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THE DESIGN AND USE OF AGROFORESTRY SYSTEMS IN BOTSWANA

BY
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ABSTRACT OF THESIS

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Botswana is a semi-arid country which has 80% of the population living in rural areas and engaged mainly in agriculture. Rural populations in Botswana depend heavily on woodlands for fuelwood, fencing poles, building and raw materials for various local industries. Batswana are traditionally pastoralists who practice mixed farming with arable agriculture as a secondary occupation. Woodlands in Tribal areas are used communally with little or no management. Increasing pressure on woodlands, especially in the eastern and southern parts of the country is resulting in rapid depletion and scarcity of wood products around major settlements.

Dryland agroforestry and rural forestry have potentials in provision of woodland resources and diversification of traditional land use systems. This report reviews tree planting activities in the country and the following constraints have been identified: lack of water, wrong species or provenance choice, insufficient seedlings, lack of technical know how, animal damage on seedlings, lack of labour and termite attack on young seedlings.

Also the existing land use systems, with special emphasis on Agroforestry were reviewed so that possibilities for improvement could be identified. The two main traditional Agroforestry systems in Botswana 'Silvopastoral' and 'Agrosilvopastoral' are described together with their management, potentials and constraints. Agroforestry research, training and extension needs were also identified.

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LIST OF ABBREVIATIONS

AHTP	Around the Home Tree Planting Programme
ALDEP	Arable Land Development Programme
ANAFE	Africa Network for Agroforestry Education
ARAP	Accelerated Rainfed Arable Programme
BAC	Botswana College of Agriculture
BLDC	Botswana Livestock Development Corporation
EEC	European Economic Community
ERL	Environmental Resource Limited
FAB	Forestry Association of Botswana
FAO	Food and Agricultural Organisation
ICRAF	International Council for Research in Agroforestry
KRDA	Kweneng Rural Development Association
MLGL	Ministry of Local Government and Lands
MOA	Ministry of Agriculture
MPTS	Multipurpose Tree Species
NPD	National Development Bank
NDP	National Development Plan
NIR	National Institute of Development Research and Documentation
NGO	Non Governmental Organisation
NTPD	National Tree Planting Day
PRICE	Pioneer Rural Innovation Centre
OSSCA	One Stop Service for Agriculture
PDT	Palapye Development Trust
SLOCA	Support Livestock Owners in Communal Areas

TGLP	Tribal Grazing Land Policy
VDC	Village Development Committee

CHAPTER 1

INTRODUCTION TO THE STUDY AND SOME BACKGROUND INFORMATION ABOUT BOTSWANA

1.1 INTRODUCTION

Botswana is a semi arid area which has two-thirds of the country covered by the Kalahari sands. More than 80% of the population live in rural areas engaged mainly in agriculture: this is mainly based on subsistence farming, which involves mainly pastoral farming and dryland arable farming. Despite the fact that there is abundance of land in Botswana, the production of food crops has not kept up with the increasing human population mainly due to unpredictable droughts, infertile soils and very low rainfall.

Most of the population also depend on the natural woodland for a variety of products such as fuelwood, poles fruits, roots, leaves, insects and honey; moreover certain trees and shrubs are valued for their different medicinal properties. Although one of the primary demands made on natural woodland is for fuelwood, in the context of the rural home one is dealing with the multiple uses of woodland resources. The natural vegetation is also exploited in a indirect manner in form of providing grazing for livestock, which in turn, supply meat, hides, milk and other products.

Botswana like many other developing countries is faced with a serious problem of over exploitation of its natural resources like the natural woodland. As traditional pastoral systems, are replaced by sedentary farming, trees and shrubs are often cut to clear land for cultivation and

to obtain fuelwood and livestock grazing for expanding rural populations. This loss of tree cover around settlements and lands has led to -

- increased wind/water erosion
- increased loss of top soil
- decrease in crop yields
- lower income to farmers

In these situations, there is a need to introduce Agroforestry technologies which focus on the maintenance or introduction of trees and shrubs into agricultural systems, both to conserve and improve the soil and to supply a variety of tree products such as dry-season fodder, fuelwood and building poles. However, even though agroforestry can increase productivity and improve sustainability, it is not a solution for every land situation. Trees are not necessarily a cure for all environmental problems, including desertification. In some cases the very advantages of agroforestry may be associated with the disadvantages due to poor planning. problems may be associated(e.g. with selection of wrong species for a particular situation). In a desert country like Botswana, woodlots and plantations yield poor economic returns due to high establishment and maintenance costs. Trees in woodlots are also prone to high mortality rates due to drought, insects and disease attacks, increasing the financial risks associated with this approach. Therefore there is need for careful planning before any technology can be implemented in any particular situation.

In view of the subsistence farming and the associated problems of declining food production and woodland resources, this study was planned to critically review and assess the factors which are a constraint to the design and implementation of agroforestry technologies in the whole country.

The objective of this study is to assess the potential for agroforestry technologies which are appropriate to both the physical and socio-economic environment, the local site conditions and also compatible with the human environment.

1.2 THE COUNTRY

1.2.1 Geography

Botswana is a landlocked country in southern Africa neighbouring Namibia to the west, Zambia to the north, Zimbabwe to the north-east and South Africa to the south and south-east(see location map Figure 1.1). The mean altitude of this country is 1000m above sea level. It covers an area of approximately 581, 730 square kilometres (Campbell 1980), of which two-thirds consists of the Kalahari desert. This area is part of the large, predominantly flat to undulating, sand-filled Southern African plateau-basin which extends well into the Namibia and South Africa and part of the south-east Angola. The basin situated at an average elevation of about 1000 meters, is fringed by the higher land masses of neighbouring countries, capturing most of the precipitation and leaving Botswana in a rain shadow.

Topographically Botswana can be divided into two main sections: a relatively narrow strip running along the eastern border and the vast western portion which is flat, semi-arid and comparatively featureless except for occasional rocky outcrops and the inland Okavango delta(Alidi, 1984). The two areas are separated by a generally well defined escarpment, forming a drainage divide between the westward flowing internal drainage system of the Kalahari and the eastward flowing Limpopo river system(Figure 1.2)

Figure 1.1 Location map of Botswana
source: Campbell, (1980).

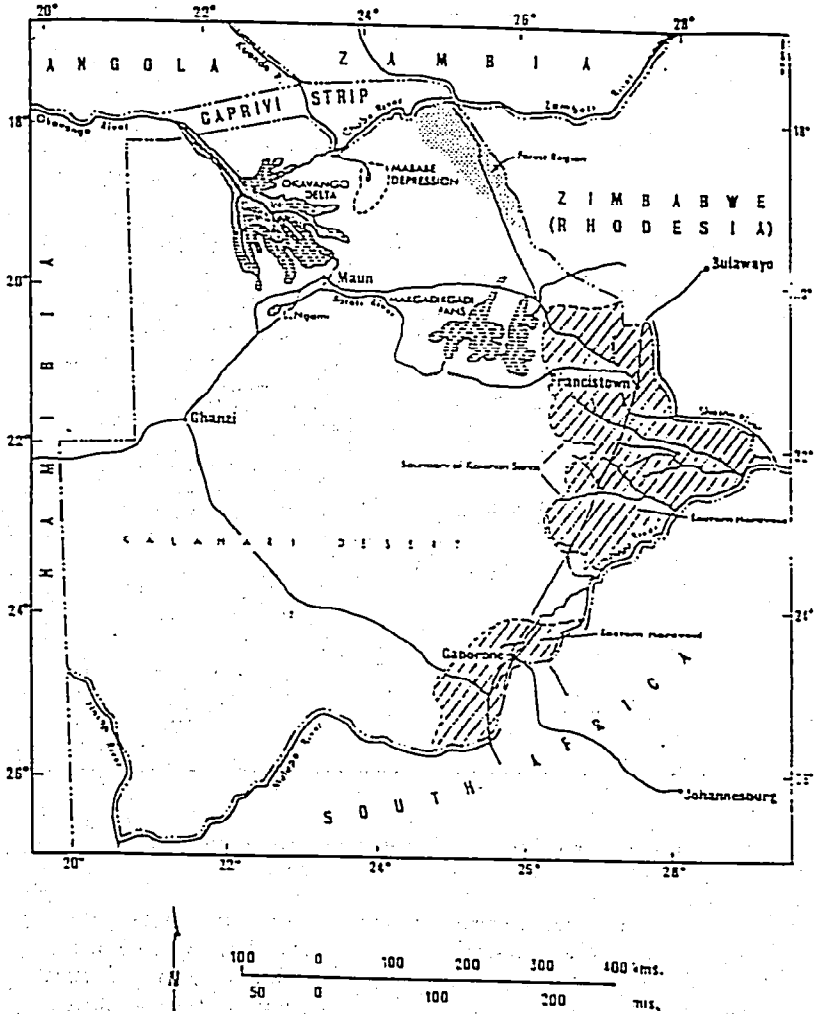
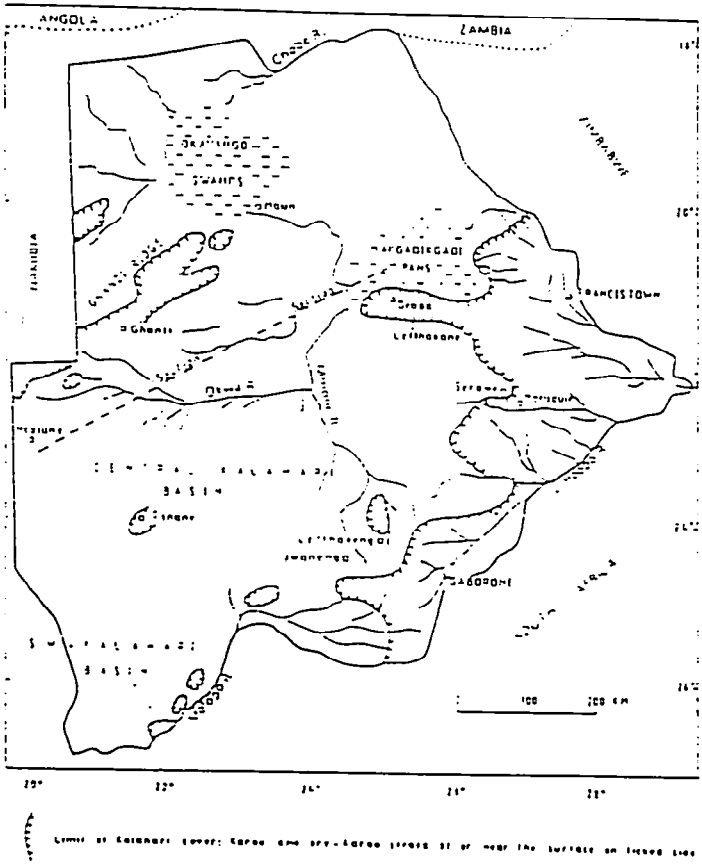


Figure 1.2. Map showing areas covered by the Kalahari sands



Outline of area covered by thick Kalahari beds. Only eastern Botswana and some isolated areas elsewhere (Chanzi Ridge) outcrops of older formations or bedrock occur at or near the surface. (Source: Geological Survey.)

The Kalahari desert covers the western parts of the country. It consists predominantly of windblown sand deposits of depths of 5 to 100 meters intermittently dotted with pans or depressions and traversed by stabilised dunes and ancient river beds. The sands have a low water capacity, a high rate of evaporation and very low in organic matter and plant nutrients. The area is almost devoid of surface water, which is therefore obtained from either hand-dug wells or boreholes.

To the north of the western section lies the Okavango Delta, which is an inland delta formed by the third largest river in southern Africa. The Okavango flows into the north eastern corner of Botswana thorough that narrow Caprivi strip(Namibia), where it spreads out over the Kalahari sands to form the Okavango delta, one of the largest most pristine inland deltas in the world. More than 95% of the water inflow evaporates or seeps into the sand on its slow course southwards through myraids of narrow water ways and vast open sheets of water(Campbell, 1980). When the water level is high in the Okavango water system, it is connected through the Selinda's spillway in to the north east extension of the swamps to Chobe river and the Linyati swamps, which form the other large river and wetland system dominating Botswana's northern region. In Zimbabwe the Chobe river turns into the Zambezi. Most of this water is not accessible because of Tsetse fly infestation.

Another part of the western section, the Makgadikgadi salt pans is the remains of an ancient super lake which at its greatest extent was as big as present lake Victoria. The Okavango-Makgadikgadi system may once have been linked to the Limpopo system, which presently forms the south-eastern border to South Africa. Numerous dry sand filled rivers in central Kalahari leading towards the Makgadikgadi pans and limestone caves containing stalcalites give evidence of dramatic variations with much wetter periods than today .

The south-eastern border of the country lies outside the Kalahari basin and is known as the eastern hardveld. Here the topography turns more varied, characterised by rocky outcrops and ephemeral waterways. Population, infrastructure and development is concentrated in this part of the country.

1.2.2 Climate

The climate of Botswana can be described in general terms as subtropical, from continental to semi-arid. Rainfall is low and erratic, annual precipitation ranges from 600mm in the Northeast to 300mm in the Southwest. The western region covers the Kgalagadi desert which is the driest part of the country with a rainfall amount of 400mm decreasing to less than 250mm in the extreme Southwest.(see fig 1.3, showing rainfall distribution and variability in Botswana). More than 90% of the rainfall occurs in the summer months between November and March but there is a significant variation from year to year.

The rainy season falls between October and March, sometimes with a dry spell in December to January. Very little or no rainfall is recorded during the winter months May to September. Although the mean rainfall may be relatively good, the prospect of receiving that amount annually may be quite poor. The reliability of rainfall in Botswana is shown in Fig. 1.4(Field 1988). This variation of rainfall within seasons and the unequal distribution of showers are more serious constraints to dryland farming and tree growing than the low rainfall as such.

Generally, Botswana experiences high daytime summer temperatures and low night-time winter temperatures. Mean annual temperatures range from 20 degrees in the south-west to 22-23 degrees in the north, but the diurnal range of temperature is large, especially during the winter months in the Southwest(monthly mean, minimum and maximum temperatures) are shown in

Appendix Table A1. Average daily maximum temperatures are about 33 degrees Celsius in January and 22 degrees in July, with extreme temperatures about 10 degrees higher. Average daily minimum temperatures are about 19 degrees Celsius in January and 5 degrees in July with extremes about 12 degrees below these values.

High winds occur in August in the Kalahari causing wind erosion and high evapotranspiration. Nowhere in Botswana in any month does precipitation exceed evapotranspiration.

Figure 1.3. Mean Annual Rainfall distribution.

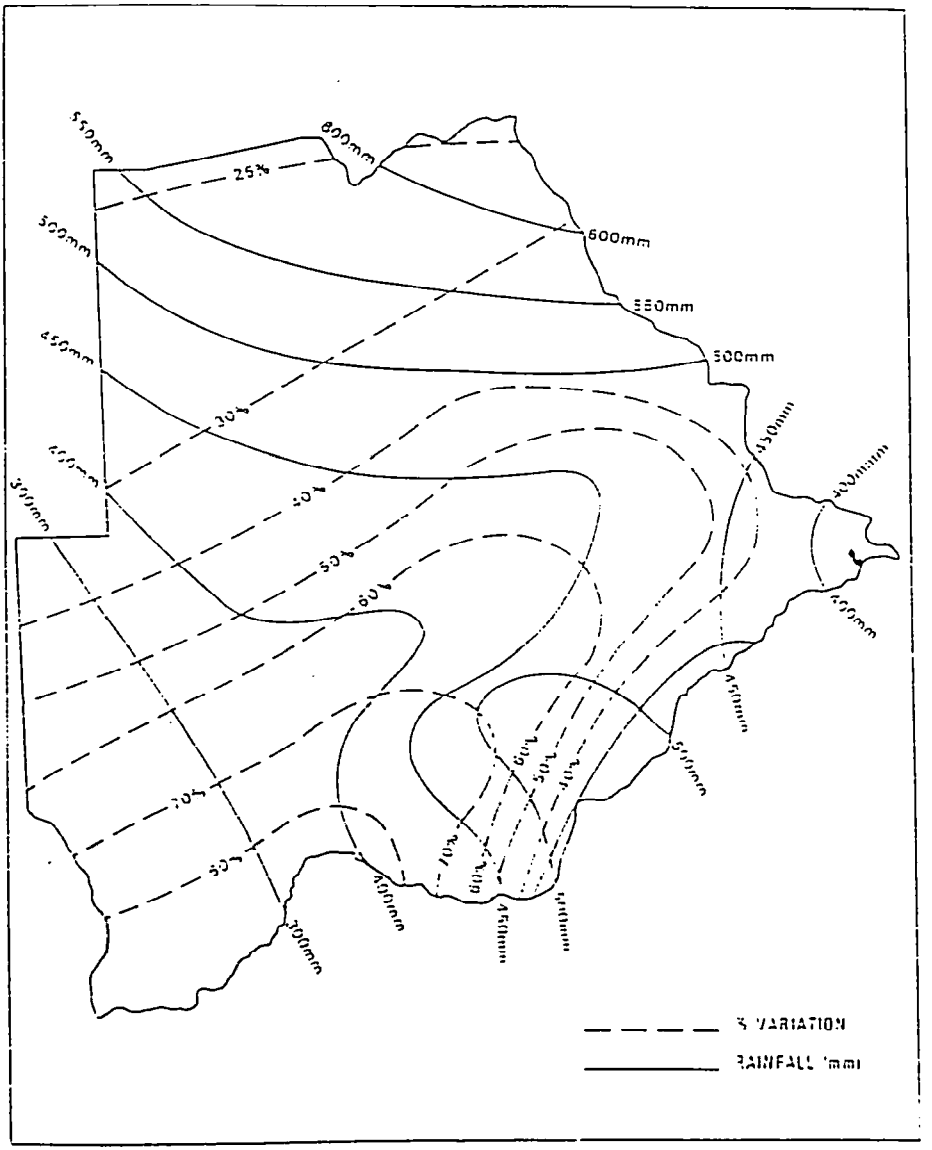
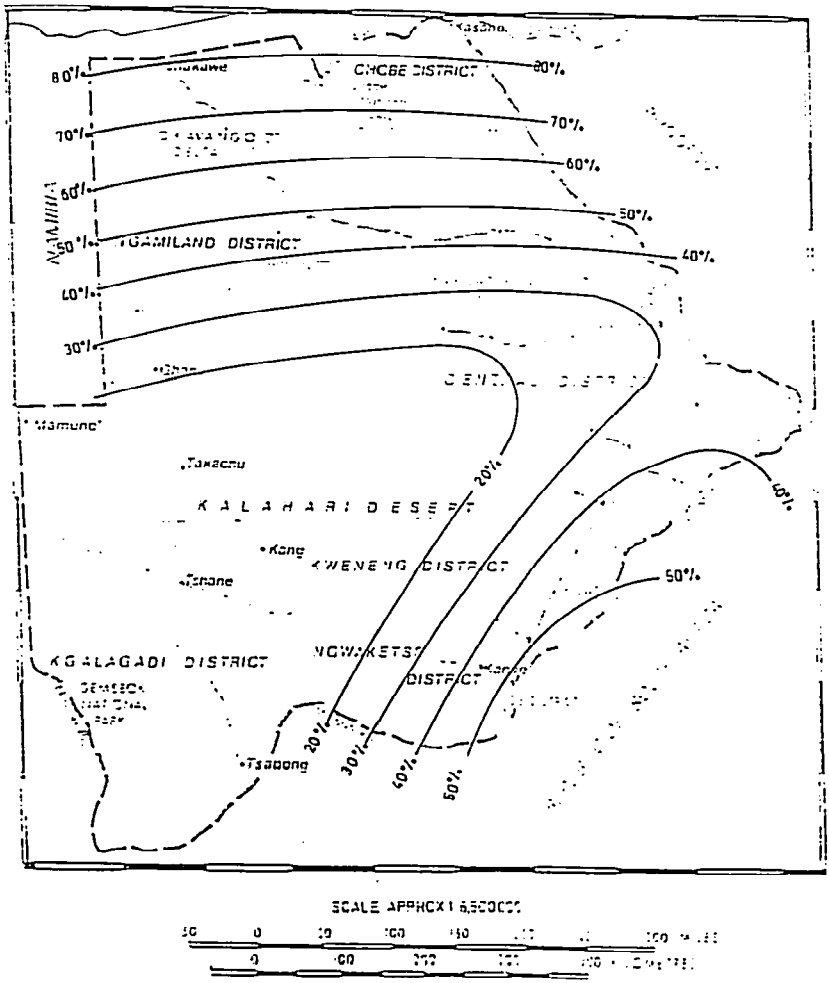


Figure 1.4 Rainfall reliability



SCALE APPROX 1:6,500,000

RAINFALL RELIABILITY

PERCENTAGE PROBABILITY OF RAINFALL EXCEEDING 500mm IN ANY ONE YEAR

1.2.3 Soils

The Kalahari sands are nutrient poor and have low moisture holding capacity. They are mostly structureless and vary in colour from grey to yellow. The calcrete rocks occasionally penetrate the sands or lie immediately under the surface.

In the east the soils are predominantly sandy loams with well developed horizons. Fertility is low to moderate and the more heavy soils tend to form crusts making tilling more important in the sandveld. (See Figure 1.5, gives more information about soils of Botswana.)

1.2.4 Vegetation

Most of Botswana is covered by savannah type vegetation, with different types predominating in different areas. Shrub savannah dominates in the south west, and tree vegetation gradually takes on a dominant role as one moves north. The shrub consists of *Acacia* species such as *A. erioloba* E.Mey., *A. leuderitzii* Engl .var. luderitzii, *A. giraffae* and *Terminalia sericea* Burch. ex DC. The all dominating shrub is *Grewia flava*. In the northern parts of the Kalahari the proportion of non-thorny species of the *Combretaceae* becomes larger.

In the extreme north-eastern corner the only extensive dry deciduous forest (Miombo woodlands) is found contiguous with the borders of Zambia, Zimbabwe and Namibia. This covers an area of 3,200 square kilometres, which is about 0,6 % of the total area of Botswana, and contains valuable timber from genera such as *Baikiaea, Pterocarpus, Afzelia, Guirbotia, Burkea* and *Brachystegia*. Elsewhere forests and dense woodlands can only be found as riparian fringe forests. In the eastern hardveld, mixed trees and bush savannah type vegetation is found

Vegetation becomes more diverse, *Andansonia digitata* L., *Sclerocarya birrea* (A.Rich) Hoscht ssp caffra (Sond.) Kok., *Peltophorum africanam* Sond., *Acacia nigrescens* Oliv. and *Combretum imberbe* Wawra. are typically large trees and where *Colophospermum mopane* (Kirk ex Benth.) Kirk ex J.Leonard. occur this species forms dense almost mono-culture thickets. (see figure 1.6, vegetation map of Botswana).

Based on assessment of climate, soils, and vegetation data, the country can be divided into 5 agro-climatic zones as shown in table 5.1 and figure 1.7 (Otsyina and Walker, 1990).

Figure 1.5 Soils of Botswana

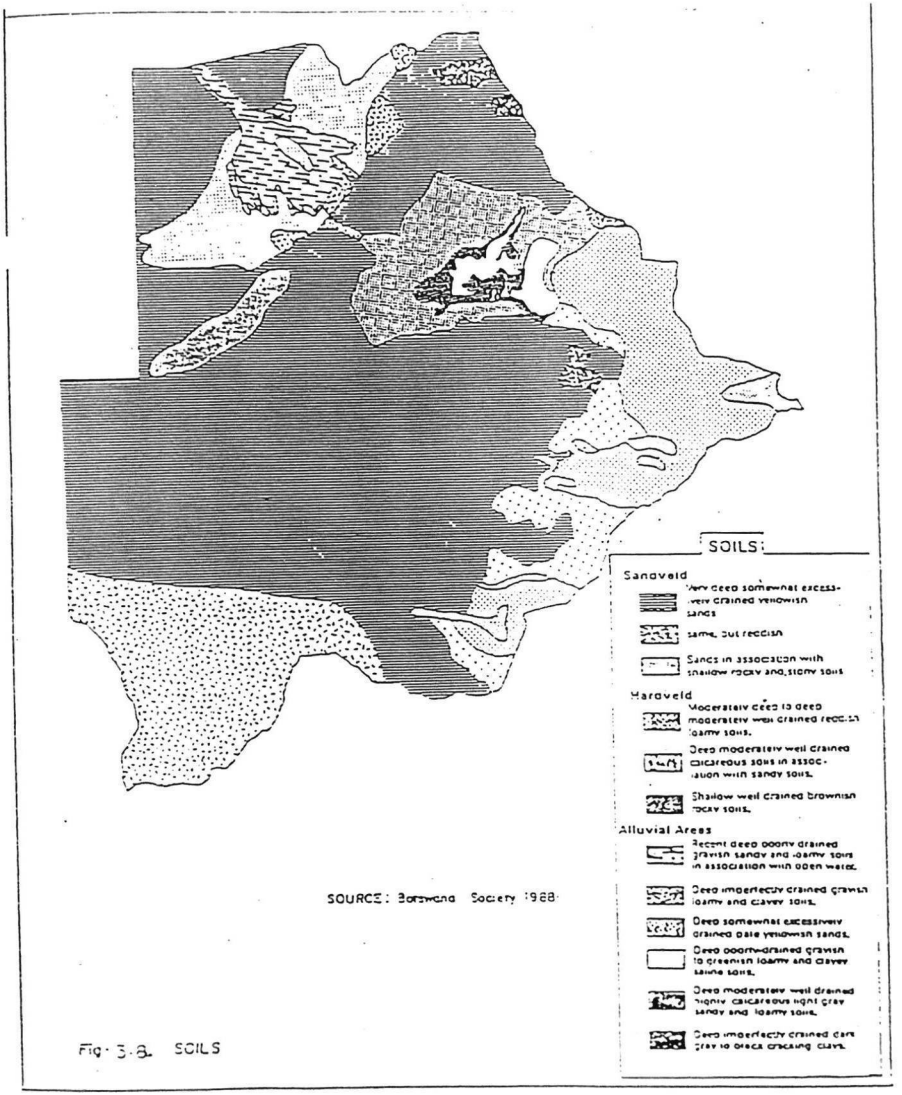


Figure 1.6 Vegetation Map of Botswana

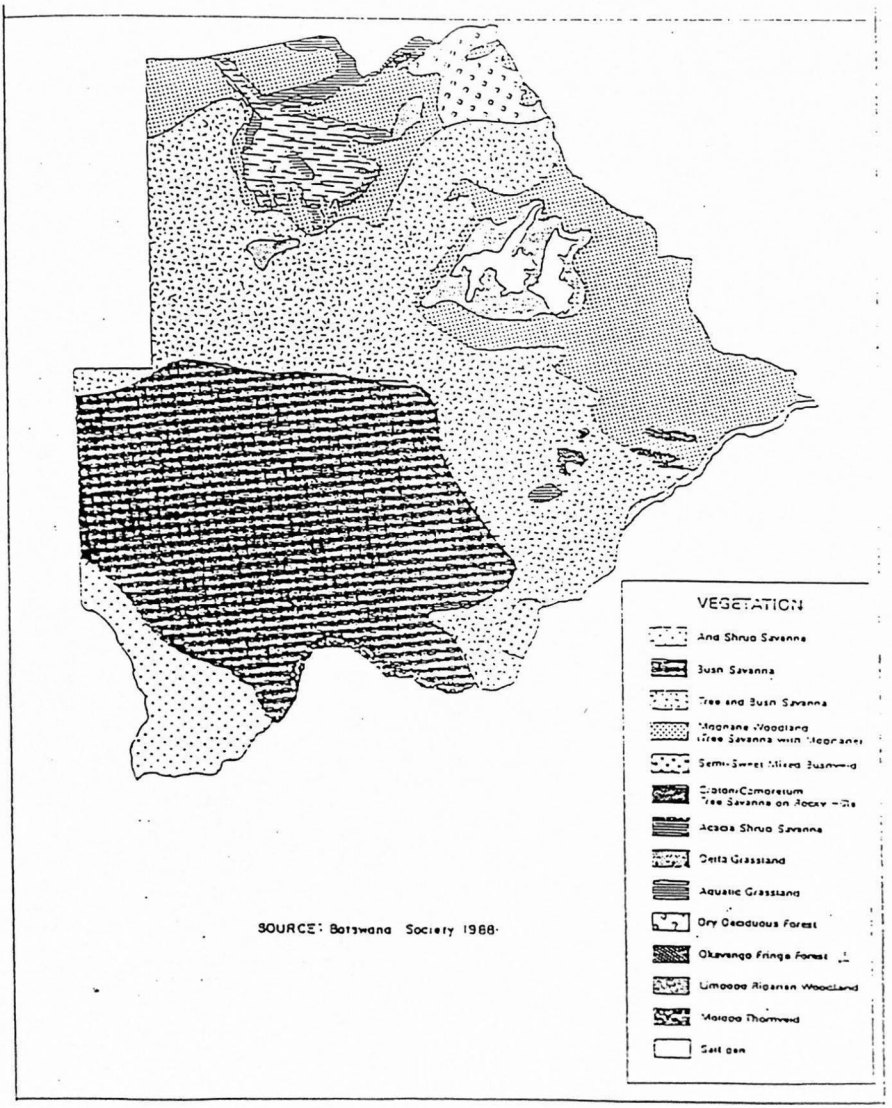


Table 1.5 Summary of Agro-climatic zones characteristics(Otsyina and Walker, 1990)

Attribute	Agro-climatic zone I	II	III	IV	V
Location (Districts)	Chobe	Ngamiland Tutume Tlokweng Kgatleng Barolong	N. Ghanzi Serowe Palapye Kweneng Mahalapye Letlhakane	Bohonong Ghanzi Hukuntsi (Kgalagadi)	Tsabong (Kgalagadi)
Rainfall (mm) Rainy season Variation (%)	600-700 Nov-June 25-30	500-600 Nov-June 30-35	400-500 Nov-June 30-40	300-400 Dec-July 40-45	200-300 Jan-June 45-60
Length of humid period (days)	60-80	40-60	40-60	20-40	20-40
Dry spells	< 20	20-30	20 - 30	20-40	30-40
Av. Temperature Summer Winter	9-42.3 -6-32.0	6-43.4 -4.5- 32.5	15- 42.0 -5 - 30	10 - 43 -5 - 35	17 - 34 -2 - 32
Evapotranspiration (monthly)	60- 180	70 - 192	85-191	85 - 199	65 - 227
No. frost days Ground Air	2	26.1 3.3	31.9 7.6	37.3 10.7	72.1 29.9
Soils	sandy to sandy loam & vertisols	sandy to sandy loams	ferrugineous sandy loam to clay sandy	sandy loam to pure sands	sandy (light sands)
pH	6.0 - 9.0	4.0- 6.5 sands 6.7 - 8.5 clays	5.5 - 6.5 sands 7.0 - 10.0 clays	5.5 - 7.2	5.5 - 7.2
Drainage	good to poor on clays	good (sands, clays)			
Nutrient status (fertility)	low on sands good on clays	moderate	low to moderate	low to moderate	good low
Vegetation type	Dry deciduous forest, aquatic grassland	mopane woodland, tree and bush aquatic grassland	Mopane woodland tree and bush	Mopane woodland bush savanna	Arid

1.2.5 Population

The population of Botswana is around 1.3 million people(1992 census). About 80% of the population is subsistence or near subsistence level by raising cattle, maize, sorghum or by hunting. Botswana's population is currently growing at a rate of 3.4% per annum which marks an increase since 1971 when it was 3.1%.

The overall population density is the order of nearly 2.0 persons/square kilometre but population distribution is skewed throughout the country: The western part of the country is very thinly populated with an average density of 0.14persons/square kilometre, while areas with high population concentrations are found mostly in the eastern part of the country along the railway line(see Figure 1.8 on population distribution in Botswana).

The environmental impacts of population growth in Botswana have not been comprehensively assessed(Arntzen, 1992). In the short term, population growth leads to an increase in subsistence activities and hence in more pressure on the associated natural resources. The demand for many renewable resources will increase: water, fuelwood, arable land, cattle and smallstock etc. Where these resources are in short supply, population growth may further affect their regeneration capacity– particularly the case of rangelands nationally. Figure 1.9 (a and b) shows the historical relationships between population numbers on the other hand and livestock units and cultivated land on the other for Botswana for 1904-1990(Arntzen, 1990). Except during droughts, there is a strong correlation between population and livestock numbers.

Figure 1.8 Population Distribution in Botswana

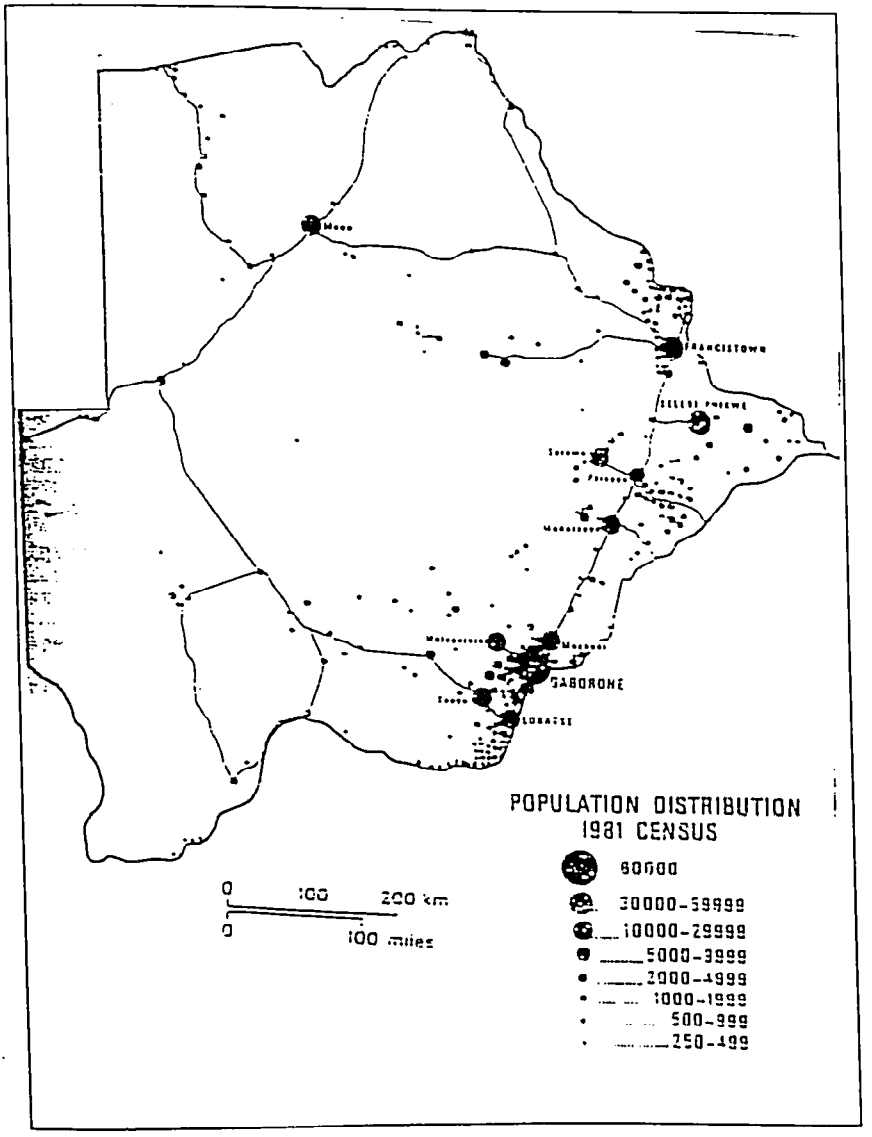
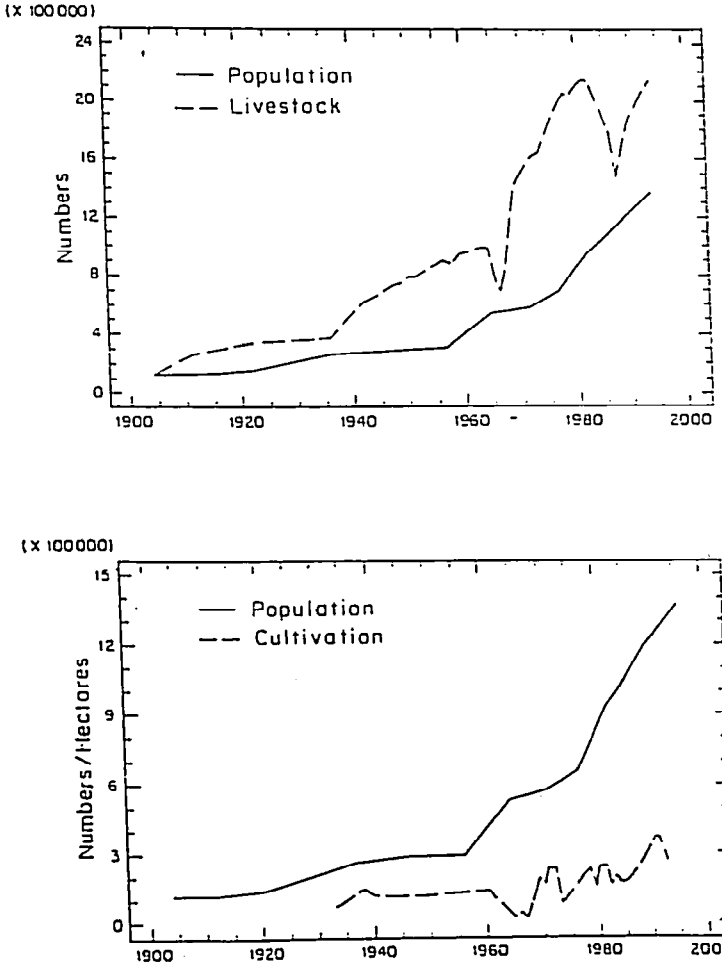


Figure 1.9 a and b. Trends in human population, livestock and cultivated area, 1904-1987(source updated from Arntzen, 1989).



Also the lack of water necessitates the concentration of the populations in large villages such as Kanye, Serowe, Maun etc. Almost every family moves to the arable lands during the planting season and remains there until the crops are harvested. Because of the relatively low population density, there is often not an absolute shortage of natural resources, but a spatial mismatch between the supply and demand of natural resources. The result is locally and even regionally serious resource shortages occur, such as:

* Land shortages in Southeastern Botswana
* Fuelwood scarcity in Southeastern Botswana and around rapidly growing settlements.

1.2.6 Economy

At independence, 30 years ago, Botswana was one of the poorest countries in Africa. An overwhelmingly rural population depended mainly on agriculture for livelihood. Beef production was the mainstay of the economy in terms of output and export earnings(NDP6,1985). Mainly due to the development of the diamond mining, the country has climbed from being one of the poorest countries in Africa to its present status as being one of the richest. Three of Botswana's towns are mining towns and Botswana became second largest diamond producer in the world after the opening of Jwaneng mines in 1980(Barclays Bank of Botswana Limited, 1985).

Although livestock production has played an important part of the economy, mining now accounts for the 51% of the gross domestic product, while the whole agricultural sector only contributes 3%. The income distribution is not fairly distributed and the wealth from the mining sector has not trickled down to the remote rural population as hoped.

However cattle rearing is perhaps more important than mineral production in terms of its effect on the majority of the people of Botswana. Botswana is a cattle country. Cattle outnumber people by three to one and provide a fundamental part of the livelihood of the majority of Batswana families. The expansion and commercialisation of the livestock production has been encouraged by the EEC's heavily subsidised beef prices, i.e. exports.

Botswana is also an arable farming country though the value of arable production is much lower than that of cattle. Many of the poorer household depend on arable production for subsistence living. Unlike much of Africa where arable cultivation is traditionally carried out by hand on relatively small plots which are intensively cultivated over a few years and abandoned, in Botswana the ox-drawn plough is used for repeated cultivation of extensive areas of arable land with rather low yield per hectare (Colclough and McCarthy, 1980). With the ox-plough replaced by tractors, markets surplus crops made available, the temptation to increase production at the expense of the fertility of land has increased so that the in some areas the process is nothing less than land mining (Fasbrooke, 1973).

The economy as a whole is characterised by lack of employment opportunities and because of the low domestic production of both food and other consumer goods, Botswana relies heavily on South Africa. The dependence on the South Africa economy has in many respects restricted the development and diversification of Botswana's economy.

As a result of the above factors, this study was planned to:

- critically review and assess the factors which are a constraint to the design and implementation of agroforestry technologies in the whole country
- assess the potential for agroforestry technologies which are appropriate to both the physical and the socio-economic environment, the local site conditions and also

compatible with the human environment.

- Recommend such Agroforestry technologies which are appropriate for different agro-ecological zones of Botswana

CHAPTER 2

CURRENT LAND USE PRACTICES

2.1 Land Use Systems

Botswana's production systems can be described as extensive and semi intensive mixed farming with arable and livestock components. Traditionally, the Batswana practice a zonal land use system. The land is divided into residential, arable and grazing land. The arable land is located around the villages at distances from 5 to 20 kilometres, whereas the grazing land is concentrated around cattle posts located much further away from the villages.

Although less than 5% of the country, (concentrated in the northern and eastern parts), is considered suitable for agriculture (Government of Botswana, 1991), most of the rural population relies on mixture of arable and livestock farming. The major crops are sorghum, maize, millet, sometimes mixed with pulses, vegetables and melons. The risk of crop failure is extremely high and therefore low input farming is practised. In the western part this mixed arable and livestock production system is extremely extensive, with agricultural crops yielding erratically due to adverse climatic conditions. In the east and Southeast where there are good soils and more rainfall the mixed land use become more intensive.

Other types of land use practices are found around the Okavango, Boteti, Chobe rivers and in the Tuli block along the Limpopo river, where freehold farmers practice intensive irrigation farming, producing almost 1/3 of the domestic grain production (Government of Botswana, 1991) and most of the vegetables and oranges. Along the Chobe and along the Okavango the so-called Molapo farming is practised. This type of farming depends on the flood regimes of the

rivers, which can fluctuate from year to year. It is therefore, much less intensive than irrigation farming, but still far more intensive than the normally practiced dry-land farming system. Subsistence fish farming is also practised in this area. Even though permanent surface water occurs in this area, livestock production is poor mainly due to tsetse infestation. In the southwestern corner of the country the ethnically mixed Afrikaans speaking communities keep small stock, sheep and goats on a much larger scale than other population groups in the country.(see figure 2.1 for land use systems in Botswana).

Traditionally, the farming systems aim at providing subsistence and secure livelihoods to households. Commercial livestock farming in the shape of both tribal and freehold ranches, however, is being strongly promoted and is leading to rapid changes in land use and land tenure.

2.1.1 Land areas

Lands in the Botswana context refers to areas where arable agriculture takes place. Lands are characterised by large fields and fairly scattered homesteads. There is a seasonal migration between lands and homesteads because such settlements are usually not within commuting distances from the villages. The ploughing season begins in Oct/Dec and harvesting ends in June/August. However, with the recent political changes since independence- the change from autocracy of the chiefs to the relevant democracy of the district council and Land Boards, more people are now settling at the lands. In the past, permanent settlement at the lands was disallowed by the chiefs(Silitshena, 1982). Another factor could be that, the provision of water and social facilities e.g., health clinics and schools by the government and the district councils has encouraged the process of land settlement.

2.1.2 Cattleposts and Small stock

Cattleposts are areas where cattle are kept all year round. They are usually more remote settlements further than the lands and they are characterised by low population densities and very few scattered homesteads. The distribution of cattleposts from the villages is dictated by the need for extensive range land and water points for the livestock. However small stock like sheep, goats and donkeys are kept mostly at the lands and are grazed/browsed around the home compounds or in the crop field. Nowadays due to lack of labour- men and boys are either working in towns or South African mines - women are now combining both works of looking after the household and small stock and hence it is practicable for them to migrate with their stock to the villages where they do so as well.

2.2 Land tenure

There are basically three types of land tenure in Botswana(see figure 2.2 for Land Tenure in)

* Freehold lands
* Tribal lands
* State lands

Freehold: This land is owned by an individual or group of people who have exclusive control over its use and it can be transferred from one owner to another without obtaining permission from the state. Only 6% of the country is freehold. This is located in the most productive areas in the Tuli block, Southeast and Northeast districts and in the Ghanzi farms where the Afrikaner community runs commercial ranches.

Figure 2.1 Land Use Systems in Botswana

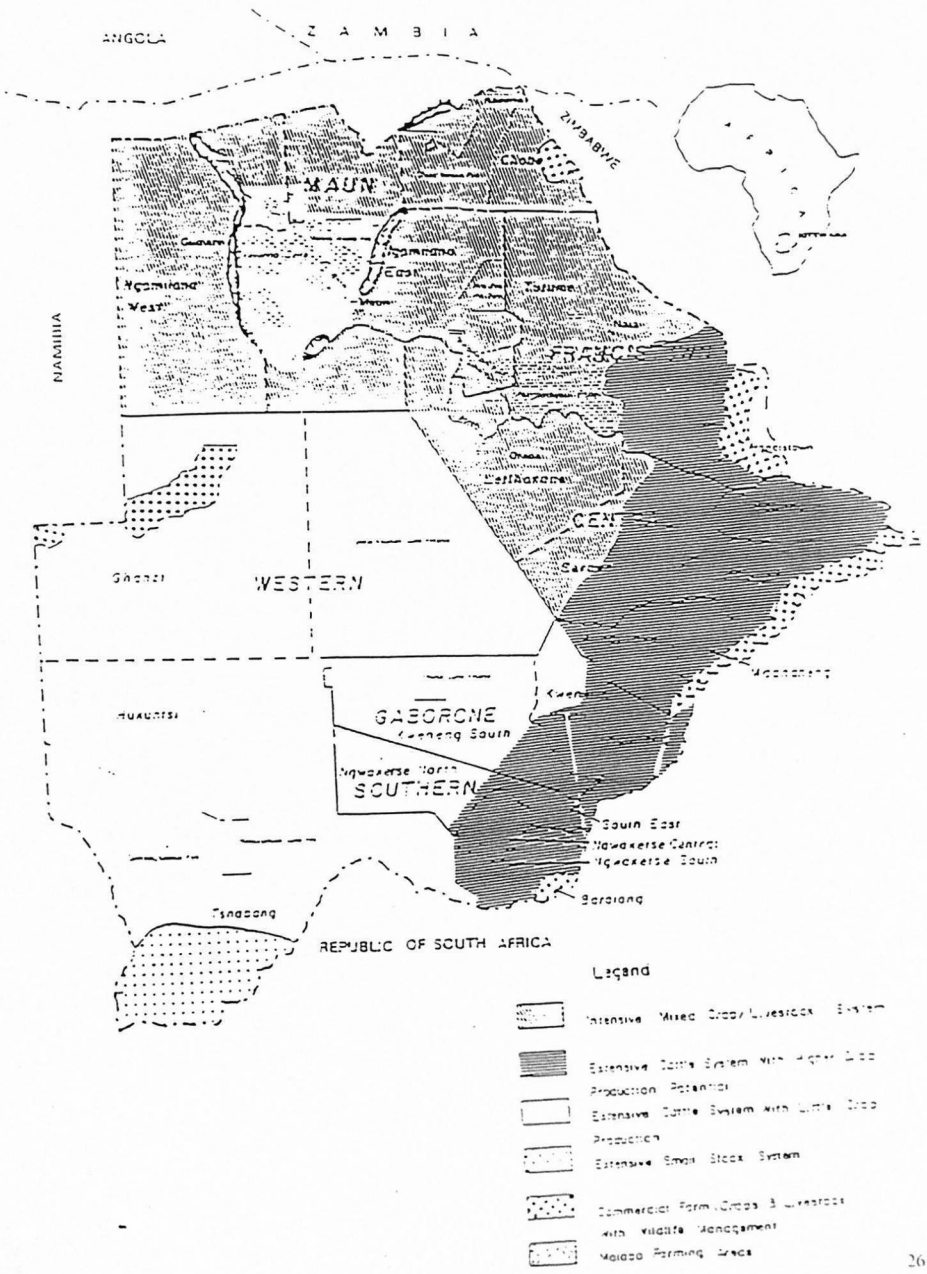
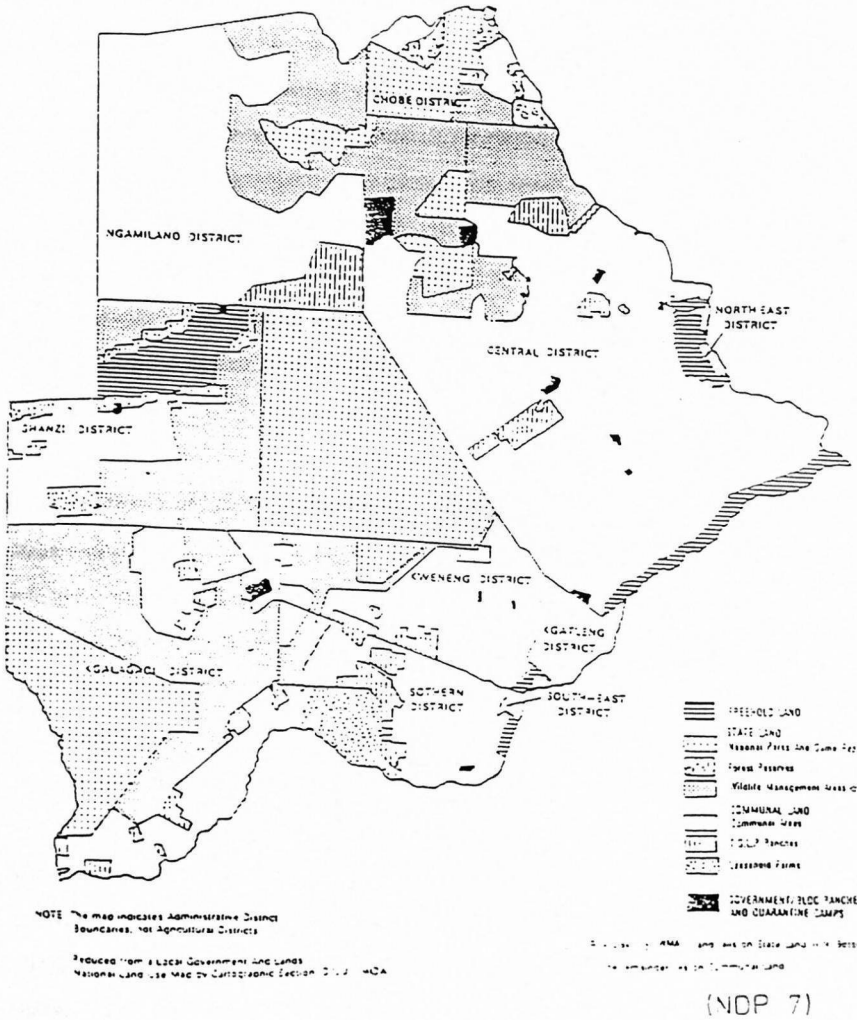


Figure 2.2 Land Tenure in Botswana



Tribal : this land is owned by the different tribes throughout the country and its administration is through the Tribal Land Board under the authority of the Land act Tribal land makes up 71% of the land area, and 80% of the people and their livestock live there(National Conservation Strategy, 1990). Every tribesman has user rights to residential, arable and grazing land within the tribal territory, but the commercialisation of livestock production and the transfer of local administrative power from chiefs to land boards has eroded the *de facto* rights of traditional users access to common property resources. Although access to communal grazing land and natural water sources is open, access to artificial water sources is not, but is controlled by the grantee, who has the right to exclude other people. However, many wells, dams, and hafirs are shared, either because they were commonly dug or because they are old and original owner's descendants share dam.

State: this land is owned by the state and accounts for 23% of the land area. It consists of national parks and forests and wildlife management areas. Leasehold rights are given to individuals or groups over certain fenced areas and also communal grazing for certain areas. Here, user rights are restricted, but violations of protective legislation take place regularly because the user rights of original users have been overlooked e.g. Bushman settlers.

The government has invested a lot of money and effort in improving traditional land utilisation. The major land reform introduced in 1982 tried to implement the zoning of all land into communal land, commercial farming and wildlife conservation areas, and the incentive packages ALDEP(Arable Lands Development Project) and ARAP(Accelerated Rainfed Agricultural Programme) supported small farmers in buying farm machinery and giving them free inputs to increase their agricultural production. and tried to persuade farmers to continue farming instead of migrating to Urban areas or South African mines. The livestock sector was heavily subsidised through SLOCA(Services to Livestock Owners in Communal areas), the Bull subsidiary

Programme, the Grazing management Areas Programme, the Drought Recovery Programme, and other programmes (Government of Botswana, 1991).

2.3 Afforestation

Over 60% of Botswana's land area is covered by sparse savannah woodland and scrub formations. Due to low and often erratic rainfall, combined with sandy and generally infertile soils, production of wood in this natural environment is less than 1 cubic meter/ha/annum, while consumption is about 1,5 cubic meters per person per year(Alidi, 1988).

Wood accounts for over half of Botswana's energy consumption and is a vital raw material for the construction of modern and traditional houses, kraal fences and for the manufacture of household goods and other utensils. Wood has been traditionally thought of as a 'free for all' item by the rural population. As a result, large areas have been stripped of tree cover, particularly around towns and villages. This same environment is also subject to heavy overgrazing, and areas surrounding many boreholes and water points have become desert-like in appearance. It has been observed that due to the combined effects of deforestation, overgrazing and improper burning methods,
20 000 ha of woodland is annually converted to less productive grasslands and scrub formations, leading to serious soil erosion problems, flash flooding and local shortages of fuel and construction wood.

As early as 1948 to 1952 during colonisation, the Forestry unit established a few *eucalyptus* trial plots to see if the species could be raised in Botswana on a plantation scale. Most of these trial plots were established in the south and eastern part of the country. Forestry has always had very low priority in Botswana: during the colonial administration, forestry was limited to the

exploitation of the forest resources of the Miombo woodlands of the Northeastern Botswana(Anon, 1968). Most of the 124,00 square miles classified as forests at that point was considered unproductive. In effect the forest resources of the savannahs have remained unmanaged up to the present day. Silvicultural activities were restricted to poorly managed government *Eucalyptus* plantations in the Southeast and the issuing of timber felling permits, mainly for *Pterocarpus angolensis* DC. and *Baikiaea plurijuga* Harms , to commercial logging companies.

In 1968 the Forest Act introduced new protection measures for the commercially valuable forest areas of the Northeast by authorising the president to designate forest reserves. There are now a cluster of 6 Forest Reserves with an estimated standing stock of about 10 million cubic meters, covering an area equivalent to about only 1% of the country's total area in the north in Chobe and north-Central districts. The forest Act also gave new regulations for the use of forest products on State land and enabled owners of freehold land and state land to request, that their land gained status as reserves(Miller,1987).

The trend in forestry development has been towards depriving traditional rights of the local community to the utilisation of the forest and savannah products. Firewood collection outside the forest reserves and national parks is still every man's right and travellers and residents are still allowed to collect firewood and building materials enough to cover their personal requirements. However, collection for sale and barter has been restricted, and people who wish to embark on such activities must obtain licences to do so(Lang 1992). Nevertheless, the trade in firewood has increased drastically, and it has not been feasible for the government to impose any regulations upon the trade.

Another act(Agricultural Resources Conservation Act) designed to conserve the forest and the declaration of protected trees of 1981, has been passed in parliament This act further regulates the villagers rights to exploit certain timber trees even for domestic purposes without a license. These trees are protected because they are considered scarce and under pressure. Enforcement has proved totally inadequate and unfeasible.

Among the most important protected timber species are;
Baikiaea plurijuga (Rhodesian teak or Mukusi)
Pterocarpus angolensis (Bloodwood or Mukwa0
Afzelia quaensis Welw. (pod mahogany or Mwande)
Spirostachys africana Sond.(Murukuru)

The *S. africana* is a very important local timber tree and fuel wood in the eastern parts of the country and was added to the list in 1981 because of severe depletion around densely populated areas.

Despite all the existing legislation for the protection and conservation of natural vegetation, the impacts have been negligible. Customary control of natural resources under chiefs and headman is disappearing fast and central and local government has not been able to replace the role of traditional management. The reasons for failure should not only be sought in lack of co-ordination, expertise and understaffing. More importantly, local communities have not been sufficiently consulted but left out in the land use planning and implementation process. Like so many developing countries, the protection and conservation of forest resources has been perceived as a task of policing and enforcing the rules. This cannot work, especially in a country where the notion of trees and forest products as free goods is deep rooted in a tradition (Lang, 1992).

2.3.1 Rural afforestation projects

The rural afforestation programme in Botswana started very late in 1979 This rural programme has not caught on fast but is now slowly being accepted by the rural population. This project is divided in to three components:

- Establishment and expansion of the government tree nurseries and small afforestation projects.
- To provide individuals, village groups and non-governmental agencies with tree seedlings for afforestation and amenity and horticultural purposes .
- To financially and technically assist village groups and non-governmental organisations in the establishment of village woodlots for the purpose of providing firewood, poles fencing posts and construction material for local users.

However, this programme does not at the present moment cater for large scale plantations for commercial production as it is in its infancy and government has set its priority on arable agriculture for food production.

The implementation of the rural afforestation programme has resulted in the establishment of additional government nurseries which are now 12 in total. All except 3 are located in the east (Otsyina and Walker, 1990). They operate with high input and low efficiency and produce mainly exotic species which are locally untested and unsuitable for the country's conditions. The production does not correspond to consumer needs and preferences; thus while live fencing plants e.g *Dodonea viscosa* are by far the major income earner for Gaborone nursery, it is often in short supply.

These nurseries are probably changing quickly, as the pressures on wood products change rapidly. Non-governmental organisations, through funding by donor agencies have also established tree nurseries in the east. Their success has also not been impressive due to high expatriate staff turnover and lack of funding.

2.3.1.1 Plantations

The government in its forestry policy encourages individuals, village groups and non-governmental organisations to establish artificial plantations and woodlots within the Tribal lands. So far there are about 400 ha under *Eucalyptus* scattered around Tribal lands which are administered by village groups and non-governmental organisations. (Alidi, 1988). The Forestry and Range Ecology unit of the Division of Crop Production Department manages about 300 ha of plantation in the whole country. It also provides extension advice, public education, production of seedlings, training and financial assistance. The management objectives of these plantations were to substitute the import of poles from South Africa, provide fuel wood and reduce pressure on natural woodlands. However, *Eucayptus* species are not preferred for firewood by villagers because the wood burns quickly with a pungent smell and leaves no coals. Also, the wood is vulnerable to termite attack, unless treated. Most government plantations are either over mature or undermanaged or have failed in the establishment phase.

From the report of the forestry sector 1984, it has been stated that the aim of Botswana government is not only to ensure a continued and sustained production of wood for building materials, fencing poles and fuel but to meet erosion, import substitution, employment and income generations objective as well. But due to the nature of the country's rainfall and the existence of better soils in the eastern parts of Botswana, which areas carry most of the population of the country, competition of land is quite high. Land is abundant but is not readily

available to the department to undertake large scale programmes. In addition the lank of funds is a major constraint

2.3.1.2 National Tree planting Programme

This programme has being mounted as a public education programme so that individual farmers, groups and rural people will understand the concept of afforestation. The National Tree Planting Programme was started in 1985 with the aim of arousing awareness of tree planting in the whole country. Since 1985 this event has been taking place annually covering all parts of the country. At the present moment, 11 community projects have been established through the National Tree Planting Day(NTPD); 3 agroforestry projects and 8 community woodlots. However, from the NTPD progress report only about half of the tree seedlings issued to farmers and planted woodlots have survived. From the observations made by the technical officers the major factors which hinders success are:

- Some trees are not planted by some farmers due to cultural/traditional beliefs among them and this could be that farmers are issued with species which are not necessarily their choice

- In most cases tree management skills are lacking or inadequate, most probably caused by lack of training and research facilities for the identification or selection of suitable tree species for given localities.

- So far the trend has been to use exotic species, giving very little attention to indigenous, even though it is well known that they are fully adapted

to the local conditions, are highly resistant to drought and termites attack and serve a great variety of functions. This is mostly true for fuelwood and timber species.

2.3.1.3 Around the Home Tree Planting Programme

The poor results of the rural afforestation programme, focusing on communal woodlots have in recent years led to a shift in emphasis towards individual tree planting around homesteads. Therefore in 1987 an NGO called Forestry Association of Botswana(FAB), launched the AHTP(Around The Home Tree Planting Programme) which is designed to back up the NTP(National Tree Planting Programme) initiated by the Forestry unit. Whereas the NTP is a one day event taking place annually at the beginning of the rainy season, the AHTP runs over the entire growing season. FAB sponsors a range of NGOs; brigades and development associations involved in agriculture and forestry activities, to grow tree nurseries and distribute them to target villages in their neighbourhood. The main objective is to raise knowledge about tree planting in the villages through distribution of seedlings and extension of tree planting techniques.

The personal contacts with farmers and the smaller scale of activities result in more effective extension and the more intimate relationship between extension agents and target groups allow better understanding of tree preferences and farmer objectives in general. The technical constraints faced by the larger projects are avoided. Individual households are mostly able to protect trees from the livestock damage and are able to use waste water to keep trees after planting and during droughts.

Normally, the villagers prefer exotic fruit and ornamental trees to all the indigenous ones. Indigenous trees are thought to be slow growers and hence are held in lower esteem. If grown by

farmers, they are expected to grow by themselves without any assistance since farmers see them grow in the wild. However a survey carried of AHTP carried out by the Palapye Development Trust showed that the survival rates of indigenous trees distributed to households did not differ significantly from survival rates of exotic species. They were distributed in the ratio 1:5 (5 times as many exotics as indigenous trees, reflecting the farmers preferences). With the same protection and care, the indigenous trees should theoretically do better than exotics, but more care was presumably taken by the villagers to keep exotics alive. These consisted of 50% fruit trees and 59% shade trees.

Even though this programme has only been carried out in a small part of the whole country, and may have not made any significant improvements to the deforestation and soil degradation problems, it has had principal merits in educating people and preparing the ground for more comprehensive afforestation activities to follow at a later stage.

2.3.1.4 Sand Dune Stabilisation Project

This project was established in the 1970s in the Kgalagadi district (southwestern part) with the aim of stabilising sand dunes which are threatening Tsabong and Bokspits areas. This project has been established through the combined effort of the Land Use Planning Unit, and the Agricultural Resource Board. The Tsabong sand dune has been successful as a *eucalyptus* windbreak but not good enough to stop the moving sand as there is no vegetation cover on the ground(Lepetu, 1993). The major constraint is mainly lack of water and poor sandy saline soils which have high infiltration rate. The project has been expanded to other villages in the district but wrong choice of species has always undermined the potential of this project.

2.3.2 Management of indigenous woodlands

Natural forests and woodlands in Botswana have been and continue to be harvested for fuel, building materials, poles and grazing by livestock. Little investment in their management has been made in the past. As a consequence, the state of knowledge and experience in the management of natural forests and woodlands are limited. Nowadays the only few protected trees are those found in the forest reserves in the north, around the home compounds, fallow lands and in the community grazing grounds.

In the past traditional management systems, trees were protected by social agreement rather than physical means. Traditional rulers or chiefs were the only people with the power to issue permission for tree cuttings. There was a fine attachment to cutting down trees without special permission from the chief or headmen. Certain trees species dubbed 'female trees' might not be cut during the agricultural growing season, the taboo applying to even the uprooting of the tree stumps at this time. It was feared that the rain might turn to hail and destroy the crop if the taboos were not obeyed(Schapera, 1943). However, with the stripping of power by the Land Boards from the chiefs, such management systems do not exist anymore. There is now an indiscriminate cutting of any trees at any time of the season.

The situation is made worse by the fact that, many rural people in Botswana do not believe in planting trees. They believe that trees are a free 'gift from god', while others fear a taboo that if one plants a tree (especially a fruit tree) that person will die when the tree starts fruiting. Therefore this means that, the present tree productivity is based on only a few naturally occurring plants that are protected. Due to increased occupation of land and changing agricultural practices, fewer trees are protected nowadays than before The situation is not conspicuously apparent at the moment, but is a severe problem for the future

The shortage of fuelwood is getting critical in some parts of the country like the Kgatleng district, southeast and worse in the Barolong farms where competition between livestock production and woodland utilisation is very high(Walker, 1992).

Unfortunately, there is a limited basis to prescribe proper management of natural forests and woodlands in this region. Ecological degradation is continuing through often conflicting demands of fuelwood, grazing lands and agricultural production. Improved management of sustainable production and conservation is essential to reduce this degradation. An objective of management, therefore, should be to ensure multiple uses of natural resources rather than to maximise returns on any product and in so doing, risk further degradation of this fragile ecosystem.

CHAPTER 3

MAJOR OBSTACLES TO TREE PLANTING

Various obstacles to tree planting have already been pointed out in the previous chapters, and hence the need for tree integration into other land use systems. The aim of this chapter, is to assess those factors which constrain tree planting both in communal areas and farming systems, with a view to identifying possible solutions to the failure of tree planting projects and incorporation of trees into farming systems.

3.1 Environmental Constraints

As in other semi-arid countries, the environmental constraints in Botswana are high temperatures, low rainfall, soil characteristics(depth of rooting zone, salinity) etc. Human resource constraints and the lack of meteorological data imply accurate determination of aridity can be done in only a few places. However, a greater problem in Botswana is the drought and erratic nature of annual precipitation. This necessitates repeated trials of species and afforestation techniques over several years. Results of survival and growth from a trial in a year of relatively abundant moisture cannot be extrapolated reliably to years of relative drought. The rainy season is short(2-3 months) and with very intense, heavy raindrops or often hailstorms which damage young plants. Because of the natural and man-made scarcity of vegetation in Botswana, and the poor texture of the surface soil horizons, rainfall is not often conducted to deeper soil layers for storage and use by plants but is lost as surface run off with subsequent erosion. This is more pronounced in Agro-climatic zones III, IV and V where the soils are sand to pure sands, rainfall averages 350mm and the vegetation is bush savanna to arid(see Table 1.5 for more information on agro-climatic zones in Botswana).

Since it is not possible to control rainfall or temperature by artificial means, successful land management and crop growth requires the use of soil and water management techniques that make more water available to the crop particularly in its early establishment phase. These can take the form of irrigation, reduction of weed competition., addition of organic materials, water retention methods such as(ridges, mounds, basins and trenches) and soil working to improve aeration, water holding capacity, and temperature relations, while reducing run-off and evaporation(Burley 1982). However it should be noted that it is possible to irrigate seedlings at planting until the rainy season is well established, but at the end of the dry season scarce water is rarely made available for trees particularly where annual crops, animals and humans themselves need the water. This is why in arable fields farmers view trees as unwelcome competition for nutrients and water with the agricultural crops. Therefore, it is important to plant trees at the right time, correct spacing and depth in order to minimise these side effects.

Soils are varied within Botswana(see figure 1.5) and the most difficult are the saline alkaline soils that develop under low rainfall and high temperatures with infrequent water percolation and leaching(e.g., zones III, V). These areas are extensive and treeless clearly need afforestation to meet local demands for fuel, small timber and fodder, but the extensive salt content frequently prevents any plant growth, and to date no cheap method of leaching out the salts has been evolved. The topic of choice of species is considered below but it is of interest here to note the need for testing alkaline and salt tolerant species. Burley (1982) stated that in Gujaret and Andrapradesh *Prosopis chelensis* establishes itself on saline patches. In other semi-arid to arid places the legume *Sesbania aculeata* can improve such soils if ploughed as green manure.
In the kalahari desert of Botswana, the salt-bush *Atriplex spp.* establishes itself very well on the sand dunes and it is a very important fodder species Techniques and species suitable for reclamation of other difficult soil types as the wind blown sands of the Kalahari desert types are described by Ghosh 1977; Kaul and Chand(1977) and by Verma (1975).

3.2 Technical Constraints

In most semi-arid conditions, there are four major technical areas in which work is required to maximise tree survival and growth and to calculate the feasibility of planting: correct choice of species and provenance, development of adequate protection methods, determination of optimum size of nursery plants for field establishment and determination of methods of management and yield of products especially in mixed crops.

3.2.1 Species and Provenance

For any tree planting programme the importance of correct seed source cannot be ignored. As conditions become more arid, the numbers of local species and their growth rates decline. Some species, particularly among the exotics, simply cannot survive due to drought and termite attack. However, a large number of species have potential for planting in Botswana, but the large choice is a constraint itself. First it is difficult to obtain seeds or propagules of many of these species and provenances; for some of them even the nomenclature and taxonomy are confused. Second, little is known in Botswana about correct seed handling for many species. Finally, genetically improved local species are not yet available. The lack of Forestry Research unit in Botswana is a major constraint itself, hence it would be a major technical and managerial task to undertake the design, management and evaluation of systematic species and provenance trials. Some such trials were set up by University of Botswana(NIR), but have completely failed due to poor management and probably due to high staff turnover of contract staff..

3.2.2 Management

For a successful tree planting programme, choice of species should be selected on the basis of ecological compatibility, physiological understanding and the enduse/products required by the local users. Lang (1992) states that in Botswana the choice of the species for the prototype monoculture *Eucalyptus* woodlots has proved inappropriate for a number of reasons. These were established to provide firewood and poles, which were perceived to be the basic needs of the villagers. However this model did not take into consideration, the variety of needs to be fulfilled by rural communities. Neither did it consider the variability of the agro-climatic and socio-economic conditions. The same species and methods of establishment and management were applied in the Kalahari tribal communities of Matsheng villages as in the eastern woodlots, where climate and soils are more favourable and the pressure on the firewood resources are much more acute, making woodlots for firewood more relevant. The products of the older woodlots turned out to be 80% poles and 20% firewood, (ERL, 1985). This ratio is the reverse of the actual demand. The KRDA(Kweneng Rural Development Association) pole plantations are technically the most successful plantations, mainly because sites have been chosen more carefully, but even they have never made any profits, which could be ploughed back into the communities around Molepolole. Therefore it is important for tree planting programmes to consult with the target groups, and also carefully consider the suitable species for different eco-regions.

3.2.3 Plant size for field establishment

Another technical constraint is the lack of experience with treeplanting/or growing. Many Batswana have much to learn about seed preparation methods, nursery techniques and timing of planting. Some would also benefit greatly, as would experts, from clearer appreciation of the values of certain local species, best forms of association with crops and pasturelands, low-cost of promoting natural regeneration, and the like. Popular education in silviculture has become indispensable as an important key to promote tree growing to the rural farmers. In Botswana this can be achieved by tree planting programms e.g, (AHTP and NTPD) which aim to arouse awareness in tree planting but have gained very little success in the past due to poor planning and implementation of the programme.

3.2.4 Protection

A survey conducted by Walker (1992) in the Barolong farms has indicated that farmers are interested and willing to plant trees, however they pointed out they need a nursery in one of the neighbouring villages and were also worried about the fencing materials for protecting the trees. This is made worse by the fact that most arable fields in Botswana are not fenced and farmers use trees or stumps to indicate their boundaries. Since after harvesting, cattle and other livestock are let in to feed on the crop stalk, it becomes very difficult to control them damaging the young trees. In that sense, the government can assist by providing the farmers with incentives e.g. barbed wire to fence their arable fields in order to encourage them to plant more trees. Another intervention would be to plant those trees that grow fast and are tolerant to grazing, e.g., pollarding and coppicing once established.

3.3 Social, Economic and Institutional problems.

The socio economic, political and cultural constraints can be greater obstacles to tree planting more than environmental and technical constraints. A knowledge of this context is crucial if potential obstacles are to be avoided. Tree planting or management of woodlands can only succeed if farmers perceive a direct and immediate improvement in their socio-economic situation. Therefore, interventions that can quickly and directly improve the situation will be adopted before interventions which solely address the problems of land degradation, erosion, low soil fertility, loss of tree cover and desertification, without attention to the socio-economic conditions of households.

3.3.1 Sources of wood

For the majority of rural populations and urban dwellers in developing countries fuelwood is the primary source of energy (Gregersen et al, 1989). According to the ERL study(1985) on energy utilisation in Botswana showed that the major energy source for the people of Botswana was from wood resources. Of all the rural energy sources, 87.4% was met through fuelwood, 7.8% from diesel fuel, and 4.4% from paraffin.

With an estimated fuelwood consumption of 0.57m^3/yr/capita (ERL 1985) a standing volume of natural woodland of approximately 20m^3/ha and an annual growth rate of approximately 5%, each person will need more than a hectare to satisfy his demand for firewood. In addition, the annual per capita consumption for making fences, kraals and Kgotla enclosures and houses probably exceeds the firewood consumption. Especially the construction of kraals consumes large amounts of timber size wood.

The demand for firewood is more than the local supply in most parts of the country and most households in urban areas still use firewood. Donkey carts from nearby villages bringing in firewood to towns is a common sight. It is true that all these contribute to removal of forests and tree cover and lead to the subsequent damages of desertification with no attempt at replacement. The simplest and most practical solution is to guarantee the fuelwood supply investing in plantation woodlots and agroforestry projects.

3.3.2 Cultural Attitudes toward Wood

Most of the rural people see wood as a free for all gift and hence do not foresee any reason why they should plant trees. Some observers suggest that the concept of wood as a free product inhibits tree planting efforts since some people do not perceive wood as being scarce. The time and labour of women and children who collect most of the wood are not seen as having a cost by the local people. Perhaps more an obstacle to tree planting and protection than the perception of wood as a free product is its a perception as a source of income. Wood fuels have become commercialised in many parts of Botswana and this trend is likely to continue. The presence of a market thus creates an incentive for consuming resources as fast as possible and without regard for future needs.

The results of tree planting projects for fuel wood production, however, have generally not been encouraging(Floor, 1987). The basic reason for this situation is that the small farmers preference is always for trees that yield multiple outputs, no matter how serious the fuelwood shortage maybe. Success has also been hampered by the fact that many woodlots were planted on communal land without a clear understanding of who, exactly, would maintain the seedlings, and who had the rights to the eventual wood products. Additionally, local people often may not consider fuelwood scarcity as an existing or impending problem, because in deficit areas,

fuelwood is replaced by such alternatives as crop stovers, dung, twigs, and bark, etc. However, other scarcities (such as lack of building materials, fencing poles and fodder) are often viewed as more important than fuelwood(Nair, 1993).

As Foley and Banard(1984) state, numerous tree-planting programs have been based on the erroneous belief that because scarcities appear to be getting worse, people will automatically want to plant fuelwood trees. It now appears that in many cases, people would have been more enthusiastic about planting trees to meet animal fodder, fruit, medicine and other needs, with fuelwood being a subsidiary benefit rather than the prime motive. Therefore care must be taken to ensure that the species chosen are saleable and desirable.

3.3.3 Land Tenure

Land tenure systems that do not guarantee continued ownership and control of land are not likely to be conducive to the adoption of longer-term strategies (and relatively short-term practices that include benefits which will be realised in the long run) such as agroforestry and community forestry. Secure land rights have proven pivotal in determining whether the benefits of agroforestry reach the intended beneficiaries(Bruce and Fortman,1988). The traditional reservations of small farmers regarding tenure have included concerns over the loss of control of land rehabilitated through tree planting, or, in the case of pastoralists the deprivation of access of grazing or fodder collection (Gregersen and Mcgaughey, 1985). Studies in Costa Rica and Haiti have indicated a clear farmers' preference for tree crop production on more securely held land, and conversely, for growing short term crops on less securely held parcels (Ehrlich et al, 1987). In certain parts of Africa, land tenure rules specifically forbid the planting of trees(Osemebo, 1987). As Francis (1989) states, the incentive for investing in soil fertility improvement for future use of land is low unless the benefits accrue to the tree planter.

Closely related to the issue of land tenure is that of tree tenure: rights to trees are often distinct from rights to land. Issues associated with tree tenure include the right to own or inherit the trees and tree products, the right to plant trees, the right to use trees and tree products as well as the right to exclude others from such uses. (Fortman and Ridell, 1985). Furthermore, these various rights differ widely across cultural zones and invariably have a major influence on the acceptability of any agroforestry initiative.

3.3.4 Labour

Tree-planting projects that demand a substantial labour component may be beyond the capacity of local communities to provide when able-bodied young people have gone elsewhere in search of work. Traditionally farm families have labour strategies to use inputs of various family members at various times of the year for different tasks. Obviously, additional labour for persons already fully occupied at peak labour seasons is considered more costly than when additional labour demands come during a slack season. For example, alley farming is labour-intensive, with much of the demand occurring in the busiest time of the year, i.e., the rainy season. As pointed out by Hoekstra(1987) the cost of production will be increased considerably if additional labour must be hired. Although these additional labour costs will be offset by additional benefits, the immediate need for additional labour could sometimes be a disincentive to the adoption of the practice(Kang et al., 1990. In this context, labour peaks and patterns are of crucial importance and needs careful planning and designing in any tree-planting projects.

3.3.5 Marketability of Products

Products of trees on farms are considered as free goods in many farming societies. Creating marketing opportunities for these "free goods", and thus increasing the demand of these products, will also require making appropriate provisions for meeting the local needs for locally-produced and "freely-available" items(e.g., tannins, medicines, wild fruits). Market support would then offer slightly different challenge to the one usually faced by agricultural extension agents whose products are more frequently fed into established markets.

3.3.6 Forestry and Agroforestry Extension

Esrkine(1991) states that, A problem encountered in Southern Africa is that of persuading government departments responsible for rural extension that the planting of trees on farms in less-developed areas is a farm system and social issue rather than a forestry issue. This, in turn, means that there is a need for an extension approach which treats tree planting as one of many productive activities that must be incorporated into the farm system. The most effective way of achieving this objective is for forestry specialists to be fully integrated into the agricultural extension service.

By far the major constraint limiting the development of the Foresty Division are manpower and Finance(Alidi 1990). It is estimated that the forestry sector is over 90% understaffed(Alidi,1990). This constraint confines the few foresters within the nursery and has not, perhaps, exposed them to extension work which can develop their necessary communication skills. Very little extension takes place beyond handing over trees on the National Tree Planting Day and woodlot establishment. Demonstrations are limited to Kgotla meetings which few people, mostly women and the old attend.

Even though the NGOs such as FAB have a more intensive extension system, they are limited by both funding which is acquired through foreign donors and the high turnover of expatriate personnel who are mostly volunteers. For the moment their impact on the public is only felt in the district in which they exist. The lack of co-ordinated effort between Government and NGOs has undermined effective utilisation of available manpower.

Dissemination of different contrasting ideas by extension officers to the same farmer also is a limiting factor to the adoption of tree growing by farmers. For example, the Crop protection Unit advises farmers to cut *Acacia* trees as its believed they harbour Quela Birds.

CHAPTER 4

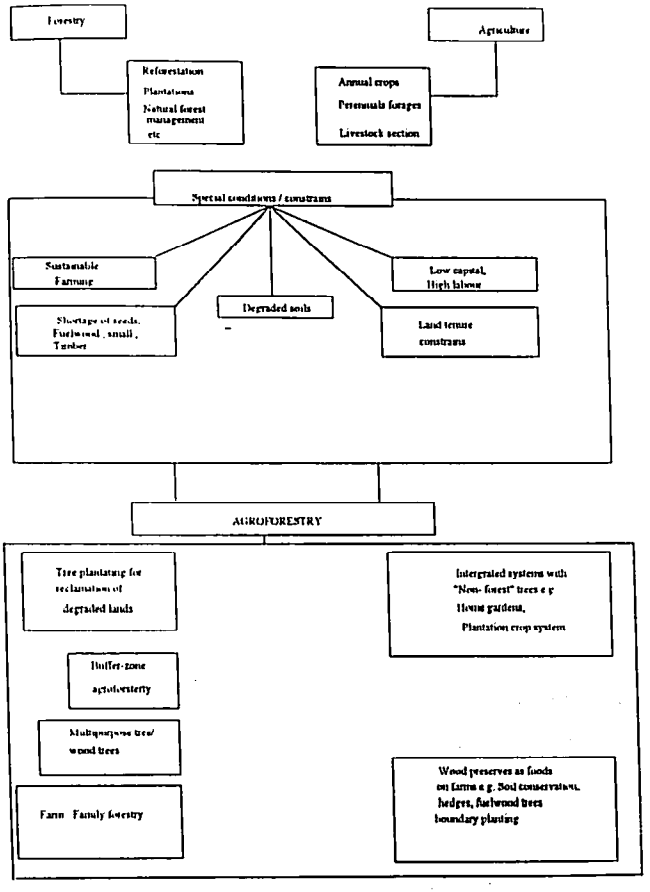
TRADITIONAL AGROFORESTRY PRACTICES AND THEIR POTENTIAL FOR IMPROVEMENT

4.1 Definition of Agroforestry

Agroforestry is defined according to Rocheleau et al (1988) as a land use system that involves a close association of trees or shrubs with crops and/or with animal pastures on the same land, either is sequence or in social arrangement. This association is both ecological and economic, the land area could be as small as a homestead garden, the size of a cropland or as large as a communally used land.

Today there is a consensus of opinion that agroforestry is practised for a variety of objectives. It represents as depicted in figure (4.1), an interface between agriculture and forestry and encompasses different land-use practices. These practices have been developed mainly in response to special needs and conditions of Tropical countries that have not satisfactorily been addressed by advances in conventional agriculture or forestry(Nair, 1993). The term is used to denote practices ranging from simple forms of shifting cultivation to complex hedgerow intercropping systems; systems including varying densities of tree stands ranging from widely scattered *Faidherbia albida* Del. trees in Sahelian millet-fields, to high-density multistoried homegardens of the humid tropics; and systems play a predominant role (e.g., windbreaks) to those in which they provide the main commercial product (e.g., intercropping with plantation crops).

Figure 4.1 Interaction between Agriculture and Forestry in response to the special needs with special reference to Botswana.



Adopted from Nair(1993)

4.2 Traditional Agroforestry Practices in Botswana

In semi-arid Africa two main types of self-sustaining production systems have evolved: Pastoral systems and crop based, often mixed farming systems (Beets, 1984). As already mentioned in the earlier chapters before, Batswana practice some form of mixed farming system. They keep cattle, goats, chicken etc., and in arable farming, the seasonal crops are mainly sorghum, maize, beans, water melons and others. Trees are also found in crop fields, homesteads and communal areas and most of them have been left deliberately in such areas either for shade, fodder or fuelwood. Traditionally, the Batswana practice a zonal land use system. The land is divided into the residential areas(villages), arable and grazing land. The arable land is located around the villages at the distances from 5 to 20 kilometres, whereas the grazing land is concentrated around cattle posts much further away from villages but small stock is usually grazed in communal areas around villages. The distribution of cattleposts far from villages is dictated by the need for extensive rangelands and water supply problems. There used to be strict separation between the different zones, but as far as land pressure increases, cattleposts and arable lands tend to be mixed in the areas with high population density like in the Southeast district, Kgatleng district and Barolong district. The risk of crop failure is extremely high and therefore low input farming is practised. But now due to climatic conditions, arable crops are cultivated erratically and livestock is extremely extensive.

Two major systems-

Agrosilvopastoral and

Silvopastoral found on the agricultural land, homesteads and communal land respectively will be described and critically analysed in the remaining chapters

4.3 Agrosilvopastoral Systems

The crop based farming system of semi-arid Africa can be divided into two the bush fallow system and the intensive sedentary (settled cultivation) systems, both of which are often mixed farming systems(Beets, 1984; Otsyina and Walker, 1990). These systems combine all three elements of crops, trees and livestock in both space and time. The common crops are sorghum, millet and maize. Variations occur for example; in Senegal groundnuts are rotated with the cereal crop or millet is intercropped with *Faidherbia albida*, which provides fodder for livestock(Beets, 1984; Wringley,1982).

In Botswana migrant labour and school attendance have created a situation of male labour shortage at the household level. Increasing distances between villages and arable fields further added to the severity of time and labour constraints. Households in many cases(and continue to do so) by moving together with their herds. Situations of mixed crop and cattle have thus emerged, mostly out of necessity, where this previously would not exist. Although this has in one away reduced some of the households problems, it has led to others, such as crop damage and excessively high stocking rates in these communal lands areas. This has led to overgrazing, soil depletion, bush encroachment, firewood exhaustion and land shortages thus face households using these areas, which more often than not, belong to poorer population groups.

Batswana farmers leave few selected trees and shrubs like *Sclerocarya birrea*, *Boscia albitrunca*, *Grewia flava* DL., *Azanza garkeana* (F.Hoffm.) Exell & Hillc. etc. on their farms and in home compounds for shade and fruits. Tree densities range from 1-3 trees per field (average 6 ha). Many of these fruit producing trees have multiple uses. Besides providing wood, leaves may be used as fodder, or to provide materials for thatching and handicrafts. Wood suitable for

construction and furniture making can be obtained from certain trees, and almost all provide a certain amount of firewood in the form of twigs pruning and dead branches

4.3.1 Tree Management

Trees left on fields are rarely managed. Management practices such as burning(2.2%), pruning(13.8%), and complete removal of trees were reported among all respondents (survey carried by and Otsyina and Walker, 1990) in the Southern district. Most of the trees have grown big and out of reach of farmers to warrant any management. Also, such trees, especially fruit trees e.g., *S. birrea* and *Andansonia digitata*, are so valuable that farmers do not cut them for fear of reduced production.

4.3.2 Tree/crop Interactions

Interactions between trees left on fields and associated crops are so variable and depend on several factors including rainfall, type of crop, soil fertility status, tree architecture etc. Therefore it is quite difficult to note accurately effects of certain trees on crops. According to Otsyina and Walker (1990)'s survey, experienced farmers indicated some effects of common trees on major crops. *Sclerocarya birrea*(morula), *Azanza garkeana*(morojwa) and (*Combretum imberbe*)motswere were reported to have good effects on crops while *Colophospermum mopane* was reported as having bad effects on all crops.

The most common tree/crop interaction is the amelioration of microclimate therefore reducing water loss through evaporation and evapotranspiration. However, an indirect benefit to crops is through dung manure from domestic animals After harvesting, animals are allowed to congregate in the fields to feed on stalks and browse the trees. So even though there is fewer

litter fall from the leaves, the leaves which are eaten as fodder, passes into the soil as dung and increases the soil organic matter.

4.3.3 Limitations of the current system

There are various reasons for farmers not planting trees on their cropland. The most important of these includes lack of water availability, lack of seedlings, lack of technical know how in tree planting and management, and Quela and doves birds damage to cereals e.g., sorghum and also grazing pressure from animals.

The major obstacles to successful tree planting as perceived by farmers of the (Otsyina and Walker, 1990) survey were in order of significance as shown in table 4.1;

Table 4.1 Results of a survey of obstacles to tree planting as perceived by farmers.

Problem	% respondents	range
water scarcity	69.4	51-87
lack of know how	16.6	13-18
termite damage	14.1	7-15
livestock damage	8.3	4-27
lack of seedlings	8.3	7-15
lack of labour to water	6.6	

While the introduction of plastic pots in nurseries has made it possible to produce planting stock of this kind, most forest services plant rapid-growing exotic species, which are not adaptable to Botswana's harsh environmental conditions. These exotic fruit trees are mainly oranges, guavas, pawpaw seedlings imported from either Zimbabwe or South Africa. These fruit trees need high input management like watering, weeding, fertilising and hence cannot be left to survive on their own in cropfields. They do not produce multiple products(firewood, fodder, medicinal) as compared to the indigenous fruit trees. However, these exotic fruit trees are recommended for home planting since they can get the care and necessary attention if farmers are taught the techniques of growing them.

Another important constraint is that most of these fruit trees are not nitrogen-fixers, therefore, it is not possible to accurately say that there is any soil fertility improvement. In the essence of this, great effort should be made to include other indigenous and exotic species which are nitrogen fixers. This could easily be achieved in Botswana as most nitrogen-fixing trees are of the leguminoseae: the *Acacia* subfamily which are also important fodder trees which have nice architecture(deep tap root system, and few branches and leaves to avoid shading the crops)

4.4 Proposed Agroforestry Technologies.

Trees can play several important roles if they are properly integrated into conservation-oriented farm practices. They produce shade, fruit and other foods, but when integrated into soil conservation activities such as the construction of bunds and water terraces, they can provide cover and protection against wind and water erosion. Furthermore, the leaves and other litter fall to the ground resupply the soil with nutrients and organic matter. Well selected trees and shrubs can contribute to soil conservation and improvement and the restoration of the ecological

balance and, at the same time play an important role in providing food, fuel, medicine and many other items that have disappeared because of advancing desertification.

The major issue in planting trees, then, is to find local people who are willing to take the extra steps to plant and protect the seedlings during the first few years. The following technologies are proposed for alleviating specific problems mainly in arable fields, communal areas and home gardens, especially in the mixed farming practices areas in the different parts of the country.

4.4.1 Multipurpose boundary planting around the croplands.

Boundary plantings allow dermacation of a farmer's land, and can provide useful subsidary products. This involves a multi-storey stand of multipurpose trees planted around farm boundaries and fields. Type and management of the trees depend on services and products required. This technology is most suitable as a form of shelterbelt or windbreak for croplands in areas with very low rainfall as it minimises competition with crops. Where wind and heat adversely affect farm fields as in most parts of the west where there is low, sparse vegetation cover and low tree densities, properly designed shelterbelts can increase production sustainably.

Properly managed shelterbelts produce not only firewood, poles and branches for fencing but also some fruit and forage. Furthermore, as leaves fall from the trees, they are scattered across the fields, providing the soil with critical nutrients and substantial amounts of organic matter. Net production of increases of over 30 percent in protected fields have been reported in Niger, in the Bouza district windbreak project(BSTINRC, 1986).

It has been reported that although people are reluctant to set aside larger blocks of farmland for tree plantations, they are less opposed to taking a strip of land out of farm production to establish shelterbelts.

The recommended approach to establish a multipurpose shelterbelt is to have a mix of rapid-growing species for immediate protection; slower- growing trees that eventually grow quite tall, extending the wind-shielded area e.g., *Grevillea robusta*, *S.birrea etc.*, and smaller trees or bushes that produce a variety of by-products(such as *Acacia nilotica* (L.) Willd.ex Del., *A. leuderitzii*, *A. karroo* Hayne., their pods and leaves are good fodder) and they fill the air spaces closer to the ground. This technology is applicable to most parts of the country especially in home compounds and may be around kraals.

4.4.2 Trees mixed in Cropland(Mixed Intercropping)

Mixed intercropping of shade trees at low densities on crop farms is traditional to Batswana farming systems. Improvements on the traditional system with local and exotic multipurpose trees such as *S.birrea*, *G.flava*, *Leucaena leucocephala*, and some *Acacia* spp. for fruit, poles shade fuelwood, fodder, soil fertility and environmental protection are highly recommended.

Important nitrogen fixing as *Faidherbia albida*(Mokosho)found in the Tuli block area and others such as *A. tortilis* (Forsk.) Hayne., *A.erioloba*, etc., which improve soil fertility and provide fodder for livestock are recommended. The one practice which has achieved success is the *Faidherbia albida* intercropped with sorghum in Senegal and Southern Niger. Research in Senegal has revealed that yields of millet and groundnuts grown under *F.albida* trees on infertile soils increased from 500 +- 200kg/ha. In addition to increased crop yields, there are 50-100

percent increases in soil organic matter, increased water holding capacity and a marked increase in soil microbiological activity beneath the trees(Felker, 1978).

This practice is highly recommended for the drier areas in Botswana e.g., Bobonong area and parts of the South western district but care should be taken to plant a reasonable density(5-10 trees/ha) to avoid tree competition with the crops.

Intercropping under scattered trees is the simplest and most popular form of agroforestry especially in dry areas. There is great need and opportunity for increasing the productivity of these widespread practices.

4.4.3 Hedgerow intercropping of MPTS for green manure and soil/water conservation

Hedgerow intercropping, also known as alley cropping involves managing rows of woody plants with annual crops planted in alleys in between. The woody plants are cut regularly and the leaves and the twigs are used as mulch on the cropped alleys in order to reduce evaporation from the soil surface, suppress weeds and/or add nutrients and organic matter to the top soil. Nitrogen-fixing multipurpose trees are the main components of the hedgerows.

Due to constraints of water, to minimise tree/crop competition, widely spaced alleys are recommended e.g. 4 m apart consisting of a single line of a legume plant(e.g *Leucaena, Acacia* spp). Another constraint is that, the presence of large termite populations in most parts of Botswana, renders inappropriate any mulch species that provide a good habitat for these pests; and this therefore, encourages the use of mulch species that have the ability to repel or discourage termite infestation. (for example, *Azadirachta indica, Adhatoda vasica, Derris indica*).

Other limitations to the adoption of this technology are:

- additional labour and skills that are required for the hedgerow pruning and mulch application
- there is potential for the hedgerow species to become a weed/or an alternative host for pests and pathogens, or harbour grain eating-bird.
- loss of cropping area to hedges.

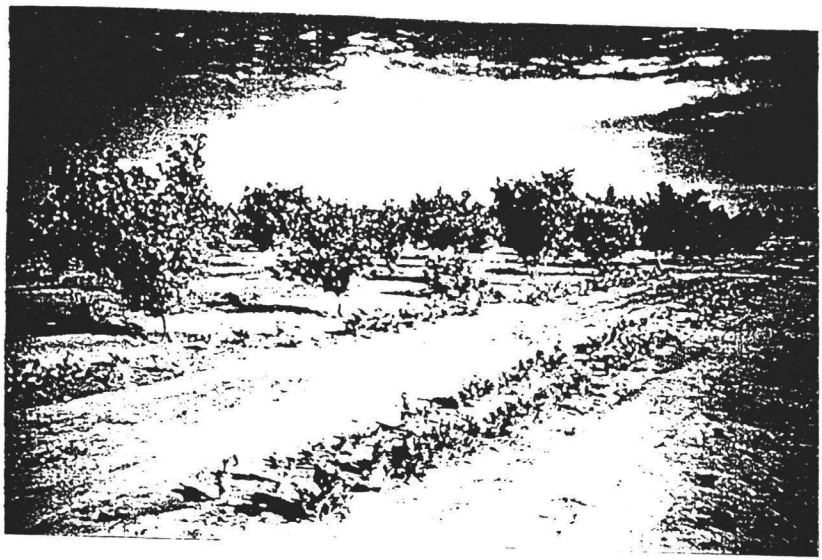
Therefore more efforts are needed to identify hedgerow species that are appropriate for alley cropping in dry areas.

This technology is only limited to high potential arable production areas in the riverine(Molapo) systems, but for the rest of the country it is unsuitable mainly due to the water constraints and it is also labour intensive.

4.4.4 Home treeplanting/Homegardens.

Amenity planting of shade , fruit and ornamental trees in and around compounds in all settlements should be promoted and encouraged by the tree planting programmes such as AHTP organised by (FAB) and NTPD by the Forestry Division in the Ministry of Agriculture. Much emphasis should be placed on indigenous fruit trees like *S.birrea*, *Vanguria infaustida* Burch., inorder to diversify household production and provide continuos supply of tree products and nutrition. Diet and taste has changed in the whole country due to South African influence, so citrus spp, guava, pawpaw and others will be an important addition. Vegetables which have great potential are creepers such as *Curcubita* species(pumpkin), watermelon, *phaseolus* species and exotic vegetables which have done quite well in group projects such as cabbage, spinach and chumolia are used widely in the country as the greens. Live fencing should also be encouraged,

Plate 4.1 Tlhareseleele Multipurpose Woodlot(summer season)



Vegetables between rows: Cabbage, Spinach, Chumolia short term crop

Fruit trees: Peaches , Apricots medium term crops and oranges long term products

Timber and pole trees: Eucalyptus trees out picture long term products

to act as a windbreak and also stop animals feeding on the crops. The most commonly used species for live fencing are exotic evergreen *Dodonea viscosa*, and *Euphorbia tiracalli* L. Indigenous species which are able to grow from truncheons are very promising e.g. *Kirkia acuminata*, and *commphoria* spp. and should be encouraged. This is a very cheap practice because animal manure from goats and chicken kept around the homesteads can be used for fertilising the crops and waste water for watering the trees and vegetables.

Tree planting activities should be supported by farmer training and extension programmes designed to improve tree planting and management. Techniques developed in home gardens may eventually be applied in cropland, rangeland and community agroforestry projects like the Tlhareseleele agroforestry group project (see plate 4.1) by Walker (1992). Such projects are found mostly in the South and Eastern parts e.g., Mogobane village along the dam and they contribute heavily to the village supply of horticultural products and to the rural income.

4.5 Silvopastoral Systems

4.5.1 General

Sylvopastoral system is defined as a land management system in which forests are managed for the production of wood as well as rearing domesticated animals. The sylvopastoral systems of the Arid and Semi Arid Lands(ASAL) are essentially savannahs with various densities of shrubs and trees from less than 100 to over 3,00 individual "trubs" per hectare dotting a herbaceous layer of annual grasses and herbs

(Steppler and Nair. 1987). *Acacia* species are dominant species in the area , as well as *combretum* spp, *Terminalia* spp and the other Mimosoideae subfamily of legumes. In terms of animal nutrition woody species play a major role in this system because they are the only source of protein during the long dry season. During these periods, grasses which are the major feed resource for livestock, dry up and deteriorate both in quality and productivity.

4.5.2 Silvopastoral System in Botswana

Batswana are traditionally pastoralists who practice mixed farming with arable agriculture as a secondary occupation. Most of the cattle are found in the Western and Northern parts of the country where rainfall is low and soils are infertile for arable farming. Trees such as *Acacia* spp, *Boscia albitrunca* (Burch.) Gilg & Ben. and *Combretaceae* family play a major role in these areas as dry season fodder. Small stock(goats and sheep) are more evenly distributed among the districts than cattle. Livestock farming is carried out under the traditional cattle post system which maintains over 85% of livestock in communal areas. Animals are left to graze freely on communal ranges with no supplementation. In mixed farming systems such as the southern and eastern regions, crop residues are an important fodder resource after crop harvesting

Constant pressure from grazing animals especially in mixed farming areas with higher population density such as the Eastern and Southern parts of Botswana poses a serious threat on rangeland resources leading to bush encroachment, soil erosion and subsequent desertification. The vegetation has been reduced to low and scattered shrubs and a sparse understory of grasses. Browse plays a very important role in livestock in this zone.

4.5.3 Design of the System

Batswana traditionally practise some form of sylvopastoral system. They keep cattle, sheep goats and in some areas donkeys which are a form of draught power. In general the Batswana communities are semi-nomadic. This is whereby livestock owners have a permanent place or residence which they maintain over several years . Whereas part of the family travels with the herds over long periods of the year and over long distances. Women, children and older men stay behind on lands which they cultivate over rainy season (Dec- April) in order to improve the family 's food reserves and income.

Semi- nomadism or transhumance derives its importance from the fact that it benefits from high quality, low-disease pastures during the short rainy season and from the opportunity of spending the dry season where larger, nutritious quantities of forage and adequate water supplies are available and where eventually agricultural crop residues can be utilised. Animals browse foliage, fruits, pods of the standing shrubs while herbaceous species are usually grazed especially by cattle. Apart from being grazed , trees provide shade to animals and promote grass growth

From the point of view of Agroforestry systems, competition complementarity and mutual dependence of animals, woody perennials and grass/herbs deserve special attention. As long as

stocking rates are low, detrimental impact remains negligible and could easily be compensated for by alternating with more favourable sites. With increasing numbers of livestock over recent decades, however problems have emerged.

Since most of the livestock ,except goats, feed selectively on specific plants or parts thereof, the more palatable species are more continuously reduced and weeds have invaded. This situation is seriously aggravated by the effects of seasonal grass/bush fires over large areas. Even though browsing is considered by Foresters as an illegal practice, causing severe damage e.g. previously open woodland with scattered trees, often only stunted thorny shrubs survive; on the other hand livestock, like game have always played an important role in promoting the growth of woody perennials by reducing competition from grass for nutrients and water, and by breaking seed dormancy through digestion and subsequent distribution and nutrient cycling with their droppings. However, when livestock numbers exceed the carrying capacity of the area, the negatives are more pronounced.

4.5.4 Management of the System

Sylvopastoral production systems are not new to Africa. In fact, many pastoral and agropastoral peoples throughout the continent have traditionally used and managed woody plants in the Savannah grazing lands to produce fuelwood, fodder, building poles and other products for sale and domestic use. Management of silvopastoral systems in drylands usually focuses on fencing, special protection of newly established plants- whether naturally regenerated or introduced, control of grazing and in some cases maintenance of micro catchments. Leaf fodder and edible pods may also be harvested on a seasonal basis. Small plots may be more intensively managed, with both tree and herbaceous fodder harvested and carried to animals.

Trees may be protected by social agreement rather physical measures(see section 2.3.2) Traditionally, specific areas are often reserved for grazing at certain times, based on control of livestock by herders. Similar cases are observed where useful tree species such as *Andinsonia digitata* were conserved spontaneously or throughout strict regulations such as in the case of *Faidherbia albida* in the Segou kingdom (Mali) or in the Sultanase of Zinder(Niger). However there are other examples from other countries where there has been maintenance of trees and shrubs in pastures. For example, in the humid highlands of Costa Rica, farmers plant nitrogen fixing *Alnus acuminata* in pastures at densities of 200 trees per hectare. In addition to a commercial timber harvest after 15-20 years, these trees help improve the condition of the pastures. In Australia, commercial ranchers in Subhumid areas have also increased total return from land by planting timber trees in pastures.

4.5.5 Limitations of the current system

Water is obviously the first limiting factor with respect to sustained livestock production in the sub-desert environment. The watering points for livestock are poorly distributed. In addition surface water is seldom available and underground water is difficult to find and often unfit for consumption by man or animal due to high mineral content and even drilling and pumping are of considerable expense which can only be afforded by most rich farmers. Drought further lowers production and limits the possibilities of exploiting plant resources on a sustainable basis.

The extension of grazing areas has in turn caused ecological change. Large trees have tended to disappear from the landscape particularly around the watering points and the grass cover has almost completely disappeared. It has been replaced by scrubby *Acacia* thornbush on which only goats can browse (Colclough and MacCarthy 1980).

Land pressures(high human and livestock densities) in Botswana occurred as a result of an expansion of human activities, initiated by rapid population growth and the low capacity of land Population has steadily increased. Human activities followed suit.

Cattle numbers have increased at a similar rate. The most dramatic increase in the numbers of cattle occurred after independence. In 1966, at the end of the drought, the cattle population numbered less than a million. Ten years later, it had increased to nearly three million (Montshiwa 1988). Apart from cattle, there are also large numbers of small stock. According the report of the Department of Information and Broadcasting, in 1978 there were 621,000 goats and about 14,000 sheep(mainly found in the Kgalagadi areas.

The growth of the national herd has led to a situation where almost throughout the country, stocking rates exceed carrying capacity, leading to overgrazing. Land degradation is also evident in areas mainly used by wildlife(e.g. in the Chobe district alone elephant numbers exceed 75 000). The competition between cattle and crop production is also a problem, commonly in small districts like Southeast. Encroachment of arable land into grazing land is seen as a serious problem. Firstly, crop damage increases as a result. For example, in Kgatleng district 80% of the farmers complain about crop damage(Anrtzen and Opschoor, 1982). The effect on arable production however is not known (NIR, 1986). Secondly, less grazing areas remain. This contributes to the drive towards exclusive rights in grazing areas. the confinement of smaller herds to mixed farming areas and the moving of cattle towards the west(Kgalagadi area), which is a desert area. Other causes of rangeland degradation and fodder constraints include:

-the communal land tenure system in which individuals have unrestricted access to rangeland but with little or no responsibility for management.

- lack of technical know- how in rangeland management

Land degradation mostly affects cattle causing high mortality ratios and lower birth rates.

4. 6 Proposed Agroforestry interventions/technologies

Effective livestock production of Botswana's rangelands depends directly upon proper management of the vegetation. The ranges deteriorate when desirable forage plants are killed by excessive grazing or browsing . The denuded vegetation cover on many rangelands is the result of overgrazing and trampling by animals and a consequent imbalance of water, soil and vegetative process. The sandy soils of the Kalahari desert are particularly vulnerable to grazing and that the deterioration of the veld for as far as much as two miles around the poorly distributed watering points. Damage by the harvester termite (*Hodotermes mossambicus*) in overstocked areas worsen the situation. This denudation of the vegetation surface results in increased environmental temperature, acceleration of runoff and reduced water penetration, retarded plant development and wind and water erosion. Therefore, the following topic deals with the establishment of the agroforestry technologies which have got potential in alleviating the fodder and land degradation problems.

4.6.1 Scattered Fodder trees in pastureland

The main obstacle to the production of fodder trees in pastures and rangeland is the need to restrict animal access and grazing until the trees and shrubs are well established. On particularly productive sites, the short-term opportunity of excluding livestock can be high. If the site is degraded, little grazing may be lost, but few woody species may be available that can tolerate the degree of erosion, compaction and poor characteristics of such sites.

Planting fodder trees in rangelands at low densities is essential for the improvement of the existing system in Botswana. The woody species to be planted should be adaptable to the local conditions and be able to withstand a certain degree of grazing pressure. *Acacia* species e.g.,

(*A.crioloba, A. tortilis*) and *Prosopis juliflora* species are well-suited to fodder-pod production in semi-arid rangelands, whereas species such as *Combretum imberbe*, are better suited for producing leaf fodder and fuelwood in improved pastures. In the Kgalagadi district, potential species are the *Atriplex* genus e.g, *A.nummularia* which is one of the most palatable species and can tolerate saline soils and drought. In addition to fodder production, some tree and shrub species encourage grass growth underneath while others do not.

Since in a communal grazing area it could be difficult to control the access of livestock to the site where trees and shrubs are to be established, then the majority of the seedlings should be non-palatable fuelwood species, along with a limited number of fodder plants that can be protected individually. This technology can be implemented in those communal grazing areas around the villages and the arable crops where trees can be protected by the local communities under the co-ordination of the Village Development Committee(VDC) assisted by the agriculture or forestry extension workers.

4.6.2 Cut- and -carry and Stall feeding

As already mentioned in the previous topic(4.5.5) apart from cattle, Batswana keep also a large numbers of small stock mainly for subsistence milk production. This system can be improved by keeping dairy goats fed in stalls which receive cut grass and lopped trees. Goats rather than cattle, can be chosen to test the value of this potential fodder resources, because of their lower total intake and acceptance of a broader range of species.

From my observation, the amount of grass and fodder available to feed in such a system is not enough due to the nature of the low vegetation cover(grass and trees) in Botswana's pastureland. The system is also labour intensive and will put a lot of pressure on the

old and young children left in villages, since all able-bodied man are either working in South African mines or in towns. However, this system has great potential especially for dairy goats Small plots of fodder trees/shrubs and grass planted underneath, can be established and maintained using existing resources of small farms(for example 2 ha of arable field). This could be cut and fed to goats during the dry months to allow vegetation to regrow and will also benefit farmers by providing them with milk all year-round. After the rainy season the goats could be allowed back into the open fields to graze and browse.

Future success of this technology will depend upon the availability of productive animals which have the capability of responding to 'cut and carry' management. Success of the extension phase will also depend on the selection of farmers who really want to keep goats rather than the selection of those with the most need. In Botswana the potential exist in the Northeast and Central districts where the existing *Colophospermum mopane* woodland can be managed as fodder banks.

4.7 Other Agroforestry Technologies.

There are other important agroforestry interventions which have great potentials in alleviating some of the environmental problems faced by the rural people. Such technologies include:

1. Multipurpose community woodlots to provide fuelwood, fruits and vegetables.
2. Multipurpose trees for soil conservation and Dune Stabilisation.
3. Veld Products/Apiculture

4.7.1 Multipurpose fruit/vegetable woodlots.

Village and community woodlots has been initiated by the Ministry of Agriculture as early as the 1970's for the provision of poles and firewood and to prevent environmental degradation. As mentioned earlier before(section 2.3.1.1) most of the established solely eucalyptus woodlots have failed to meet the needs of the villagers mainly due to poor management and lack of involvement of the local people. Introduction of multipurpose fruit(local and exotic), pole and fuelwood tree species is desirable.

Integration of food and horticultural crops, (vegetables and fruits) with trees would provide tree products as well as food for households consumption and sale of surplus. There are about 3 Agroforestry group projects already established in the country, one in the Northern part(Maun) and two in the Southern part(Malokaganyane and Tlhareseleele). These are mostly women's group projects and through the help of the government and some NGOs are growing fruit trees(e.g. oranges and peaches) interplanted with vegetables like spinach and cabbage.(see plate 4.1 by Walker, 1992). From my personal observation and communication with the group members, the major constraint in such projects is lack of water. The group depends on reticulated water for which they have to pay high water bills at the end of every month and it is quite expensive since trees need a lot of water. Although the group members are able to get profit after selling their products, most of the money ends up in paying bills and other management inputs of the project.

However these project have got a lot of potential in other areas like Kanye, Maun ,Kasane and which have existing water facilities e.g. constructed dams with furrows where irrigation is possible. Potentials also exist in the Southeast district in villages like Mogobane where there are already existing vegetable farmers groups and improvement can be done by introducing

multipurpose local and exotic fruit trees to diversify production Irrigation enable plants to benefit from the high soil fertility in the top soil under woody plants. Woody species should be selected that do not resprout when vegetables are irrigated. Such an integration of trees and crops is effective because water and nutrients are both found in the topsoil during crop growth and tree production. Most vegetables are C3 plants, that can benefit from the shade of woody plants, even during the dry season.

To be successful, vegetable/fruit woodlots should be limited to areas where water facilities exist or could be reticulated at very low costs and they are recommended especially for Zones I and II.

4.7.2 Multipurpose trees for soil conservation and Sand dune stabilisation

Moving sands are influenced by winds which are responsible for dune formations in the southern Kgalagadi district. It is in the interest of the local inhabitants and the government to stabilise existing dunes, prevent further dune formation and eventually put the area into productive use. In order to halt this encroachment of sand into the community areas, pilot projects have been initiated by the government in some villages in the Kgalagadi areas in order to reduce dune movement by tree planting . Although the trees have successfully grown in such projects, (Tsabong project which consists mainly of *eucalyptus* species and *Acacia cynophylla*), there is nothing stopping the sand movement because there is no ground vegetation cover(Lepetu,1993). The species chosen is fast growing, but does not encourage any undergrowth because of its deep rooting and hence taps all the water underground.

Because of the water constraints, wide-scale tree planting effort will not be feasible. However, small areas on and around dunes should be fenced and planted with trees and grasses. The use of local tree species(which are bushy) and adapted exotics are recommended such as *Boscia*

albitrunca, *Acacia Luederitzii*, *Acacia karroo* and the *Atriplex* genus Local residents should be encouraged to participate and contribute effectively to the establishment, management and utilisation of trees and available land.

A summary of proposed agroforestry interventions and potential roles in each land use system is presented in Table 4.2.

Table 4.2 Agroforestry interventions and potential service and production roles in each land use system.

Intervention	Major output/function	Agro-ecological adaptation	Remarks
Boundary planting around croplands and homestead	- soil conservation - moisture conservation - poles - fuelwood - fruits, fodder - wind protection - live fencing	suitable for the whole country	not labour intensive
Trees mixed in cropland	- soil conservation - improve soil fertility - poles - fodder, fruits	suitable for drier areas. e.g. Bobonong and South western zones I, II, III and IV	simple and popular
Hedgerow intercropping for green manure and soil conservation	- organic matter - soil fertility - soil conservation - fuelwood - fodder, fruits - poles	not really suitable for most parts of the country except may be zones I	* labour intensive *competitive with crops
Home treeplanting	- soil surface protection - nutrient recycling - fruits, fodder - fuelwood, poles etc. - live fencing	In all ecological regions of the country	simple and popular
Scattered trees in pastureland	- soil conservation - shade - fodder, pods - fuelwood	-extensive grazing areas. all communal areas	Tree protection from grazing is a major constraint
Cut and carry system	- soil conservation -environmental conservation - Fodder	suitable in the intensiv mixed farming e.g SouthEast. Borolong. Kgatleng Districts Zone II	* labour intensive
Dune fixation with multipurpose trees	- prevent wind erosion - prevent sand movement - environmental protection - soil conservation - fuel wood - fodder, poles	Kgalagadi areas where there are sand dunes Zones IV and V	*drought resistant species highly recommended. *community participation
Multipurpose fruit/vegetables woodlots	- soil protection - poles, fodder - fruits -vegetables/crops	high rainfall areas or surface water available e.g Chobe, Maun Southeast Zones I and II	*cash surplus

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4. 7. 3 Veld Products/Apiculture

Amongst these known Agroforestry interventions of tree/crops and animals, potentials also exists in other forms of production systems such as beekeeping and mophane worm(*Gonimbrosia melima*) which is found in *Colophospermum mopane* tree. The mophane worm is a great protein delicacy and is eaten by both people and livestock in Southern Africa. The mophane worm has got great potentials in the Central and Northeastern Botswana areas where extensive mopane woodland is found. For the sustainability of this system, protection of this already depleted woodland is of profound importance. Indiscriminate cutting of live trees for fencing and poles should be stopped and management practices e.g. pollarding , lopping and thinning which are compatible with the system should be adopted. Most important, studies on the natural regeneration biology of this species and the production potential of the mopane worm need to be carried out.

The beekeeping production system has been a traditional system for decades. However this only involved tapping honey from wild bees found in the forest. With very little tree cover available, nowadays it is quite hard to find honey bees in the wild. Potentials for improving their production exists in the Chobe forest reserves where there are still large numbers of flowering forest trees intact in the miombo woodland. In response to this, the ministry of agriculture has set up the beekeeping section which is responsible for teaching and assisting farmers in the beekeeping farming. This is still a new and very small section and its potentials has to be realised in the future. Phokedi, (1985), writing about apiculture and its problems in Botswana noted that the shortage of qualified personnel to extend and consolidate beekeping among farmers was a major constraint. This situation is aggravated by drought as a result of which colonies abscond from hives because of starvation. However with agroforestry, this situation can be solved by growing appropriate trees which can extend the period when nectar and pollen are

available. A tree potential for dryland beekeepers is *Faidherbia albida* which has the advantage of flowering after the rains(during the dry season). Therefore increased planting of this species could possibly provide valuable bee forage. Also improved extension programmes, or organisation of co-operatives and training in the use of modern hives and hiving techniques are also required.

CHAPTER 5

RECOMMENDATIONS AND CONCLUSIONS

The challenges facing agroforestry development in Botswana are daunting. The primary aim of the farmer is to meet subsistence food needs and improve farm incomes through cash flow. Any practice that conflicts with these aspirations is resisted. Adoption of agroforestry faces these following drawbacks:

- Introduction of trees hardly complements the traditional farming systems
- It incurs extra costs in terms of labour, protection and maintenance(pruning, thinning)
- The planting season is very short 2-3 months. Trees compete with crops particularly due to uncertainty in rainfall and poor soils.
- Lack of seeds, seedlings and effective extension of tree propagation and management practices.
- Lack of drought and termite resistant species providing services according to farmers preferences and needs
- Lack of government commitment due to the low status of forestry compared with livestock production and agriculture.
- Lack of processing and marketing of tree and forest products necessary to contribute to a diversification of the rural economy.
- Lack of involvement of the rural people when establishing forestry projects. A history of unsuccessful community woodlot schemes has led to reservations among villagers against community tree planting interventions and has made it more difficult to create motivation for new and better proposals.

5.1 Recommendations

Although there are constraints to the design and implementation of agroforestry technologies in the country, there is potential for improvement of the traditionally managed systems described here, so that their potential can be realised. Thus it is important that these systems are studied in detail: as a first step, accurate baseline data of the systems need to be collected in order to facilitate in depth evaluation and subsequent improvement. On the basis of my findings, the following recommendations can be made.

5.1.1 Potentials for increasing production

It is in the higher rainfall areas that there is moat potential for Agroforestry. In the lower rainfall areas especially the kalahari district, where livestock husbandry predominates, poor growth rates do not favour widespread tree planting.

Shelterbelts, live fences, boundary planting and fruit treeplanting seem to have the greatest potential in Botswana, whereas the intensive integration of trees in cropping systems is less feasible. This has something to do with the wide spread fear of bird damage. Quela birds and doves are serious threats , especially to the sorghum cultivation and there is also the water constraint. Besides compatibility with intercropped plants, and suitability to the end uses trees used must be able to thrive under the semi-arid conditions of Botswana. Great potential exists in indigenous species which are already adapted to the drought and are termite resistant. However, there is also a group of exotic species which is not well known but has great potential. There is a great need for research to explore potentials of these species so as to enable land users to make fuller use for such under exploited species. Priority should be given to high rainfall areas in the intensive/livestock system.

Fruit tree planting(exotic and indigenous) in homegardens is the cheapest and simplest form of tree growing. Multipurpose tree screening and selection for improved fruit production, fast growth and early maturing and adaptation to climatic conditions are essential. These trees have a great potential for marginal, semi-arid areas with sandy soils, and planting trials are recommended for the whole country. In addition farmers already possess indigenous technology for managing these fruit trees to produce multiple services and products such as shade, food, medicine etc. The fact that farmers require little persuasion to plant fruit bearing species can be exploited in Agroforestry initiatives by including fruit crops with other innovations to enhance acceptance of a package as a whole. The present productivity is based on naturally occurring plants that are protected, but increased occupation of land has led to changing agricultural practices and nowadays fewer trees are protected than before. Therefore, the future development of this resource necessitates the encouragement of people to continue protecting these trees, even those existing in parks.

Silvo-pastoral development is more appropriate in the western and southern parts, where there is extensive livestock farming for both cattle and small stock. Planting of fodder banks can be successful if undertaken by individual farmers or small farmers syndicates, who have better chance to agree on management rules and distribution of benefits. This type of Agroforestry practice has potential throughout the country. The best option will be to use drought resistant species e.g. *Acacia* species. Trees with protein rich pods like *Acacia crioloba*, *Acacia tortilis* are widely recognised as an important dry season animal feed. In the *Mopane* belt, *Colophospermum mopane* is an abundant source of fodder and could be managed as fodder banks. Probably, the management of existing vegetation is more important than planting of new fodder species. However, in Botswana tree planting is an unknown concept therefore a lot of work by extension workers should concentrate on increasing awareness.

Any tree planting away from homesteads without permanent and secure water sources and individual responsibility for protection and monitoring seems at the moment very difficult However, potentials exist in the fruit tree/vegetable woodlots where vegetable group projects are already in place and operating successfully. For this group projects to be successful, the horticultural unit should help farmers with the techniques and management aspects of fruit tree growing and should also monitor the projects.

5.1.2 Research

Agroforestry research is vital to the development of the various technologies and interventions proposed. At the present there is very little research in forestry and agroforestry being conducted in Botswana. Research efforts in forestry, e.g., local tree screening trials by (FAB), (PDT), and biomass accumulation studies by (NIR) are not backed by actions from the government. This is clearly shown by low hierarchy of the forestry unit in the Ministry of Agriculture. It is very small and understaffed. Because of such a constraint, there is no Forestry Research Institute in Botswana. The only work of the forestry staff being the production of seedlings of unknown origin or provenance, mostly exotic species incompatible with the farmers needs. This limits the development and improvement of forestry and agroforestry technologies and consequent transfer to farmers.

Intensive research into adaptable tree species, and technologies conducive to local biophysical, socio- economic environments and land use systems are required through on-station and on farm trials before technologies can be effectively transferred to farmers. Exotic and less known species as well as new technologies, fodder banks, boundary plantings and mixed intercropping interventions, should be adequately tried to suit local conditions and available resources. (Otsyina and Walker, 1990)

On the basis of the diagnostic survey and existing farming systems, the following are some of the aspects that need immediate attention in controlled on-station field trials

a). Agroforestry research should be directed at germplasm identification, screening and selection of multipurpose trees suitable for the various bioclimatic zones and favoured by local farmers(fruit, fodder, basketry) in order to identify high yielding trees. This will provide a germplasm base for further development/selection of superior trees. A number of factors may be evaluated, including site adaptability, propagation techniques, establishment, and quality of leaf fodder, pods, fruit taste and other products.

b). Examination of rooting pattern and root distribution of the component tree crops for understanding nutrient-moisture interaction and utilisation.

c). Evaluation of the economics of different systems and of their costs and benefits with reference to conservation and development objectives.

NGO's such as Veld Products and Thusano Lefatsheng are currently involved in the improvement and evaluation of indigenous fruit trees that are potentially valuable in Botswana; improved valuable fruit trees such as *S.birrea, Grewia flava, Vanguera infaustida*, fodder trees e.g. *Colophospermum mopane and the Acacia* species also deserve special attention. Germplasm materials and management packages could be made available to farmers via extension workers. The National Tree Planting Day which currently funds tree planting activities can have a major role to play.

Lastly, the research institutions NIR, APRU, and NIR, BCA and all research projects taking place sporadically within NGOs around the country, (e.g, FAB trials, Veld Products propagation trials and Thusano Lefatsheng propagation trials, and all other applied research projects), need to cooperate more closely to compile and sort out already available information. Their goal should be to harmonise and strengthen agroforestry research and development programmes through a

multidisciplinary approach and inter-institutional approach rather than by fragmented efforts of the past, all too often characterised by competition, overlapping and lack of co-ordination.

1.3 Agroforestry Extension

At the moment, agroforestry has not been introduced to many farmers except the National Tree Planting programme which only occurs once a year. Extension officers are inadequate to take this forward. Most of them are Agricultural Demonstrators who lack the technical know how in tree planting and management. Community forestry extension is limited to NGOs and a few foresters in the Ministry of Agriculture. Rapid staff turn-over in NGOs and insufficiency of trained forestry extension officers have contributed to the ineffectiveness of forestry activities.

There is no proper logistic support for extension services, Each of the four field Departments of the Ministry of Agriculture maintains an extension unit and disseminates different ideas to farmers separately on pest control(which favours cutting down *Acacia* trees to stop Queala birds), animal husbandry, tree planting and soil conservation. Because the extension agents speak different languages to the same farmers, they create confusion and farmers only accept programmes with short term gains leaving out trees with long term gains.

In view of the above factors and the lack of proven technologies, agroforestry extension is almost non-existent. Agroforestry extension and technology transfer needs serious re-organisation and an increase in personnel to meet farmer training and guidance needs. Agroforestry extension should include agents from all agricultural departments, rural development and Non-governmental organisations engaged in Forestry and Agriculture.

The following factors are recommended for an effective agroforestry extension programme.

1. Development of suitable technologies (tree planting and management techniques) conducive to farmer resource levels.

2. Continued training of extension personnel in improved methods of technology transfer and available technologies in tree planting and management and integration into existing land use systems. This should be supported by Botswana College of Agriculture which runs short courses at its Centre of Inservice Continued Education.

3. Farmer training on an individual and group basis to acquire basic silvicultural techniques including seedling establishment and handling, treeplanting, management(pruning, pollarding). Approaches such as establishment of backyard nurseries, farm trials, field days, and film shows should be adopted.

4. Farmer involvement in all aspects of project planning, design and implementation, coupled with constant follow-up and evaluation. This would improve technology transfer and the success of community level agroforestry projects.

5. Collaboration between all government departments and NGOs working on forestry, agriculture and agroforestry projects in each community. This is essential in avoiding duplication of efforts and potential conflicts as well as confusing farmers by relaying different ideas to them.

If extension systems function properly, they will encourage farmers and help them to tailor solutions in light of what they know about the limiting factors in their environments. The lack of

awareness in tree planting should continue being supported by the ongoing National Tree Planting Day programme.

5.1.4 Agroforestry Training

At the present moment the only formal training in forestry and agroforestry in the country, is the certificate course in Forestry and Range offered only to an average of 15 students at the Botswana College of Agriculture. This programme is at an infant stage and only started in 1992. Forestry training at degree and diploma level is conducted overseas and in other African countries. A significant part(degree level) is done under temperate conditions which do not have much relevance to the arid and socio economic conditions in Botswana.

The low emphasis on forestry training may be attributed to the lack of staff trained in forestry and agroforestry and low priority given to forestry and natural resources management in the past. At the moment at BCA, which is the only institute in the country offering agricultural courses at certificate up to degree levels, has only 2 professional forestry teachers. The college does not include forestry or agroforestry as a taught course to one of their agriculture programmes. Because of this, the institute produces graduates or extension workers who disseminate different ideas separately to the same farmers. Ever since the college was established in the 1960's there has not been any curriculum development activities to try to develop it to accommodate changing land use practices.

This acute lack of trained manpower in forestry and rural resource management is having serious deleterious effects on the development and implementation of several development projects such as village woodlots, aimed at improving fuelwood supplies to rural communities and reducing pressure on the already depleted woodlands.

In order to establish agroforestry education, research and extension on proper footing, additional manpower and the establishment of supporting infrastructure is required. Indeed such a support can be sought from institutes like International Council for Research in Agroforestry which has an education branch called Africa Network For Agroforestry Education(ANAFE). ANAFE's objective is to promote and support agroforestry education in institutes of learning e.g. by training teachers, distributing and developing teaching materials, curriculum development etc. This is a very useful organisation and is highly recommended for Institutions of learning in Botswana like University of Botswana and BCA to make use of it. Attention to curriculum structure is required in order to broaden the education to include arid zone forestry and rural development in general.

Training is required at all levels for personnel already involved in forestry and agriculture as well as in land use planning. Training should also involve NGOs and parastatals. Formal training/education in agroforestry and forestry should be integrated into existing agricultural and land use training programmes at primary school level, technical training colleges and to university degree programmes.

5.1.5 Providing Market Support

Tree based products(e.g. fuelwood, fruits, basketry from palm trees) are an important source of income for many people in the rural areas of Botswana. They are of greatest importance to the poor sections of the population, particularly in the west and north of the country where economic oppoturnities such as crop and livestock production are limited. For example Mokola tree *Hyphaena pertasiana* which is found in the Chobe and Okavango areas is used to make baskets which have been marketed successfully in and outside Botswana. Many women in these areas derived a major part of their income from the baskets. There is now a clear evidence that most of

these resources are being depleted, both at local and regional level as a result of excessive and poor harvesting methods.

For those involved in the sale of tree-based products, the benefits they obtain are directly linked to their access to the markets. In many cases, local people receive very little for the products they sell. Instead, most of the benefits are captured by middleman and urban traders operating further along the marketing chain. However, there are a variety of measures that can be considered in the marketing of tree products, with the aim of providing rural incomes. The government should assist by:

- strengthening the bargaining power of producers by setting up marketing co-operatives, or producers' associations.

- supporting the marketing of tree products by providing transportation and storage facilities, linking sellers with buyers at markets and fairs, and giving advice on advertising and marketing strategies.

5.2 Conclusions

Attempts have been made in this project to highlight the constraints and prospects of integrating agroforestry into traditional land use systems. The study indicates that the main factors constraining design and implementation of agroforestry projects are water, labour, access to land and birds damage to crops. Current constraints to farmers adopting agroforestry such as land tenure issues or seedling availability, may be eased through policy changes in land tenure, nursery establishment and credit subsidies. Promotion of multipurpose species (e.g. indigenous

fruit trees) may become advisable for diversity of income potential as well as for environmental/ecological considerations.

Despite the limitations of agroforestry adoption in Botswana, other programmes such as Around the Home Tree Planting Day and Malokaganyane and Maun horticultural group projects have shown success and therefore, future potential exist in other areas of Botswana in which the population traditionally show co-operative ability and marked business acumen. In other parts of the country, where these desiderata are less developed, it is more difficult to overcome environmental constraints(e.g. drought) even when socio-economic problems can be defeated. It is important that methods of involving individuals and communities in tree planting must be developed, but closer monitoring of tree growth and control of the distribution of benefits are needed.

Above all, what is needed in pastoral communities is an integrated approach to rural development in which activities with tree and crop species and their efficient use are paralleled by research into the carrying capacity of the land, by development of improved breeds of domesticated animals which accept stall feeding and by public education in the concepts of limiting the herd size and natural resource management aspects in general. Improvement and expansion of information through farmer associations, as well as through national and international institutions can spread more wide adoption of agroforestry practices and as such is highly recommended. Most important Forest policy must play a more central role in land use planning and have more direct influence on overall policy making.

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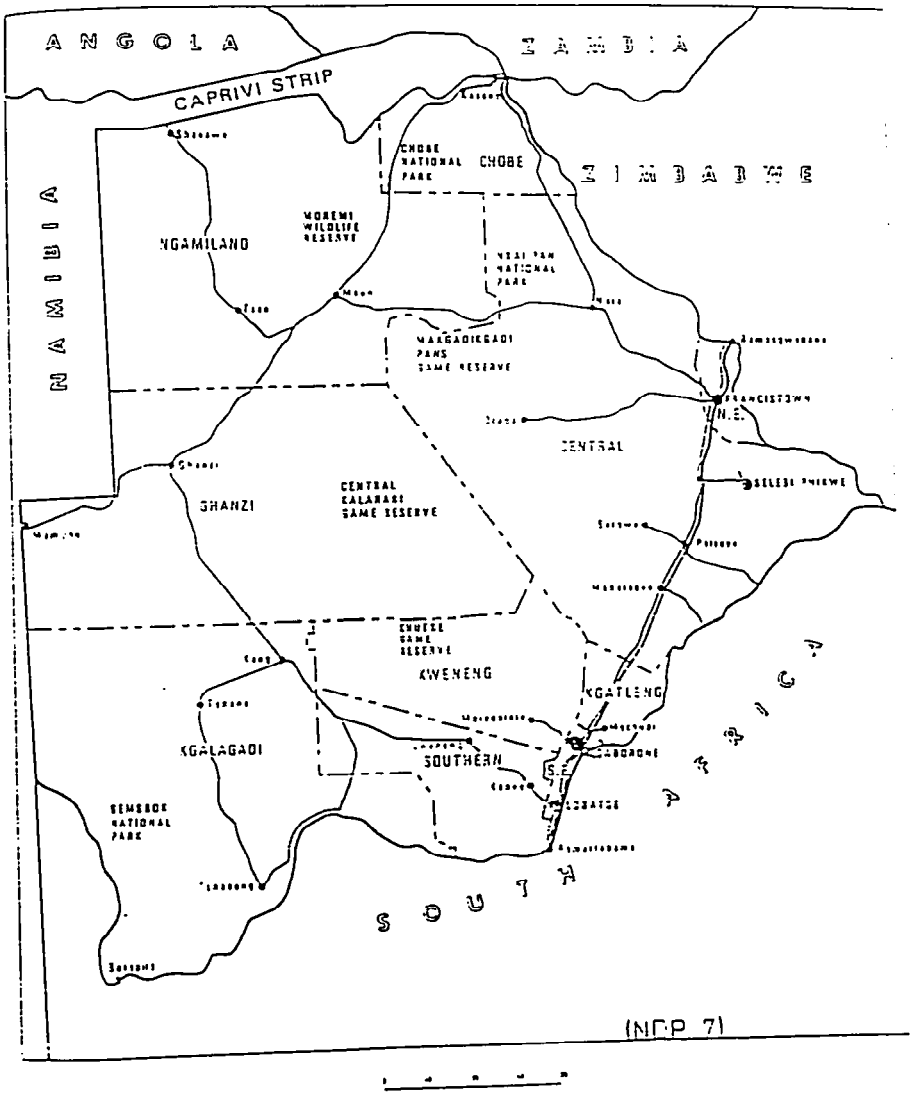
APPENDICES

Table A.1 Monthly maximum and minimum temperatures

Station	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Gaborone													
max	32.6	31.3	30.1	27.3	25.3	22.2	22.7	25.6	29.4	30.9	31.5	31.9	28.4
min	19	19	17.2	11.3	8	4.1	3.9	6.9	11.8	15.8	17.7	18	12.9
Mahalapye													
max	31.8	30.7	29.2	26.9	24.6	21.5	22	24.4	28.5	29.2	30	32	27.6
min	18.8	19.1	17.1	13.2	8.2	4.6	4.5	7.6	12.6	15.6	17.6	18.9	13.2
Francistown													
max	31.2	30.1	29.6	27.8	25.9	23	23.1	26.1	29.8	31.3	31.3	30.4	28.3
min	18.9	18.3	16.9	13.6	8.4	5.2	4.8	7.9	12.3	16.2	17.7	18.4	13.2
Maun													
max	32.1	30.8	31.2	30.1	27.8	25.3	25.3	28.5	32.5	33.6	33.3	32.7	30.3
min	19.6	19.2	18.2	15.1	10.4	7.1	7.1	9.9	14.7	18.6	19.5	19.2	14.9
Shakawe													
max	30.8	30.1	30	28.9	27.6	25	25.3	25.8	32.6	34	32.7	31.7	29.8
min	19.4	19.7	18.6	16.3	11.2	6.4	7.1	9.1	12.9	17.5	18.6	19	14.7
Ghanzi													
max	32.7	31.7	30.9	28.7	26.4	23.8	24.1	27.2	31.1	33	33.2	33.3	29.7
min	19.4	18.4	16.7	13.3	7.9	4.3	4	7.2	11.9	15.5	17.6	18.4	12.9
Tshane													
max	34.1	32.6	31.4	28	24.7	21.8	22.2	25.1	29.3	31.7	33	34.1	29
min	19.5	18.7	16.9	12.7	7.4	3.9	3.4	6	10.6	14.5	17	18	12.4
Tsabong													
max	34.8	33.7	31.7	28.1	24.7	21.7	22.1	24.4	28.9	31.4	33.2	34.5	29.1
min	19.1	18.5	16.4	11.6	5.8	2.1	1.9	4.3	8.2	12.3	15.9	17.7	11.1

Map A.2: Map showing the nine districts of Botswana



Map A.3: Potential carrying capacity of Botswana's range lands (Field 1978)

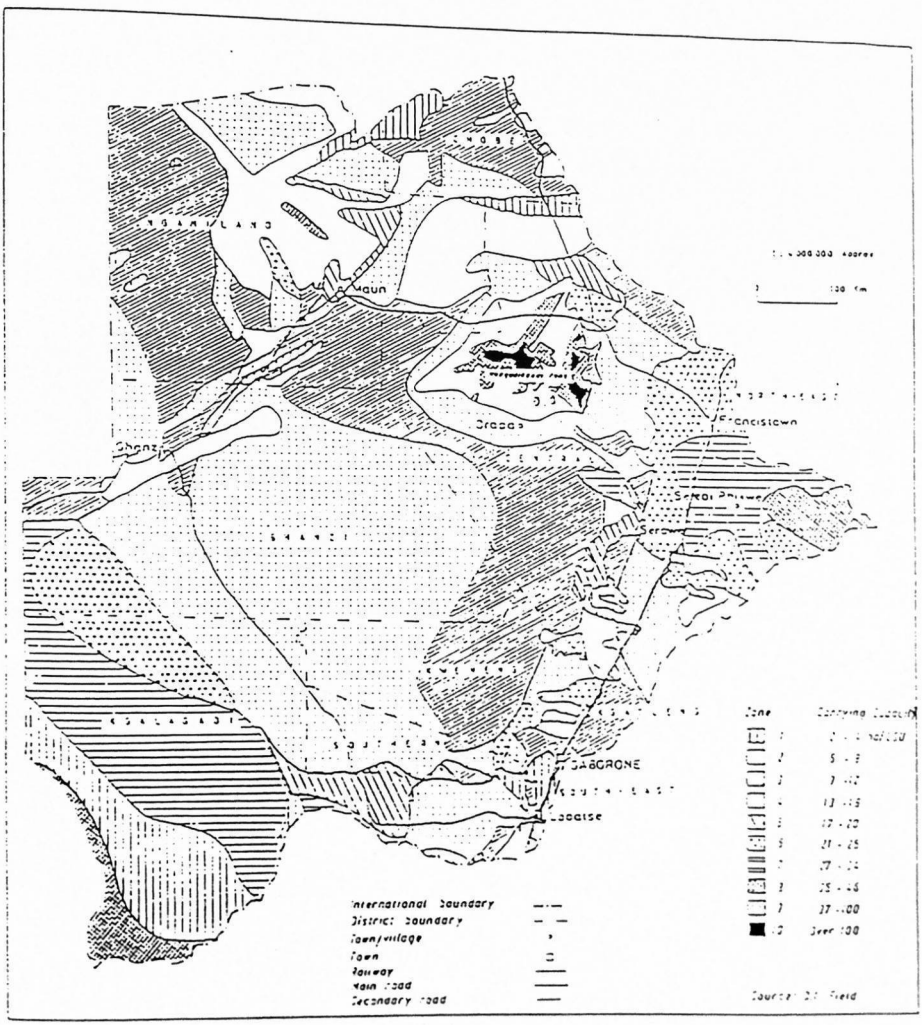


Fig A.4: Structure of MOA 1991, (NDP 7)

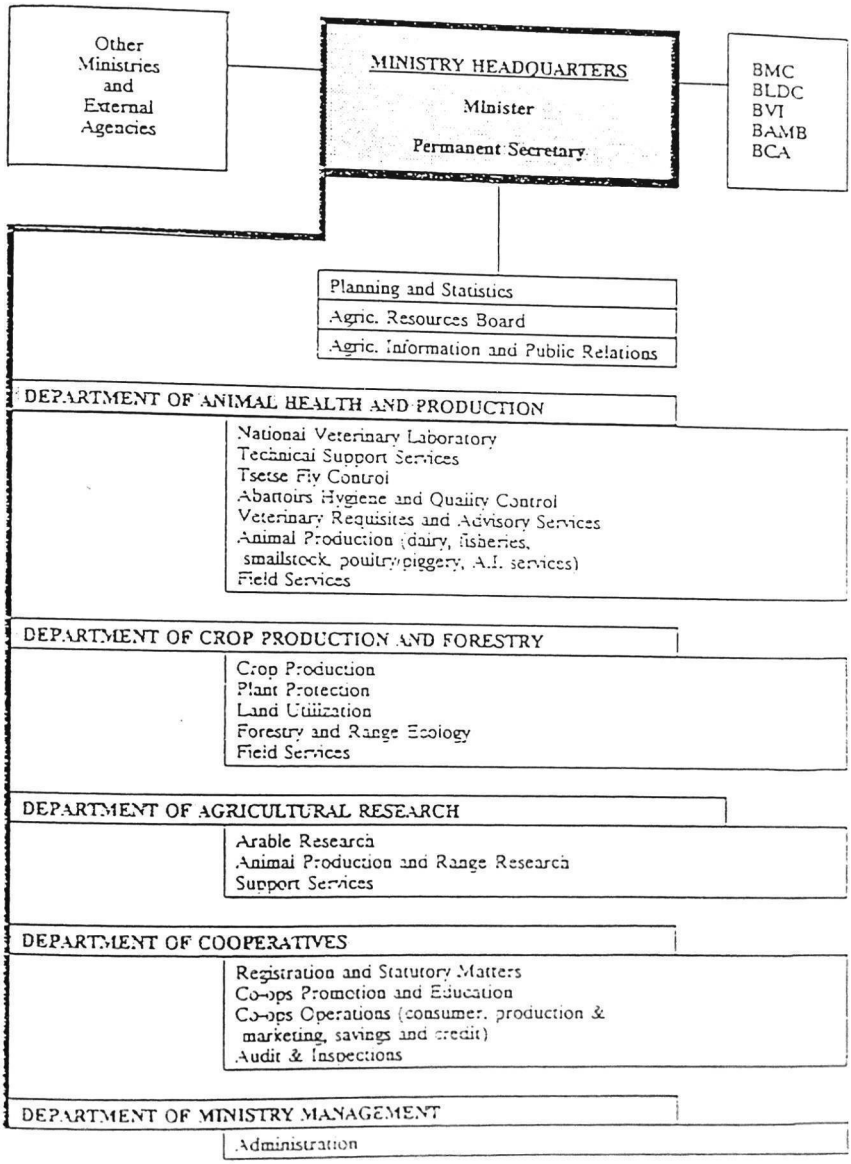
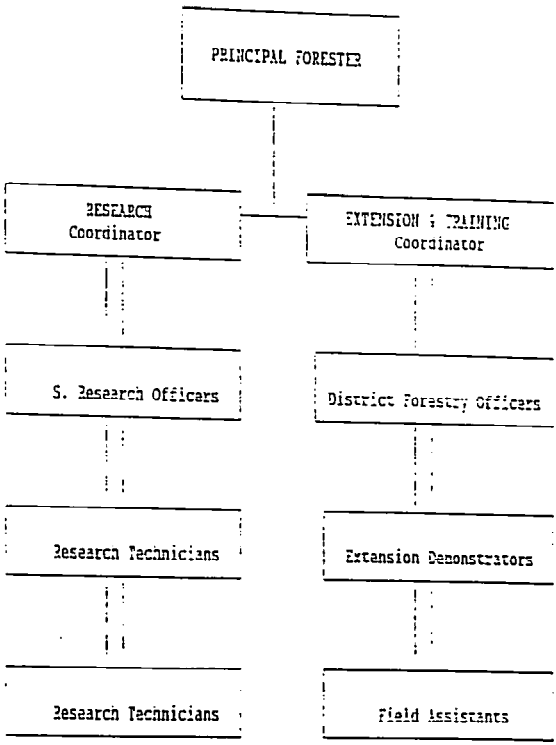


Fig A.5: Proposed Organisational chart for Forestry Division (Government of Botswana, 1992)



Map A.6: Existing and Proposed Nurseries in Botswana

Table A.7: Locations and area of Woodlots and Plantations in Botswana

Location and Area of Woodlots and Plantations in Botswana		
Location	Hectares	Comments
Forestry Unit		
Diphawana	3.7	
Francistown	25.0	Part taken over by Town Council
Gaborone	80.0	Mainly over-mature
Good Hope (1)	5.0	" " "
Good Hope (2)	41.8	" " "
Kasane	6.0	
Lobatse	20.1	
Palapye	2.5	
Phareng	4.5	
Rauthebane	34.8	
Tonota	5.0	
Tsabong	5.0	Sand dune stablisation
	233.4	
Kweneng, Rural Development Association		
Kopong	44.0	
Letlhakeng	18.6	
Molepolole (Airport)	148.0	
Ntsono	9.9	
	220.5	
Brigades etc.		
Serowe	40.0	Very poor survival
Mahalapye	1.0	
S.P. Lions/Mmadinare Cooperative		
Selibe Phikwe	5.0	Agro-forestry project
Kgatleng Development Board		
Morwa	25.0	Poor survival in parts Currently being harvested
Kgalagadi Settlements Project		
Takatokwane	6.0	
Community Schemes		
Hukuntsi	30.0	
Shoshong	25.0	
Commercial Sector		
Jwaneng	50.0	
Total area =	635.9 hectares	

Table A.8: Important browse trees,(Otsyina and Walker 1990).

Setswana name	Botanical name	Respondents %
	Zone I	
Mopane	Colophospermum mopane	77.8
Mongana	Acacia nigrescens	11.1
Mogotlho	Acacia eriolaba	44.4
Mokgalo	Ziziphus mucronata	33.3
Moselesele	Dichrostachys cinerea	22.2
	Zone II	
Mosu	Acacia tortilis	61.5
Mohudiri	Combretum apiculatum	28.2
Motlopi	Boscia albitrunca	26.9
Mogonono	Terminalia sericea	11.3
Mopane	Colophospermum mopane	16.6
Moretlwa	Grewia flava	24.4
Mogwana	Grewia bicolor	20.5
Mokgalo	Ziziphus mucronata	29.5
Moselesele	Dichrostachys cinerea	11.5
Modumela	Kirkia acuminata	8.9
	Zone III	
Mosu	Acacia tortilis	40.1
Mohudiri	Combretum apiculatum	27.2
Motlopi	Boscia albitrunca	27.9
Mongana	Acacia nigrescens	9.5
Moretlwa	Grewia flava	36.7
Mogotlho	Acacia eriolaba	17.7
Mogwana	Grewia bicolor	18.4
Mokgalo	Ziziphus mucronata	25.9
Mopane	Colophospermum mopane	21.1
Mogonono	Terminalia sericea	18.4
	Zone IV	
Mosu	Acacia tortilis	25.3
Mohuduri	Combretum apiculatum	28.0
Motlopi	Combretum apiculatum	24.0
Mogonono	Terminalia sericea	32.0
Mopane	Colophospermum mopane	38.7
Moretlwa	Grewia flava	44.0
Mogwana	Grewia bicolor	29.3
Mokgalo	Ziziphus mucronata	24.0
	Zone V	
Motlopi	Boscia albitrunca	73.3
Mongana	Acacia nigrescens	40.0
Mokala	Acacia galpinii	46.7
Moretlwa	Grewia flava	66.7
Mogotlho	Acacia erioloba	40.0
Mokgalo	Ziziphus mucronata	26.7