuse smooth boundary.

C2 60 - 130 cm 6YR 4/6 (moist) and 6YR 5/6 (dry), fine sand, weakly coherent massive structure, soft, few very fine and fine pores, non calcareous, few fine and medium roots,

S T A N D A R D S O I L A N A L Y S I S R E S U L T S

PROFILE: SA 0042

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	25	5.8	4.9	0.1	2	0.4	3.0	1.4	0.7	0.2	0.2	84	0	4	36	44	9	1	0	6	26		
B	30	55	4.9	3.8	0.0	2	0.1	3.0	0.8	0.6	0.1	0.2	56	0	4	34	47	9	1	0	6	40		
C	80	110	4.7	3.7	0.0	2	0.0	3.4	0.6	0.7	0.2	0.3	53	0	6	37	42	7	1	0	7	49		

Soil Survey of Botswana FAO/BOT/85/011

Print date: 29/11/88

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: SA 0045 Unit: KS03 Status: 2

SHEET : 1824A
LOCATION : 8km from Gcoha hills to Kachikau.
AUTHOR(S): G.Baert
CLASSIFICATION FAO: Ferralic Arenosol (1974)
ST : Ustic Quartzipsamment
LANDFORM : sand plain
TOPOGRAPHY: flat
SURF. CHAR: no sealing, no cracks, nil evidence of salt,
LAND USE: no apparent management system
SPECIES : Trees -
: Shrubs - Terminalia sericea (dom.) Grewia flava Burkea africana Baikiaea plurijuga
: Grasses/forbs-
PARENT MATERIAL: aeolian sand
MOIST. COND: dry 0 - 130 cm
SURF.STONES: none
EROSION : nil

GRID : KK-103-672
COORD: 18-22-05-S 24-15-30-E
DATE : 08/08/86

LAND ELEMENT : not applicable
MICRO TOPOGRAPHY: even

VEGETATION: dense shrub savanna

ROCK TYPE:

ROCK OUTCROP: none

AGRO CLIM.ZONE: 1B1
ELEVATION :

SMR: ustic

POSITION:
SLOPE : 0 - 1 %

GRASSCOVER:

GEOL.UNIT:
DRAINAGE : somewhat excessively drained

HUMAN INF: nil

REMARKS: Area flat compared with SA 44.

SAMPLES: A: 0 - 20 B: 25 - 45 C: 60 - 85 D: 95 - 120

A 0 - 20 cm 10YR 4.5/3 (moist) and 10YR 5.5/3 (dry), fine sand, very weak medium subangular blocky structure, soft, common very fine and fine pores, non calcareous, many very fine and fine roots, gradual smooth boundary.

C1 20 - 53 cm 10YR 5/4 (moist) and 10YR 6/4 (dry), fine sand, weakly coherent massive structure, soft, few very fine and fine pores, non calcareous, common fine and medium roots, gradual smooth boundary.

C2 53 - 90 cm 10YR 5/6 (moist) and 10YR 6/6 (dry), fine sand, weakly coherent massive structure, soft, common very fine and fine pores, non calcareous, common fine and medium roots, diffuse smooth boundary.

C3 90 - 130 cm 10YR 5/6 (moist) and 10YR 6/7 (dry), fine sand, weakly coherent massive structure, soft, common very fine and fine pores, non calcareous, few fine and medium roots,

S T A N D A R D S O I L A N A L Y S I S R E S U L T S

PROFILE: SA 0045

SAMPLE	DEPTH		pH		EC	P	C	CEC	Ca	Mg	K	Na	PBS	Particle size (weight %)								CECclay	METH	PRETR
			H2O	CaCL2	mS/cm	ppm	weight %	ù----- meq/100gr soil -------ù					%	vcS	cS	mS	fS	vfS	cSi	fSi	Clay	meq/100gr		
A	0	20	4.9	3.8	0.0	3	0.2	1.5	0.2	0.1	0.1	0.0	26	0	3	35	49	8	1	0	4	13		
B	25	45	4.7	3.7	0.0	2	0.0	1.3	0.1	0.1	0.1	0.0	24	0	4	38	45	8	1	0	4	29		
C	60	85	4.5	3.6	0.0	2	0.1	1.3	0.1	0.1	0.1	0.0	23	0	3	31	51	10	1	0	6	19		
D	95	120	4.5	3.5	0.0	2	0.0	1.5	0.2	0.1	0.1	0.0	27	0	3	31	48	11	1	1	5	25		

Soil Survey of Botswana FAO/BOT/85/011 Print date: 08/03/89

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 CLASSES OF SELECTED SOIL PROFILES FOR LARGE SCALE IRRIGATED AGRICULTURE AND TRADITIONAL MOLAPO FARMING.

Table 3

LAND SUITABILITY CLASSIFICATION SHEET

SOIL SURVEY BOTSWANA BOT/80/003

location: Chobe Enclave

sheet: 1824A date: 02/03/87

agro-climatic zone: 1b.1

mapping unit: (L)A42-42a

author: G. Baert

site characteristics: low areas, channel complex

remarks: more regularly flooded not accessible for long periods after very high floods

			LAND USE TYPE: large sc. irrig.			LAND USE TYPE: tradit molapo		LAND USE TYPE:
LAND QUALITY	CDE	RTNG	crop Sorg	Maize		Sorg.	Maize	
accessibility	a	1	S1	S1		S1	S1	
correct temp. regime	c	1	S1	S1		S1	S1	
soil drainability	d	4	N2	N2		N/A	N/A	
resistance to erosion	e	1-2	S1/2	S1/2		S1/2	S1/2	
absence of damaging floods	f	1	S1	S1		S1	S1	
conditions of germination	g	1	S1	S1		S1	S1	
moisture availability	m	1	N/A	N/A		S1	S1	
nutrient availability	n	2	S2	S2		S2	S2	
oxygen availability	o	3	S3	S3/4		S2	S3	
absence of pests	p	?	-	-		-	-	
availability of water of good quality	q	1	S1	S1	assum	N/A	N/A	
foothold for roots	r	1	S1	S1		S1	S1	
absence of toxic substances	t	1-2	S1/2	S2		S1/2	S2	
workability	w	2	S2	S2		S1	S1	
adequacy of topography	x_I x_{II} x_{II}	N/A 3 N/A	- S3	- S3		- N/A	- N/A	
adequacy of flooding	y	N/A	farmers follow the recession of the floods					
land drainability	z	N/A						
CURRENT LAND SUITABILITY		N2	N2	N2		S2o	S3o	

RECOMMENDED IMPROVEMENTS

Due to low position, flood protection not possible in years of very high floods. Avoid very wet areas for traditional molapo farming. Somewhat higher areas in channel complex have a slightly better oxygen availability

POTENTIAL LAND SUITABILITY	N2	N2		S2o	S3o	

Table 4

LAND SUITABILITY CLASSIFICATION SHEET

location: Chobe Enclave

agro-climatic zone: 1b.1

author: G. Baert

remarks: more regularly flooded slight accumulation of salts

SOIL SURVEY BOTSWANA BOT/80/003

sheet: 1824A date: 02/03/87

mapping unit: LA42b, L38b

site characteristics: low areas, few channels

			LAND USE TYPE: large sc. irrig.			LAND USE TYPE: tradit molapo		LAND USE TYPE:
LAND QUALITY	CDE	RTNG	crop Sorg	Maize		crop Sorg.	Maize	
accessibility	a	1	S1	S1		S1	S1	
correct temp. regime	c	1	S1	S1		S1	S1	
soil drainability	d	4	N2	N2		N/A	N/A	
resistance to erosion	e	1-2	S1/2	S1/2		S1/2	S1/2	
absence of damaging floods	f	1	S1	S1		S1	S1	
conditions of germination	g	1	S1	S1		S1	S1	
moisture availability	m	1	N/A	N/A		S1	S1	
nutrient availability	n	2	S2	S2		S2	S2	
oxygen availability	o	3	S3	S3/4		S2	S3	
absence of pests	p	?	-	-		-	-	
availability of water of good quality	q	1	S1	S1	assum	N/A	N/A	
foothold for roots	r	1	S1	S1		S1	S1	
absence of toxic substances	t	2-3	S2/3	S3		S2/3	S3	
workability	w	2	S2	S2		S1	S1	
adequacy of topography	x_I	no data						
	x_{II}	no data						
	x_{II}	N/A	-	-		-	-	
adequacy of flooding	y	no data						
land drainability	z	N/A	-	-				
CURRENT LAND SUITABILITY		N2	N2	N2		S2o	S3o	

RECOMMENDED IMPROVEMENTS

Due to low position, flood protection not possible in years of very high floods. Avoid very wet areas for traditional molapo farming. Somewhat higher areas in channel complex have a slightly better oxygen availability

POTENTIAL LAND SUITABILITY	N2	N2		S2/3t	S3ot	

Table 5

LAND SUITABILITY CLASSIFICATION SHEET — SOIL SURVEY BOTSWANA BOT/80/003

location: **Chobe Enclave** — sheet: **1824A** — **date:02/03/87**

agro-climatic zone: 1b.1 — mapping unit: **L43a**

author: **G. Baert** — site characteristics: **intermediate position, many anthills.**

remarks: **hard massive layer in subsoil. Area very seldom flooded but may be subjected to shallow groundwater**

			LAND USE TYPE: large sc. irrig.			LAND USE TYPE: tradit molapo		LAND USE TYPE:
LAND QUALITY	CDE	RTNG	crop Sorg	Maize		crop Sorg.	Maize	
accessibility	a	1	S1	S1				
correct temp. regime	c	1	S1	S1				
soil drainability	d	4	S4/N	S4/N	when very high floods			
resistance to erosion	e	2-3	S2/3	S2/3				
absence of damaging floods	f	1	S1	S1				
conditions of germination	g	1	S1	S1				
moisture availability	m	N/A	-	-				
nutrient availability	n	3	S3	S3				
oxygen availability	o	4	S3	S4	when very high floods			
absence of pests	p	?	-	-				
availability of water of good quality	q	1	S1	S1	assumed			
foothold for roots	r	1	S1	S1				
absence of toxic substances	t	1-2	S1/2	S2				
workability	w	1	S1	S1				
adequacy of topography	x_I	N/A	-	-				
	x_{II}	2	S2	S2	many anthills			
	x_{II}	N/A	-	-		-	-	
adequacy of flooding	y	N/A	-	-				
land drainability	z	N/A	-	-				
CURRENT LAND SUITABILITY			S4/N	S4/N				

RECOMMENDED IMPROVEMENTS

When flooded, practically impossible to drain. After very high flood, watertable remains high for a considerable period. Drainage only possible by pumping. Area remains very marginally suitable. Fertility is very low. Soil needs high fertilizer imputs.

POTENTIAL LAND SUITABILITY	S3dn	S4do				

Table 6

LAND SUITABILITY CLASSIFICATION SHEET — SOIL SURVEY BOTSWANA BOT/80/003

location: Chobe Enclave — sheet: 1824A — date: 02/03/87

agro-climatic zone: 1b.1 — mapping unit: L11b

author: G. Baert — site characteristics: intermediate position, many anthills.

remarks: sand throughout very high pH in subsoil.

			LAND USE TYPE: large sc. irrig.			LAND USE TYPE: tradit molapo		LAND USE TYPE:
			crop			crop		
LAND QUALITY	CDE	RTNG	Sorg	Maize		Sorg.	Maize	
accessibility	a	1	S1	S1				
correct temp. regime	c	1	S1	S1				
soil drainability	d	4	S4/N	S4/N	when very high floods			
resistance to erosion	e	2-3	S2/3	S2/3				
absence of damaging floods	f	1	S1	S1				
conditions of germination	g	1	S1	S1				
moisture availability	m	N/A	-	-				
nutrient availability	n	3	S3	S3				
oxygen availability	o	4	S3	S4	when very high floods			
absence of pests	p	7	-	-				
availability of water of good quality	q	1	S1	S1	assumed			
foothold for roots	r	1	S1	S1				
absence of toxic substances	t	2	S2	S2/3				
workability	w	1	S1	S1				
adequacy of topography	x_I	N/A	-	-				
	x_{II}	2	S2	S2	many anthills			
	x_{II}	N/A	-	-				
adequacy of flooding	y	N/A	-	-				
land drainability	z	N/A	-	-				
CURRENT LAND SUITABILITY			S4/N	S4/N				

RECOMMENDED IMPROVEMENTS

Same remarks as L43a. Very low suitability based on years with very high floods.

POTENTIAL LAND SUITABILITY	S3dn	S4do				

Table 7

LAND SUITABILITY CLASSIFICATION SHEET — **SOIL SURVEY BOTSWANA BOT/80/003**

location: Chobe Enclave — **sheet:** 1824A — **date:** 03/03/87

agro-climatic zone: 1b.1 — **mapping unit:** L38a

author: G. Baert — **site characteristics:** transition from intermediate position to low areas (LA42-42a). No or less anthills than L43a and L11

remarks: heavy topsoil sandy subsoil with very high pH

			LAND USE TYPE: large sc. irrig.			LAND USE TYPE: tradit molapo		LAND USE TYPE:
LAND QUALITY	CDE	RTNG	crop Sorg	Maize		crop Sorg.	Maize	
accessibility	a	1	S1	S1		S1	S1	
correct temp. regime	c	1	S1	S1		S1	S1	
soil drainability	d	4	N2	N2		N/A	N/A	
resistance to erosion	e	1-2	S1/2	S1/2		S1/2	S1/2	
absence of damaging floods	f	1	S1	S1		S1	S1	
conditions of germination	g	1	S1	S1		S1	S1	
moisture availability	m	2	N/A	N/A		S1	S2	
nutrient availability	n	2	S2	S2		S2	S2	
oxygen availability	o	3	S3	S3/4		S2	S3	
absence of pests	p	?	-	-		-	-	
availability of water of good quality	q	1	S1	S1	assum	N/A	N/A	
foothold for roots	r	1	S1	S1		S1	S1	
absence of toxic substances	t	1-2	S1/2	S2		S1/2	S2	
workability	w	2	S2	S2		S1	S1	
adequacy of topography	x_I x_{II} x_{II}	N/A 3 N/A	S3 -	S3 -		N/A -	N/a -	
adequacy of flooding	y	N/A	-	-		no data		
land drainability	z	N/A	-	-				
CURRENT LAND SUITABILITY		N2	N2	N2		S2ot	S3o	

RECOMMENDED IMPROVEMENTS

These soils are more flooded than L43a and L11. With recession of the flood, these soils are the first to be cultivated (molapo frg)

POTENTIAL LAND SUITABILITY	N2	N2		S2ot	S3o	

Table 8

LAND SUITABILITY CLASSIFICATION SHEET — SOIL SURVEY BOTSWANA BOT/80/003

location: Chobe Enclave — sheet: 1824A — date: 03/03/87

agro-climatic zone: 1b.1 — mapping unit: A40-40a

author: G. Baert — site characteristics: slightly undulating

remarks: loose sand, high infiltration rate. Very low AWHC.

			LAND USE TYPE: large sc. irrig.			LAND USE TYPE: tradit molapo		LAND USE TYPE:
			crop			crop		
LAND QUALITY	CDE	RTNG	Sorg	Maize		Sorg.	Maize	
accessibility	a	1	S1	S1				
correct temp. regime	c	1	S1	S1				
soil drainability	d	1	S1	S1				
resistance to erosion	e	2-3	S2/3	S2/3				
absence of damaging floods	f	1	S1	S1				
conditions of germination	g	1	S1	S1				
moisture availability	m	N/A	-	-				
nutrient availability	n	3-4	S3/4	S3/4				
oxygen availability	o	1	S1	S1				
absence of pests	p	?	-	-				
availability of water of good quality	q	1	S1	S1	assumed			
foothold for roots	r	1	S1	S1				
absence of toxic substances	t	1	S1	S1				
workability	w	1	S1	S1				
adequacy of topography	x_I	N/A	-	-				
	x_{II}	N/A	-	-				
	x_{II}	N/A	-	-				
adequacy of flooding	y	N/A	-	-				
land drainability	z	N/A	-	-				
CURRENT LAND SUITABILITY			S3/4n	S3/4n				

RECOMMENDED IMPROVEMENTS

High fertilizer applications.

POTENTIAL LAND SUITABILITY	S2/3n	S2/3n				

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