ENVIRONMENTAL PROFILE

WESTERN PROVINCE, ZAMBIA

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Dr. Hein van Gils

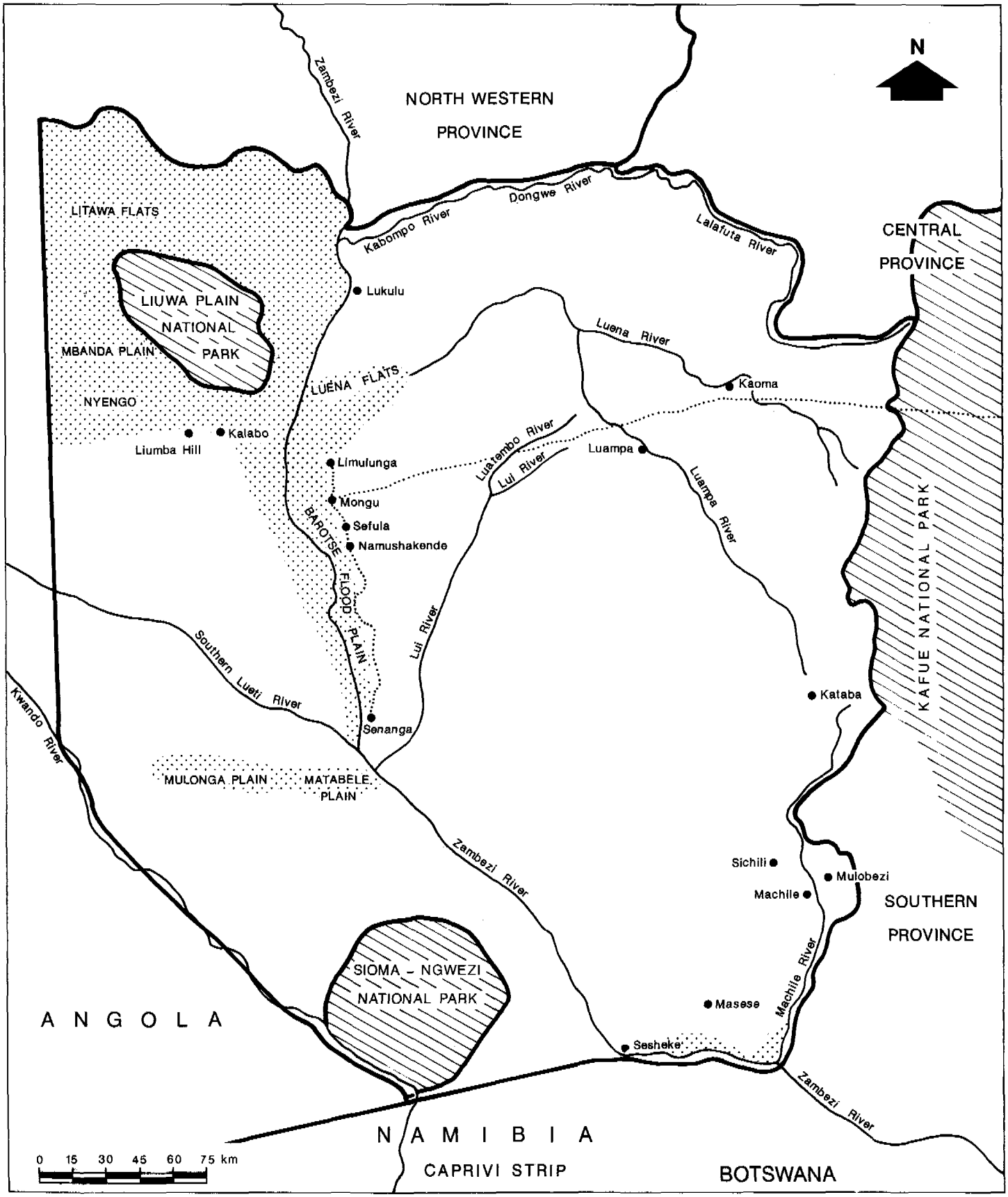
with contributions from:

G. Aongola
Jan Broekhuis
Jasper Fiselier
Kevin Jeanes
S.J. Mulungushi
Rob Robelus
Carin W. Verduyn

International Institute for Aerospace Survey and Earth Sciences (ITC)
P.O. Box 6, 7500 AA Enschede, The Netherlands

Provincial Planning Unit, Mongu, Zambia

May 1988


N
NORTH WESTERN
PROVINCE
Zambezi River
Kabompo River
Dongwe River
Lalafuta River
CENTRAL
PROVINCE
LITAWA FLATS
LIUWA PLAIN
NATIONAL
PARK
MBANDA PLAIN
NYENGO
Lukulu
LUENA FLATS
Luena River
Kaoma
Kalabo
Liumba Hill
Limulunga
Luatembo River
Lui River
Luampa
Luampa River
Mongu
Sefula
Namushakende
BAROTSE FLOOD PLAIN
KAFUE NATIONAL PARK
Southern Lueti River
Lui River
Kwando River
Kataba
Senanga
MULONGA PLAIN
MATABELE
PLAIN
Zambezi River
Sichili
Mulobezi
Machile
SOUTHERN
PROVINCE
SIOMA - NGWEZI
NATIONAL PARK
Machile River
Masese
A N G O L A
Sesheke
Zambezi River
N A M I B I A
CAPRIVI STRIP
BOTSWANA
0 15 30 45 60 75 km

PREFACE

In 1983 the Provincial Planning Unit (PPU) of Western Province commissioned a study on the forestry resources of the Province. Very little was known about the forest resources let alone the rate of exploitation of hardwood trees such as the Mukusi, Mukwa and Muzauli. Among the various recommendations of this study, was a forest inventory. A similar resolution was formulated at an international conference on Zambezi Teak in Livingstone in March, 1984. The PPU held the opinion that it might be better to embark on a comprehensive study on all natural resources rather than on forests alone.

There is so much interaction between water, soil, vegetation and land use that a complete picture cannot be obtained by looking at one aspect only.
Also the second Western Province Development Plan is not feasible with the scanty information currently available on natural resources.

The Ministry of Lands and Natural Resources of the Republic of Zambia and the International Union for Conservation of Nature and Natural Resources (IUCN) published the National Conservation Strategy (NCS) for Zambia in 1985 recommending a follow-up on the provincial level. The NCS was funded by the Netherlands and Swedish Governments. The compilation of this Environmental Profile of Western province is meant as a contribution to conservation-oriented planning at the provincial level. The outline of the NCS has been chosen as a model for this Environmental Profile.

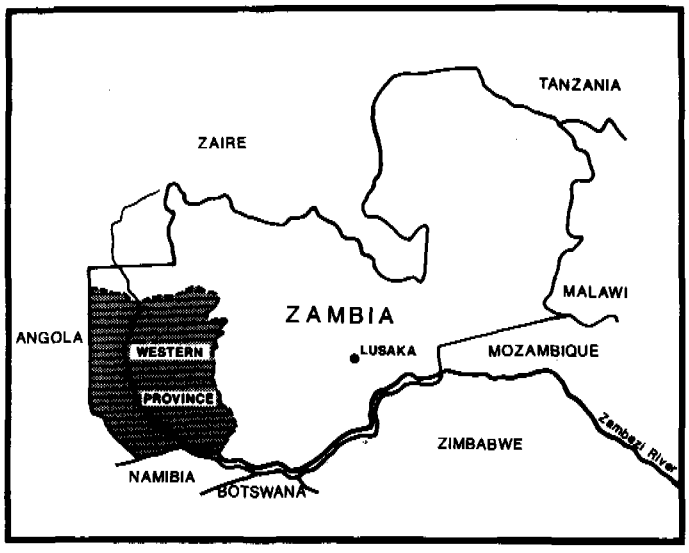


Figure 1

The Netherlands Government installed a Commission Ecology and Development Cooperation (CECOS), which reported in May 1986. A main recommendation of the CECOS is to prepare an Environmental Profile for areas where Netherlands Development Cooperation is concentrated. The Western Province of Zambia is the third area for which an Environmental Profile is commissioned by the Netherlands Government. The other areas are West-Java (Indonesia) and the Senegal River Valley (West Africa).

The Environmental Profile of Western Province is aimed for the Zambian and Dutch officials, consultants and decision makers who must assess programmes and projects financed by the Netherlands on their environmental soundness.
The Profile may also serve as part of the base line information for the second Western Province Development Plan due in 1991.

This Environmental Profile is based on compilation, evaluation and on integration of secondary data available before July 1987. The budget and the time schedule did not allow for the collection of new data. Therefore area-wise (the south) and resource-wise (water resources) information gaps are obvious. Especially data to assess trends in resource exploitation are scarce.

The Profile is meant for provincial planning purposes and therefore describes and analyses the Environment on the land system level. This level of abstraction allows only limited conclusion for de farming system or project level.

The various co-authors contributed to the Profile by supplying written information and/or a presentation at the Seminar "Environmental Profile Western Province" held in Mongu on the 3rd of July 1987. The final text, the conclusions and recommendations are those of the first author.

ACKNOWLEDGMENTS

Most of the photographs have been taken by Mick Pilcher (Lusaka). Editing was done by Carin W. Verduyn (Schayk). Both are acknowledged for their sincere interest in the Profile and their pleasant company during the work.
Numerous people have contributed to the Environmental Profile by sharing their expertise, supplying their comments, asking questions, giving their suggestions or supplying food and transport. We are especially greatful to J. Banda (Mongu), M.L.E.J. Beerling (Mongu), Jacques de Graaf (Kalabo), J.W. Harnmeyer (formerly Mongu), J. Harnmeyer (formerly Mongu), Rob Havekes (Mongu), Albert Elshof (formerly Mongu), Peter Hayward (Lusaka), Dennis Huckabay (Lusaka), J. Liswaniso (Kaoma), G. Mann (Mongu), G. Maxwell (Maxwell's island), G.M. Milindi (Mongu), S.A. Mulala (Lusaka), Jacob M. Muwamba (Mongu), Petra Penninkhoff (Mongu), Rob de Rooij (Mongu), Alister Scott (Lusaka), S.C. Zimba (Mongu).

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1. INTRODUCTION

1.1 GENERAL

The National Conservation Strategy of Zambia has chosen for the conservation in the broad sense and consequently this approach was followed for the Western Province (Figure 1). In this view conservation deals with the sustained use of the renewable resources. Consequently it includes the preservation of specimens of each plant species, animal species and ecosystem.
For the near future the potential environmental risks in the Western Province are to be expected in the overexploitation of the renewable resources:
the Forest Resources (chapter 2), Wildlife Resources (chapter 3), Agricultural Resources (chapter 4), Livestock and grazing resources (chapter 5), Fisheries (chapter 6), Water Resources (chapter 7) and human health hazards (chapter 8). Currently no major mining, industrial, infrastructural or reclamation developments are taking place nor are they envisaged in the Provincial Five Year Development Plan (1986-1991) of Western Province.

1.2 CLIMATE

In Western Province, four climatic seasons can be distinguished. In July the Province is dominated by high pressure, dry weather and cold nights. This continues through August and mostly September. October to December is a transitional period of dry and hot weather and day temperatures may reach 38.4 °C in Mongu. The low pressure period is between December and March when most rain falls. The fourth season is from April to June. High pressure again builds up over Southern Africa and the dry season with cool nights begins.

There is strong seasonality in rainfall in Western Province. The rainy season usually starts in November and ends in March/April. There is a gradient running from north to south. Lukulu district in the north receives an average rainfall of 1021 mm per year while Sesheke in the south receives an average of 730 mm.
93% of total rainfall falls between November and March, with a peak between December and February. The wettest month is January. During the onset of the rains in November thunderstorms alternating with hot sunny weather are most common while in the wetter months the cloud cover is more persistant.

The onset date of the crop growing period in the Upland for most stations is within the range from the 1st of November to the 10th, except for Senanga where it is around the 20th November. The end of the growing season varies between the last week of March (Senanga town) and the first of April (Lukulu and Mongu town).

Farmers in Western Province rely mostly on local 'varieties' the growing period of which is relatively long. This implies that growing periods of 95 days as encountered in Sesheke (Table 1) are critical for cereal crops especially for maize. The required growing period of the main crops in the area is as follows: maize, sorghum and millet 140 days, rice 180 days, wheat 130 days and cassava 1.5 to 3 years. For maize, a drought period of one week during the growing period will reduce yields considerably. Greatest decrease in grain yield (up to 50%) is caused by water shortages in the flower initiation period resulting in decrease in grains per cob. The likelihood of drought is greater in the south and south-west of the province (Table 2). These are areas where the growing period is also short.

Growing periods for rainfed crops based on 70% rainfall probabilities (Table 2) are consirable lower than those based on average rainfall (Table 1). Especially in Sesheke this difference is dramatic.

Station	Mean annual rainfall (mm)	Growing period (days)	Drought periods
Mongu	900	126	2×10 days
Kaoma	1000	113	2×10 days
Kalabo	800	111	2-3×10 days
Sesheke	700	81	4×10 days

Table 2 Growing periods for rainfed crops on Upland sandy soils at 70% probability of rainfall (wet season).

The rainfall is variable throughout the years. The 30 year running average of total seasonal rainfall in Mongu (Figure 2) shows a cyclic pattern. There were series of relatively wet years in the beginning of the forties, the sixties and the end of the seventies and relatively dry ones in the first half of the fifties, the second half of the sixties and at the start of the current decade. The period since 1934 has been relatively wet throughout. The current annual rainfall is only relatively low compared to the wet parts of the rainfall cycle, but in no way extremely low.

Night frost occurs frequently in the south in June/July, occasionally in Mongu and Kalabo and only rarely in Lukulu. Night frost occurrence may be severe on the windward sides of dambos in the upland and less so in the Zambezi floodplain. Frost occurs 2-8 days in Mongu but up to 16 days in Sesheke in the south. The duration of the frost is usually 2-4 hours. The effect of frost is most severe on tree crops like banana, cashew and mangoes, but also plays a role in the distribution of cassava. These frost-sensitive crops are hardly grown in the southern part of Western Province. Occasional hail storms are known to have damaged crops. Data on frequency, distribution and seasonality are absent.

Period	Station	Rainfall mm/y	S.D.	C.V.(%)	Range (mm)	Days
1946-1984	Lukulu	1021	180	17	444 - 1317	140
1957-1986	Kaoma	937	226	24	387 - 1507	140
1957-1986	Mongu	949	211	22	496 - 1353	135
1941-1971	Sefula	977	199	20	581 - 1459	135
1944-1976	Kalabo	949	234	25	446 - 1353	145
1957-1986	Senanga	753	208	28	355 - 1422	135
1952-1986	Sesheke	730	233	32	442 - 1542	95
1952-1986	Masese	732	194	27	360 - 1270	95
1945-1974	Mulobezi	830	202	24	493 - 1255	100
1954-1986	Machile	753	192	25	444 - 1154	100
1950-1986	Namushakende	993	200	20	597 - 1527	135
1937-1966	Liumba hill	971	240	25	517 - 1424	145
1945-1976	Luampa	963	220	23	347 - 1301	135
1951-1981	Sichili mission	888	214	24	595 - 1284	100

Table 1 30 year rainfall averages (mm/y), its standard deviation (S.D.), coefficient of variation (C.V.) and range; the last column gives the calculated length (Days) of the growing season for rainfed crops on the Uplands.

Figure 2

1.3 LAND SYSTEMS

The environment of Western Province and adjacent parts of Northwestern Province are rather distinct from the remaining parts of Zambia especially because it is dominated by Kalahari sandplains.

The Barotse floodplain between Mongu and Kalabo ("Central Barotse" land system in Table 3) features prominently in descriptions of Western Province. However, within this Province there is considerable differentiation in environment and it is crucial for all practical purposes to realize this.
Therefore the Western Province has been subdivided in 10 land systems. The land systems serve as geographical reference throughout the text. The guiding principle for the distinction of these land systems is the actual and potential land use. The land characteristics used for land system delineation are:

i) *the vegetation* types as depicted on the 1:500,000 map (Edmonds 1976) and satellite imagery*.
ii) *landform:* lowland as proportion of total surface area; water divides.
iii) *land use:* staple crops, head of cattle per person and tsetse occurrence.

The distinction of land systems by land characteristics is given in table 3 and mapped in figure 4. These land systems are preliminary and subject to improvement after more data are collected and processed on land use, soil, climate, vegetation and hydrology.

* Landsat 1:250,000 of the Department of Veterinary Services and Tsetse control.

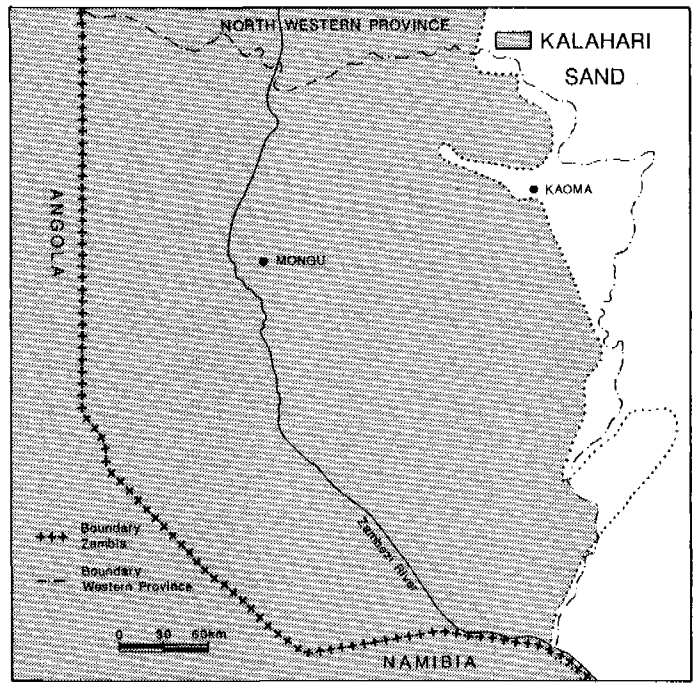


Figure 3 Extent of Kalahari sand in Zambia and Western Province. Towards the eastern margin of the marked area the Kalahari sands become less dominant.

Table 3 Land systems in Western Province.

LAND SYSTEM	CLIMATIC STATION Table 1	VEGETATION (Chapter 2) dominant	co-dominant	additional	LOWLAND floodplain + dambos in % surface area	STAPLE CROPS	TSETSE* fig. 9	CATTLE**
Mukwe	Lukulu	Mukwe	Chipya	Miombo	< 5	Cassava (Maize)	—	
Luena	Lukulu	grassland	Miombo	Mukusi/ Mukwe	10-25	Cassava (Maize)	—	+
Northwestern Plains	—	grassland	Miombo	—	> 50	Cassava (Maize)	—	+
Eastern Kaoma	Kaoma	Miombo	Termitaria Bushgroup	—	< 5	Maize/Cassava	± (east only)	—
Luampa	Luampa	Mukwe	Miombo	Termitaria Bushgroup	< 5	Cassava (Maize)	—	—
Central Barotse	Mongu Kalabo Namushakende	grassland	Miombo	—	25-50	Cassava (Maize)	—	+
Southern Barotse	Senanga	Miombo	grassland	Termitaria Bushgroup	5-10	Cassava (Maize)	—	+
NE Sesheke	Sichili	Miombo	—	—	< 5	?	—	—
Mukusi	Sesheke Mulobezi Masese	Mukusi	Miombo	Mopane	< 5	Millet, Sorghum, Maize; Cassava (east only)	+	—
Munga	—	Munga	Miombo	Mopane/ Mukusi/ grassland	< 5	Millet, Sorghum	+	+

* — tsetse absent
\+ tsetse present

** + cattle/person > 1 implying cattle being an important component of the farming system
— cattle/person < 1 implying cattle not being important in the farming system except for ploughing.

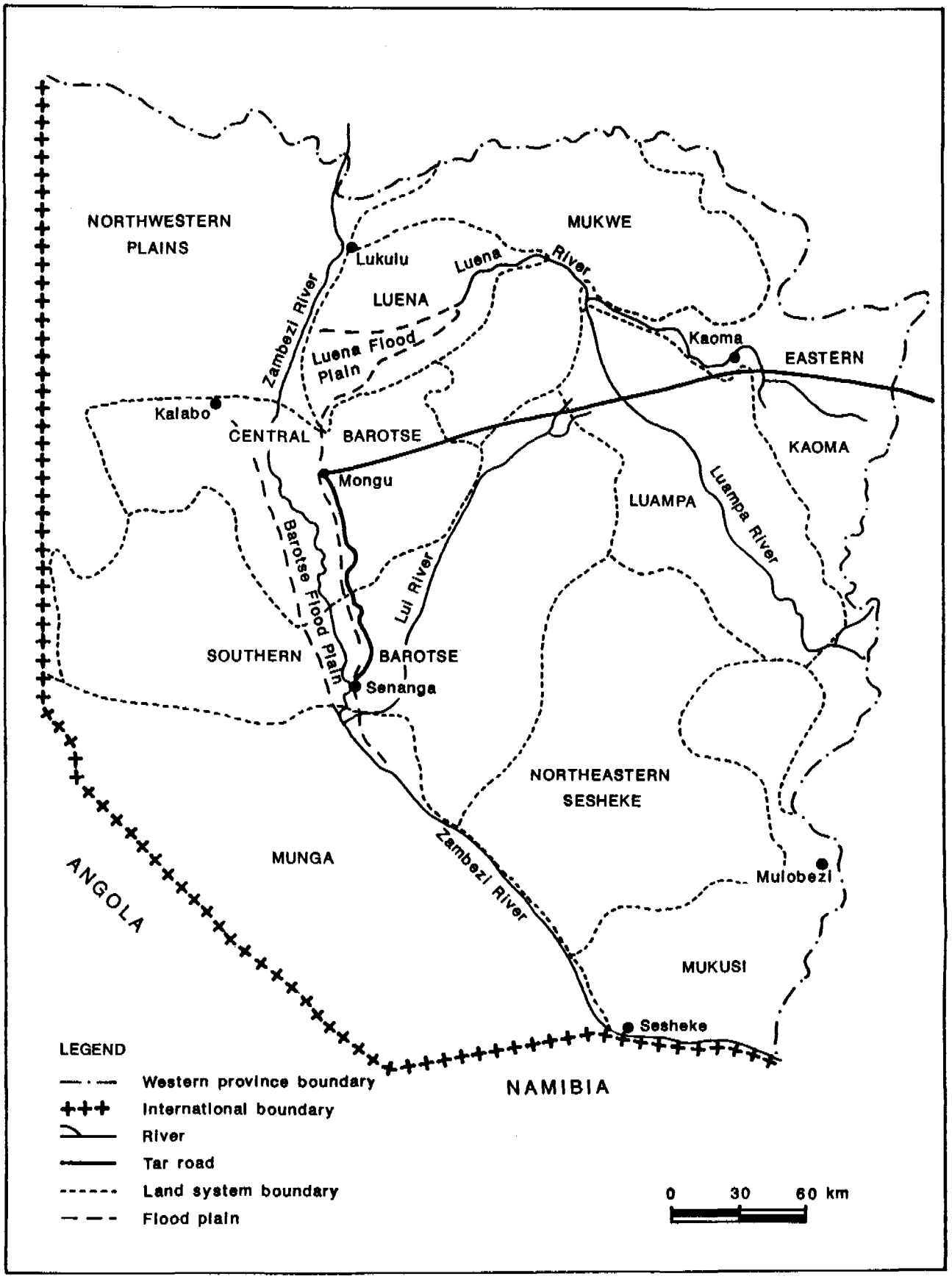


Figure 4 Land systems in Western Province.

2. FOREST RESOURCES

2.1 GENERAL

The dominant soils in Western Province are on Kalahari sands which favour tree growth (section 4.7). Threequarters of Western Province is wooded (9.4 million ha) the remaining part being unsuitable for tree growth due to waterlogged soils and/or flooding. Seven percent (7%) of the wooded area, about 5% of the total surface area of Western Province, belongs to the Demarcated Forest or Forest Estate. The Forest Estate consists of Local Forest and National Forest. This distinction has no legal consequences (section 9.4).

The wooded areas near settlements are used for fuelwood, poles and shifting cultivation of mainly cassava and/or bulrush millet (compare section 4.7). Generally less than 2% of the forests areas is used for crops at any particular moment. After a few crop harvests the area has to be rested and forest regeneration takes place. Up to 50% of the forest area may be in the forest regeneration phase. Even outside the latter there is hardly virgin forest to be expected due to shifting cultivation, burning, logging, etc.

From satellite images (Landsat MSS) and the vegetation map of Zambia(1:500 000; 1976) it is evident that forest/woodland patterns are associated with drainage patterns. The Uplands next to many valleys and floodplains carry forests/woodlands differing from those on the water divide plains. Climate is the controlling factor in the change from the deciduous Miombo (section 2.3) in the south to the evergreen Mukwe (section 2.4) in the more humid and less frost-prone northern part of Western Province.

"The risk of destroying woodlands (by fuelwood cutting or shifting cultivation) is very slight, because of the low fertility and excessively free drainage of the soil means that grass and other herbaceous plants can not compete effectively with trees and shrubs for soil moisture and nutrients. After temporary clearing of the tree cover, these factors prevent invading grasses from growing densely enough to either smother tree regeneration or from burning so fiercely as to kill off all regeneration of trees, although individual species may be eliminated" (White 1983). Moreover woodlands on sands have a large root system and consequently fires remove only part of the plant nutrients (Walker 1980).

Details on timber and grazing resources in the forest are given under the various forest types below and on forest shifting cultivation in section 4.7. The distribution of the forest types can be seen by using table 3 as legend for the land system map (figure 4).

2.2 FUELWOOD

The yearly fuelwood consumption of Western Province may be estimated at threequarters of a million m^3 (approximately 0.5 million inhabitants x 1.5 m^3wood/person/year). A conservative estimate of fuelwood production (1 m^3/ ha/year) would result in an estimated 9 million m^3 fuelwood production per year outside the Forest Reserves. From these estimates it may be concluded that there is no overall shortage of fuelwood at present. Around Mongu, people may have to walk 10-15 km in search for fuelwood and elsewhere along the Barotse floodplain and around the district centres this is 5-10 km (Photo 1). A market for fuelwood has been developed around Mongu (Photo 2).

In the Barotse floodplain, people use dung and herbs for fuel, because of the absence of woodland. In Mongu town people have started burning charcoal since the end of the seventies. In Western Province licences for choarcoal production are currently only given in relation to land clearence for shifting cultivation or tree plantation. Currently half of the Mongu town households use purchased charcoal (Photo 3) at some time. However the bulk of the fuel used even in Mongu town is wood.

The existing licence system for fuelwood collection serves neither conservational, management nor silvicultural purposes and results in an administrative burden on the Forestry Department. **Therefore the changes in legislation proposed by White (1983) are recommended once more: (1) gathering of dead wood for fuel free of permit or fee both in the Forest Estate and elsewhere and (2) cutting of poles of unprotected tree species for the cutter's own use free of permit or fee.**

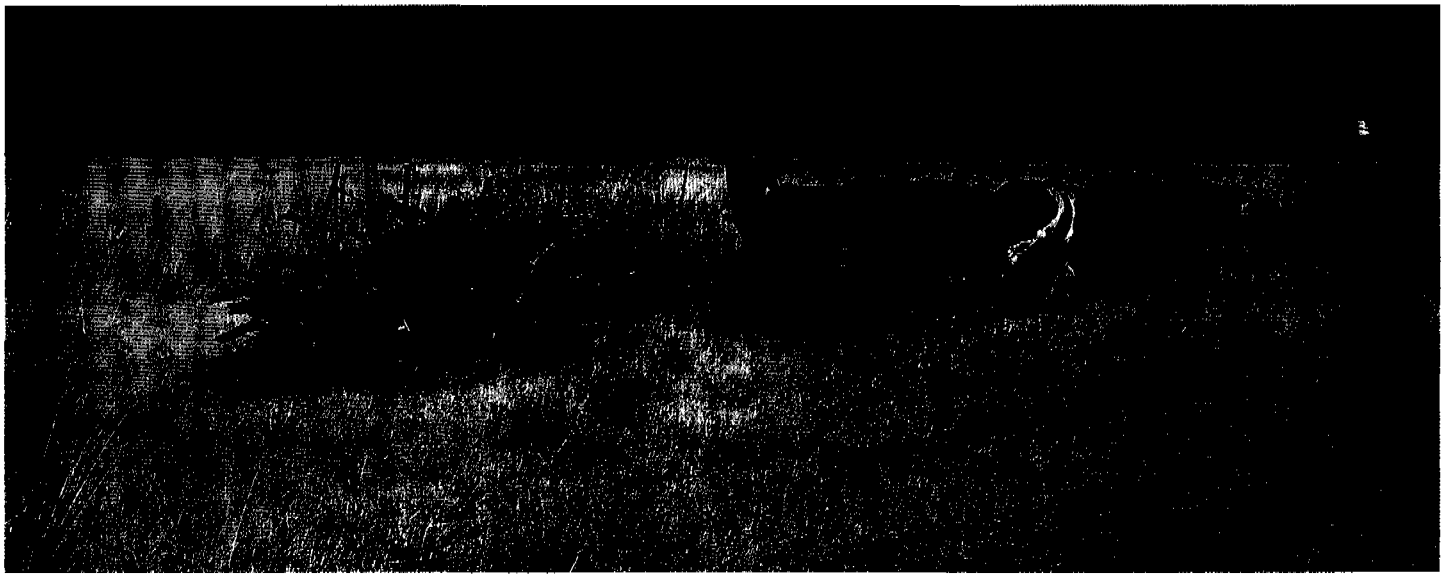


Photo 1 Fuelwood transport from the wooded Upland towards the seasonal settlements on Mazulu in the Barotse floodplain grasslands near Limulunga by a sledge drawn by 6 oxen.

Photo 2 Fuelwood for sale along Mongu - Kaoma tar road. Cassava field in the background.

Photo 3 Charcoal for sale. Charcoal covers only a small part of the fuel requirement of Mongu townschip, wood being the major source. In rural areas charcoal is insignificant

2.3 THE TYPICAL WOODLAND: KALAHARI MIOMBO

Miombo woodlands cover main parts (70%) of Zambia and are typical of Africa south of the equatorial tropical evergreen forests and north of the Savannas that start approximately at the Tropic of Capricorn. The major towns (Mongu, Kalabo, Senanga, Kaoma) of Western Province as well as the tar road are situated in the Miombo and this is therefore the woodland type that most visitors to Western Province will observe.

Miombo woodlands (Photo 4,5) are characterized by a canopy of broad-leaf tree species of the subfamily Caesalpinoids: *Julbernardia* (Mutondo) and *Brachystegia* mainly and further *Erythrophleum africanum* (Mubako) and *Guibourtia coleosperma* (Muzauli); species of the genera *Combretum* and *Terminalia* also occur frequently. Most Miombo trees are deciduous that is they drop their leaves for a short period in the dry and cold season. The trees have a canopy height of 15-25 m. Trees may be single stemmed, but many are two or three stemmed, thus reducing their timber value, and this being intermediary between the single stemmed equatorial forest trees and the multi-stemmed Savanna trees further south. Another typical feature is the inclination of many Miombo trees. The Miombo on Kalahari sands is sometimes referred to as Kalahari Woodland (compare App. 12).

The Kalahari Miombo may include the following marketed valuable hardwood timber trees: *Pterocarpus angolensis* (Mukwa), *Guibourtia coleosperma* (Photo 6), *Erythrophleum africanum, Brachystegia boehmii* (Mubombo) and *Afzelia quanzensis* (Mwande). Currently, the marketing of other Miombo trees (e.g. *Brachystegia spiciformis)* (Mutuya) is under consideration.

The amount of exploited hardwood timber in the Kalahari Miombo reaches locally 2-3 m^3/ha. The poles and timber standing crop/ha may add up to 15-25 m^3. The Miombo timber is exploited in a few areas by commercial sawmill companies. The complete logs or planks are sold to Lusaka, the Copperbelt or exported. Individuals exploit timber on an extensive scale mainly for canoes and locally sawn planks. At present there is a high demand (several thousands) for large sized hardwood poles produced from the Miombo woodlands to be used in the Mongu-Kalabo canal. These poles will need replacement in the future.

Photo 4 Miombo woodland on Kalahari sands in early dry season. The grass is already yellow and deciduous tree leaves start colouring.

In closed Miombo woodland and Miombo with shrub understorey fire is often not fierce enough to kill trees. In fallow or areas logged for timber, grass cover may reach the critical 30% cover and in absence of grazing, enough combustible material may be accumulated for fierce late dry season fires which will destroy sensitive tree species. Regular burning also means a loss of nitrogen and organic matter at the soil surface; at the same time fire releases plant nutrients (especially potassium and phosphorus) from this organic matter which makes these available for plant production. Regular burning may be considered as a normal component of Miombo woodland. Protection from yearly early dry season fires will result in occasional late dry season fires which will destroy valuable timber. Early annual burning (Photo 7) as management tool prevents late destructive forest fires, but inhibits seedling establishment of fire sensitive species.

Some of the common Miombo trees and shrubs (*Julbernardia, Baphia, Dalbergia, Brachystegia*) are known to be palatable for cattle. However the amount of leaves lower than 1.5 m from the ground and available for cattle browsing is minimal within Miombo woodland. *Brachystegia spiciformis* and *Baphia* may not be resilient under permanent browsing (Lawton, 1980). Miombo woodlands therefore have such a low grazing capacity (20 ha/animal) that cattle cannot collect enough forage to maintain weight. Miombo bush fallow might be slightly better but also there cattle will usually suffer from energy deficiency while most of the forage consists of shrub and tree leaves.

It is estimated that there is approximately 1 million ha (may be even 2 million) Kalahari Miombo woodland that is currently not used for forest shifting cultivation mainly in the land system Northeastern Sesheke and adjacent areas (Figure 4). Assuming 2 m^3 exploitable timber per ha and an average market value of 400 Kwacha/m^3 the timber value might be conservatively set at 800 million Kwacha. The total timber value could rise considerably if more Miombo trees could be marketed. **An inventory of the timber stock of the Miombo woodland (and the Mukwe as well) is urgent as well as gazetting the best areas as National Forest before the timber is destroyed by the cassava/millet shifting cultivation practices. Research in Miombo forestry as to develop management techniques for a sustained timber yield is most urgent.**
Agroforestry or the integration of millet/cassava shifting cultivation with timber exploitation may be a promising development.

The ground cover of the Miombo varies. It is sparse in the Central Barotse land system (section 1.3). Elsewhere a considerable grass and/or shrub cover has developed on the woodland floor. Most Kalahari Miombo is regenerated from bush fallow after forest shifting cultivation. Miombo may result from elimination of the fire sensitive Mukwe or Mukusi. Also Muzauli is not fire tolerant.

Except for the Forest Estate around Mongu, Kalabo and Lukulu shifting cassava/millet cultivation and fires have changed the Miombo woodland (and Mukwe forests as well see 2.3) up to a distance of 50 km, into bushland (Mahula) or low open woodland from which most of the valuable timber species have disappeared. In the Eastern Kaoma land system along the road from Kaoma to Kafue National Park considerable Miombo areas (±10.000 ha) have been cleared and stumped and are used for semi-permanent cultivation (section 4.8).

Neither the dominant Miombo trees *Brachystegia spiciformis, Brachystegia longifolia* (Muhamba), *Guibourtia coleosperma, Julbernardia globiflora, Dialium engleranum* nor the dominant fallow shrubs: *Bauhinia macrantha* (Mupondopondo) and *Baphia obovata* (Isunde) fix nitrogen. *Erythrophleum africanum, Pterocarpus angolensis* and *Pterocarpus antunesii* (Mwangula) fix nitrogen in Zimbabwe and probably in Western Province as well. The input of nitrogen by N-fixing trees may be estimated as a few kg N/ha/yr in the Miombo. **The preservation and planting of the nitrogen fixing trees has a positive influence on soil fertility.**

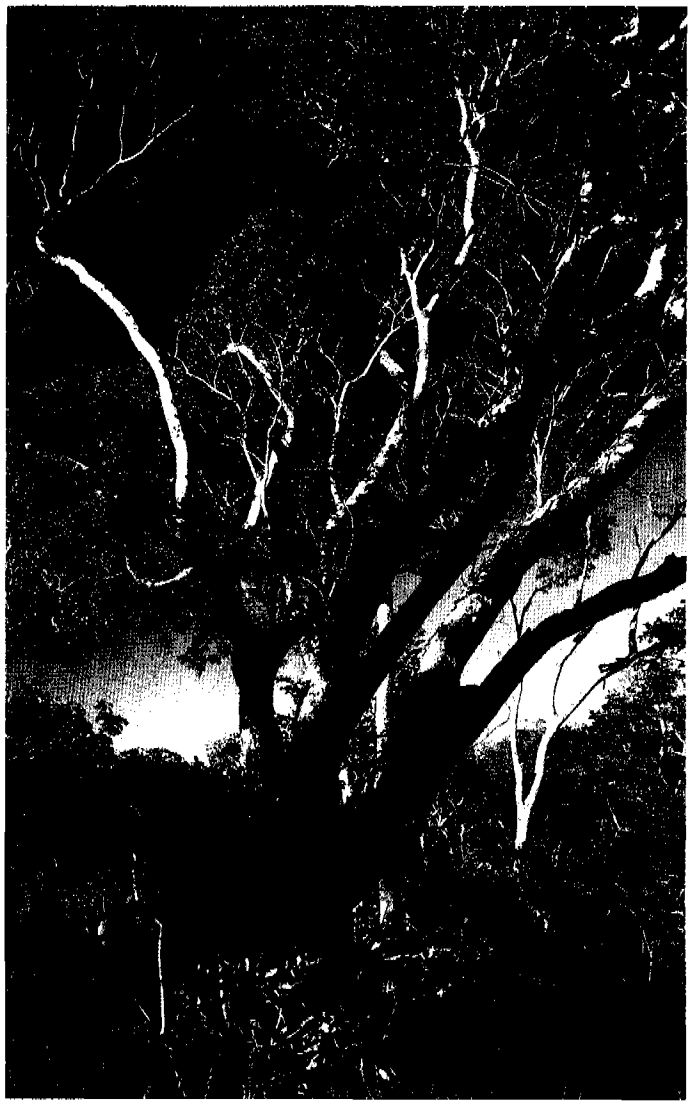


Photo 5 Miombo woodland on Kalahari sands. The irregular shape of the trunks limits their use as timber.

Photo 6 Muzauli logs ready for export in the concession of the Mongu Timber Merchants along the Mongu - Kaoma road near Looma. Sustainability of this timber exploitation is doubtful. Resource inventory and research is urgent.

2.4 EVERGREEN FOREST AND WOODLAND: MUKWE

The evergreen Mukwe forest is found in the northeastern part of Western Province and also occurs on the Kalahari sands of Northwestern Province.
More specifically they extend north of the Luena river and on the water divides of the Luampa river. There the Mukwe gives way to the Miombo on valley slopes. Pockets of Mukwe forests are found throughout Western Province east of the Zambezi river and north of the Munga and Mukusi land systems.
Most of the dambos in the Mukwe are permanently dry as a result of which there are hardly any settlements in these areas. The Mukwe dominates woodlands in the higher rainfall areas of the Kalahari sands away from cultivation, burning and grazing.

Mukwe forest is characterized by canopy dominance of the evergreen Mukwe or *Cryptosepalum exfoliatum* subspecies *pseudotaxus*. *Guibourtia coleosperma* (Muzauli) is often co-dominant and an important exploitable timber. Both dominants, Mukwe and Muzauli, do not fix nitrogen.

Mukwe is associated with Chipya. The latter is believed to be a degradation phase of the first. Characteristic canopy trees are *Burkea africana* and *Combretum collinum*. It has a dense, low and strubby understorey.

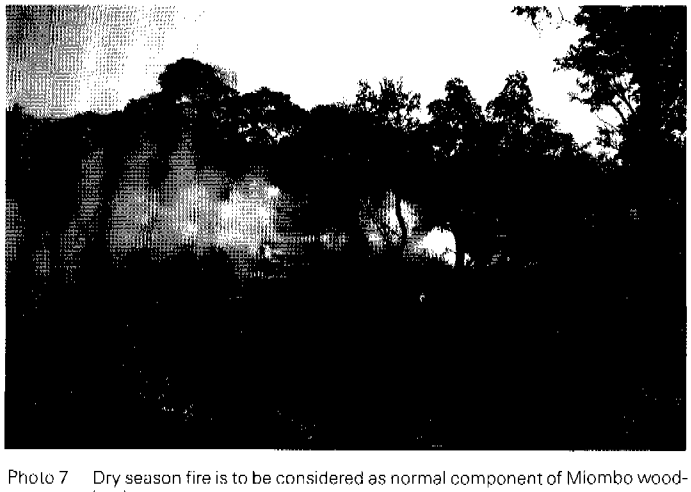


Photo 7 Dry season fire is to be considered as normal component of Miombo woodland.

2.5 ZAMBEZI TEAK TIMBER: MUKUSI

Mukusi or Zambezi Teak forest represents the most important timber resource of Zambia. Most of the Mukusi forests of Zambia are located in Western Province, and considerable areas are found in the Southern Province as well as in small patches in the adjacent parts of Central Province and northwestern Botswana. The largest Mukusi forests are situated in northeastern Namibia and southeastern Angola. A smaller area is found in Zimbabwe. The Mukusi belt in Southern-Central Africa is limited by the frost to the south, to the east and west by the extent of the Kalahari sands and to the north with the more humid climate by the evergreen Mukwe.

Mukusi *(= Baikiaea plurijuga)* is the characteristic canopy tree together with *Pterocarpus antunesii*. A deciduous thicket up to 6 m high that is called Mutemwa is found below the trees. The Mukusi does not fix nitrogen.

Mukusi forests are mainly found adjacent to river valleys usually in the lower and middle course of the river. They are rarely found on the water divide plains and are therefore always within 20 km from a river as is also the case in northern Botswana. Factors for the characteristic Mukusi pattern are probably: optimal drainage, slightly different soils, lower frost incidence near the rivers and the grazing by livestock and elephants near rivers which prevents fuel accumulation and consequently forest fires that destroy the fire-sensitive Mukusi.

The Mukusi forest on the eastbank of the Zambezi is exploited at a rate of 20.000 m^3/year since the mid seventies and between 1935 and 1972 about 70.000-80.000 m^3/year was logged (Figure 5). No natural or artificial regeneration from seed is taking place. The rotation age for Mukusi is minimally 80-100 years but optimally closer to 220 years. The current stock of Mukusi is not even remotely known. If the estimate of the Mukusi forest in W.P. is 450.000 ha and taking current stocks as 1.5 m^3/ha (Zimba 1986), this implies 675.000 m^3 Mukusi. This 675.000 m^3 Mukusi in Western Province represents a value in the order of 300 million Kwacha at 1983 price levels, depending on the proportions exported or used for low quality purposes.
In 1962 the average logging yield of Mukusi was estimated as 2.3 m^3/ha, maximally up to about 10 m^3/ha (Cumming). The last comprehensive Mukusi timber inventory (Finnconsult 1969) gives a somewhat lower average Mukusi stocking of about 1.5 m^3/ha. At the current exploitation rate of 20.000 m^3 /year the Mukusi logging would end within 30 years. This is not different from hardwood exploitation elsewhere in the tropics or the hardwood logging in the temperate zone.

In view of the above, the timber inventory recommended by Piearce (1986) of the Zambezi Teak Forest is of a lesser priority than the inventory of the Miombo and Mukwe forests (section 2.3 and 2.3). With so many non-timber yielding trees and the undergrowth of shrubs (Mutemwa) in the Mukusi forest the depletion of timber does not lead to either deforestation, desertification nor erosion. The process could be described as Savannization, meaning transforming forest and woodland into savannas. The fear for encroachment of the Kalahari desert into Zambia due to the logging of Zambezi Teak, as is sometimes expressed, is thus unfounded.

At present the Mukusi in the Forest Estate is annually burned in the early dry season. This prevents late wild fires which would destroy the boles of the Mukusi trees. However the prescribed early dry season fires preclude the regeneration of Mukusi by seedlings, coppice or from roots. Furthermore the leaves of the Mukusi are destroyed by the early dry season fires (Photo 8) at a time when the Mukusi outside the Forest Estate still may carry their green leaves implying that growth of Mukusi trees is reduced by this burning. **It is recommended to experiment with prescribed rotational burning (e.g. every 5 years) in unexploited Mukusi forests. Degazetting of most Mukusi Forest Estates could be envisaged** since the Mukusi trees are protected in the customary law. After degazetting livestock grazing and cultivation may replace prescribed burning in removing potential fuel for destructive late fires. Mukusi degazetting should be considered concurrently with gazetting extensive Miombo and Mukwe Forest Estates (compare sections 2.3 and2.4).

For the conservation of genetic resources some Zambezi Teak (Mukusi) forests should be carefully selected for gazetting as National Forest and a proper management plan including grazing (e.g. elephants) should be developed.

Photo 8 Leafless Zambezi Teak (Mukusi) trees after the prescribed annual dry season burning near the confluence of the river Lui and the Barotse floodplain. This prescribed burning preserves the old Teak trees but diminishes their growth and prevents Teak regeneration.

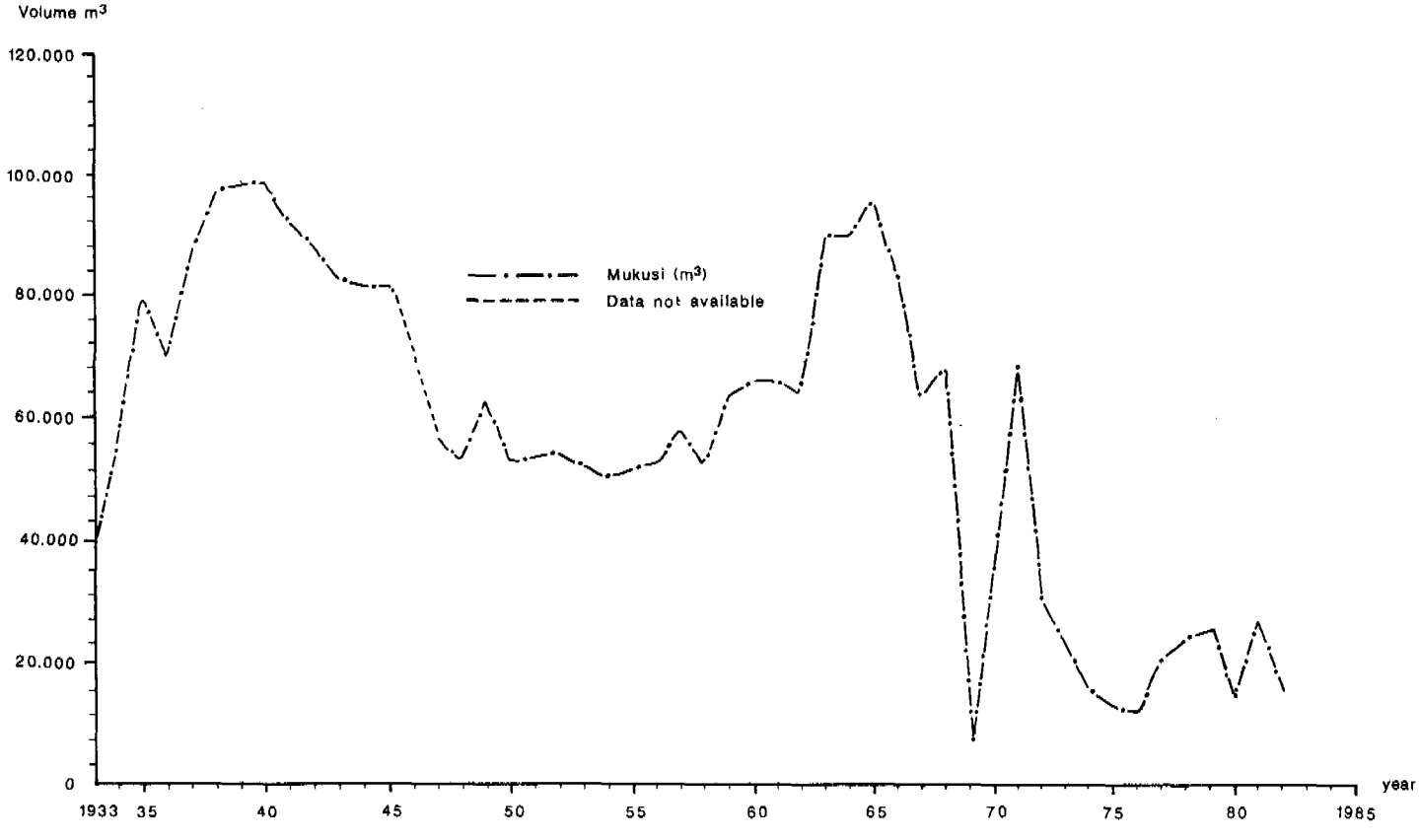


Figure 5 Volume (in m³) of Zambezi Teak (Mukusi) logged in Zambia from 1933-1982. Almost all Teak logging occured in this period in Western Province.

2.6 THORNY WOODLAND AND SAVANNA: MUNGA

Munga means thorn and refers to thorny narrow-leaved trees and shrubs: *Acacia erioloba, Acacia sieberana* (Mutubatuba), *Acacia fleckii* (Mukoka), *Acacia ataxacanta* (Munyantatau), *Peltophorum africanum* (Munyele) and *Dichrostachys cinerea* (Musulesele). *Terminalia sericea* (Muhonono) and *Combretum* (several species) are characteristic broad-leaf trees of the Munga woodland. Zambezi Teak is also found occasionally in the Munga woodlands.
Munga woodland do not contain exploitable timber, with the possible exception of *Terminalia sericea.*

Munga woodlands in Western Province occur mainly parallel to the Kwando river and its tributaries, the southern fringes of the Mulonga plain as well as the Zambezi downstream of Sesheke. Small patches are found along the Zambezi, the Luena and Kabompo rivers and on termitaria. Munga woodlands often develop after logging and/or burning Mukusi forests.

Munga forest probably indicate slightly better crop soils by the presence of more clay, silt and/or fine sands as compared to both the more northerly Kalahari sands and those in the south on water divide plains. The climate of the Munga land system is relatively dry (compare section 2.2 and 2.3).

Munga woodlands occur elsewhere in Zambia on relatively good crop soils. The Munga in Western Province is strikingly similar in its tree canopy to the Acacia savannas on Kalahari sands in Botswana. However it differs in its grasses.

All the Acacias as well as the *Peltophorum africanum* and *Dichrostachys cinerea* are known in Zimbabwe to fix nitrogen and probably do the same in Western Province. The nitrogen input by this manner may be considerable (up to 50 kg/ha/yr).

2.7 MOPANE

Mopane is deciduous and indigenous to southern central Africa roughly between the Tropic of Capricorn and 12° southern latitude. The southern limit coincides approximately with the 5 °C isotherm of the coldest month. Mopane is not found on typical Kalahari sands. Mopane is Western Province occurs both as woodland of single-boled trees and termitaria bushgroup savanna.

Mopane *(Colophospermum mopane)* is a legume but does not fix nitrogen.

There are four extensive areas of Mopane in Western Province, the largest occuring in the Sioma-Ngwezi National Park (Figure 6) and is partly associated with termitaria. The second largest Mopane patch is found in Sesheke East and associated with the inland deltas of a number of rivers, that currently do not flow into the Zambezi. Two smaller areas of Mopane occur on the valley floors of the Zambezi near Ngoma and the Machili river.
Mopane wood is used for poles, sleepers, canoes, carving and fencing posts.

Mopane is an important habitat for game, particularly elephant, as the leaves stay green far into the dry season and have a high nutritional value; moreover Mopane coppices easily after frost or fire damage and therefore the leaves are also within reach of herbivores, other than giraffe and elephants. Mopane is good browse for cattle, however part of the Mopane woodlands are in tsetse infested areas. Mopane is often found on black sodic clay soils with high degradation hazards if used for cattle grazing and/or cropping. **Tsetse control in the Mopane areas should therefore be preceded by an inventory of Wildlife and other resources (compare par. 5.3).**

2.8 POLEWOOD PLANTATIONS: EUCALYPTUS

The Forestry Department has established Eucalyptus plantations (Photo 9) near Mongu town (±300 ha) and the other district capitals (±10-25 ha each). The most successful tree species are the *E.tereticornis, E.camaldulensis* and *Eucalyptus tereticornis x grandis.*

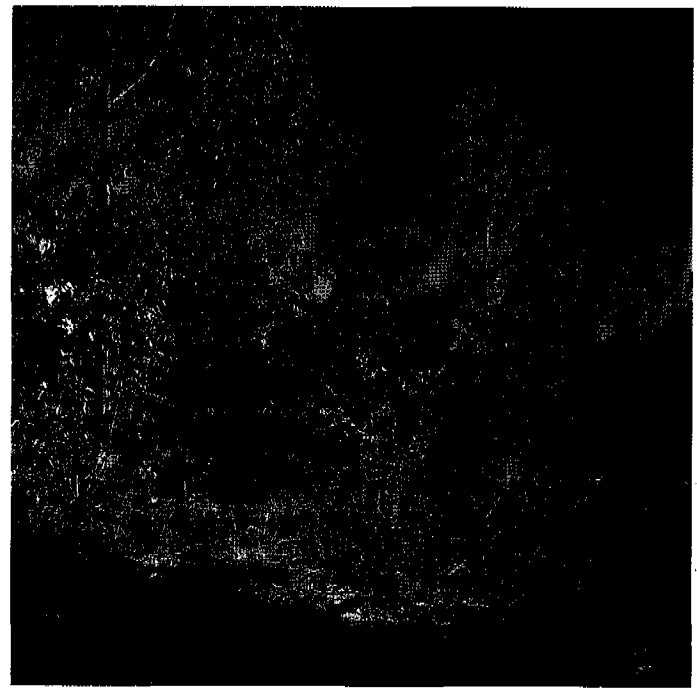


Photo 9 Eucalyptus plantation in Mongu for polewood. Demand exceeds supply.

Near Mongu the productivity varies considerably with the site (Photo 9). The yield of the better species/provenances of *Eucalyptus* is estimated as low as 5-7.5 m³/ha/ year on the most optimal sites. Kaoma plantation appeares more homogeneous and productive. Demands for *Eucalyptus* poles exceeds supply and exploitation of *Eucalyptus* plantations is potentially a profitable enterprise (White, 1983). **Some limitations in the organisation of the Forestry Department (White 1983) as well as the price setting need improvement before economically viable *Eucalyptus* plantations are feasible.**

2.9 SUMMARY ON FOREST RESOURCES

Kalahari Upland sands favour trees as may be observed when entering in the Kalahari sand region. The important timber trees of Zambia: Mukusi, Mukwe and Muzauli, all occur only on Kalahari sands.

The Kalahari woodlands and forests are generally highly resilient against shifting cultivation, fuelwood cutting, cattle grazing and fire. However logging and decrease in wildlife grazing have probably changed the Mukusi forest to the point where sustainable timber production is not feasible anymore. Resilience of woodlands against goat grazing is unknown.

Zambia's most important hardwood timber resource is the Zambezi Teak (Mukusi). At the current exploitation rate of 20.000 m³/year this timber resource will be depleted around the year 2000. Forest management practices for sustainable Zambezi Teak exploitation are not discovered yet. There is an estimated 1.000.000 ha of 1.5 m³/ha hardwood timber in the Kalahari Miombo and Mukwe. The current mining of Zambezi Teak and other Kalahari hardwoods has no environmental hazards except resource depletion. The timber resource is declining from the beginning of this century.

Data requirement on forest resources is a timber inventory of the Kalahari Miombo and Mukwe. Research on forest management to achieve sustainable timber exploitation is necessary.

3. WILDLIFE RESOURCES

3.1 GENERAL

Since the second half of the last century wildlife is a declining resource in Western Province. During the last century the Barotse floodplain contained large numbers of wildlife among others Elephants and Red Lechwe, both presently occuring only in relatively small numbers south respectively north of the Barotse floodplain.

Under customary law, hunting was reserved in certain areas for the Royal Establishment including the two areas now National Parks in Western Province: Sioma-Ngwezi National Park (527 600 ha), Liuwa Plain National Park(366 000 ha) and the Luena Flats. Hunting of large animals such as the Elephant, Hippo, Eland and Red Lechwe could only be done by the Litunga in the past. One large Game Management Area (GMA) covers the remaining part of the Westbank of the Zambezi (3 807 000 ha). The National Parks (NP) in Western Province are too remotely situated, not spectacular enough and almost inaccessible to compete with other Zambian NP's (Luangwa, Kafue) for mass tourism. There might be scope for small scale wilderness tourism combining fishing, waterfowl and crocodile watching, canoeing on the Barotse floodplain with hunting or photo-safari in the Liuwa Plain National Park and visits to various cultural places of interest.

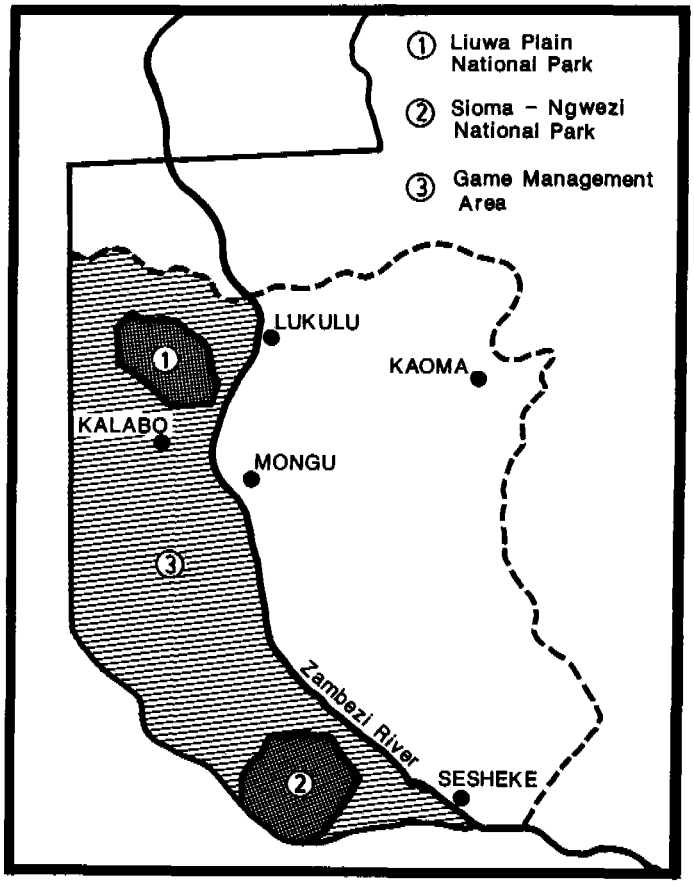


Figure 6 Location of the two National Parks and the Game Management Area in Western Province.

3.2 NATIONAL PARKS AND GAME MANAGEMENT AREA

Each of the two National Parks (location Figure 6) contains valuable wildlife, the most important are the Giraffe population in Sioma-Ngwezi NP and large numbers of Elephants, furthermore there are Buffalo, Kudu, Tsessebe, Roan Antelope, Reed Buck, Lion, Baboon, Vervet Monkey, Leopard, Cheetah and Hyena. In dry years wildlife from the Sioma-Ngwezi NP migrates eastwards to the Zambezi river in search for drinking water. Along the Zambezi river are settlements where crops may be damaged and illegal hunting is hard to control.

The Liuwa Plain NP supports a large number of Wildebeest (±20,000), which migrates westwards over the international boundary in June. The discussed relocation of the Cattle Cordon line (paragraph 9.7) should take the migration of Wildebeest into account. Red Lechwe (±3000) move eastward from Liuwa Plain NP in the dry season to the Zambezi floodplain for green grass and water. Furthermore Zebra, Tsessebe, Roan Antelope, Oribi, Reed Buck, Sitatunga, Sable Antilope, a few Buffalo, Lion, Leopard, Cheetah and Hyena are found. Management of the Liuwa Plain NP is complicated by the presence of many villages including cattle.

Both the NP's do not cover the complete migration range of the main protected wildlife species. Elephants resp. Wildebeest migrate through and into the Game Management Area (location Figure 6) as well as over the international borders into war zones. The absence of land use plans, for which the resource data base is lacking, is a potential threat to the loss of essential wildlife habitat in the Game Management Area.

As in the whole of Zambia poaching is a serious problem in conservation of the large mammals faced by the National Parks and Wildlife Service (NCS).

Poaching is difficult to overcome because of lack of transport in the Wildlife Department. Two types of poaching occur. First most people believe that game animals can be hunted and eaten by who ever wishes to. This might be seen as illegal subsistence hunting. Secondly, illegal commercial hunting is done in order to sell horns, tusks, skins and meat for cash.

The Liuwa Plain NP is a wetland area and exceptionally abundant in waterfowl especially during the floodseason. Examples are Pelicans, Egrets, Ibis, Marabous, Herons, Cranes and others. The same species of water birds are abundant in the Zambezi floodplain. There is no threat to the birdlife at present nor in the foreseeable future.

The suggestion to give the population around and in the NP's a certain number of licences for controlled hunting under close supervision of the Wildlife Department is encouraged. It can be expected that the licence holders will thus be concerned with protecting their wildlife resources and they can probably offer effective assistance to the Wildlife Department in poaching control.

Hunting is prohibited in the National Parks. For hunting in the GMA both a licence for a certain animal and a hunting permit are required. Some animals are fully protected e.g.: Rhino, female Eland, Giraffe, Cheetah and several birds like Pelican, Eagle, Crane, Buzzard.

The National Park and Wildlife Act does not protect against mining activities. At the moment prospecting for oil and gas in Liuwa NP has started.
Before allowing oil and/or gas extraction on Environmental Impact Assessment should be required.

Besides poaching control there is hardly any management of the National Parks in Western Province. Data on wildlife habitat especially vegetation as animal feed resource and drinking water are lacking almost completely.

3.3 WILDLIFE IN AND EAST OF THE ZAMBEZI

Outside the NP's and the GMA large herbivores are found on the eastside of the Zambezi river locally. In Sesheke District there are elephants which migrate over the Zambezi river into Zambia from Angola and the Caprivi in Namibia. The poaching pressure on this population is high in the Zambian part of their range and this results in Elephants remaining in Angola and Namibia as long as possible. In 1986 67 Elephant tusks were confiscated from poachers mainly in Sesheke District. Damage to fields by Elephants is reported from Sesheke District. The habitat of these elephants is not protected over major areas.

The Luena Plain and adjacent Ushaa Flats contain some Buffaloes, Eland, Reed Bucks and Sitatunga. There is also wildlife at the eastern border of Western Province along the Kafue NP.

Crocodiles and Hippos abound in the Zambezi river. No hunting licenses for Crocodiles were given for 1987 in Western Province. Hippos are also found in some river valleys in Kaoma District.

Zambia is a member of the CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora). This implies that Zambia has banned commercial trade in endangered species and regulates and monitors trade in other species about to become endangered. Zambia and a few other African countries excluded deliberately the crocodile from the list of endangered species in signing the CITES treaty.

Hunting outside the National Parks and Game Management Area requires only a licence. Licences are cheaper for residents and subsistence hunters than for non-residents and commercial purposes.

3.4 SUMMARY ON WILDLIFE RESOURCES.

The larger wildlife (Elephants, Red Lechwe etc.) is a declining resource since the second half of last century, when the area was renound for the export of ivory. Currently wildlife may partly be stabilizing (Wildebeest; Crocodiles), but a further decline is expected (Elephants) due to both diminished habitat and to poaching. The wetland birdlife seems stable both in numbers and species.

The replacement of the CBPP cordon fence is a potential hazard for the Wildebeest migration. The absence of Provincial and District land use planning may lead to increased farming, which can be expected to lead to loss of wildlife habitat (e.g. Elephants) in the Game Management Area and elsewhere.

Photo 10 Plain edge with cropland and settlement (foreground) and Barotse floodplain in the background. The trees on the plain edge are mangos and indicate the Wet Itongo.

4. AGRICULTURAL RESOURCES

4.1 AGRO-PASTORAL FARMING SYSTEM

Agriculture in half of the land systems is by means of mixed farming. Sustainable permanent cultivation of dryland crops on Barotse sands is rare and dependent on cattle manure. Acreage of lowland fields to be cultivated can be currently extended above subsistence level only by ox-ploughing, since tractor ploughing is economically out of the question. Stubble grazing of cropfields for the sedentary cattle is important in a few areas in the dry season. Crops and cattle are more or less complementary in relation to weather dependent yields. When dryland cereals show low yields due to unfavourable rainfall distribution such as in 1987 cattle productivity is influenced to a lesser degree.

Along the Zambezi floodplains fisheries are an important aspect of the farming system in the allocation of land, settlement, labour and water. Fish is the main protein dietary component for one third of the population living in and around the Zambezi floodplains.

This environmental assessment of the agricultural resources is on exploratory or land system level. On the more detailed level of farming system there might be farming practices (like cropping patterns, grazing pattern, period of sowing, weeding, ploughing) that have each their own environmental impact. The farming system level is however outside the scope of this Profile.

Pesticides or herbicides are currently hardly used in Western Province except for sulphur on Cashew trees.

4.2 LOWLAND VERSUS UPLAND

The two main land units are the grass-covered lowlands or wetlands and the wooded uplands or drylands (Photo 10, Photo 11, Photo 12, Photo 13)). The uplands are a few to 50 meters above the level of the lowlands. The lowlands cover approximately 10% of Western Province and the uplands the remaining 90%.

Photo 11 Plain edge with cassava field (foreground), settlement and Mango trees. The floods have just receded from the Barotse floodplain in the background.

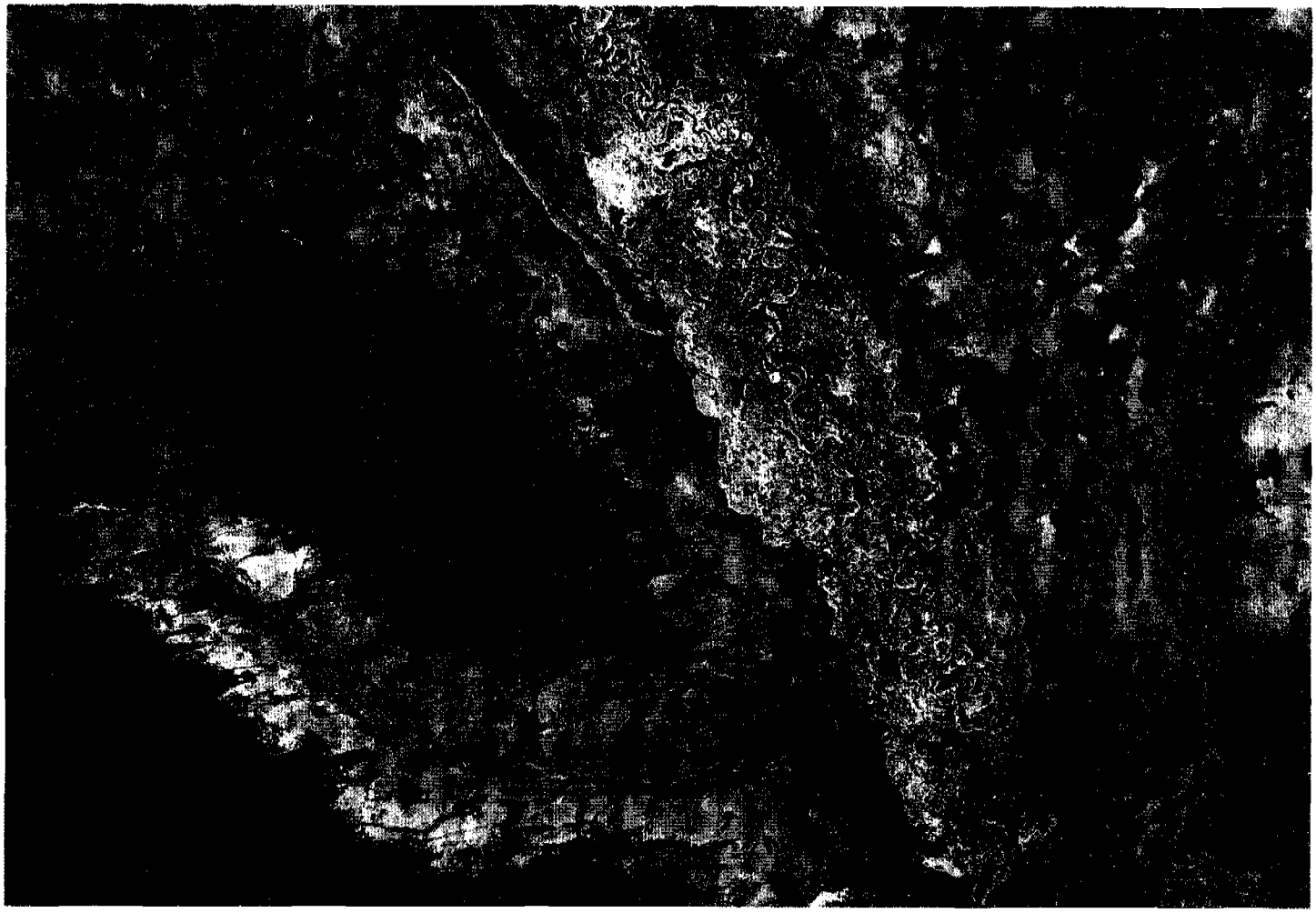


Photo 12 Satellite image showing the Zambezi river, the Barotse floodplain in the centre and to the left and right the uplands with dambos. The tributary on the right is the Lui river, the one on the left the Southern Lueti. Expert interpretation will yield information on soils, forests, flooding and land use. Approximate scale 1:570.000. Overlay of three images: 23-2-83 labeled with red, 30-6-85 labeled green and 26-8-85 labeled blue.

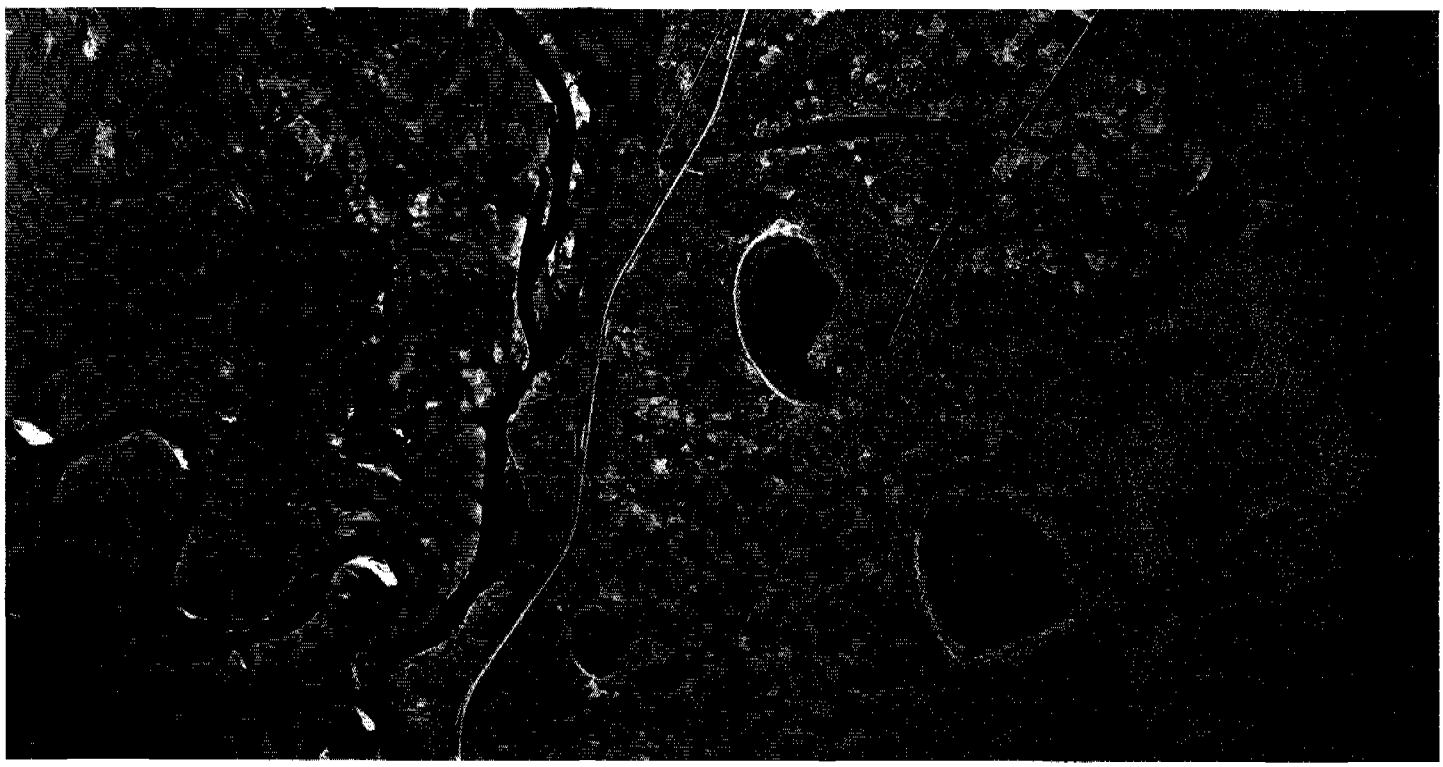


Photo 13 Aerial photograph of Barotse floodplain at Senanga. The first few kilometres of upland near the floodplain show cassava/millet forest shifting cultivation fields and fallows. Further away only Miombo woodland occurs. Approximate scale 1:80.000

Both the upland and lowland are part of the uplifted Kalahari-Okavango basin which is situated approximately at an altitude between 900 meter in the south to 1350 meter in the northeast. Kalahari sands, locally also known as Barotse sands, are the dominant soil material throughout Western Province (Figure 6).
The lowlands include the floodplains of the Zambezi, the main one being the Barotse floodplain, its tributaries and the dambos. For a good understanding of the ecology of the Zambezi, the Luena and the Northwestern floodplains it should be borne in mind that the extent of these plains is only partly shaped by erosive river action and/or scarp retreat, but these are mainly determined by tectonic events. The larger floodplains are usually bounded by scarps which result from block faulting, thus in fact these plains are rift valleys.

The pattern of the Zambezi tributaries is also induced by tectonics as may be deduced from their parallel directions and abrupt nick points in extremely flat areas. These tributaries are fed by seepage and therefore have a relatively low but constant waterflow. The ridges along the major floodplain may be shaped by mass movement.

The dambos are treeless depressions in extremely flat terrain. *Pan* dambos (Photo 14) are more or less circular and they are near water divides. They have typically a diameter between 0.5-6 km. Chains of Pan dambos may join away from the water divide into a flat-bottomed drainage system, sometimes referred to as *valley* dambos. *Headwater* dambos are pear-shaped heads of smaller drainage systems (e.g. near Kataba and on Luampa water divide). *Linear* dambos are straight depressions with internal drainage in between parallel low sand ridges. Linear dambos occur in Western Province only in the Shekela area.

Seepage valleys (e.g. Lui valley) often follow tectonic patterns and are sometimes referred to as valley dambos.

Dambos (pans, vleis) are more widespread in southern Africa then anywhere else in the world. They are found especially on Kalahari sand, gneisses and granitic areas and always on extremely flat plains (slope less than 4%) and in climates with alternating dry and wet seasons. Currently, pans occur in a rainfall zone from 100-1300 mm/yr; however, it seems possible that these include relicts from other climatic periods. The dambos and smaller valleys originate in mass movement of wet sands. Some Pan dambos are flanked by dunes that may originate from deflation.

Many dambos in Western Province are recently in the process of drying up as is deducted from the invading trees at the fringes and from interviews with people living around them. Most pans show to be wetter in 1982 airphoto's than they are currently. However there are numerous dead trees along dambos margins as a result of the high water levels in the fifties and the sixties. There is possibly a fluctuation rather than a trend in drying up. Locally long term (20 years) dambo desiccation is reported.

The crop calendar (Figure 7) for Western Province is determined in the Uplands by the climate (paragraph 1.2) and in the Lowland by the flooding (compare paragraph 6.2 and Figure 7).

Photo 14 Subcircular dambos in different sizes in wooded upland. This are the main grazing areas during the floods. Aerial photograph approximate scale 1:140.000.

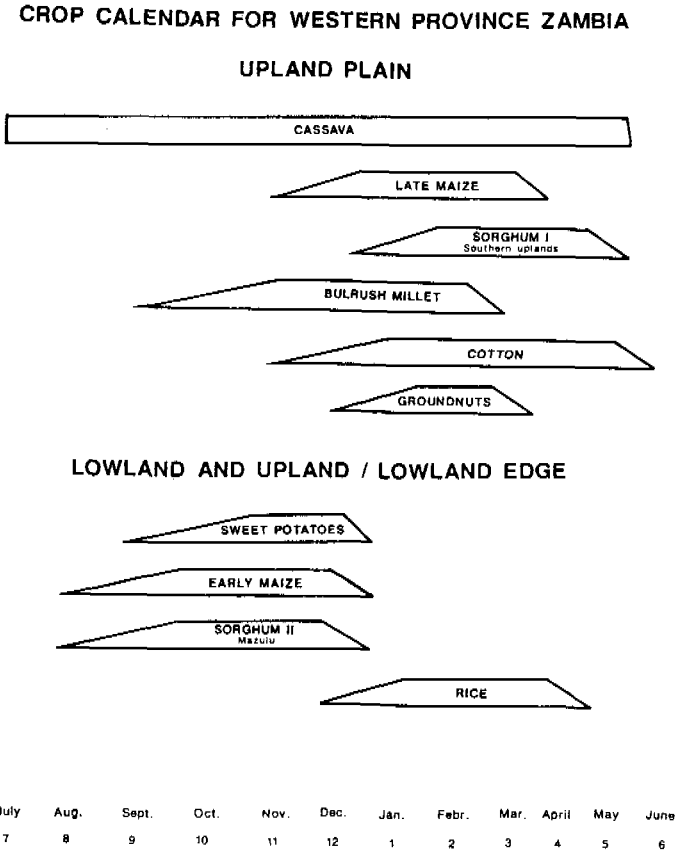


Figure 7 Crop calendar for Western Province Zambia.

4.3 DRAINED ORGANIC WETLAND SOILS: SISHANJO AND WET LITONGO

Photo 15 Peat soil with drainage ditch for seepage water. This traditional drainage leads to irreversible loss of the peat soil. On left bank intercropping of cassava and maize. Mongu township.

Photo 16 Wet Litongo with vegetable gardens (foreground) and Mango trees (background) at Kaande dambo near Mongu, June 1987.

Both Sishanjo (Photo 11, Front cover, Photo 15) and Wet Litongo are found at the edges of the floodplains (Figure 8), river valleys and dambos (Photo 16).
The Sishanjo is a trough permanently waterlogged by seepage water of the Upland and where a peat layer of up to several meters has developed. On the Sishanjo horticulture of cassava, early maize, sweet potatoes, finger millet, rice (Photo 19), sorghum and vegetables is undertaken. Rice is a relatively recent crop dating back probably to the forties of this century. Acreage of Sishanjo soils was estimated at approximately 4000 ha at the eastern edge of the Zambezi floodplain between Limulunga and Namushakende and another 5000 ha on the western side of the Zambezi floodplain, in its tributaries and in dambos. The cultivated portion is about 10% of the total Sishanjo area (Peters 1960).

The Wet Litongo (plural Matongo) has a mucky or peaty top over sandy subsoil and is situated in the drier part of the seepage zone of the scarp and dambo (Photo 16) edges. On the Wet Litongo mango, early planted maize, banana, sugarcane, wheat, vegetable, cassava, sorghum and sweet potatoes are grown, the latter two on raised beds, the so-called Mikomena. The acreage of cultivated Wet Litongo soils on the Zambezi floodplain may be about 2.500 ha which is about half of what is available there (Peters 1960). The total area of Wet Litongo soils in Western Province may be around 10.000 ha.

The wet organic soils are laborious for cultivation. They are covered by sods of stoloniferous grasses and sedges, which require tough hoe cultivation and burning to eradicate weeds. However, the burning destroys the organic matter.
Ox-ploughing on Sishanjo depends on adequate water control. The organic wetland soils may need water control for crop production.
Traditional drainage by "canals" (ditches is the more appropriate word) as has been applied since the end of last century, results in rapid and irreversible shrinkage and irregular subsidence of the surface thus impeding further drainage and leading to oxidation and wind erosion of the organic top soil. Banks of ditches in peat are very unstable and have become the starting point of land degradation (Sefula). Since the meso- and micro-relief of the floodplain is extremely intricate suitable location of drainage ditches is hardly possible without the aid of modern techniques of preparing detailed spotheight maps as a basis for the design of water control systems. The water control required is by sluices in the drainage ditches which are opened and closed to regulate the water level at around 50 cm below surface level during the dryland crop growing season and at the surface level during fallow. Rice cultivation requires a higher water level. Even under optimal water control conditions realized at present only in Namushakende (Photo 17, 18), some loss of peat through oxidation is unavoidable (a few cm/yr).

This soil shrinking and surface subsidence should always be accounted for in the reclamation design for organic wetland soils. From interviews it has become clear that several farmers are aware of the negative effect of traditional drainage ditches (e.g. Niesten 1986).
Probably some ditches have been dug after series of wet years (section 1.2) and they overdrain in the current period with a sequence of normal rainfall years (section 1.2). Other ditches might have been constructed to facilitate fisheries or to create employment.

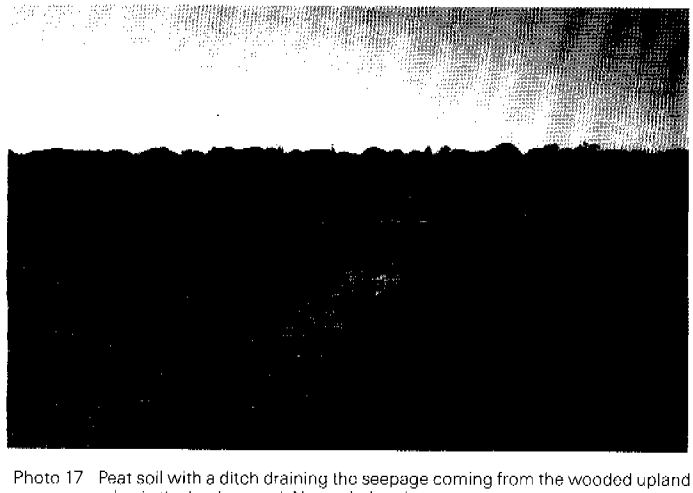
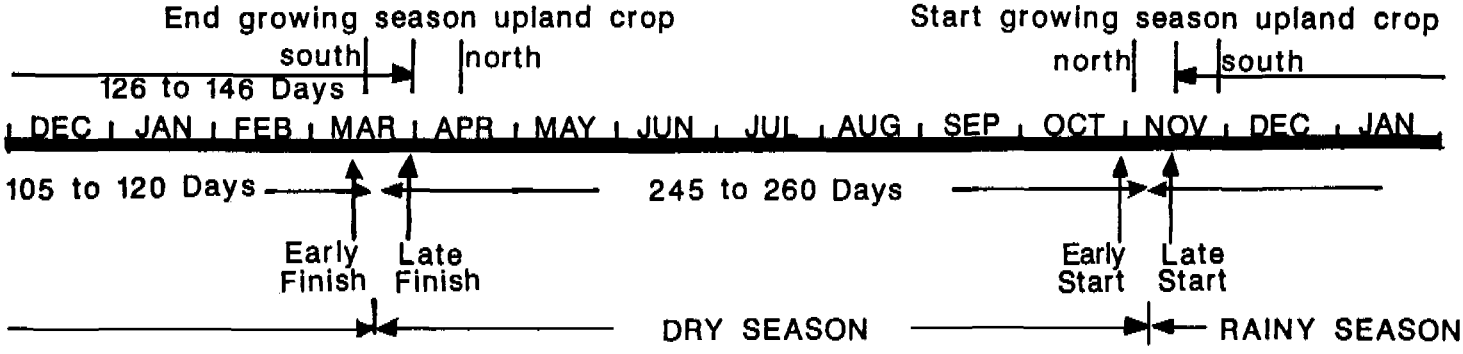


Photo 17 Peat soil with a ditch draining the seepage coming from the wooded upland edge in the background. Namushakende.

UPLAND CROP GROWING SEASON



FLOODING OF BAROTSE FLOODPLAIN

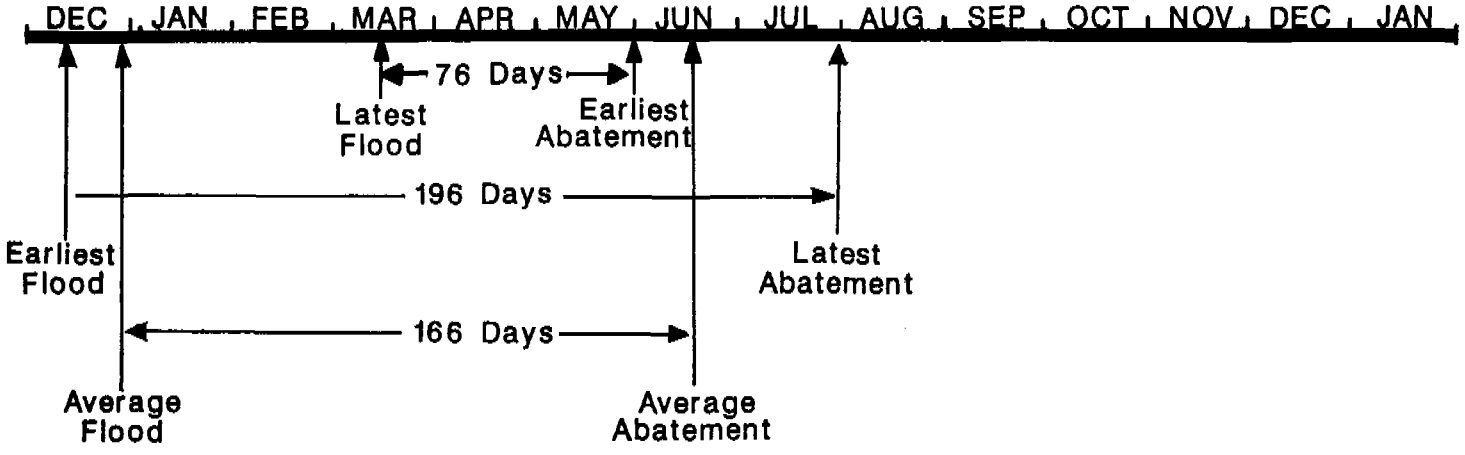
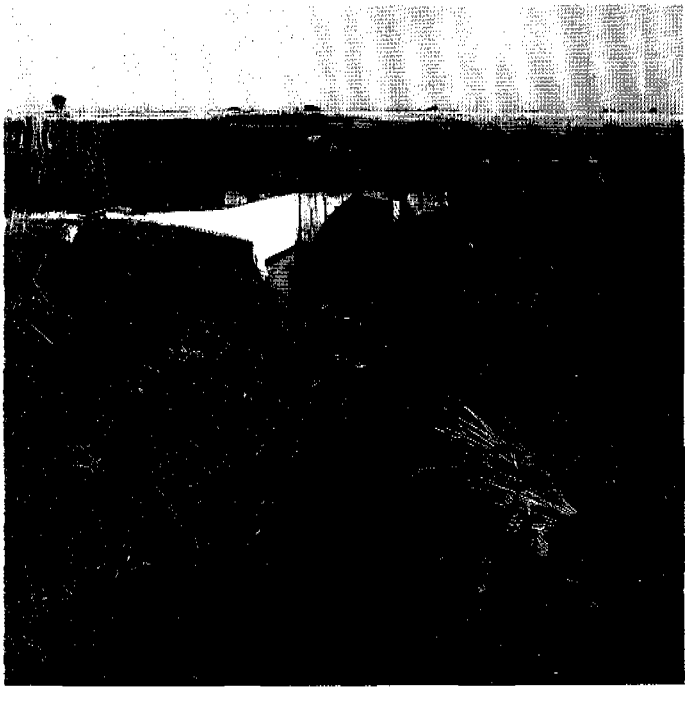


Figure 8 Upper half : *Above;* start and end of the crop growing season in the Upland for the northern and southern part of the province.
Below: Rainy season and dry season and its variable duration.
Lower half : Period of flooding of the Barotse floodplain and its variability.
Source: Jeanes 1986

Photo 18 Modern drainage ditch for seepage flow with sluices to regulate water levels for irrigated rice cultivation. Such stagnant water bodies may create health hazards. Namushakendo.



The water control problem is specific for Western Province and cannot be dealt with at the national level. **The Provincial Natural Resource Committee could be instrumental in preventing unnecessary degradation of peat soils by creating by-laws and regulations to enforce a water control system by sluices instead of traditional drainage.**

The low pH (3.0-3.8) of the Sishanjo peat makes it unsuitable for crops like maize and may result in the release of the toxic trace elements aluminium (Al) and locally iron (Fe) which will diminish crop growth. The organic soil may show relatively adequate supplies of macro-nutrients such as nitrogen, phosphorus and potassium, the latter two especially released after burning.
Deficiencies of calcium (Ca), magnesium (Mg), copper (Cu), molybdene (Mo) may become apparent after a few years of permanent cultivation thus compelling shifting grassland cultivation. Deficiencies may develop more quickly when standard chemical fertilizers are applied. **Crop and fallow grass analysis for the mentioned elements is recommended as part of a land evaluation.** Wetland rice on deep peat soils may suffer from male sterility.

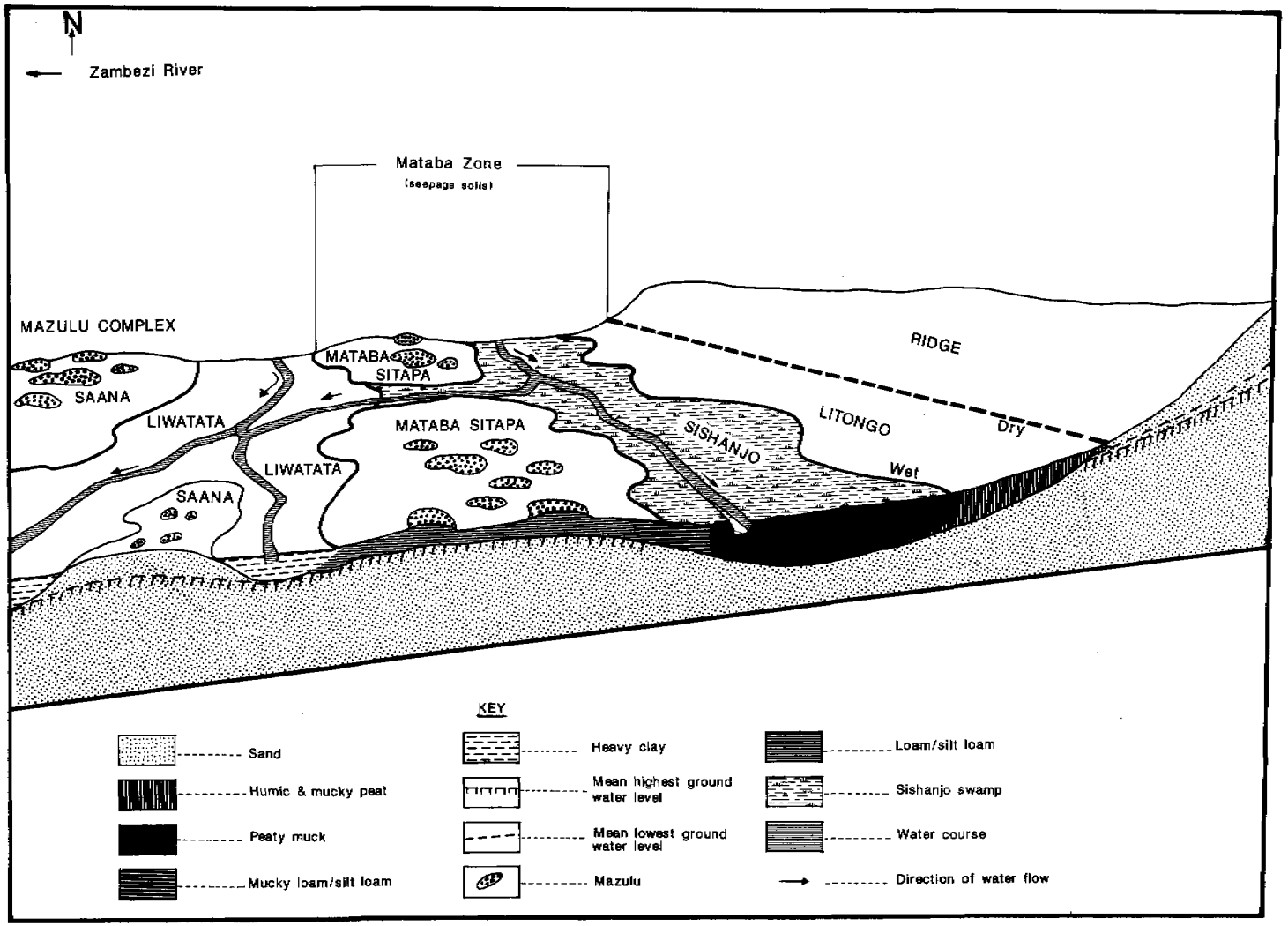


Figure 9 Land facets at the edge of the Barotse floodplain. Source Mulungushi 1986.

The Sishanjo and Wet Litongo are unsuitable for cattle grazing due to susceptibility to trampling and damage caused to the ditches. Moreover these are often covered by unpalatable sedges.

Each part of the wetland has long been granted to groups and individuals, mainly Lozi. The fact that in 1960 only 10% of the Sishanjo and 50% of the Wet Litongo was cultivated (newer data not available) can be explained ecologically and economically as described earlier. Customary land tenure which permits absentee land ownership may play a role in the extent of fallow (compare Chapter 9). If this is so, customary law has contributed to the conservation of wetland soils which otherwise probably would have been degraded by now through traditional drainage techniques. **If land tenure conditions are changed to preclude fallow due to absentee land ownership, a provision is required to enforce a minimum fallow or rest period.**

Photo 19 Downstream of Photo 18; Transplanted rice is still rare compared with broadcasted rice in Western Province; the first rice cut has just been harvested (June 1987); a second cut is expected.

4.4 FLOODED OUTER PLAIN: SAANA

The Saana is primarily shaped by mass movement from the scarps bordering the floodplain. River flooding, fan deposition by tributaries and seepage water flow further modify the Saana. The Saana covers approximately 25% of the Zambezi floodplain between Mongu and Kalabo. Towards Limulunga the Saana becomes absolutely and relatively wider, whereas towards Senanga the Saana disappears. This is caused by the funnel-shape of the Barotse floodplain.

The Saana consists of poor upland Kalahari sand covered only by shallow organic alluvium. Due to this and the short and shallow flooding of some months the Saana has more organic matter than the upland Kalahari sands. However, the risks of early flooding limits crop production. Under the sandy top soil there might be clayey material between 1 and 2 meters under the surface.

The Saana is sometimes subdivided into interfluves known as Plain Litongo and stream channels or Liwatata. The Plain Litongo is covered by grassland with poor grazing quality: the Mwange *(Loudetia simplex)*. This poor grazing is only available after the rains and before the flood. After the floods the Plain Litongo is not suitable for grazing, because by the time the floodwater recedes from the Saana, the grasses are mature (yellow) and have protein and mineral levels below cattle requirements. Locally these grassland may be burned at this stage and cattle grazed on the green regrowth. The Plain Litongo can only permanently be cultivated with manure. Alternatively shifting grassland cultivation is practized with raised beds, known as Mikomena, mainly for sweet potatoes or cassava. Only 0.5% of the Saana is cultivated. Some Mango trees are grown on the higher parts. The stream channels in the Saana, the Liwatata, contain better soils with more alluvial loam, clay and organic matter and they are similar to the Bulozi meanderbelt (section 4.5). They carry the best grasses for cattle grazing *(Vossia cuspidata, Echinochloa stagnina, Oryza barthii, Leersia hexandra)*. Early flooding is a risk and therefore crop cultivation is rare.

Mapping of groundwater levels and flooding regime is essential for suitability assessment for rice.

4.5 FLOODPLAIN MOUNDS: MAZULU

Mazulu (singular Lizulu) are dome-shaped mounds, typically 20-150 m in diameter or larger elevated areas. The origin of the latter is much debated. The river levee hypothesis of Verboom for the larger Lizulu is contradicted in some cases by the more clayey and/or loamy character of the Mazulu compared to the surrounding areas. The dome-shaped Mazulu are often associated with termitaria or ant hills. The Mazulu surfaces are situated 1.5-3.0 m above the general floodplain or water divide plain level and are therefore often the site for seasonal settlements (Photo 20, 21), sorghum, millet and/or

Photo 21 Floodplain mound (Lizulu) at the Zambezi river between Mongu and Kalabo.

Photo 20 Floodplain mound (Lizulu) in Barotse floodplain near Limulunga. In the foreground: yellowing and green grasses after flood recession. Cattle grazing is not practiced because inaccesibility due to standing water under the plant cover.

late maize gardens (Front cover). The Mazulu occupy from about 20% in the Matabele Plain, 5-10% in Siloana Watershed Plain down to 0.5% in the Barotse floodplain. This implies that land systems with the largest proportion of Mazulu are situated in the south of Western Province, were the drought risk is relatively high and therefore maize cultivation rather uncertain.

The fertility, workability and drainage of the Mazulu make these the best soils in the area. However, many Mazulu in the Barotse floodplain are permanently fallow. This is a result of the risks of early flooding, drought hazard after early seeding and inaccessibility from settlements at the plain edge, where part of the formerly transhumant floodplain population is settling permanently. The risk of overgrazing of the Mazulu is relatively large but the acreage involved is low.

4.6 THE GRAZING RESOURCE: BULOZI MEANDER BELT

The Bulozi meander belt is the inner part of the Barotse floodplain and consists of complexes of levees/creeks and pointbar/swales. The soils consist of layers with textures varying from clay over silt to sand. The clayey and loamy stream channels (Sitapa) and especially the seasonal ponds and lakes (Mulapo) produce good forage grasses as *Echinochloa stagnina* and *Vossia cuspidata* vital for cattle growth during the non-flooding season. Similar floodplains elsewhere in Africa (Okavango, Sudd) carry often more reed vegetation. However the Bulozi meanderbelt is mainly covered by grasses; Papyrus and reeds occur locally only. The Sitapa and Mulapo are also suitable for early maize and rice cultivation, but the friable loams and sand layers make the irrigation/drainage ditches expensive in terms of construction and/or maintenance cost. Mulapo cultivation occurs also in the Okavango Swamps in Botswana. Cultivation of the Sitapa is uncertain as it depends on residual moisture during seeding, early rainfall for crop growth yet timely flooding to allow maturing and harvesting.
Access to the Sitapa from the population centres at the plain edge is another limitation for their cultivation. The fragmented and complicated land holdings as well as fishing rights inhibit adequate water control. Moreover, large scale rice cultivation in the Bulozi would be in direct competition with grazing and fisheries and should therefore only be considered in an overall land use planning including crop cultivation, fisheries and animal husbandry. Any substantial increase in rice cultivation here will run into the problem of land preparation. Tractor and oxen are not suitable everywhere and buffaloes are not available.

The Bulozi meander belt is the main grazing resource of the Western Province (Photo 25) and is quite resilient to overgrazing due to the annual floods (which limits the grazing period) and no signs of such overexploitation are observed. Burning during the nonflooding season in the Bulozi meander belt does not lead, in contrast to organic and upland soils, to soil and/or grass degradation, because soil fertility and water holding capacity of the clay and loam soils does not depend on the soil organic matter. The good grasses are perennials and well adapted to the yearly burning for green regrowth necessary for a good livestock production. Thus burning of the Bulozi is not damaging and has a positive effect on cattle production.

4.7 FOREST SHIFTING CULTIVATION: UPLAND SANDS

The upland Barotse Sands have a low mineral content, low organic matter content, a low absorption complex and consequently a high leaching potential also for chemical fertilizers and poor water retention capacity in the top soil. Thus these soils are only suitable for shifting cultivation of cassava (Photo 22) and intercropped bulrush millet in the north and millet alone (Photo 23) or intercropped with

Photo 22 Poor cassava stand on Upland Barotse sand near Mongu. Bushfallow in the background. After a few successive cassava harvests the land has to be rested for one to several decades. Near settlements the rest periods are shortened and consequently yields per ha decline.

maize (Photo 24) and/or sorghum in the south, in so-called Matema (plural of Litema). The bush/woodland regeneration is 30 years, but the bush fallow is shortened down to 3-6 years near to the main settlements.
Moreover the sand is so loose that it precludes draught by oxen or tractors.
The upland cassava in the northern half of Western Province requires 3-4 years before harvesting, in exceptional cases only 2 years; it drops its leaves during winter. The growing season for rainfed crops like cassava, maize and millet on Upland Barotse Sand are discussed in paragraph 1.2.

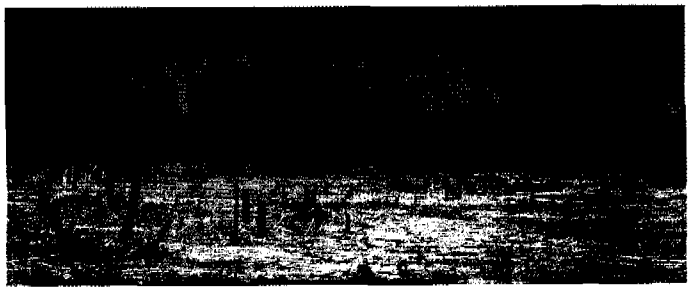


Photo 23 Shifting forest cultivation of millet in Munga woodland on Upland Barotse sands south of Mulonga Plain in Senanga west.

The Barotse sands are more suitable for trees, the reason being that the infiltration capacity for water is high and steep slopes are absent. This implies that most of the rain infiltrates into the soil, where it is stored and can be used by trees. Therefore Barotse sands, as all Kalahari sands, are far more wooded than other soils in similar climatic conditions and the woods are more resilient to destruction (compare section 2.1). Due to the low soil fertility the growth rate of these woods are, however, of the same order of magnitude as those on other soils (a few m^3/ha/yr). Forest and fruit tree plantations may require mineral fertilisers because of development of nutrient deficiencies.

Photo 24 Recent forest clearing with a good cassava crop, banana and harvested maize along road from Kaoma to Kafue National Park.

The only way for semi-permanent cultivation of the sands for cereals and cassava is currently by the application of cattle manure. Especially cassava cultivation on manured land is currently extremely rare, for maize it is more common. Even close to the floodplain there is not enough cattle to manure all fields. Only a minor part of the Matema fields is currently manured. The effect of manuring lasts probably for one or a few growing seasons only and when there are alternative soils available manure is more effectively applied there. Fertilizers are not used to any extent on the Barotse Sands. The recovery rate of standard chemical fertilizers would be low due to low Cation Exchange Capacity and low organic matter content. Supplementation of the macronutrients (N,P,K) alone to Barotse Sands may result in a deficiency of other nutrients (Mg, Bo, etc.). Because of the low soil pH and low Cation Exchange Capacity (CEC) the application of the most common nitrogenous fertilizers in Zambia (ammonium nitrate, urea) has an acidifying effect on the soil, which could result in aluminium (Al) toxicity and/or increasing the phosphorus (P) deficiency. Liming to correct the low soil pH may lead to deficiencies of phosphorus, magnesium, zinc, copper and/or boron due to the low CEC. The adequate approach to fertilizing Barotse Sands would be to combine cattle or green manure and chemical fertilizers. In practice cereals and cassava can be cultivated on the sands only by shifting cultivation.

The Barotse Sands are suitable for tree crops like cashew and mango. There are currently approximately 35.000 mature Cashew trees producing nuts. Recently 250.000 Cashew seedlings have been produced by the Zambia Cashew Company Limited and the planting of at least 140.000 trees per year is scheduled uptil 1991. Currently there is 500 ha of Cashew plantation with 100 trees/ha and another 3.500 ha is planned. The remaining part of the trees are to be planted by smallholders. The areas around the Cashew is kept bare, in between trees the vegetation is kept low by slashing. The Dry Litongo along the floodplain and dambo edges are the best areas for cashew and mango. However, low night temperatures in winter preclude fruit trees in much of the southern half of the Province. Cold air lakes cause damage to fruit trees in the Central and Southern Barotse land system. **Measurement of topoclimates is recommended there.**

There are suggestions for distinguishing two categories of Barotse Sands: the southern or Transitional Sands, slightly finer and fertile and carrying Munga or Mukusi forests and the Central Barotse Sands covered by Kalahari Miombo or Mukwe. However, this subdivision needs to be substantiated by data and it seems possible that the supposed difference in sands as indicated by forest vegetation as well as by crops are related more to drainage and climate than to soil texture.

The extent of shifting forest cultivation of cassava and millet is close to the maximum in the Central and Southern Barotse land systems (section 1.3) as well as the Luena land system or roughly within a radius of 50 km from Kalabo, Mongu and Lukulu. Around other population centres, Kaoma, Senanga and Sesheke that holds true on a smaller scale. Judging from space imagery there seem to be large tracts of land especially in the Mukwe land system (northern and in the eastern Lukulu District), and northeastern Sesheke District currently not used intensively for subsistence forest shifting cultivation. The main ecological reason probably is the relative scarcity of both easily accessable drinking water and lowlands soils, which are an essential part of the subsistence farming system. Higher frost incidence towards the south is a limition for cassava cultivation. **Minimum temperature measurements should therefore be part of a land resource survey. Forest cultivation of cassava in these areas would destroy the potential for timber exploitation (section 2.2 and 2.3) and any development should therefore only be considered after a comprehensive resource survey followed by land use planning.** Both cassava and timber development also depend on improvement of roads.

The forests on Upland Barotse Sands are marginally suitable for floodseason (summer) grazing. Their grazing capacity may be as low as 20 ha/head of cattle implying energy deficiency for cattle. In fact, most of the floodseason grazing takes place on grassland in non-inundated (parts of) dambo's and smaller rivers as well as on waterdivide grassland plains, the latter occurring in the southwest of the province. Overgrazing by cattle alone in the Upland Barotse Sand does not lead to desertification or erosion, but results in the disappearance of certain grasses and in increase of some woody species. The sandy soil is not susceptible to trampling. **However, expansion of the presently insignificant goat grazing, especially when combined with the intensification of upland shifting cultivation, could possibly lead to bare ground and soil degradation. Research into goat grazing is recommended for developing guidelines to prevent potential land degradation.**

4.8 UPLAND AWAY FROM BAROTSE SANDS: THE MAIZE POTENTIAL

In the Eastern Kaoma land system (Munkuye, Kahare, Dongwe river, Lalafuta river, Mangango, Machili river) soils have developed locally from material different to Barotse Sands (siltstones, schists, granites, basalts). These are partly more reddish when compared to Barotse Sands and range from sandy loams to clayloams. Most of these soils have a relatively sandy top soil which improves their water infiltration capacity and reduces rainwater erosion hazards. Waterlogging is a limitation in part of the Upland away from Barotse Sands. These soils are more fertile (higher mineral content and CEC) and react more positively to the application of fertilizers. However, some of these soils have limitations for mechanical farming others are susceptible to rainwater erosion. The area of the Upland other than soils developed in Barotse Sands is unknown, but estimated at least at hunderd thousand ha, around 1% of the Province. Currently only a small proportion (±10.000 ha) of these relatively good soils is cultivated. Fortunately the Eastern Koama area receives a higher and more reliable rainfall than most of Western Province.

Estimates of the maize yield at 2000 kg/ha and a fallow proportion of 50% lead to the conclusion that the current maize deficit of Western Province (25.000 ton/year) can be produced in the Eastern Kaoma land system. A considerable benefit of expansion of semi-permanent cultivation would be the easier control of tsetse by the removal of the fly habitat. This would reinforce semi-permanent cultivation by facilitating the use of oxen for ploughing. **More precise data on the acreage of upland soils other than Barotse Sands are essential for an estimate of the crop production capacity and land use planning of Western Province.**

4.9 SUMMARY ON AGRICULTURAL RESOURCES

More than 95% of Western Province, the Upland Barotse sand and the sandy lowlands (Saana, parts of Bulozi meanderbelt) are not suitable for permanent cultivation of staple food crops.

The current subsistence crop farming on one or few percent of Western Province or its expansion on the limited suitable area will not result in environmental degradation except that traditional drainage will lead to irreversible loss of organic soil material.

There is potential for extension of *forest shifting cultivation* in remote areas. This is associated with the hazard of losing timber resources and reversible soil nutrient depletion. An inventory of timber resources is required to assess such losses. Regional topoclimatic measurements are essential in land evaluation for cassava cultivation.

Concentrated *semi-permanent* cultivation of *maize* as *cash crop* takes place on approximately 10.000 ha in the Eastern Kaoma land system. Potentially there is about 100.000 ha land suitable for the cash crop maize. In main parts of the Eastern Kaoma land system the environmental hazards of the current semi-permanent maize cultivation are low. Locally erosion hazards are associated with the introduction of semi-permanent cultivation.

Data requirement for maize expansion in Eastern Kaoma is a soil survey with emphasis on waterlogging and erosion as limitations for sustainable crop production. Further a timber and fuelwood survey followed by land use planning is required to avoid resource depletion.

Concentrated semi-permanent cultivation of *rice* as *cash crop* currently occurs on approximately 1000 ha. A further 500 ha of small, dispersed fields is cultivated for rice. The rice is currently grown either with ground- or seepage water supplemented by rain (Kalabo District), rains plus floods of small rivers (Lui and tributary rivers) or controlled seepage water (Namushakende).
The potential for these types of rice cultivation are two- or multifold within the near future, the related environmental hazards are low. Locally there may be salinization hazards in the small rivers. The main potential for rice cultivation is in the control of floods in the Bulozi meanderbelt of the Barotse floodplain. This may entail several 10.000 ha in the long term. However the potential environmental hazards are considerable: decrease of cattle grazing (leading to off-site overgrazing), decrease of fisheries (leading to off-site overfishing) and human health hazards (water-associated diseases especially bilharza and protein deficiency). These hazards are controllable by taking timely measures. Salinization hazards are low in the Bulozi meanderbelt. Traditional drainage technology does not lead to sustainable crop yields.

Data required for rice development in the Bulozi meanderbelt are flood duration and depth, groundwater depth in the non-flooding season, a snail survey to assess bilharzia hazard, a soil survey and a land use/grazing survey. Further development of fish farming and forage crops is required as compensation for losses of grazing and capture fisheries.

The cashew covers ±3000 ha, of which 500 ha is in plantations and the rest is dispersed over small-holders. Another 5000-10.000 ha of cashew is planned till 1991, which implies that less than 1% of the Upland Barotse Sand will be covered. The potential for more cashew is manyfold and depends mainly on frost hazards. Cashew does not influence groundwater recharge and no other environmental hazards of cashew are identified. Data on frost hazard are required for land evaluation.

5. LIVESTOCK AND GRAZING RESOURCES

5.1 GENERAL

Livestock in Western Province implies cattle. The number of goats, pigs and donkeys is negligible (probably a few thousand each). More than 75% of the cattle migrates short distances (up to 20 km) between lowland (Photo 25, 26) and upland, the remainder being sedentary around settlements.

The function of cattle in the subsistence farming system is, in order of importance: to supply manure (Photo 16, 28), draught for ploughing (Photo 29) and transport, milk, security, investment, cash income and meat. Meat is (besides timber and fish) an important export commodity of Western Province to the Line-of-Rail, partly as frozen meat processed by the parastatal Zambia Cold Storage Corporation in Mongu and partly on the hoof by private traders.
Meat export fluctuates substantially during the years (table 4). So far Western Province only exports more than about 7000 head of cattle during years when cattle trade from other areas nearer to the market is prohibited due to disease outbreaks (e.g. footh-and-mouth).

Photo 28 Close-up of the kraaled, long horn Barotse cattle of photo 26.

Photo 25 Cattle just entering the Bulozi meander belt (June 1987) for winter grazing after staying the floodseason in the summer on the Upland.

Photo 29 Ox-ploughing is essential for the cultivation of lowland soils. Tsetse infestion in the Eastern Kaoma, Munga and Mukusi land systems is a serious limitation for ox-ploughing.

Photo 26 Cattle kraaled near the Barotse floodplain edge in Mongu to collect manure for crop cultivation. To the left are the immatures and to the right the mature cows and oxen. Mango trees in the background.

5.2 GRAZING RESOURCES

Photo 27 Cattle grazing on dambo grassland in Kaande near Mongu during the flooding of the Barotse floodplain. Note unpalatable high grasses in the centre of the photograph. Under and overgrazing may lead to increase of this unpalatable grass.

Livestock production is on grasslands mainly, forest being supplementary for energy intake but essential for protein and some minerals. Three types of grasslands are found in Western Province: rainfed grassland, seepage grassland and floodplain grassland, the first being green during the rainy season, the second yearround and the latter is available for livestock after flood recession and in the early rainy season. These three grasslands types and forests complement each other seasonally and for minerals and this results in the prominence of livestock in the economy of Western Province. The most important grasslands are situated in the Bulozi meanderbelt (section 4.6). The ongoing growth of the livestock industry can only be sustained in the long run by improvement of the cattle feed resources.

5.3 GROWING CATTLE NUMBERS

Since record keeping started in 1964 cattle numbers are increasing by an average of 2.5% per year and is currently approaching 0.5 million head of cattle, thus implying roughly one head of cattle per person in Western Province. The people/cattle ratio of 1/1 in Western Province is low compared with pastoral areas in Kenya where these range from 1/1-1/6 and in addition these Kenyan pastoralist have considerable numbers of sheep, goats and/or camels. A people/cattle ratio of 1/1 does not allow people to subsist on livestock only; this would require a 5-10 times higher ratio. This points to the fact that cattle is part of mixed farming. In one area (Niesten, 1986) only 10% of the farmers owned cattle. Caretakership, borrowing, and hiring out oxen give more than half of the farmers access to cattle. There are large fluctuations (Table 4) in annual increase in cattle numbers due to varying weather, floods and sales as well as diseases. The herd growth is achieved by disease control (Tryponosomiasis and Contagious Bovine Pleuro Pneumonia (CBPP) mainly).

In the future (5-10 years from now probably), cattle herd growth will be limited by the the vegetation forage supply in the flood season. Currently a grazing capacity survey is being conducted to predict this. A grazing assessment includes two levels: the matching of cattle requirement with seasonal grass supply and second the sustainability of grass production under a specific grazing regime. If herd growth results in cattle numbers approaching the grazing capacity either the increase in cattle numbers will cease or the vegetation/soil system will start degrading. While waiting more detailed data we predict that increase of cattle numbers will stop. Most land units (see previous sections) are not susceptible to overgrazing due to yearly flooding, high bush cover or low nutrient content of grasses. The sandy soils are not susceptible to trampling. The vegetation/soil system of the floodplain mounds (Mazulu) and the Mopane cracking clays are highly susceptible to degradation.
The Mopane clays are currently partly protected from overgrazing by the presence of tsetse, flooding and/or lack of drinking water. The Mazulu mounds show a change in grass species while under moderate grazing pressure, by the dominance of stargrass *(Cynodon dactylon)*. This replacement is positive. **Land resources survey including Wildlife (par. 2.6) and land use planning should be carried out before embarking on tsetse control and water development for cattle in the Mopane clays.**

Table 4 Head of Cattle, herd increase and cattle export from Western Province, 1964-1986.

Year	Head of Cattle (×1000)	Herd increase (×1000)	Exported (×1000)
1964	271	—	n.a.
1965	284	13	n.a.
1966	301	17	n.a.
1967	324	23	n.a.
1968	328	4	n.a.
1969	347	19	n.a
1970	354	7	1.6
1971	359	5	6.2
1972	372	13	7.2
1973	374	2	17.2
1974	375	1	12.7
1975	376	1	10.6
1976	380	4	11.6
1977	386	6	13.6
1978	391	5	12.2
1979	378	−13	12.5
1980	385	7	8.9
1981	382	− 3	7.2
1982	404	22	8.0
1983	445	41	7.8
1984	471	26	7.2
1985	483	12	7.1
1986	479	− 4	22.0*
1987	495	16	25.0

n.a. = not available

* assummed is that all the cattle slaughtered by the Z.C.S.C. has been exported.

Customary law does not include provisions to prevent overgrazing. The Natural Resource Conservation Act provides the legal framework to regulate stock numbers.

5.4 ENDOSULFAN SPRAYING AGAINST TSETSE

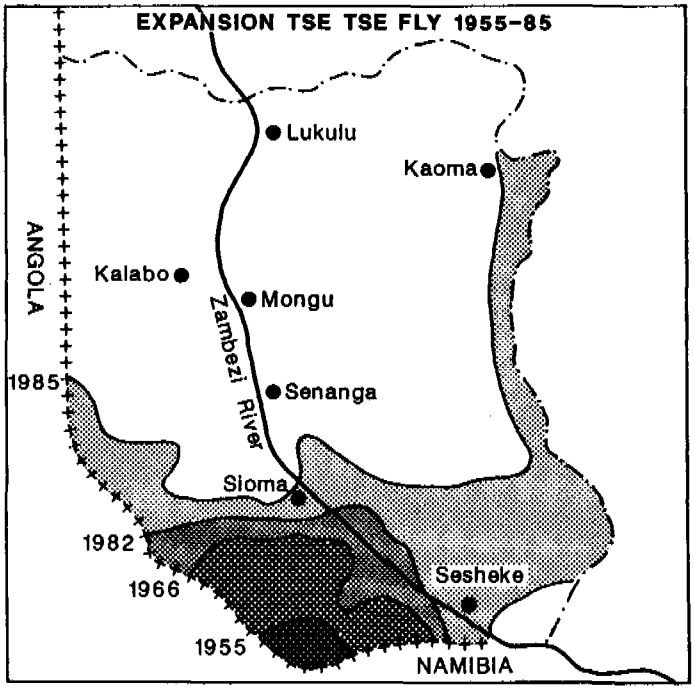


Figure 10 Expansion of tsetse fly in Western Province

Aerial application of insecticide by fixed wing aircraft has been undertaken on several occasions at the end of the sixties and first half of the seventies in Western Province. However these sprayed areas are currently infested by tsetse. Presently Trypanosomiasis is controlled by injecting cattle in areas of tsetse challenge with chemoprophylactic drugs and spraying of vehicles entering Western Province from the tsetse infested Kafue National Park area.

Aerial endosulfan spraying has been considered useful to reduce cattle mortality by Trypanosomiasis in the southern part of the province by controlling the vector tsetse fly and to check the spread of the tsetse fly in northern directions (Figure 10). This technique could be proposed in the future again and therefore its environmental hazards are discussed here. The aerial endosulfan spraying technique does not result in human health hazards. Mammals including cattle, birds including poultry and insects, with the exception of predatory insects, are not affected if endosulphan is sprayed in the proper way. Fish populations of rivers are clearly affected, whereas in dams only minor or no fish kills has been observed. There are indications that the breeding performance of the important Bream fishes are affected negatively.
The tsetse control operations using this technique are carried out during the dry season, which reduces the danger of endosulfan reaching the open water courses.

In the Zambezi south of Sesheke floodplain, with a yearly fish production of about 2.000 tons, upstream applications of endosulfan may cause fish kills, depending on the distance upstream of the treated area. The main fishing ground the Barotse floodplain is situated outside and upstream from the tsetse infested area. **Spraying with endosulfan of the open waters of the Zambezi floodplain should be avoided. There will be also effects on the smaller rivers, which are few in number providing small quantities of fish, but are of prime importance to the rural population (compare section 6.1 and 8.3).**

The use of endosulfan is prohibited in the Netherlands. The Government of the Netherlands has the declared policy not to sponsor the use of pesticides in development projects abroad that are prohibited within the Netherlands.

The possible secondary effects of tsetse control operations including those with targets should be evaluated. Eradication of the tsetse flies may lead to overgrazing especially on the Mopane clays (paragraph 4.9). **Expansion of the tsetse control activities in Western Province should only be undertaken as part of a larger development programme including land evaluation and land use planning.**

5.5 GOATS

Goat grazing is still insignificant, but is potentially a serious threat for the environment (compare section 4.7) especially in Eastern Kaoma. Goats in contrast to cattle will feed to a large extent on small shrubs and trees and prevent woodland regeneration. **Therefore it is recommended to develop laws and regulations to allow only for a limited number of milk goats per household and/or to require permanent kraaling and hand-feeding to avoid the development of destructive free-roaming goat herds.**

5.6 SUMMARY ON LIVESTOCK

Currently there are approximately 500.000 head of cattle in Western Province. The potential for increasing this number is not known.

The resilience of most grasslands and woodland for the current cattle grazing system is high, consequently the overall hazards of environmental degradation by cattle are low in the coming 5-10 years. However the sustainability of the grassland productivity under the present or increased cattle numbers has not been established. The Mopane clay areas are prone to overgrazing by cattle.
The expected expansion of goat grazing may be associated with high environmental hazard locally.

Endosulfan spraying against tsetse should exclude surface water contact and include monitoring of fish populations. Tsetse control and development of cattle ponds should have been preceded by a land evaluation for cattle including considerations on the sustainability of the grassland production under current and improved livestock management systems.

6. FISHERIES

6.1 GENERAL

The main fisheries in Western Province are on the Barotse Floodplain, which is approximately 240 km long and about 5000 km² in surface. The major factor governing the ecology of fisheries is the annual flood cycle (Figure 7, 10).
During the flood season, starting in December, January or February, most of the adult fishes are widely dispersed throughout the inundated plain, withdrawing to the main river as the water starts to recede in April or May. The migration of the young-of-the-year back to the river follows in May and June.
All fish spawn before the height of the flood in late March/April. Most of the young fish hatch and grow to around 10 cm in length during the flood season, when there is almost no zooplankton (microscopic aquatic animals). The food they need to reach this size is largely periphyton, organisms which grow on submerged grasses and bushes. Phytoplankton (microscopic aquatic plants) which is an important source of food for certain fish species, is practically absent from the floodplain. Thus most of the fish food either originates from or is dependent on the grass vegetation in the floodplain.

The water of the Upper Zambezi appears to be poor in nutrients with extremely low concentrations of nitrogen, phosphorus and other elements and has relatively acid water (pH 5.8). Cattle grazing, manure production and burning of grass in the floodplain release nutrients for the expanding aquatic system at the beginning of the flood period.

The major portion (80% or more) of the catches is bream. Fish growth, especially of cichlids or bream species (Table 7) is better in high flood years. Also increased survival rates are observed then.

The open water of the Upper Zambezi main channel contains comparatively few fish of less than 20 cm length, since tiger fish eats most of the smaller ones. Another important fish eater, the pike *(Hepsetus odoe)* is restricted to lagoons and backwaters where they hunt on smaller fishes.

Gill nets are the main fishing gear used. They are set overnight in standing water and landlocked lagoons and are responsible for the majority, over 75%, of the fish catches, mainly bream. Other gear types used are ring and draw nets also mainly for capturing bream. Drift nets (Photo 30, 31), operational in the main Zambezi River channel, are almost exclusively for tiger fish.

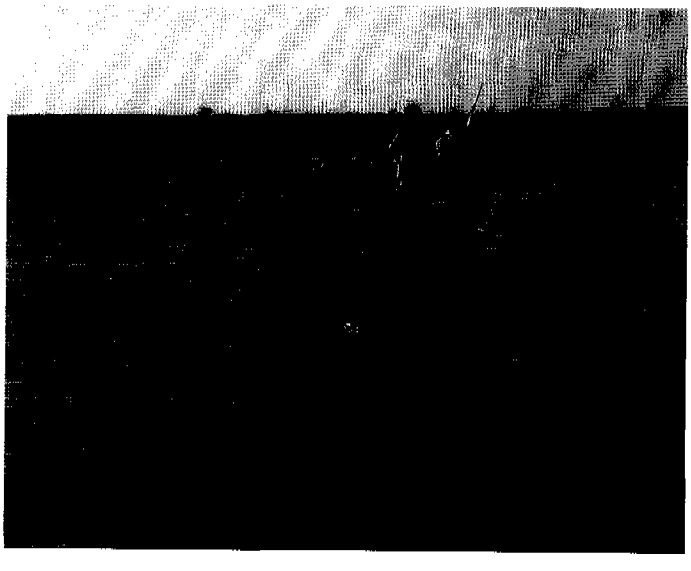


Photo 30 Ring-net fishing on the Zambezi river for bream.

Photo 31 Ring-net fishing on the Zambezi river for bream.

Fishing with these types of nets takes place during the peak of the fishing season until December. In the floodplain a wide variety of traditional gear types, like baskets and spears, are used but are of minor importance.

The only fishing method which supplies fish protein during the summerflooding, is the "maalelo" fishery (Photo 32). This fishing gear consists of a traditional weir made of earth, reeds and valved conical traps of reeds and coarse grasses. The maalelo removes about 4 percent of the juveniles of the most important species. It is therefore incorrect to believe that the maalelo is harmful for the fish population.

Fishing is a seasonal activity of mixed (crop/livestock) farmers living in and around the Barotse floodplain. Seasonal fishing camps (Photo 33) are established in this plain. There are only few full-time fisherman in Western Province (Photo 34). In general, cattle and fisheries are complementary in utilization of the floodplain. Cattle converts a part of the floodplain vegetation into readily dissolved organic and mineral nutrients, which have an important impact on the chemistry of the flood waters. Standing fish crops in lagoons frequented by cattle can be more than three times higher than the standing crop in other pools.

The wet dambos and Zambezi tributaries supply the local population with a small, but essential, quantity of fish protein. This amount of fish protein is, however, insufficient to cover the animal protein needs of this population who have no or only limited access to the fish and livestock resources of the Barotse floodplain. The productivity in the majority of these dambos seems quite low, because of the acidic nature of both the water and land environment (pH 4).

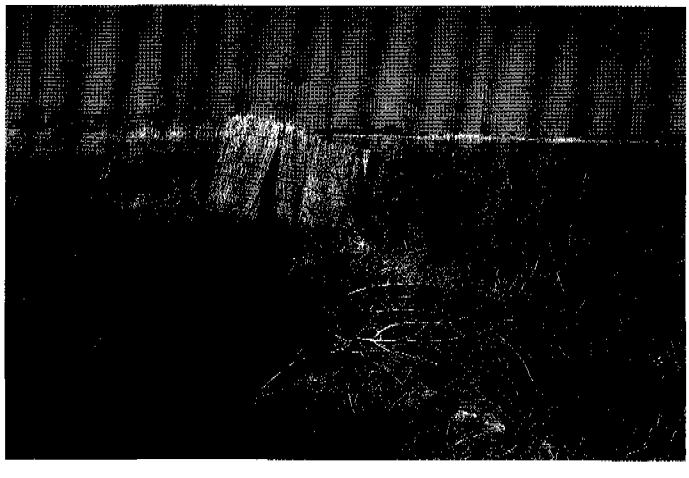


Photo 32 Maalelo fish trap in Lui floodplain. It supplies also fish protein during the summer. Maalelo is not harmful for the fish population.

Photo 33 Drying fish at a seasonal fishing camp on the Zambezi shore.

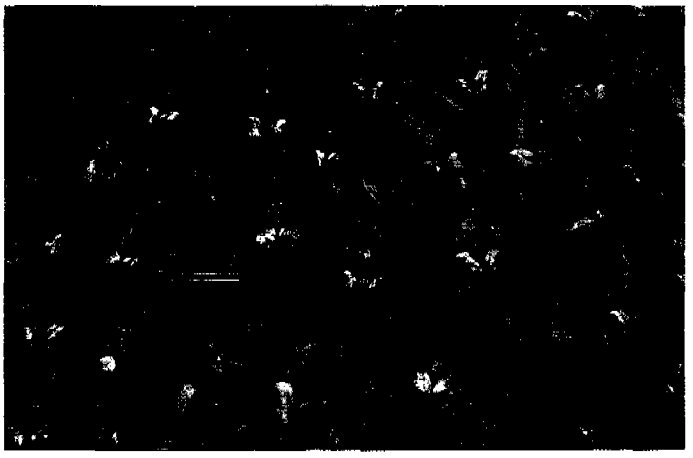


Photo 34 Sun-drying tiger fish on Maxwell's island.

6.2 ACTUAL AND POTENTIAL FISH CATCHES

A rough estimate of total fish catch is approximately 7000 tons/yr and has been derived by analyses of individual catches and interviews with fishermen and fish consumers. The flood intensity has a marked effect on the annual catch, as shown in Figure 12.

J F M A M J J A S O N D

rainy season	dry season		rainy season
Fish move up channels	Fish dispersed on floodplain	Fish move back to channels and lagoons	Fish restricted to dry season refuges.
production of young by most species	rapid fish growth	heavy losses after fish catching by man, piscivorous fish and birds	reduction in fish population
maalelo almost no fishery fishing	maalelo fishery	intensive fishery	fishing in pools swamps and land locked lagoons

Figure 11 Yearly flood and fish cycle; movements and distribution of fish (first row), fish reproduction and growth (second row) and related fisheries.

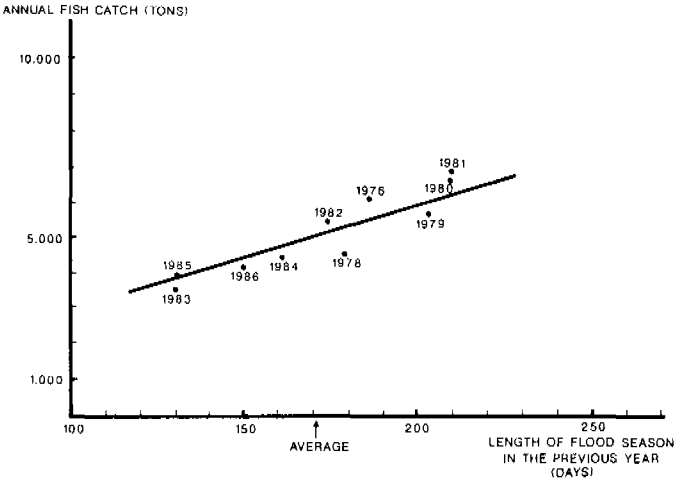


Figure 12 Influence of flood regime on total fish catch.

The fish, which passes the fish barrier on the Mongu - Lusaka road constitutes approximately 25 percent of the total annual fish catch of the Barotse floodplain. It is estimated that of the total fish exported from Western Province 10 percent goes to Kaoma district, 15 percent proceeds to the Copperbelt and around 75 percent reaches Lusaka.

The prices the fishermen receive for their fish have increased since 1986 from 1,20 Kwacha to 2,00 Kwacha per kg fresh fish in 1987. For dried fish prices have increased from 2,00 to 4,00 Kwacha per kg. Prices in Mongu are considerably higher than the prices the fishermen receive themselves, respectively4,00 Kwacha per kg fresh fish and 6,00 Kwacha per kg dried fish. In Lusaka and the Copperbelt fish prices are twice the Mongu price, respectively 8,00 Kwacha per kg fresh and 12,00 Kwacha per kg dried fish.

The number of net fishermen in the floodplain is estimated at 2,500. These fishermen and their family members, on average 6 per family, consume about 115 kg of fish per capita per year which is a rather high figure. Fish consumption of the people around the floodplain, which is about one third of the total population of Western Province, totals approximately 20 kg per capita per year. The fish protein intake of people outside the area around the floodplains is negligible.

The estimated catch per net fisherman constitutes approximately 2,1 ton per year. In developing countries a catch of 1 ton per year is considered the survival minimum. This minimum will be reached when there are about 8 fishermen per km^2. The net fishermen density in the Central Barotse floodplain amounts to 0,5 net fisherman per km^2. Compared to other floodplains this figure is rather low.

A model used for predicting yields of floodplain fisheries in tropical regions gives a figure between 40 and 60 kg of fish per year per hectare inundated area. The maximum inundated surface for the Central Barotse floodplain amounts to 5000 km^2. By applying the formula deducted from 25 tropical floodplains (see Appendix) a yield of approximately 22.000 tons per year for the Barotse floodplain is calculated. This figure needs some corrections for the low nutrient content especially phosphorus of the water, the low pH, the marked cold water season and the incomplete water coverage of the floodplain. The corrected estimate may be between 12.000 and 15.000 tons per year depending on the flood regime.

6.3 RISK OF OVERFISHING

By comparing the estimates of the actual catches of less than 7.000 ton per year with the potential of 15.000 per year one may conclude that there is no overfishing yet and thus a doubling of the catches seems feasible. Many lagoons are not fished at all or are underfished, because of the fishing rights tenure system. Therefore the Central Barotse floodplain is not overexploited as many other comparable fisheries in Zambia, elsewhere in Africa and in Asia.
The size of commercial fish species has not significantly diminished since 1967 also indicating the absence of overfishing. Floodplain fish have a high natural mortality rate and are therefore more resilient to heavy fishing than those in lakes. There is no need to impose a closed season from the Government's side since the flood cycle takes care of this.

With increased fishing intensity a stricter control should be applied on the mesh sizes of fishing nets. Many fishermen fish with 38 mm to 50 mm mesh size, while 75 mm is the minimum allowed by the Fishery Act. Some parts of the floodplain should remain as they are, to allow restocking of the system.

When rice cultivation expands considerably (10.000 ha or more) in the Barotse floodplain, considerable conflicts may arise with fisheries development, because both use the same phase of the hydrological cycle. Rice culture may affect fisheries adversely by modifications of the environment detrimental to the traditional fisheries. Rice and fish are not necessarily mutually exclusive as is shown by the widespread practice of fish culture in rice fields in Asia, which may amount for 65-80 kg fish per hectare per year. **Fish culture in rice fields may be initiated along with the expansion of rice cultivation in the Barotse floodplain.**

The possibilities for expansion of the capture fishery will be exhausted in the future. Alternatives should be developed in time to safefuard the fish supply to the growing population. Simple methods such as blocking of floodplain depressions, construction of drain-in ponds and refuge traps, which are already applied in floodplains in parts of Africa, Asia and South America, may be relatively easy to introduce into the Barotse floodplain.

6.4 FISH FARMING

For the moment fish farming or aquaculture development in Western Province seems only desirable and feasible where a scarcity of fish is felt, thus in areas away from the Zambezi floodplain, where the population shows to be motivated to take up the heavy labour involved in fishpond construction. Care should be taken to give the population a realistic understanding of the support the Western Province authorities can provide and the benefits fish farming may offer. A problem is that few favourable fishpond sites in these remote places exist and the inaccessibility of these spots. Excavating a fishpond in peaty soil is laborious. The production of a fishpond is probably not more than 300 kg fish per hectare per year under low input. Only with supplementary feeding, fertilizing with superphosphate or manuring, water quality control, and regulating stocking density a yield of around 3 tons per year per hectare per year may be feasible in the long run.

A type of aquaculture development, which is feasible in Western Province is the stocking of cattle drinking ponds, some with a surface of more than 1200 m^2 and 1,5 m depth, with Barbel fish. In 25 ponds a start has already been made. The stocked fish grow reasonably well. The young Barbel fish can be easily transported because oxygen supply is not critical. Also the stocking density in the cattle drinking ponds is not very crucial. Feeding is not essential because enough cow manure will reach the water. Cow manure in the ponds will not provide a human health risk in case the fish is well cooked, as is the African custom. In the dry season these ponds decrease in depth from around 1,5 m to 30 - 40 cm depth. Barbel fish is the only suitable fish species for such conditions. In ponds of this nature and with this fish species a production of is feasible 240 kg per year for a pond of 1.200 m^2. In order to obtain a high production, an adequate stocking rate of approximately 1 to 2 juvenile fish per m^2 should be applied. It is the intention to deepen the ponds till a minimum level of 80 cm in the dry season has been reached. In this situation also other fish species like bream could be considered. The stocking rates must be adapted to the new situation.

In some dambos stocking with bream species, to enhance fish production, will be possible in case the fertility of the water is increased, for instance through application of cow manure. Production levels may reach between 50 and 100 kg per hectare per year. However, it should be realized that manure is often the limiting factor in cereal cultivation (maize, millet) and increasing fish production in this way implies decrease of crop production.

6.5 SUMMARY ON FISHERIES

Actually 7000 ton fish per year is captured in Western Province mainly by subsistence farmers in the Barotse floodplain. Approximately a quarter of the catch is exported from Western Province. The potential catch is estimated at 15 000 ton/year.

The hazard of overfishing in the Zambezi floodplains is low in the coming 5-10 years. In due course regulation may be necessary.

The customary land tenure has contributed to the conservation of fishery resources. This tenure system should therefore not be abandoned suddenly and if it is replaced enforced by-laws and regulations to prevent overfishing are essential.

Continued monitoring of the fish population is required.

7. WATER

7.1 DRINKING WATER

The surface water in dambos and small rivers is frequently bacteriologically contaminated. No other contamination is recorded or suspected in drinking water in Western Province. The sources for drinking water are mostly hand dug waterholes (Photo 35) made in the sand until the groundwater level is reached.
A few of these waterholes are covered by a lid (Photo 36), but mostly they are open. Because of the sand they easily collapse and regularly a new hole is constructed next to a defunct one. Often series of old waterholes are found adjacent to the water supply actually used. Shallow wells (Photo 37) have been constructed in the past. A minority of these (15%) do not function through lack of maintenance, construction errors or (seasonal) subsidence of the groundwater level below well depth. A program for constructing deep boreholes is in progress. Supplying 60-70% of the rural population with safe drinking water from boreholes is aimed for by mid 1989.

In most places of Western Province exceptionally good groundwater for drinking and/or irrigation is available often within a few metres but locally up to a depth of tens of meters. Yields are typically 8-10 liter/sec. In the Mukusi land system, in the Machile-Masese-Mulobezi area, moderately saline (sodic) groundwater (conductivity 500-1000 micromhos/cm) is encountered in the Karroo aquifer below the Kalahari sands. In Senanga town, Sesheke town and Kalabo town river water is available but has to be treated by filtration and chlorination. The high iron concentrations (5-10 mg/l) sometimes encountered in groundwater is far above the W.H.O. standard (0.3 mg/l), but probably pose no direct health hazard and the population is used to the taste of this water.
Well materials need much maintenance due to the iron content and low pH (5).
The high permeability of the sandy soils may expose the groundwater to pollutants such as sewage and agricultural chemicals; however no contaminated groundwater has been encountered sofar.

There are no indications in the well monitoring program of the depletion of groundwater at the current rate of exploitation mainly for domestic purposes.
Groundwater recharge of the Kalahari sand aquifer by rain is low to nonexistent. Therefore lateral recharge by Zambezi floodwater and/or from Uplands outside the Kalahari sands must be assumed.

Sanitation in rural areas has low priority. Excreta related diseases (compare paragraph 7.2) have low prevalences and latrine construction requires considerable effort in the sandy soils especially if a high groundwater level occurs.

Sanitation in urban areas requires more attention in near future.
Overloaded septic tanks cause pollution of the surrounding areas. The waste stabilization lagoons of the Mongu hospital and the Mongu slaughterhouse are overloaded with dangerous effluents. The effluent, highly polluted, is discharged into public streams. The slaughterhouse effluent could probably be used to irrigate and fertilize pastures. This requires proper grazing management to avoid health hazards.

Photo 35 Hand-dug waterhole in dambo; water table depth approximately 3 m. Heaps of bare soil at sites of older defunct waterholes are visible. Cattle may contaminate drinking water. Near Lukulu.

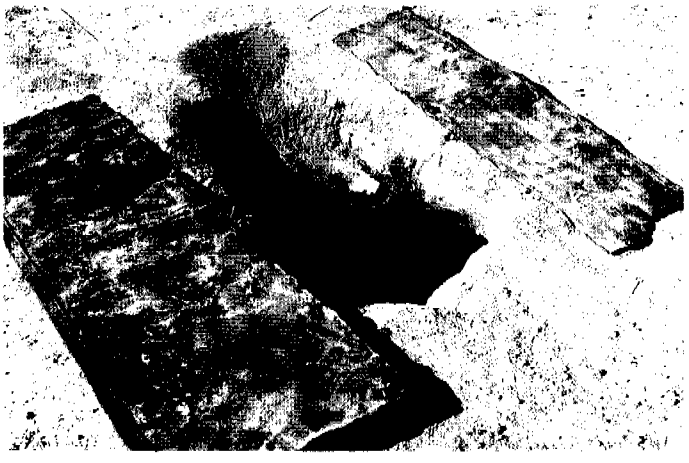


Photo 36 Hand-dug waterhole covered by wood and a metal lid; water table depth approximately 3 m; water supply of the settlement on photo 24.

Photo 37 Shallow well lined with concrete at floodplain edge in Mongu; note that the winch has been removed.

7.2 ZAMBEZI FLOODWATER

The key environmental factor for both the fisheries and cattle industry of Western Province is the Zambezi floodwater. Red Lechwe and the abundant and varied waterfowl depend on it as well. Staple food production relies only for a minor part, a quarter or less, on the Zambezi floodwaters. Currently the small acreage of rice (Photo 19) in the Zambezi floodplain is fed by seepage water supplemented by rain. There is also considerable potential for expansion of rice cultivation based on floodwater control possibly at the expense of cattle grazing and capture fisheries. **Given the importance of the Zambezi flooding regime for both the economy and ecology of Western Province remarkably little is known on flooding depth and duration and their spatial variety. Data collection on these aspects therefore should feature prominently in a Land Resource Survey.**

Photo 39 Water transportation between Mongu and Kalabo.

Western Province includes the middle course of the Zambezi river. The main catchment of the Zambezi upstream of Livingstone lies north of Western Province mostly in Angola and only less than 10% of the Zambezi water at Livingstone comes from its tributaries in Western Province. Downstream from Western Province the Zambezi water is used for hydro-electric power generation at several places. Within the Province Sioma Falls offers the only potential site for blocking the Zambezi for hydro-power generation. **For reservoir constructions an Environmental Impact Assessment is required to allow a comparison of the benefits and negative impacts of such works.**

Theoretically polders might by constructed in the Bulozi meanderbelt. Such reclamation is however not foreseen in the 5 year Development Plan 1986-1990, nor are there any pilot studies underway. In principle, tropical crops (maize) could be cultivated by pumping water from the polders during the summer flooding or alternatively rice by regulation of the water table. In the winter, the non-flood season, temperate crops (e.g. wheat, potatoes) could be grown. However, a polder scheme in the Kafue Flats with far superior infrastructure and soil conditions than the Barotse floodplain was unsuccessful. Such polder scheme would require large amounts of inputs (seeds, fertilizer), which if available in Western Province could increase crop production also without a polder. Moreover the possibilities of small scale control of seepage water are not fully exploited yet. In a previous chapter (4) it has been indicated that most floodplain soils are infertile and construction of drainage/irrigation ditches and dikes will be costly in the Zambezi floodplains, due to peatiness, sandiness and the instability of the clays of this plain.

Before embarking on a polder scheme, a detailed inventory of fishing and livestock grazing patterns should be carried out to allow a proper land use planning in order to compensate for negative impacts on the fisheries and on the cattle industry larger that the benefits of a polder.

Besides diking of polders, it might by considered in the future to remove (blast) the natural barrier in the Zambezi near Sioma. This would have an unknown impact on the height and duration of the flooding in the Barotse Plain. This could possibly reduce the risks of early flooding for the Bulozi floodplain cultivation and allow cattle to enter the floodplain earlier and stay longer, but would at the same time have unknown impacts on the grazing capacity and fisheries. It would have also impact on the downstream flow of the Zambezi as well as the regional climate by reducing evaporation from the floodplain. **An Environmental Impact Assessment should precede any such drainage engineering.**

Data on flood duration, extent and depth are necessary in order to assess impact on the livestock industry and fisheries, as well as the potential and current developments in water control for cropping. Presently only water levels are recorded in the Zambezi stream-channel. Lowest gauge heights are found in October-November (±0.5 m at Matongo; ⊥1.80 m at Senanga), the highest in March-April (±5.5 m - 7.5 m at Matongo; ⊥3.5 m - 5.0 m at Senanga). The flooding of the Barotse floodplain starts in January and ends mid June (compare Figure 6). Data on spatial variation in flood duration on the Barotse floodplain as well as depth of flooding are lacking completely.

7.3 SUMMARY ON WATER

Surface drinking water is usually bacteriologicaly unsafe. Groundwater is omnipresent on a depth of few to several tens of meters. The groundwater quality is generally excellent except that locally iron concentrations are above World Health Organization (W.H.O.) standards. However, these high iron load presents probably no human health hazards. In the Machile-Mulobezi area, in the southeast of the Province, saline groundwater is encountered. There are no indications of groundwater depletion. Monitoring of boreholes is essential to assess the groundwater potential.

Data collection and model building on the flooding regime of the Barotse floodplain is urgent given its key role for cattle grazing, fisheries and future expansion of rice cultivation and thus for both the protein and energy component in the human diet as well as the cash economy.

8. POPULATION AND HEALTH

8.1 POPULATION

The number of inhabitants of Western Province was 487.988 at the last census in 1980. Currently the population may be approaching the 550.000. The annual population growth rate was 2.1% in the period 1963-1969 and between 1969-1980 it was 1.6% in Western Province compared to 3.1% for the whole of Zambia. The lower population growth in Western Province indicates emigration. Also the fertility in Western Province is lower (5.7 children born per woman) than in Zambia as a whole (7.2 children/woman). The population lives mainly in rural areas; the three largest townships are Mongu (24.919), Kalabo (7.398) and Senanga (7.204). The Kaoma and Mongu Districts show population growth rates of 3.0 respectively 2.5% (1969-1980) and are approaching the national figure.
Population growth rate in the remaining districts Kalabo (0.4%), Lukulu(1.1%), Senanga (1.3%) and Sesheke (1.6%) falls below national population growth rate due to emigration.

The sex ratio in Western Province was 837 males to 1000 females (1980). This is considerably below the national ratio of 962. Furthermore the trend in sex ratio is a further decrease of males. Within the province the lowest sex ratio is found in Kalabo District (782) coinciding with the lowest population growth. The sex ratios in the major townships are more balanced (Mongu 966; Kaoma 994; Kalabo 927) than those in rural areas (Mongu District Rural 817; Kalabo District Rural 771).

The growth rate and sex ratio figures together show that emigration from Western Province is especially from the more remote rural areas and start with men emigrating first. The migration is currently directed to the Line-of-Rail.

8.2 HUMAN HEALTH HAZARDS

Especially water related projects like irrigation development and fish and cattle pond construction have potentially negative effects on public health. In order to make a rapid assessment of hazards of specific development projects a brief overview of the actual health situation is provided.

Malaria is endemic in Western Province. Widespread are diarrhoea, acute respiratory infections, pneumonia, tuberculosis, chronic malnutrition, anaemia, eye diseases like trachoma and skin diseases. Amoebic and bacillary dysentery, typhoid fever, filariasis and human Trypanosomiasis have a low prevalence.

The Bancroftian filariasis is related to irrigation and reservoir development, because vectors like *Anopheles gambiae* and *Anopheles funestus*, also the transmitting mosquitos for malaria, prefer to deposit their eggs in water unpolluted with organic wastes and breed in these water bodies. These mosquitoes are also vectors for various arboviruses. The main mosquito vector for Bancroftian filariasis in urban areas, *Culex quinquefasciatus* preferentially use polluted water for egg laying and may increase by development of irrigation canals and reservoirs. Thus, the naturally occuring low prevalence of this type of filariasis might rise when irrigation schemes are initiated. This holds true for other water associated diseases.

Cholera is not found in most of Western Province, probably because groundwater is mainly used as a potable water source and excreta deposition occurs away from the groundwater well areas. Cholera may be expected in places where local water courses are used as drinking water sources like in Kaoma district and the Sefula river.

Bilharzia is prevalent near certain slow flowing rivers in Kaoma District, like in Banjutu, upper Luena river, Mangango and Luampa areas and in Sesheke District in the upper courses of the Zambezi tributaries like Sichili river, where population densities are high enough to sustain the parasite's cycle. Other foci are found in Lukulu and Kalabo districts. The disease is most prevalent in children because of frequent water contact. *Schistosoma mansoni* and *Schistosoma haematobium* are the parasites. Around Mongu bilharzia is not endemic, probably due to the dynamic floodplain environment of the Barotse floodplain and the fact that the major settlements are all situated along the plain edge, upstream of the seepage that flows towards the Zambezi. Downstream of the main settlements the communities are small, sparse and isolated.
Another reason for the current low prevalence of bilharzia may be the fact that the people use mainly groundwater and do not foul the water sources with excreta. Theoretically, mineral ratios of the water for snail habitat and snail predation by birds and/or fishes could influence bilharzia distribution as well. When water control for crop cultivation is introduced, the increased number of more stagnant water bodies favourable for the development of the intermediate snail hosts of *Schistosoma* species will increase resulting in increased bilharzia prevalence especially when people use ditches for washing and excreta deposition.

Malaria is highly endemic in Western Province. In 1985 7000 cases were registered, probably a fraction of the number of malaria cases. Almost 100% of the malaria cases are caused by *Plasmodium falciparum*, the lethal cerebral type. The most important malaria vectors are the mosquitoes *Anopheles funestus* and *Anopheles gambiae*. Chloroquine resistance against this malaria form is on the increase. More and more quinine infusion must be applied to treat malaria cases. Chloroquine and also Fansidar are sometimes unobtainable in Western Province.

Formerly, residual spraying of houses was done with DDT. Today this practice has been abolished because of lack of funds. The previously effective malaria unit in Zambia is nowadays practically defunded. Measurements promoting village hygiene and improvements in screens should reduce the risks of malaria.

Yellow fever apparently does not occur in Western Province since no cases have been reported recently, even though its mosquito vector *(Aedes aegypti)* is present. Cases of dengue, a disease characterized by high fever transmitted by the same mosquito have never been reported.

A type of Rift Valley fever, caused by a virus transmitted by mosquitos and producing symptoms like pain in the joints and rash occurs quite commonly in Western Province.

Worm diseases including ascaris have low prevalences due to the sandy soils as well as the low winter night temperatures. Hookworm has a high prevalence. These excreta related diseases occur in areas also infested with bilharzia like in dambos and small river valleys.

It is recommended to pay proper attention to health hazards in any project developing irrigation especially in the Barotse floodplain still free of bilharzia; this includes simultaneously supplying wells to avoid the use of irrigation ditches for drinking water and washing, snail surveys of upstream water bodies, health education of the participating farming families and bilharzia prevalence monitoring.

8.3. NUTRITION

Approximately one third of the children under 5 years in Western Province are under 80% weight for age. Among the 1-2 year age group this even increases to 40%. The latter is related to the change from breast feeding to solid food.

Malnourishment (either by calorie deficiency or imbalanced diet) also prevails among adults both in the rural and urban areas and is

increasing in the latter. Anaemia is quite common in pregnant and breast feeding women. Traditional eating habits and preferences also foster poor nutrition as for instance it is taboo for pregnant women to eat eggs.

Photo 38 Crop storage hut near settlement of photo 24.

The staple foods are cassava, maize and millet. Along the floodplain and in the dambos this is complemented with fish and some sour milk and meat from cattle. In the smaller floodplains there is almost no fish. Thus the malnutrition rate along the Zambezi floodplains is lower than in other parts of the Province. The greater the distance from the floodplain and the dambos, the higher the protein deficiency in the diet. For instance, in Kaoma district the prevalence of Kwashiorkor is higher than in other districts.

Preliminary calculations (Table 6 and 7) indicate a staple (starch) food deficiency in Western Province. Maize and even more so cassava are relatively poor in proteins when compared to other staples (wheat and millet) and therefore need to be supplemented with protein-rich food: cashew, beans, milk, fish and/or meat. Only the one third of the population *living adjacent to the Zambezi floodplains* may obtain sufficient proteins in their diet from cattle keeping and fisheries. There is hardly any scope for increasing animal production in the upland away from the lowlands.

8.4 SUMMARY ON HUMAN RESOURCES

The treatment of the effluent of the hospital and abattoir in Mongu should be improved to avoid water pollution and health hazards.

Development of the Eastern Kaoma land system for semi-permanent maize cultivation is recommended as the environmentally most sound solution for the current staple food deficiency.

Expansion of seepage and floodwater rice cultivation could create a staple food surplus even in drought years.

Once bilharzia *(Schistosomiasis)* is introduced, erradication proves almost impossible. Therefore any large scale expansion of water control for rice cultivation especially in the Barotse floodplain should include specific measures to prevent the introduction of bilharzia. Data requirement include a snail survey.

9. LEGAL AND INSTITUTIONAL ASPECTS OF NATURAL RESOURCE CONSERVATION

9.1 INTRODUCTION

Zambia, like most African countries, has a dual law and court system, a relict of the colonial past when different laws were applied to Crownland (now Stateland) and Reserve and Trustland (now Reserve), and to white settlers and indigenous people. Due to the Subordinate Courts Act (section 16) and Local Courts Act (chapter 54, section 12), customary law is still applicable in Reserveland as long as 'such law is not repugnant to natural justice of morality or incompatible with provisions of any written law'. In this sense statutory law predominates customary law, but in spite of the Land Tenure Act (1970), wherein all the land was vested in the president, customary law still prevails in matters concerning land rights in Reserves. Due to its special status, autonomous history and strongly centralized traditional law and courtsystem, customary laws are still firmly established in Western Province, despite the Western Province Act (1966) when Barotse land lost its special status and was converted into Reserveland and whereby the Barotse Native Courts Ordinance Act (1939), which granted overall power over land to the Litunga (the Paramount Chief) was repealed.

The laws concerning environment: the Land Tenure Act (1970), the Land Acquisition Act (1960) as well as the Land Reform Act and the Township and Country Planning Act (1979) are not enforced in Western Province at present. The National Parks and Wildlife Act (1971), the Forest Act (1974), Natural Resource Conservation Act (1970) and Water Act (1971) are wholely or partially applied. One could say that the legislation in Western Province is in transition from a customary towards a statutory system under influence of market economy, eroding traditions, changing landuse, moral values and institutions.

9.2 CUSTOMARY LAW IN GENERAL

Land rights in Western Province are characterized by a multilevelled control and a multi-purpose access. Gluckman made a distinction between 'estates of administration' and 'the rights to production'. These 'estates of administration' are levelled from Litunga, the king, down to Ngambela, the district chiefs, Silalo indunas (the district councellors) and the village headmen, the latter only being elected by the village. All these administrators from village headmen to the Litunga, can grant land as 'the rights to production' to familyheads. Four different categories of land can be distinguished:

- Ngweshi, royal property of the Litunga and royal family.
- Mubu wa Luu, for the use of indunas and attached to its title.
- Mubu was Lusika, land with production rights given to a familyhead.
- Mubu Mbuwa, unoccupied land directly under the control of the Litunga.

Control and access to land are both inheritable but also form part of a title, like that of induna or resident of a certain village. As soon as the holder looses his/her title or leaves the village the control and access to the land of that village are also lost. The eldest son is normally appointed as distributor of land among the heirs who receive equal shares. Women can only obtain land "as rights to production" from their fathers but never through a divorce.

Different 'rights of production', such as picking of fruit or the grazing of cattle, can be attached to the same parcel of land and subject to rights vested in different persons at various times. The land (as 'estate of administration' and 'rights of production') can not be sold, can be leased - but not for a reward - and mortgaging is also impossible.

Usually a village-headman admits new people to his village with the consent of elders but only if they can be given enough land to cultivate. In this way overexploitation was prevented and cultivation remained on subsistence level. Furthermore the land was evenly divided according to the individual needs, although most of the better land was and is "owned" by the Lozi who are concentrated in and around the Zambezi floodplain and adjacent dambos. The villagers further away from the floodplains often do not dispose of fishing rights and grazing rights in the plain or only via relatives.

The traditional organization has insuffient means to enforce customary law which is mainly based on moral obligations. Furthermore the Local Courts Act (1966) enabled the appointment of judges but they have little knowledge of prevailing customary laws. Meanwhile old people die and with them disappears the memory of boundaries between properties of which there is no registration.
Some distortion of customary rules like intolerably high tributes, settling without permission and illegal lease of land exist. Besides, the judges in the traditional system may not have the technical knowledge required to deal with questions concerning modern agricultural methods. Local courts nevertheless remain *indispensable* for they are well distributed, close to the people and cheap.

9.3 STATUTORY LAW IN GENERAL

The framework of statutory law as applicable in Western Province is fairly complete for controlling environmental problems. Most of the acts and regulations are not regularly updated. Coordination between departments is not institutionalized and is often missing. In the so-called "Open Areas", outside the National Parks and Forest Estates, the wise use of resources depends almost entirely on extension work and on the goodwill of the people as far as soil, water and forests are concerned. The Agricultural Lands Act and the Town and Country Planning Ordinance (1971), which provide regulations for the proper management and planning and also include restrictions against subdivision of land, are not enforced in Western Province.
The Natural Resource Conservation Act (no. 53 of 1970) and the Provincial and District Natural Resources Committees Regulations should be mentioned explicity. These empower the government to restrict and regulate land and water uses in case of flood, erosion, overgrazing and pollution hazards, although these do not specify rules nor create offences except for bush fires but authorises the minister to control and direct actions of individuals. The Natural Resource Department advices in these matters. Bylaws and regulations have to be made by the Provincial and District Natural Resource Committees but between 1980 and 1988 these have not been operating in Western Province.

Most governmental departments lack funds for enforcement, extension work and research. Planning and licensing has to be done on presumptions because necessary data are lacking. The incidence of poaching, illegal treecutting and illegal burning is high.

9.4 THE FOREST RESOURCES

Around the turn of the century Royal Forests were protected by unwritten law. Before the enactment of the Forest Act (1974), Barotse Forest Reserves were protected under customary law (Barotse Forest Orders, 1939). Subsequently the Barotse Forest Reserves became Protected Forest Areas under the Forests Ordinance and National or Local Forests under the Forest Act 1974. The Forest Estates in all covers a total of about 5% of the Western Province (in 1986).
New areas are regularly added to the Forest Estates. For the gazetting of new areas the local indunas must be consulted. They are mo-

re and more reluctant to convert open areas into Forest Estates because this deprives them of virtually all former landuse rights.

The Forest Act (23rd September 1974) recognises *Local Forest and National Forest* where logging and firewood collection is licensed and controlled by the Forest Department, and the open area, where commercial logging and charcoal burning is licensed, while the gathering of firewood is free of charge and under the control of the indunas. The purpose of National Forests and Local Forests is the conservation and development of forests with a view of securing supplies of timber and other forest produce, while in the National Forests also the protection against floods, erosion and maintaining river and base flow is emphasized. However, this distinction between National and Local Forests has no legal consequences.

There are two types of forest licences: a local licence for firewood and extraction of poles (subsistence logging) and a concession licence for commercial logging. Both are given under the same regulations, but for the latter there are additional obligations such as providing fire-control measures and preventing the obstruction of waterways and roads (Forest Act 311, subsidary legislation). Regulations for both licences are that trees for timber or poles should be felled by sawing, be cut thirty centimeters from the ground, and that branchwood and waste should be disposed of in such way as not to hamper growing trees. Local indunas are trained by the Forest Department and are encouraged to apply Forest Regulations and some of them do. Licences for trees are sold per tree and cubic metre, fuelwood per cubic metre, headload or cords, charcoal per bag, and building materials per hut. In some circumstances also topsoil and other forest produce may be collected per person per day, grazing licences are given per animal per month and land may be given for temporary cultivation per hectare per annum.

The Forest Act has sufficient personnel for the control and extension tasks but lacks the logistic support. It is difficult to stop illegal cutting, partly due to immobility and to the fact that people are ignorant of the existence of Forest Estates and regulations but foremost because fines for offences are extremely low. Fines for offences and fee for licences were set by the 1974 Forest Act but have not been up-dated since. At this very moment a licence for 3 cubic metres of firewood costs 35 Ngwee, which in the market will sell at 500-600 Kwacha.

The Forest Act makes burning in Forest Estates a serious offence, while in the open area of Western Province the Fire Authorities as foreseen under the Natural Resource Conservation Act are lacking. The Forest Act also protects certain trees, known for their poor regeneration, however replanting after logging is not obligatory. Neither are there regulations which could prevent shifting cultivation or the shortening of fallow. Illegal cutting and subsequent arrests are believed to be increasing especially around the larger townships of Mongu, Limulunga and Kaoma.

The Forest act should be amended to make it clear that persons planting trees, whether introduced or indigneous species retain the right of property there in, and are free to dispose of them as they see fit.

It is important for erosion prevention to use the provision of the Forest Act to declare all trees within a certain distance from dambo and valley edges as protected trees.

Licences and fees for commercial timber, pole- and fuelwood could be updated to a reasonable percentage of the market value and differentiated for residents and outsiders. Part of the revenues could be directed to the Forestry Department, village councils and/or Natural Resource Committees.

9.5 WILDLIFE AND HUNTING

In former days under customary law certain animal species were fully protected (like the cow-egret), others could only be hunted with permission of the induna (like the hippo and elephant). Hunting was restricted in wildlife conservation areas created by the Litunga and these areas came in the hands of the Government in 1970 as National Parks in the sense of the National Parks and Wildlife Act. Liuwa National Park (3660 km²) falls under special regulations, which permits residents to remain in the park and have their gardens, cattle and firewood.

Hunting in all areas is now by licence and under the control of the Wildlife Department. Some animals like for instance the Rhino, Eland (female), Girafe, Cheetah and several birds like Pelican, Bittern, Eagle, Creane and Buzzard are fully protected. In the National Parks hunting is not permitted. In the Game Management Area hunting with a licence and a hunting permit is however possible. A licence gives a right to a certain animal type, while a permit is required for the act of hunting itself and is valid for a two-week period. In the open area only a licence is required. The Act distinguishes between District Game Licence, Bird Licence (both payable to the funds of the respective councils), National Game Licence, Special Licence, Safari Licence and professional Hunting Licence which are payable to the government. The Safari Licence, which is issued for hunting under the guidance of a professional hunter, is not issued in Western Province yet, but recently interest was shown for the Game Management Area west of Liuwa National Park.

Licences are cheaper for residents and subsistence hunters than for non-residents and for commercial purposes. Licences for subsistence hunting are relatively too expensive (e.g. Wildebeest 80 Kwacha) to generate cheap meat, while licences for commercial hunting are too low; for example a licence for a Crocodile costs 60 Kwacha, and the skin is already valued at 1500 Kwacha.

The Wildlife Department has created several camps around the National Parks to control poaching. The single vehicle and insufficient petrol allowances form a serious constraint for law enforcement. The increase in arrests from 1985 to 1986 (from 80 to 150) was mainly due to an extra petrol allowance and confirms this. There is still a high incidence of poaching especially on elephants for tusks and meat as well as trophy-poaching along the border of the Kafue National Park. Poaching seems to be organized and also subsistence hunting has increased.

The National Park and Wildlife Act does not provide habitat protection in Liuwa Plain National Park and in the Game Management Area and till now this was not a major problem due to low population densities. The Act does not protect against mining activities which are considered to be of national interest, while at the moment prospecting for oil in Liuwa Park has started. The trade in trophies is also licensed.

9.6 AGRICULTURAL RESOURCES

The access to crop land is entirely under customary law. Most of the arable land close to water supply has long been granted to groups and individuals mainly Lozi. However there is still land, especially along the Luena river, and in the forest areas in Lukulu, Shesheke and Senanga Districts which as "Mubu wa Luu" is under the control of indunas.

The traditional land tenure leads to insecurity which is the result of the loss of production rights with the loss of title, uncertainty over who inherits what, the loss of production rights for women with divorce and the uncertain position of non-residents or non-Lozi with regard to most land rights. The fear of magic powers plays an important role as well as the distortion of customary rules under influence of the market economy. This insecurity might form a hinderance to land improvements such as anti-erosion measures and water control.

Because the land is divided among the heirs, increasing households lead to excessive fragmentation particularly of the most valuable crop land. This fragmentation leads to unworkable parcel sizes and impedes the maintenance of waterworks and land improvements. Large-scale improvements may be carried out only on a communal basis due to the complex and fragmented ownership, especially in

the high population density areas and is therefore laborious and slow. There is no customary law on utilization of irrigation water, thus the Water Act (1971) may serve as the framework for licencing. The traditional law does not prevent excessive drainage and subsequent irreversible loss of peat soils. **Bylaws and regulations should be provided by the Natural Resource Committees.**

Together with labour migration from Western Province around the turn of the century absentee landownership appeared. The migrant worker holds his right to land, which he often does not lend for cultivation, fearing the lender might make improvements which would allow him to stay. Uncultivated arable land is common while other gardens are intensively cultivated and subdivided because of growing households. How much fallow can be attributed to absentee landownership is difficult to say. Necessary fallow periods, the lack of labour, the increased number of women-headed households and neglectence of drainage ditches may have contributed as well.

Banks are reluctant to give loans for land under customary law. However, farmers have the possibility of allowing the Agricultural Department to assess their production and therefore payment capacity by which they can obtain seasonal loans. Large longterm loans remain a problem. In other Reserves outside Western Province farmers try to obtain a state leasehold which enables them to lend. But also under the Land Acquisition Act land is not freely exchangable and cannot be sold and therefore cattle and movable property as a security is preferred. This conversion of reserveland into state leasehold is still very scarce in Western Province. The recently granted state leasehold to the Zambia Cashew Company Limited is in many ways a precedent showing that land tenure is not necessarily a constraint on agricultural development.

Before Independence the cleaning of drainage ditches ("canals") was done on a communal basis. After Independence the Department of Water Affairs maintained the larger drainage ditches but stopped cleaning because of decreasing funds. Also the communal selfhelp ceased to exist, however it is revived in some areas with rice cultivation.

9.7 CATTLE AND GRAZING RESOURCES

Grazing including prescribed burning of pastures is regulated by customary law with exception of the National Parks where livestock grazing is not permitted (except for Liuwa Plain National Park) and the Forest Estate where a licence is required for grazing. In principle everyone may graze his cattle outside the gardens on the land belonging to the village. In spite of the increasing numbers of cattle (section 5.3) no disputes over grazing rights are recorded.
People may give their cattle in custody of relatives who have access to good grazing land. Customary law does not include provisions to prevent overgrazing. The Natural Resource Conservation Act enables the minister to regulate stock numbers when deemed necessary. The Provincial and District Natural Resource Committees set up to monitor and enact the necessary bylaws are not functioning at the moment. The Game Management Area is not under their full juridiction and also the Wildlife Department lacks the mandate in this area to regulate grazing.

The system of communal grazing lands poses some problems for the construction and maintenance of dikes and ditches for rice cultivation.

The trade and the movement of cattle from the Angola-Barotse cattle cordon is regulated by the Stock Diseases Regulations (1937). This cordon dates from 1933 and was partly disbanded in 1955 but reopened by the Barotse Native Government in 1960. In 1967 parts were disbanded but its reintroduction was established in January 1970. The Barotse-Namwala cattle cordon, opened in 1922 was disbanded in 1947.

The cordons were constructed in order to prevent the spread of contagious bovine pleuropneumonia (CBPP) which is endemic in Angola. Between the border with Angola and the cordon, a 12 to 45 km wide bufferzone was created where movement of cattle is regulated. All cattle moving from this zone to Western Province is tested twice for CBPP, while within the bufferzone all cattle is branded and vaccinated once a year.

The cordon line, a partly fenced and cleared strip 4-5 meters wide, was realigned by the Veterinary Department in 1975 and 1977. The cordon forms an obstacle to transport, the loaning of cattle for manuring and ploughing. Nevertheless the cordon is respected and purposeful crossing is rare although the cordon guards (100 in total) do not have full control. Testing of cattle for CBPP, required for cattle trading, can take several months and vaccination is irregular. Long waits in quarantine areas has already lead to overgrazing and water shortage. At the moment the relocation to the international border has been proposed, which may disrupt grazing of Wildebeest in Kalabo district.

9.8 FISHERIES

Fishing is dominated by customary laws. The fishing rights for most of the lagoons and smaller lakes were given to villages or individuals long ago. The Zambezi river and the larger canals in the floodplain are open fishing areas. However a non-residential commercial fisherman requires the permission to camp. At the moment the customary law prevents overfishing. Although fishing rights cannot be leased for a reward, there seems to be a tendency to commercialize tributes. Fishing rights are more freely leased than production rights on arable land because there is no fear that major improvements will enable the leaser to hold on to the lease.

In spite of efforts of the National Government, fishing in Western Province is not licenced and is free of charge. The Fishery Department is small and lacks the personnel and logistic support to control fisheries. Their role is mainly advisory and the Fish Conservation Ordinance (1955) and Fishery Regulations (1974) are only partly enacted as far as unpermissible fishing methods are concerned.

9.9 MINISTRIES AND DEPARTMENTS

Ministry of Lands and Natural Resources
- Department of Forestry
- Natural Resources Advisory Board
- Department of Natural Resources
- Water Board

Ministry of Agriculture and Water Development
- Department of Agriculture
- Department of Water Affairs
- Department of Veterinary and Tsetse Control Services
- Department of Fishery

Ministry of Tourism, National Parks and Wildlife
- Department of Wildlife and National Parks

Ministry of Health

9.10 NON-GOVERNMENTAL ORGANISATIONS

Both the Wildlife Conservation Society of Zambia and the Zambia Ornithological Society are based in the national capital Lusaka and do not have branch offices in Western Province. The Wildlife Conservation Society set up a Chongololo club for primary school children in all District capitals and some smaller villages in the Mongu District to stimulate conservation awareness.
Members of the Zambian Ornithological Society are inventorizing birdlife in Western Province here and there as far as their private time and budgets allow.

9.11 CONCLUDING REMARKS

It is obvious that customary law plays a dominant rol in the use of natural resources in Western Province. The traditional structure is firm

but certain facts indicate that this may gradually erode. This could create a vacuum in legislation when statutory law, which lacks the grassroot acceptance, cannot be enforced due to lack of funds. This may present a serious situation for the forest resources but also development in agriculture and fisheries can be hampered and lead to conflicts over water use, grazing land and the dates for prescribed burning.

The basic philosophy in environmental legislation should be that benefits and therefore responsibilities and control should be based at district and village level whenever possible, while coordination and extension should be undertaken by the relevant departments.

The Natural Resource Committees may become instrumental for regulation of burning, water control, minimum fallow period. The pole and fuelwood collection, charcoal production and hunting outside the Forest Estate and the National Parks could be assigned to the Natural Resource Committees as well. These Committees could be self-financing by the revenues of updated licence fees and fines.

10. GENERAL CONCLUSIONS

The present state of the environment in Western Province is generally good.
The environment is resilient to the current method and rate of exploitation of natural resources except for (i) the timber exploitation, which is not sustainable, (ii) the ongoing decline in some of the larger wildlife species and (iii) the traditional drainage technology that leads to irreversible loss of good soils.

Most land resources exploitation is interrelated in Western Province. Therefore ongoing resource inventories (soil survey, grazing capacity survey, farming system survey) should be coordinated by the Provincial Planning Unit and be expanded as to include Forest and Water Resources especially the Zambezi floodwaters.

A considerable development potential for maize, rice, cashew, cassava, timber, fish and (irrigation) water has been identified and rough quantitative estimates were possible except for water. More accurate assessment of these resources is necessary for development planning and in order to avoid overexploitation. Possible negative impacts on the environment associated with the development of the identified resource potentials are discussed. Those identified are local soil erosion hazard in maize expansion in Eastern Kaoma, and bilharzia establishment, off-site overgrazing and off-site overfishing for large scale rice development in the Bulozi meanderbelt. These reported environmental hazards seem to be controllable by starting data collection and preventive measures soon.

Customary law showed to have many positive conservational aspects as well as hampering some resource development.

Statutory law together with customary law provide a good framework to prevent environmental degradation. The potential of the existing laws are not always used optimally and suggestions for improvements are given.