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Notes on Terrace Soils of the Kavango River, Northern SWA/Namibia

(8 Photographs, 1 Table, 4 Maps)

Zusammenfassung

Verschiedene Flußterrassen des Okavangoflusses im Norden SWA/Namibias konnten aufgrund aeolischer Sandablagerungen und fluviatiler Schüttungen im Bereich der Überschwemmungsflächen unterschieden werden.

Mit Hilfe einer bodenkundlichen Kartierung der Flußterrassen des Okavangoflusses wurden entsprechend der südafrikanischen Bodenkartieranleitung westlich und östlich von Rundu Böden der Clovelly-, Oakleaf- und Hutton Form identifiziert und mit den international gebräuchlichsten Bodenklassifikationssystemen korreliert.

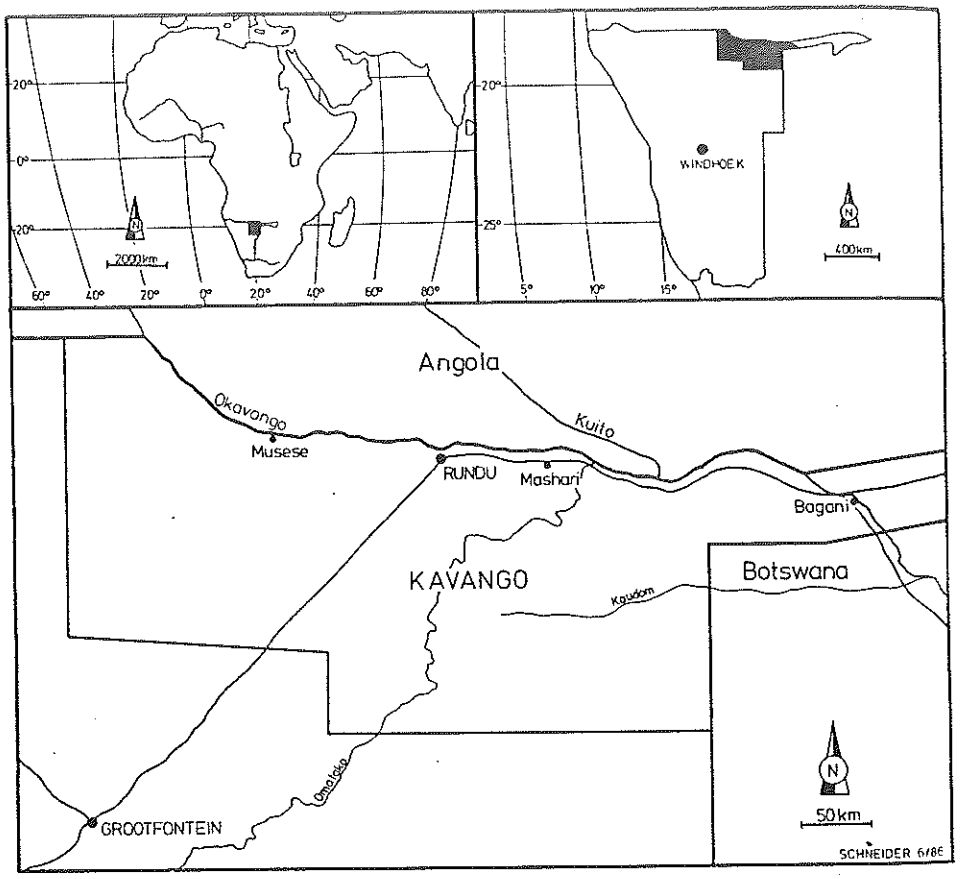
Charakteristische Merkmale arider Bodenbildung konnten in drei Bodenprofilen festgestellt werden. Die pH Werte liegen in der Mehrzahl über 7,0. Die mineralogischen Auswertungen ergaben, daß Kaolinit und Montmorillonit als Tonminerale dominieren. Die Humusgehalte der verschiedenen Bodenhorizonte sind wegen der spärlichen Vegetation gering. Die Texturanalysen ermöglichten eine weitere Einteilung der drei Bodenformen in dreizehn Bodenserien. Die chemischen Laboranalysen ergaben sehr geringe Werte an austauschbaren Kationen (Ca, Mg, Na, K). Dies ist u.a. auch auf die Auswaschungsprozesse des stark meandrierenden Okavangoflusses während der Regenzeit zurückzuführen.

1. Physical Environment

The Kavango region, situated in north-eastern SWA/Namibia between longitudes 18° and 22° E and latitudes 17°20' and 19°10' S, occupies an area of almost 46 000 km² (Map 1).

The Kavango region lies within the tropical summer rainfall zone. The climatic conditions are classified as semi-arid warm, with a moisture deficiency in all seasons. There is a single rainy season that lasts from October to April. The mean annual rainfall is 625 mm, the mean annual temperature is 22,4°C and the mean annual gross Class A pan evaporation rate is almost 2600 mm. Generally the amount of rainfall is never greater than the absorption capacity of the soil and therefore the area lacks small permanent streams (SOINI, 1981: 171-172; GIBSON *et al.* 1981: 12-13 and WATTS, 1980: 661-662).

Geologically most of the Kavango is underlain by superficial Cenozoic deposits of the Kalahari Group. Older rocks (greyish quartzite of the Damara Sequence) are exposed only near Andara in the eastern part of the Kavango. In general, the Kalahari



Map 1: Geographical location

Group consists of light coloured sands, chalcedonic limestones, silicified sandstones and ochreous sands, the last mentioned forming the Kalahari Sandveld in SWA/Namibia, Botswana, Angola and Zambia (HAMILTON & COOKE, 1960). The Kalahari sands appear to be primarily of Pliocene age that were subsequently redistributed during the Quaternary. Calcrete-like materials occur along the riverbank and at shallow depths in the terraces associated with the Okavango River (NETTERBERG, 1982: 160). The sand layers are tens of meters deep and pre-Kalahari rocks suboutcrop at depths of over 200 m (SOINI, 1981: 172).

Aeolian sand and water-deposited gravel are dominant in the soil body. The relatively sterile sandy soils of the Kavango are enriched by silt, deposited by the Okavango River, in both the river terraces and on the flood plain.

The Okavango River, which is the largest perennial river in SWA/Namibia may rise as much as 4,6 m in flood stage. Even in periods of extended drought the river does

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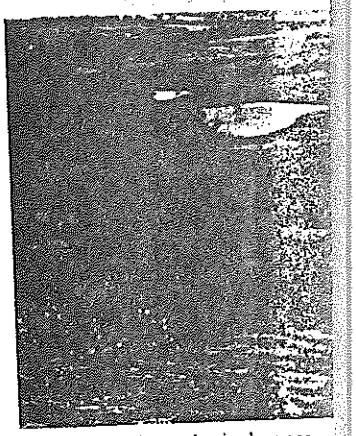

Photo 1: Main ecological zones

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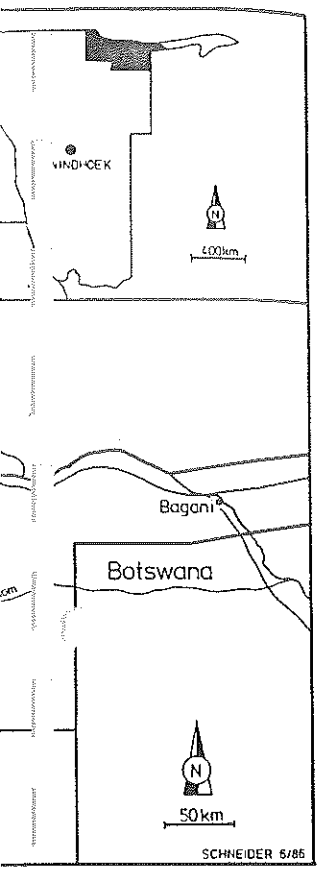

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not cease to flow. The flood plain is partly under water during the rainy season and as the water level drops, various ponds and lakes remain (Photo 1).

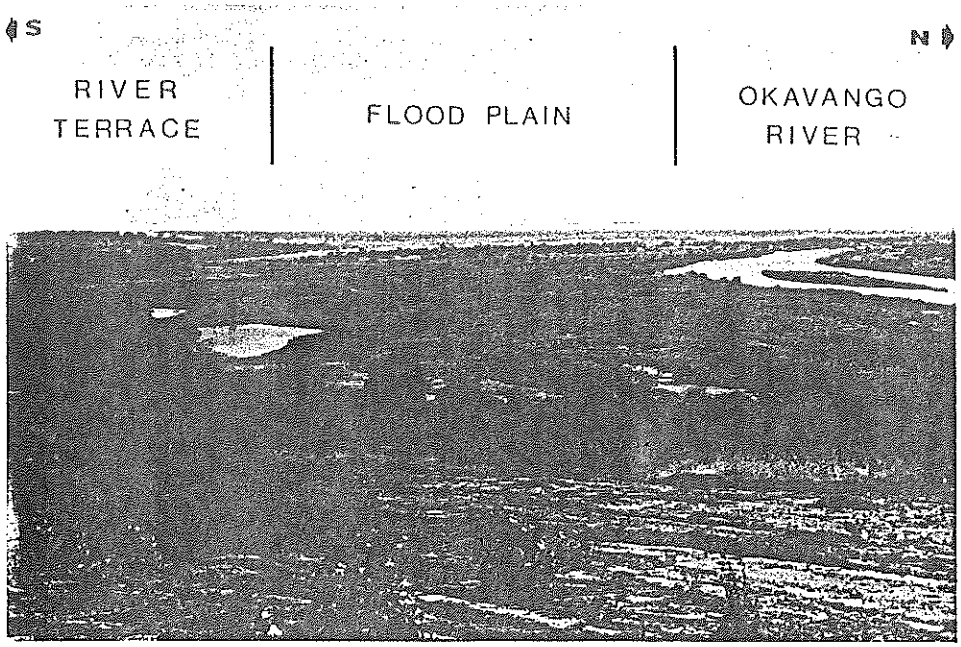

Photo 1: Main ecological zones

Two physiographical regions are dominant in the Kavango. They are the terrace system of the Okavango River and the inland sand plateau. The riverine landform consists of a flood plain, showing evidence of a braided river system, and a terrace, situated 6-7 m above the river bed and covered by alluvial deposits. On the sand-covered plateau, the relief is flat to gently undulating in regions where low, linear dunes occur. Intervening troughs (*omiramba*) and parallel low dune systems are the dominant feature in the central and southern parts of the Kavango area. This area is crossed by the Omatako Omuramba, the largest tributary of the Okavango River in this region. As is the case with all other tributaries too, the valley of the Omatako Omuramba is very steeply incised and free of terrace deposits. The surrounding country does not slope gradually towards the Omuramba.

Each of the ecological zones — river, flood plain, the terrace system of the Okavango River Valley and the aeolian sand plateau — has a characteristic vegetation type. Generally, the Okavango River Valley hosts a medium to tall open riparian woodland. The main tree species of these zones are Rhodesian teak *(Baikiaea plurijuga),* Dolfwood (*Pterocarpus angolensis),* Chivi (*Guibourtia coleosperma),* Yellowwood (*Terminalia sericea)* and various types of Acacia such as the Camelthorn (*Acacia erioloba*). Herbs and grasses (e.g. *Eragrostis spp.*) are spreaded intensively, despite the overgrazing in the inhabited areas along the Okavango River.

Farming activities are restricted to areas adjacent to the Okavango River, where sorghum and mahangu (*Pennisetum americanum*), a kind of pearl millet, are the main crops of several indigenous peoples in the Kavango region (Photo 2 and 3).

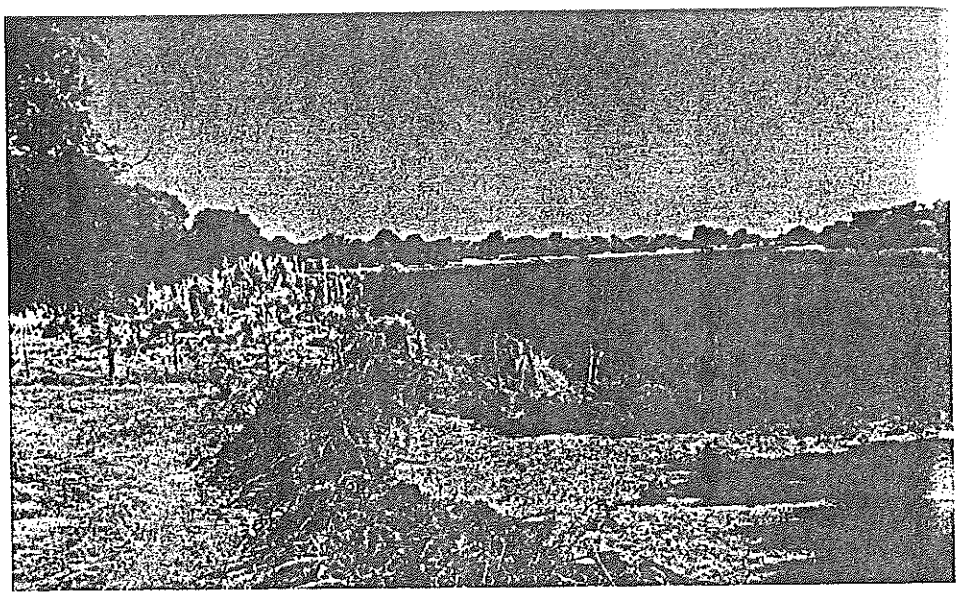

Photo 2: Soil utilization on the river terrace

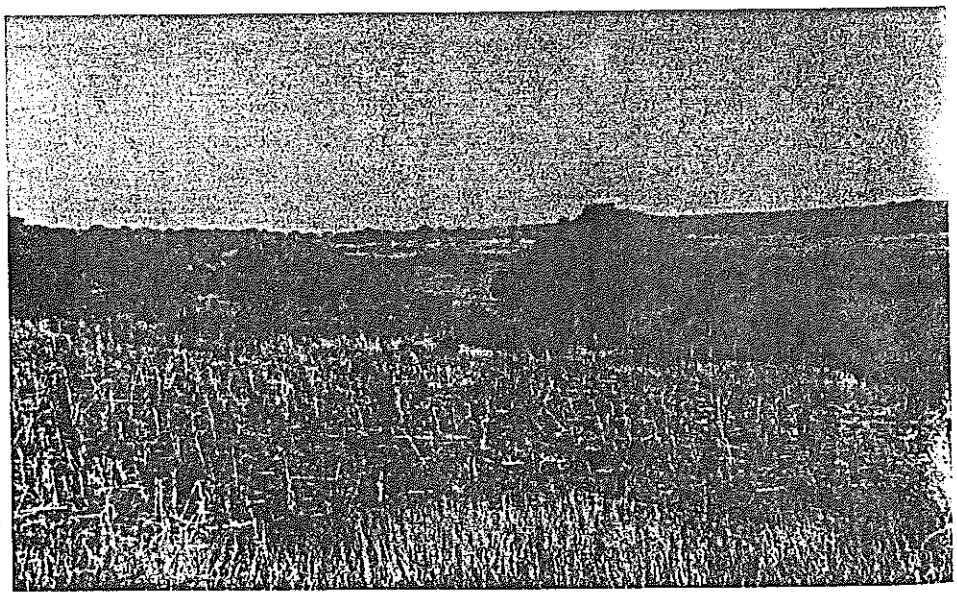

Photo 3: Soil utilization on the river terrace

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2.1 Clovelly Form Soils

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Depth of horizons A
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B2 6
B3 9

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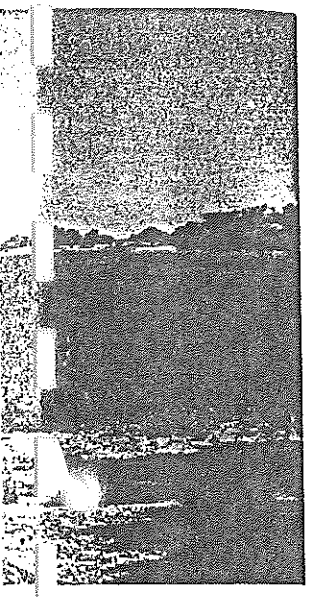
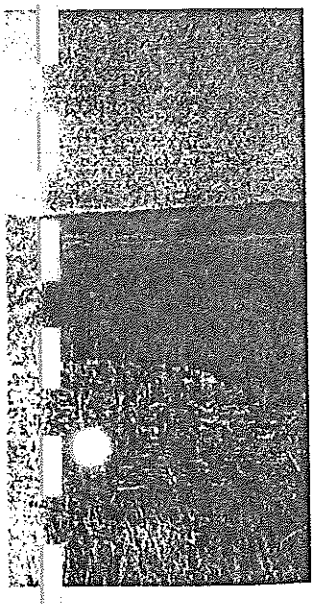




2. General description of the Soils

A soil reconnaissance survey, to evaluate the irrigation potential of soils on the terraces of the Okavango River, was carried out during 1985 and 1986. This was a preliminary study that concentrated initially on the terraces of the Okavango River System (Map 2). The South African Soil Classification System — *Binomial System* — (MACVICAR *et al.* 1977) was used in the survey and the soil colour is described according to Munsell notations (MUNSELL COLOR COMPANY, 1971). The colour is given in terms of a verbal description (e.g. yellowish brown). The Munsell colour system specifies the degrees of the three simple variables of colour: Hue, value and chroma. During the present soil survey, three Soil Forms were identified to be of major importance in the area (Map 2); namely Clovelly, Oakleaf and Hutton Forms (Map 3 and 4). Each Soil Form was subdivided into Soil Series of which 13 were identified.

2.1 Clovelly Form Soils

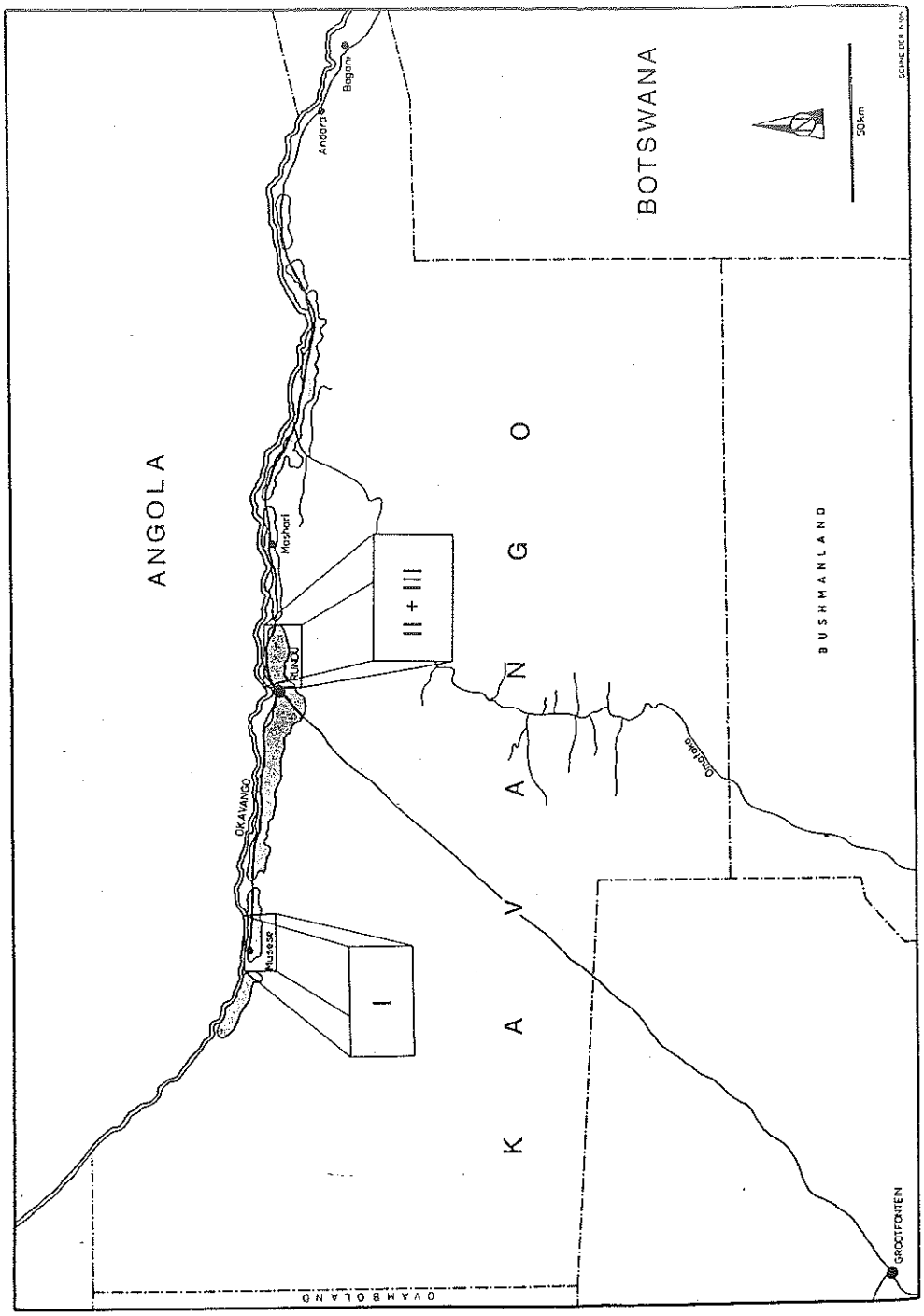
The Clovelly Form Soils generally consist of an orthic A-horizon (a specific surface soil horizon, consisting of features such as: High organic carbon content, thickness, dark colour, strongly developed structure and expansive properties) on top of a yellowish brown (10YR 5/4) apedal B-horizon (the term 'apedal' is generally used for soil material which is well aggregated, although a well formed unit of soil structure can not be detected macroscopically). Clovelly Form Soils are by far the most common soils in the Kavango and occur extensively to the west and east of Rundu. A typical Clovelly profile was described 5 km east of Rundu (Map 4). In this case it was identified as a **Clovelly Sunbury** which occurs on an upper terrace position.

A typical feature of the yellowish brown (10YR 5/4) apedal B-horizon of the Clovelly Form Soils, is that the soil material, although coherent, is macroscopically structureless. This typical feature is related to weathering in a well-drained oxidizing environment that results in coatings of iron oxides on individual soil particles and clay mineral suites in which non-swelling 1:1 and 2:1 layer clays e.g., illite, kaolinite and montmorillonite are predominant.

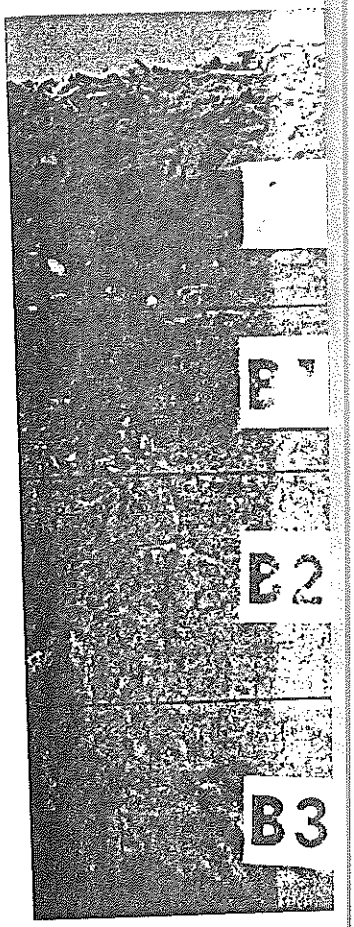
Profile description

The A-horizon was a brown to dark brown (10YR 4/3) sand, well aggregated and slightly hard in structure. The B1, B2 and B3 horizons were also brown to dark brown (10YR 4/3 and 10YR 3/3), the structure of the sand was slightly hard and rare fine fossil $CaCO_3$ nodules and white sand infillings occured in termite passages; the permeability of all three horizons was very high and the transition gradual (Photo 4).

Depth of horizons	A	0 - 35 cm
	B1	35 - 60 cm
	B2	60 – 95 cm
	B3	95 +



Map 2: Survey areas in the Kavango (hatched areas indicate developed soils).



2.2 Oakleaf Form Soils

Clovelly Form Soils are as
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An **Oakleaf Levubu**, in w
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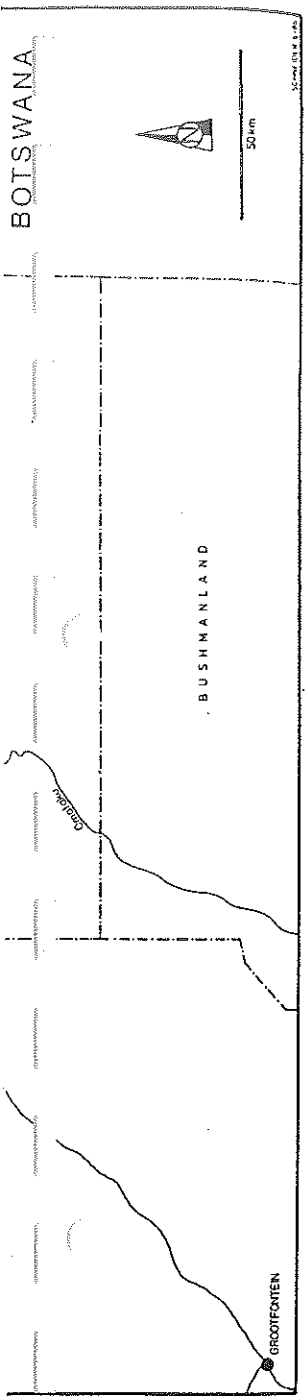

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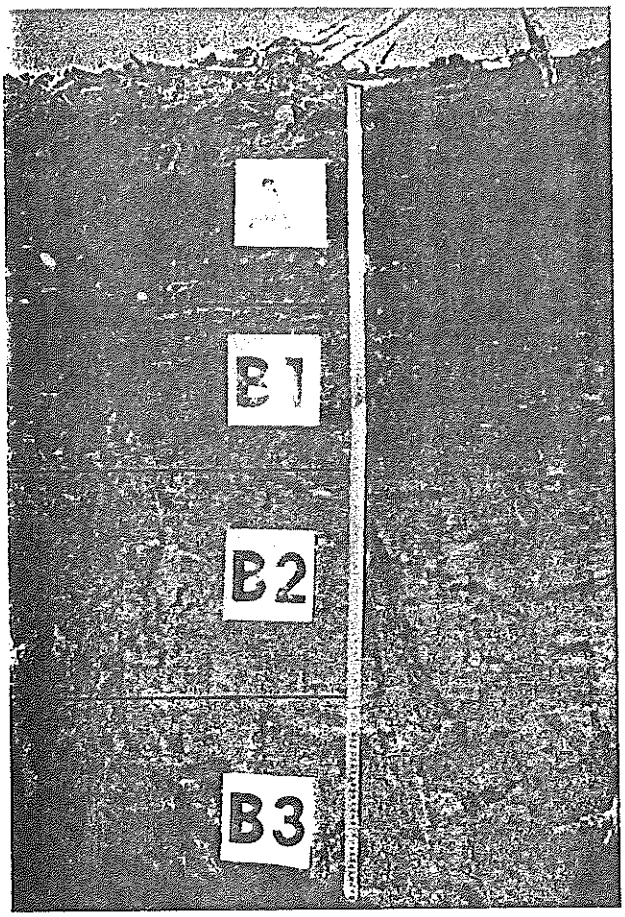


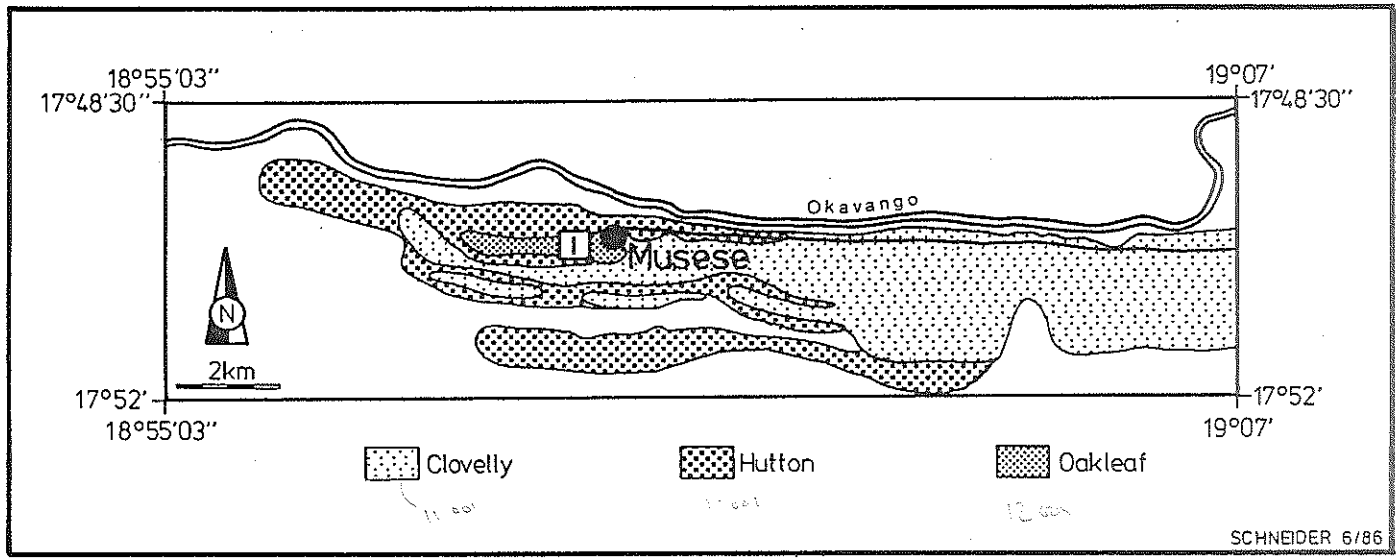
Photo 4: Soil profile: Clovelly Sunbury

2.2 Oakleaf Form Soils

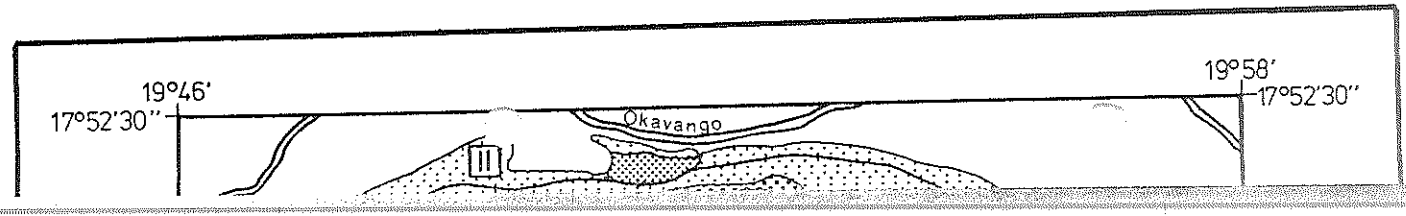
Clovelly Form Soils are associated closely with series of the Oakleaf Form, of which a representative profile was described near Musese in the western part of the Kavango (Map 3). The soil was developed on an upper to middle terrace position and was particularly common adjacent to a dry river bed cutting through the terrace.

Profile description

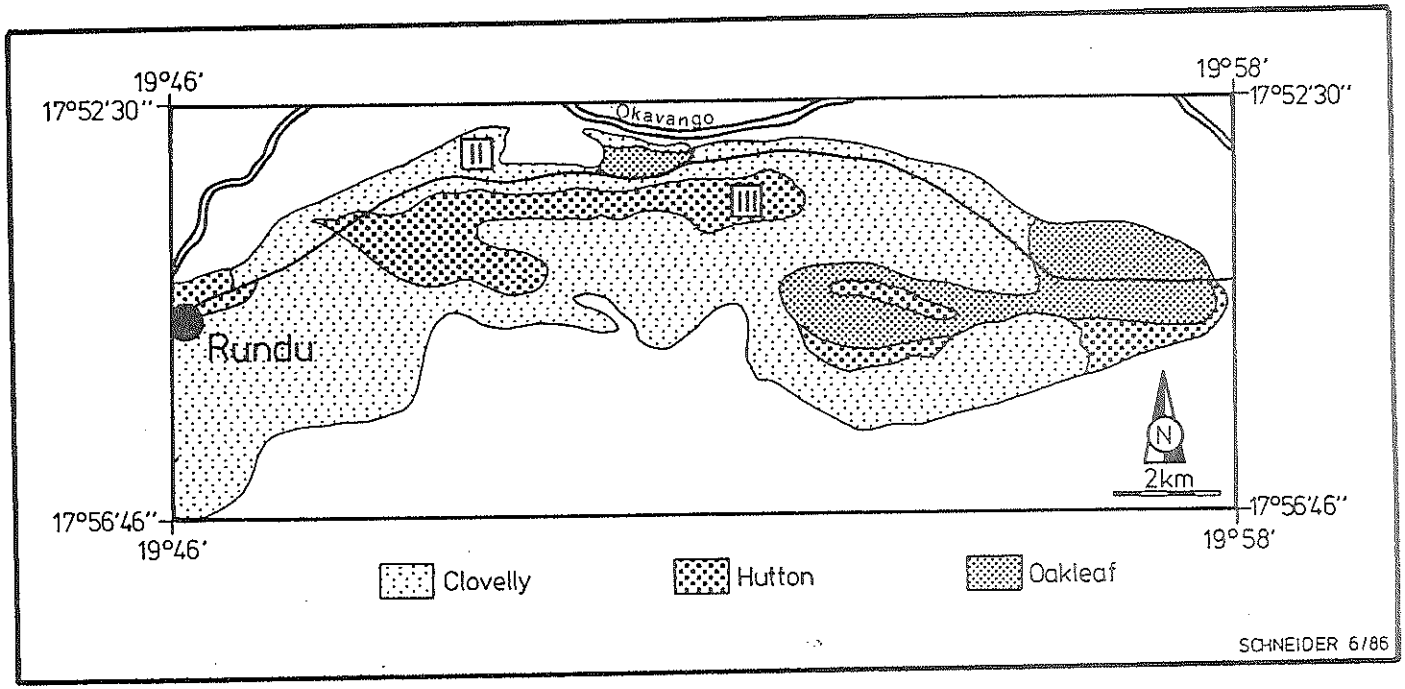
An **Oakleaf Levubu,** in which an orthic A-horizon overlies a neocutanic B-horizon (a specific subsoil horizon where colour variegations of the soil material are the main distinguishing feature), was identified. The structure was poorly developed and consisted of mediumsized, subangular peds (a 'ped' represents a unit of soil structure, whereas 'subangular' defines a secondary structure type). Neocutanic horizons usually form in alluvial or colluvial material and the A-horizon of the Oakleaf



Map 3: Survey area at Musese



Map 3: Survey area at Musese



Map 4: Survey area at Rundu

Levubu is thus found typically in landscape positions, e.g. on river terraces. Soil formation was minimal and the A-horizon was marked by rather weak structural development. The structure of the sand in the A-horizon was loose, the colour dark greyish brown (10YR 4/2) and the transition from the A-horizon to the B1 horizon was gradual. The sand material of the B1 horizon was greyish brown (10YR 5/2), the structure loose and the transition to the B2 horizon also gradual. The B2 horizon had the same colour as the B1 horizon (10YR 5/2) and the material was identified as loamy sand with a very weak-medium-subangular blocky structure. The transition from the B2 to the B3 horizon was also gradual. The structure of the greyish brown (10YR 5/2), loamy sand in the B3 horizon was found to be loose again and the sand material was well aggregated (Photo 5).

Depth of horizons A 0 - 40 cm
B1 40 - 75 cm
B2 75 - 110 cm
B3 110+

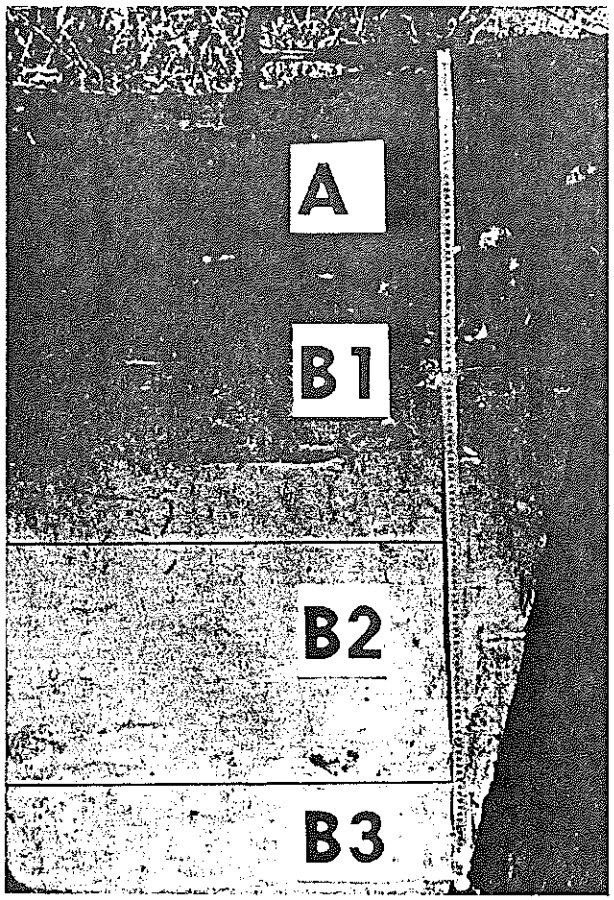


Photo 5: Soil profile: Oakleaf Levubu

2.3 Hutton Form Soils

Hutton Form Soils occur o
Zwartfontein was described

Profile description

An orthic A-horizon was fou
comprised a reddish brown (
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The permeability was very h
The B1 horizon showed the s
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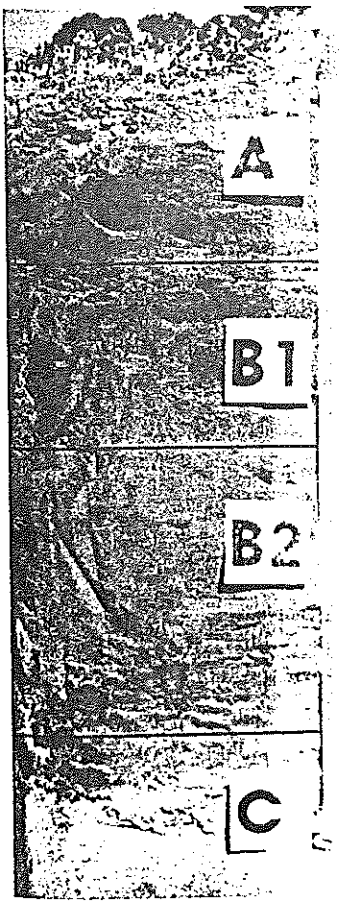
Depth of horizons A 0 -
B1 30 -



3. General Soil Properties

The three dominant soils in the Kavango exhibit physical, chemical and mineralogical properties typical of arid-region soils, e.g., a moderate to high base saturation as due to slow leaching of the basic cations. This high base saturation results in pH values that are between 6,8 and 7,6 (slightly acid to slightly alkaline). The cation exchange capacity is low to moderate and in all three Soil Forms kaolinite is the most abundant clay mineral. The semi-arid climate is the dominating ecological and soil-forming factor in the Kavango region. Therefore, vegetation cover is comparatively sparse, resulting in a low organic matter content of the Kavango soils.
The identified Soil Series are mostly sandy and differ little in colour. Particle size analysis showed that the sand fraction dominates in all series by more than 50%. The clay content of all identified series varies from 0-15%; locally more clay was recorded, as for example in case of an Oakleaf Limpopo (Oa 46).

Table 1 comprises some chemical, physical and mineralogical properties of the three dominant Soil Forms as well as a comparison of these with two main soil classification systems, which are used internationally (USDA, 1975 & FAO/UNESCO, 1974 & LOF & VAN BAREN, 1987).

All three soils have a relatively thin surface layer of non-calcareous loamy sand, overlying thicker non-calcareous — loamy and clayey sand B1 and B2 horizons. Calcareous subsoils are found in the lower parts, e.g., in the C-horizon of the Hutton Zwartfontein. The calcic C-horizon (which has more carbonate than the parent material) appears to have formed by the upward movement of carbonate-rich capillary water from the shallow groundwater table. The calcic C-horizon is generally referred to as calcrete (Photo 6).

4. Utilization of the Soils

Soil formation in the Kavango is influenced by the topography, the semi-arid climate, the sandy parent material, the accumulation of carbonates, soluble salts and silicia and the sparsity of vegetation cover, thus causing low organic matter content in the soils.

A large and increasing number of people living in the Kavango area depend on traditional subsistence farming. The environment is only marginally suited for agriculture due to its climate, soils and availability of water and therefore limiting agricultural production in terms of certain crops. These environmental factors could be expected to yield soils unfavourable for agricultural purposes, but all the same, the terraces of the Okavango River and its tributaries are intensively cultivated (Photo 7 and 8).

Agricultural production by the Kavango people is primarily at the subsistence level and arable cropping is supplemented mainly by cattle farming. Sorghum (*Sorghum bicolor* (L.) MOENCH) and Pearl Millet (*Pennisetum americanum* (L.) LEEKE) are traditionally the most important subsistence food crops in the communal Kavango areas. They are also used as alternative starch sources to maize, for beer brewing.

Soil Form	Dominant Profile: Diag. Horiz.	Depth (cm)	Munsell Colour	pH (H_2O)	Particle Size Analysis (%): Sand	Silt	Clay	Exchangeable Cations (me/kg soil): Na *	K **	Ca ***	Mg ****	Organic Matter (%C)	Mineralogy: Dominant Clay	Correlation USDA [1] Order (1) / Suborder (2) / Great Group (3)	FAO[2] Soil Units
Clovelly Sunbury (Series: 30, 31, 34, 41, 43, 44)	A	0 – 35	10YR 4/3	7,2	90	8	2	0	1	22	5	0,3	Kaolinite, Montmorillonite	Alfisols (1) / Udalfs; Ustalfs; Xeralfs (2) / Hapludalfs; Paleudalfs; Paleustalfs; Palexeralfs (3). Aridisols (1) / Argids (2) / Haplargids; Paleargids (3).	Arenosols Luvisols Rhegosols Xerosols Yermosols
	B1	35 – 60	10YR 4/3	7,0	88	9	3	0	1	21	10				
	B2	60 – 95	10YR 4/3	7,1	90	8	2	1	1	20	6				

[1] United States Department of Agriculture
[2] Unesco & Agric. Organ. of the United Nations

Soil Form	Dominant Profile			pH (H_2O)	Particle Size Analysis (%)			Exchangeable Cations (me / kg soil)				Organic Matter (%C)	Mineralogy Dominant Clay	Correlation USDA * Order (1) / Suborder (2) / Great Group (3)	FAO[5] Soil Units
	Diag. Horiz.	Depth (cm)	Munsell Colour		Sand	Silt	Clay	Na *	K **	Ca ***	Mg ****			* United States Department of Agriculture	[5] Food & Agric. Organ. of the United Nations
Clovelly Sunbury (Series: 30, 31, 34, 41, 43, 44)	A	0 – 35	10YR 4/3	7,2	90	8	2	0	1	22	5	0,3	Kaolinite, Montmorillonite	Alfisols (1) / Udalfs; Ustalfs; Xeralfs (2) / Hapludalfs; Paleudalfs; Paleustalfs; Palexeralfs (3). Aridisols (1) / Argids (2) / Haplargids; Paleargids (3). Entisols (1) / Orthents; Psamments (2).	Arenosols Luvisols Rhegosols Xerosols Yermosols
	B1	35 – 60	10YR 4/3	7,0	88	9	3	0	1	21	10				
	B2	60 – 95	10YR 4/3	7,1	90	8	2	1	1	20	6				
	B3	95 +	10YR 3/3	7,0	91	7	2	0	1	20	5				
Oakleaf Levubu (Series: 30, 31, 34, 41)	A	0 – 40	10YR 4/2	7,4	88	7	5	0	1	28	4	0,3	Kaolinite, Montmorillonite	Alfisols (1) / Udalfs; Ustalfs; Xeralfs (2) / Hapludalfs; Haplustalfs; Haploxeralfs (3). Aridisols (1) / Argids; Orthids (2) / Haplargids; Calciorthids (3). Entisols (1) / Psamments (2). Inceptisols (1) / Ochrepts (2) / Eutrochrepts; Ustochrepts; Xerochrepts (3)	Arenosols Cambisols Luvisols Xerosols Yermosols
	B1	40 – 75	10YR 5/2	7,6	87	5	8	0	1	28	3				
	B2	75 – 110	10YR 5/2	7,3	92	6	2	0	1	27	3				
	B3	110 +	10YR 5/2	7,0	92	6	2	0	1	27	3				
Hutton Zwartfontein (Series: 34, 44, 46)	A	0 – 30	5YR 4/4	6,9	96	2	2	1	1	30	5	0,3	Kaolinite, Montmorillonite, Illite	Alfisols (1) / Udalfs; Ustalfs; Xeralfs (2) / Paleudalfs; Paleustalfs; Rhodustalfs; Palexeralfs (3). Aridisols (1) / Argids (2) / Haplargids; Paleargids (3). Entisols (1) / Orthents; Psamments (2)	Arenosols Luvisols Regosols Xerosols Yermosols
	B1	30 – 60	5YR 4/4	6,8	96	2	2	1	1	30	10				
	B2	60 – 110	5YR 4/6	7,0	76	14	10	1	1	27	10				
	C	110 +	white	7,6	89	0	11	1	1	26	10				

* Sodium – ** Potassium – *** Calcium – **** Magnesium

Table 1: Analytical data of three dominant Kavango Soils

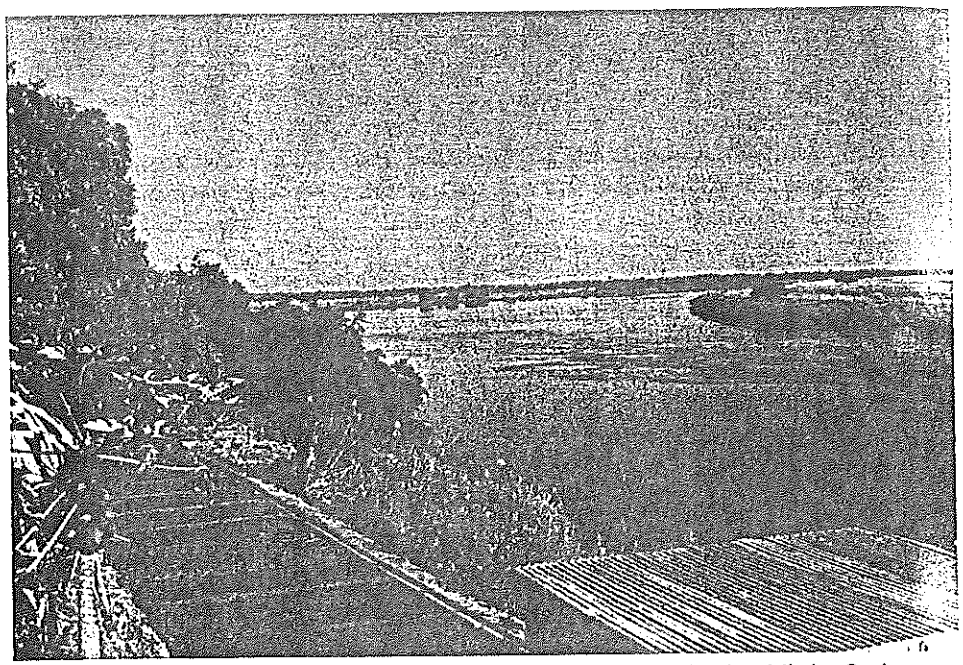


Photo 7: Vegetable gardening with flood irrigation on the river terrace at Shambyu Mission Station.

Irrigation schemes have been developed within the past few years along the Okavango River to expand and stabilize the food production in the area. To extend the grazing of cattle into the aeolian sand plateau, fencing and water points adjacent to settlements on the river terraces have also been provided.

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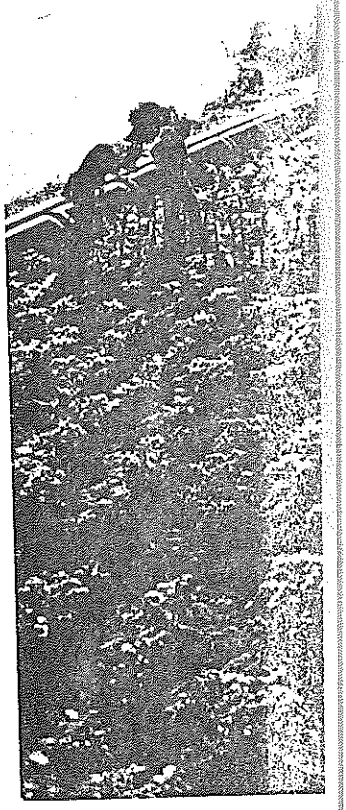

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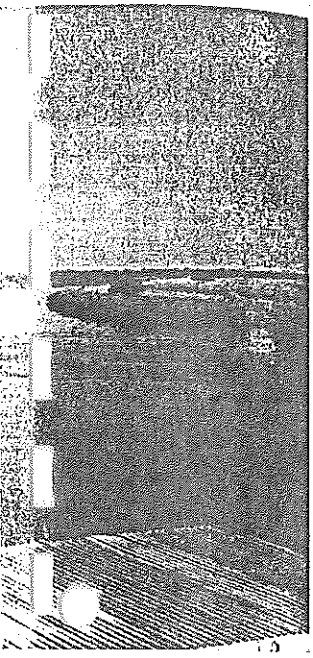

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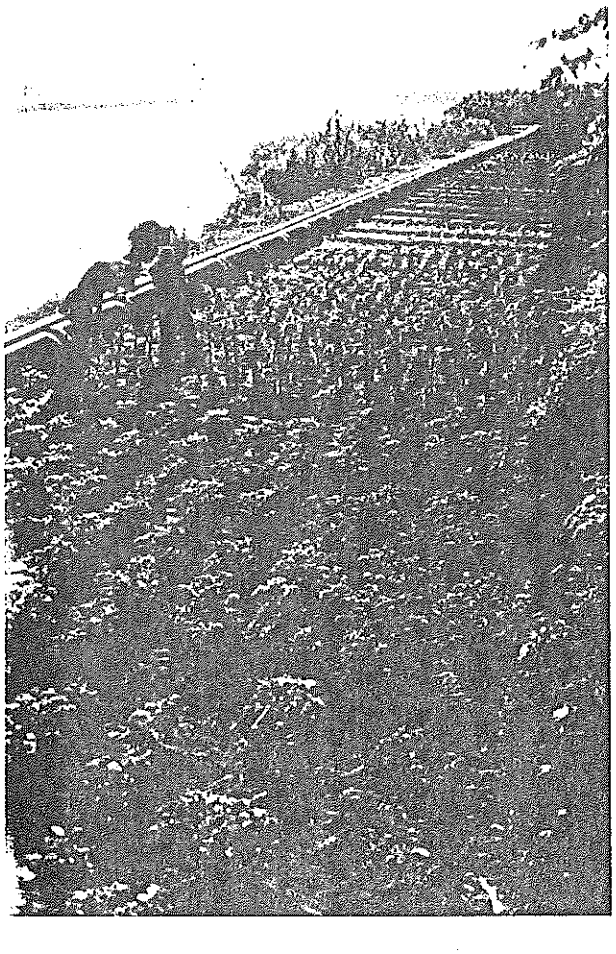

Photo 8: Vegetable gardening with flood irrigation on the alluvial terrace at Shambyu Mission Station.

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