THE IMPACT OF PLANT PRODUCT HARVESTING ON DERRE MIOMBO WOODLANDS, MOZAMBIQUE

by

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Pectora roborant cultus recti

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I, the undersigned, hereby declare that the work contained in this thesis is my own original work and that I have not previously in its entirety or in part submitted it at any university for a degree

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Abstract

This study investigates how information on plant products can be used to incorporate local users into joint forest management planning by developing guidelines for sustainable collaborative management in Derre miombo woodland in the Zambézia Province in Mozambique. From the participatory appraisal, it was found that 46 woody miombo species were used in the five villages for at least 29 different purposes. Five of these species (*Brachystegia boehmii*, *B. spiciformis*, *Pterocarpus angolensis*, *Terminalia sericea* and *Swartzia madagascariensis*) were selected for analysis because of their multiple uses and the unknown impact of their harvesting on the future survival of those hardwood trees species.

In order to determine the impact of human resource extraction on the forest and on the dynamics of tree canopy populations an inventory of woody plants was carried out for two categories of forest land-use, namely selective harvesting and fallow land (approximately 15 years old). This was done for Golombe and Arame villages and for selective harvesting only for Mphoto village, on 23, 1-ha random selected plots in the woodland adjacent to the three villages.

The population structure of the five species *T. sericea, S. madagascariensis, P. angolensis*, *B. boehmii* and *B. spiciformis* showed different trends in each of the three villages. Size class distribution of the first tree species gave evidence that the species were being harvested for building poles.

This study has shown that, through plant species products, miombo contribute to the livelihoods of the local communities living in Derre woodlands. In this study it was found that usually more than one species were used for one product as well as most of the species being trees with multiple uses.

This study has also provided some evidence that *P. angolensis* and *S. madagascariensis* can benefit from shifting cultivation and fire, which encourages coppice regeneration. More research is required to further validate this evidence.

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Opsomming

Hierdie studie ondersoek die moontlikhede wat inligting oor spesifieke plantprodukte bied, in die betrekking van plaaslike gemeenskappe in die proses van gesamentlike bosbestuurs- en beplanningspraktyke. Verder word riglyne opgestel aangaande die volhoubaarheid van die gesamentlike bestuurs- en beplanningspraktyke in die Derre miombo bosveld, in die Zambézia Provinsie in Mozambique. Inligting verkry vanuit die deelnemende opname dui aan dat in die vyf nedersettings wat ondersoek is, 46 houtagtige miombo spesies vir ten minste 29 verskillende doeleindes aangewend word. Vyf van die spesies (*Brachystegia boehmii*, *B. spiciformis*, *Pterocarpus angolensis*, *Terminalia sericea* en *Swartzia madagascariensis)* is geselekteer vir gebruik in analises as gevolg van hul benutbaarheid deur plaaslike inwoners en die feit dat minimale inligting beskikbaar is oor die impak van gebruik van die harde hout spesies op hul volhoubare benutting en voortbestaan.

'n Opname van houtagtige spesies is uitgevoer in areas wat val in een van twee bos-grondgebruiks kategoriee nl. areas wat selektief geoes en benut word, en braaklande (ongeveer 15 jaar oud). Dit is gedoen om die impak wat verwydering van boshulpbronne deur mense op die boomkruin populasies het, vas te stel. Die opname strategie is gevolg in 23 ha persele, uitgelê in die gebiede wat die Golombe, Arame en Mphoto nedersettings omring – in die geval van laasgenoemde nedersetting is slegs die impak van selektiewe benutting ondersoek.

Die populasie struktuur van die vyf studiespesies (*T. sericea, S. madagascariensis, P. angolensis*, *B. boehmii* en *B. spiciformis)* het verkil vir elk van die drie nedersettings wat ondersoek is. Die verspreiding van grootte klasse vir die eerste spesie, het aangedui dat die spesie vir gebruik as konstruksie pale geoes word.

Die miombo bosveld plantegroei-tipe dra by tot die lewensonderhoud van plaaslike gemeenskappe in die vorm van plant produkte, in die Derre omgewing. Daar is verder gevind dat meer as een spesie dikwels vir dieselfde doel aangewend kan word en die meeste van die spesies wat benut word is boomagtig met meer as een gebruik.

In die studie is verder aanduidings gevind dat *P. angolensis* en *S. madagascariensis* kan baatvind by grondverbouings praktyke wat gereeld verskuif word en ook brande, omdat beide praktyke kreupelhout regenerasie stimuleer. Verdere navorsing word egter benodig om dié bevinding te ondersteun.

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1. Introduction

The degradation of natural forests by human activity is causing concern to governments, resource managers, environmentalists and conservationists alike (Redford 1992; Myers 1994; Hoffmann *et al.* 2000). Four of the most important factors contributing to the destruction of forests are human population pressure, weak government institutions and poor policies, open trade liberalisation and industrial logging (Laurence 1999). In contrast with commercial logging companies that harvest large timber trees, rural communities use a variety of forest resources known as non-timber forest products (NTFP)[1]. It is believed that through the management of those products, tropical forests would be better conserved (Myers 1986; Peters *et al.* 1989a; Bennett 1992). However, despite the economic value of NTFPs, a cause for concern among researchers (Hall and Bawa 1993; Peters 1996a) is the scarcity of some of these products as well as the lack of information on the impact of harvesting NTFPs on the natural resources and their sustainability. Most of the studies mentioned above were done in tropical forests, mainly in the Amazon, but the harvesting of such products is equally important in savannas and woodlands in Africa.

Human pressure, such as fires, collection of firewood, clearing for agricultural purposes, grazing and other activities (Dewees 1994) has caused a decline in miombo woodland as well as a modification of species composition and forest structure (Abbot and Homewood 1999). In Zimbabwe, Botswana, Senegal, Kenya and Tanzania, research has been done on a wide variety of products used for the livelihoods and development of the local communities (Grundy *et al.* 1993; Clarke *et al.* 1996; Campbell *et al.* 1997; Luoga *et al.* 2000), as well as on the impact of the exploitation of these products on forest structure and composition (Hall and Rodgers 1986; Tietema 1993; Lykke 1998; Kirubi *et al.* 2000). For southern African savannas in particular, there is presently little understanding of the effects of extraction of

[1] NTFP are "all biological resources except timber which are harvested from natural ecosystem or managed forests for human use" (Peters 1996b; Profound 2000).

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various forest products on the stability of populations of tree species (Shackleton 1993a; Shackleton 2001). Similarly in miombo woodland, little is known about the rates of deforestation and the impact of extraction on the population dynamics of tree species. This makes it difficult to determine whether, for a given tree species, the rate of harvesting of poles and other forest products is sustainable or not (Chidumayo 1987; Chidumayo 1989; Campbell and du Toit 1994).

Several studies have been done on the impact of human disturbance on miombo woodland. Some of these include the impact of shifting cultivation systems on regeneration (Boaler and Sciwale 1966; Strang 1974; Robertson 1984; Stromgaard 1985; McGregor 1994), the effect of burning on vegetation (Trapnell 1959; Trapnell *et al.* 1976), the impact of human disturbance on small-scale vegetation structure (Campbell *et al.* 1995) and the impact of harvesting firewood on wood species (Chidumayo 1987; Chidumayo 1989; Chidumayo 1993). Nevertheless, more studies are needed to evaluate the impact of wood harvesting by local dwellers in miombo woodland (Campbell and Byron 1996). With regard to biological conservation, researchers need to conduct their studies in collaboration with local communities rather than try to find their own solutions to improve local development (Cunningham 1996; de Boer and Baquete 1998; Cunningham 2001), by promoting collaborative management within and outside conservation areas (Vandergeeste 1996).

1.1 Use of non-timber forest products

1.1.1 Definition of terms

The importance of plants for almost every aspect of human activity is well known (Alexiades 1996). In tropical areas, knowledge of the use of forest products has been part of indigenous people's lives for many centuries (Nath 2000). Scientific studies on the extraction of tropical natural resources, such as medicinal plants, fibre, tannins, oil and nuts were published in 1910 (Worboys 1990 cited by Neumann and Hirsch 2000). Until recently, these were considered to be "minor forest products", with timber being the central product to be managed (Arnold and Ruiz-Pérez 1996).

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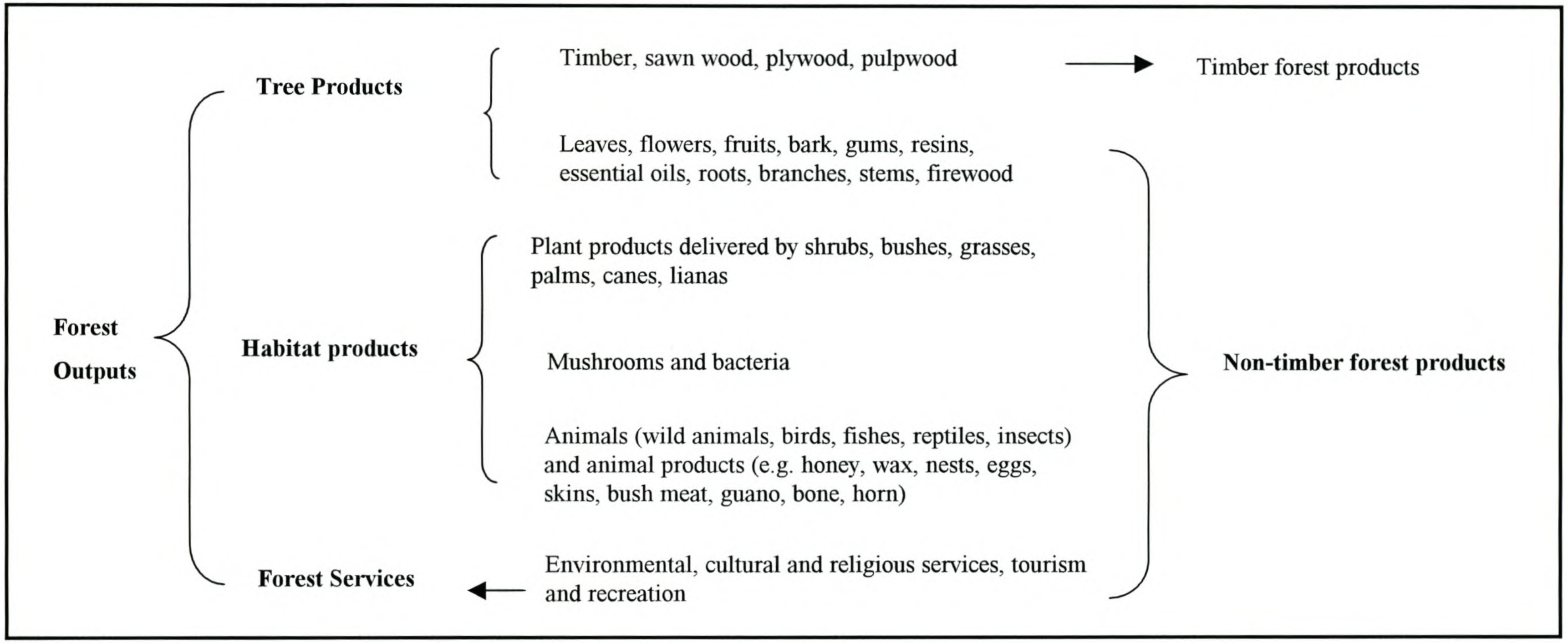

Figure 1.1 Forest outputs showing the wide diversity of non-timber forest products. These products occupy three different functional categories: tree products (individual species), habitat products (groups of individual species in different structures and patterns) and forest services (environmental, cultural and tourism). Source: Walter 1998.

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Figure 1.1 illustrates the diversity of possible forest outputs as well as the differences between timber products and NTFP. To differentiate all other biological resources from timber, two distinctions have been made by researchers: non-wood forest products (NWFPs) (Wong *et al.* 2001) and non-timber forest products (NTFPs) (Arnold and Ruiz-Pérez 1996). This study will focus on non-timber forest products, using the ethnobotanical classification by type of use (Wong *et al.* 2001). The types of forest products used by local communities vary from region to region. An example of selected NTFPs and their forms of utilisation is given in Table 1.1.

Table 1.1 Examples of sources, forms of use and selected types of non-timber forest products. (Adapted from: Peters 1996b; ProFound 2000).

Source of the resource	Form of use	Examples
Plants	Edible (plant exudates and reproductive propagules)	Fruits, nuts, seeds, tubers, leaves, oils, spices and honey
	Non- edible	Building poles, thatching grass, firewood and chemical products
Animals	Edible	Terrestrial animals, fish and aquatic invertebrates
	Non-edible	Wild animal products and live animals
Plants and animals	Medicinal products	Leaves, roots, seeds, resin, bark and animal products

Table 1.1 shows the categories of NTFPs and a wide variety of different types of products. The ecological impact of the harvesting of such products on the remaining natural resources depends on the portion harvested and the harvesting intensity (Cunningham 2001). For example the impact of fruit harvesting on the sustainable use of fruit trees differs depending on harvesting intensity (Peters 1996b). Similarly, the impact of the use of bark or sap for medicinal purposes depends on whether it is for subsistence or commercial purposes. For instance, commercialisation of turtles meat and eggs for industrial purposes may lead to overexploitation of this animal in the

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rivers of the Amazon basin (Redford 1992). Each product therefore, requires different management strategies (Peters 1996b).

The use of non-timber products does not apply only to local communities who use them for subsistence, but also to industrial production. Examples of this include the heart of palm (Pollak *et al.* 1995), the commercial use of the seven-weeks fern, *Rumohra adiantiformis* in forests in South Africa which resulted in over-exploitation (Milton 1991), and the commercial harvesting of seeds and fruits that led to sparse regeneration of some Indian tree species (Neumann and Hirsch 2000).

Conflicts between conservation and development become apparent when the intensity of harvesting products exceeds the site-specific maximum level of harvest (Peters 1996b). An example of this is when animals are regarded only as a resource for people and not as an integral ecological component of natural ecosystems (Redford 1992). Another example is the extraction of a product, which will benefit only a small group of local dwellers when encouraged, and, there is no recognition of the limits of this resource (Browder 1992). In these cases the market demand motivates unsustainable use, because the harvest rates exceeded the regeneration rates (Neumann and Hirsch 2000).

Due to a renewed interest in biodiversity and carbon sequestration in tropical forests, researchers favoured harvesting of non-timber forest products in the Amazon, above shifting cultivation (Myers 1986; Bennett 1992) and timber harvesting (Peters *et al.* 1989b; Peters 1996b), because it is considered to be more sustainable. Non-timber products may also have a market value, for example medicines (Balick and Mendelsohn 1992; Mander 1998). Local communities may also benefit from NTFP harvesting as the forest is not destroyed and the resource use may therefore be sustainable (Falconer 1996).

Local people use non-timber forest products for subsistence when they have access to little else due to the inadequate development of infrastructures such as roads, to long distances to the nearest town (Kaimowitz 1997), as well as when they do not find employment to earn money to buy alternative commodities. For this reason the most

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important aspect of the use of NTFPs is the role that they play in the livelihood of people in rural areas (Falconer 1996). Also, cultural and religious tradition influences the way of using particular plant or animal species, or group of species (Cunningham 2001).

1.1.2 Forest products in livelihoods in Africa

The African savannas and woodlands are a source of raw materials such as poles and construction materials (Liengme 1983; Hall and Rodgers 1986; Milton and Bond 1986; Grundy *et al.* 1993; Vermeulen *et al.* 1996), firewood (Ohler 1985; Grundy *et al.* 1993; Shackleton 1993a), medicines (Jansen and Mendes 1984; Cunningham 1995; Cunningham 2001), wild food (Malaisse 1978; Lawton 1982; Campbell 1987) and implements (Clarke *et al.* 1996). Numerous researchers in the last two decades have shown the importance of woodlands to rural livelihoods (Clarke *et al.* 1996; Campbell *et al.* 1997; Chidumayo *et al.* 1997; Grundy *et al.* 2000).

The major woodland products are firewood and poles. The criteria of the species preferences for building poles depend on factors like high tensile strength and termite and fungal resistance, as well as durability (Muir 1990; Grundy *et al.* 1993). The type and size of poles also vary depending on building styles. Poles for walls are heavier than those used for roofing and thus canopy tree species are preferred (Muir1990). Choice of species depends on the available species within each biome. Women usually collect fuelwood on their way home after their work in the fields (Leingme 1983). Dead wood is usually preferred for firewood (Liengme 1983; Abbot and Homewood 1999) and the species used depends on availability and the distance from the wood source (Grundy *et al.* 1993).

Roots, leaves, bark and sap from a wide variety of plants are used for medicinal purposes (Jansen and Mendes 1984; Cunningham, in Brigham *et al.* 1996). Miombo woodlands also provide a wide variety of wild foods such as fruits (Campbell 1987; Grundy *et al.* 1993), mushrooms, tubers, insects, leaves and roots, small mammals and birds (Clarke *et al.* 1996), most of which are consumed during periods of

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seasonal food stress (Campbell 1987). Wood is also harvested for use as implement handles and tools such as hoe and axe handles, and pestle and mortars (Clarke *et al.* 1996).

The selective exploitation of a large number of non-timber forest resources can have long term ecological impacts. The level of this impact depends on species composition, type, nature, time and intensity of the resource harvested. However, information on the ecological impact of NTFP harvesting on natural resources is limited. For example, a particular species or group of species can be severely depleted by reducing the establishment of seedlings or disrupting local populations of animal dispersants (Peters 1996a; Peters 1996b).

1.1.3 The Impact of extraction of non-timber forest products on natural resources

While animals also form part of the NTFPs and are an integral ecological component of any forest ecosystem, this study will focus only on plant resources. In order to ascertain the impact of harvesting a NTFP one has to take into account the particular type of product, the species, the part of the plant that is used, its structure, floristic composition, and also the characteristics of the specific type of forest (Peters 1996b), such as whether it is tropical rainforest or African savanna. Just how vulnerable plant species are to harvesting depends on their ecological characteristics, such as reproduction, recruitment, growth and mortality (Cunningham 2001; Wong *et al.* 2001), as well as their ability to resist or benefit from disturbances (Medley 1993).

The impact of harvesting NTFPs depends on what is being harvested. Collecting mushrooms or tubers that appear seasonally would differ from cutting a female tree for commercial fruit purposes, as done in the Peruvian Amazon (Peters 1996b). This, in turn, would differ from the harvesting of bark for medicinal purposes (Cunningham 1995) or the selective harvesting of the stems of young live canopy trees for construction poles (Hall and Rodgers 1986). In Malawi, the use of domestic firewood and building materials by local people in miombo woodland is likely to have less impact than the commercial harvesting of firewood (Abbot and Homewood 1999).

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1.2 Miombo

Miombo woodland, which occurs only in Africa (Frost 1996), extends through parts of Angola, southern Zaire, Zambia, Malawi, Zimbabwe, Tanzania, South Africa and Mozambique. This woodland has been differentiated into savanna (Rutherford and Westfall 1994), Zambezian phytoregion (White 1983) and forest (Malaisse 1978). The diverse sub-classifications are made on the basis of physiognomy, structure and functionality with the interaction of many climatic factors at a regional level, as well as vegetation, soil and various types of disturbances at a local level (see Frost in Campbell *et al.* 1996). These habitat factors usually influence and gradually change the natural vegetation composition (White 1983). Despite their diversity, the common feature among these miombo woodlands is the dominance of three genera: *Brachystegia – Julbernardia – Isoberlinia*, (all Fabaceae, subfamily Caesalpinioideae) (Frost in Campbell *et al.* 1996).

These woodlands are classified into wet and dry miombo, characterised by more or less than 1000 mm mean annual rainfall respectively (White 1983). Approximately two-thirds of the region falls into the Köppen C*w* climatic class, which is indicative of a warm climate with a five to seven month hot wet season, and a dry winter (Frost 1996).

The miombo tree species have some characteristics that make them different from other forest tree species. They are largely fire-tolerant, although the shoots of the annual seedlings die back when burnt (Trapnell 1959; Boaler 1966; Robertson 1984). The seedlings sprout from the roots in the year following die back (Chidumayo 1991). In his earlier studies Trapnell (1959) suggested that above ground shoot die back provided the seedling with a defensive system against burning.

Later, Chidumayo (1991) thought that annual shoot mortality might be associated with nutritional stress factors during the early stages of establishment and root development, or due to drought. Chidumayo (1992a) found that slow shoot growth in early years was a result of the allocation of most of the biomass to root growth during the development of the seedling, or because of water stress (Chidumayo 1992b).

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Another feature that distinguishes miombo from other dry tropical woodlands and forests is the number of tree species that have ectomycorrhizae. Many fungus species are found in miombo woodlands, some of which are edible (Malaisse 1978; Frost 1996). Most of the tree species are frost intolerant (Chidumayo 1997). There are also differences in nitrogen-fixing capacity between canopy and under-storey species, with understorey species found to have greater N-fixing ability (Frost 1996).

Many miombo woodland tree species have sparse crowns, small pinnate or bi-pinnate leaves, and two-year fruiting intervals (Malaisse 1978), with explosively dehiscent pods (Strang 1966). Most of the dominant species are insect pollinated and dispersed (Frost in Campbell *et al.* 1996). This type of vegetation is generally known for its great number of endemic tree species (White 1983), as well as some endemic birds (Rodgers *et al.* in Frost 1996).

1.2.1 Ecology and dynamics

In studies of vegetation dynamics, Lawton (1978) described Zambian miombo as deciduous woodland with a closed canopy, shrub and grass layers. Furthermore Chidumayo (1997) differentiated miombo woodlands in Zambia more specifically into five subtypes, all with a common dominance of the genus *Brachystegia* in the canopy layer. Researchers have found that the different spatial patterns in the miombo woodlands were a result of a variety of factors including different land-use practices (Stromgaard 1985; Campbell *et al.* 1995), differences in fire tolerance within tree species (Trapnell 1959; Lawton 1978) and variations in soils (Childes and Walker 1987; Grundy 1995). Termite mounds of varying size, density and frequency are one of the main features of miombo. They are colonised by a rich flora distinct from that of the surrounding areas, which usually forms an attraction for birds and other animals (Trapnell *et al*, 1976; Malaisse 1978; Campbell *et al.* 1988; Frost 1996).

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The clearing of the original vegetation for intensive agriculture, timber logging, road building, long-term grazing, mining operations (Contreras-Hermosilla 2000), firewood and charcoal production (Abbot and Homewood 1999; Kirubi *et al.* 2000), expansion of commercial agriculture (Paulson 1994) and rapidly growing human populations (Sai 1984) have all had negative impacts on the world's natural vegetation including miombo woodlands. Therefore, it is essential to know how all these factors relate to miombo woodland dynamics and how human disturbances affect this vegetation type.

1.2.1.1 Effects of disturbance on woodland dynamics

Disturbance is a process that removes organisms from within an ecosystem and opens up gaps that can be colonised by individuals of the same or different species (Begon *et al.* 1996). The size of the gap results in a distinct species composition in the next cycle (Whitmore 1989) where neighbouring trees usually fill the smaller gap and the larger gaps lead to the establishment of shade-intolerant trees (Deshmukh 1986).

There are factors that distinguish different types of disturbance (Sousa 1984), for example fine- and coarse-grain disturbance (Spies and Franklin 1989) of human or natural origin (Begon *et* al 1996). Coarse-grain disturbances are those that create large gaps such as those created by elephants in the Budongo rain forest (Eggeling 1947) and in woodlands in Tanzania (Barnes 1985). Hurricanes, landslides (Deshmukh 1986), and earthquakes (Veblen *et al.* 1980) are also coarse-grain disturbances. Fine – grain disturbance are the small gaps created in closed forest, due to pathogens or the wind (Spies and Franklin 1989).

Tropical rain forest is driven by shade-tolerance. Differently in miombo, shade tolerance may not be sufficient criteria for determining the grain of natural disturbance Grain is a concept that reflects the scale of dynamic processes within forest communities, with the result that forests can be classified as either fine-grained or coarse-grained (Everard *et al.* 1995). Coarse-grained forests comprise monospecific tree cohorts that emerged in response to a medium to large-scale disturbance such as fire or clear-felling.

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In studies on *Brachystegia,* researchers concluded that these species require the shade of other species from the sapling stage until they reach a mature woodland canopy stage (Lawton 1978; Grundy *et al.* 1994). Continuous recruitment of these species can therefore be expected in undisturbed forest, and continuous recruitment gives forest communities a fine-grained texture. Nevertheless in the miombo woodlands the dominant tree species (*Brachystegia* sp. and *Julbernardia* sp.) grow better from root suckers or coppice shoots than from seedlings (Strang 1966). It can not be considered fine-grain texture. The current knowledge of the dynamic nature of miombo woodland is not sufficient to produce sustainable collaborative management plans. More research is necessary.

Disturbance patterns are differentiated by type, size, intensity, duration and frequency (Loehle 2000), and are influenced by the response of organisms to the disturbance (Sousa 1984). Some of the evolutionary consequences of disturbances are fairly well understood (Lytle 2001).

Tree species in tropical rain forests may be grouped as climax or pioneer species (Swaine and Whitmore 1988). Tree species may also be arranged into a competitive hierarchy according to their tolerance of shade in forest (Everard *et al.* 1995). In the woodlands, examples of succession in gaps are the establishment of the wind-dispersed seeds of *Terminalia sericea* (Strang 1974), and the fire-tolerant canopy tree *Pterocarpus angolensis* (Trapnell 1959; Boaler 1966; Lawton 1978), both of which are considered miombo pioneer species (Boaler 1966). A better understanding of the of miombo woodlands dynamics will help to fine tune the measurement of the tolerance to fire, annual shoot die-back and sprouting.

Cultivation practices, fire and clear-felling for firewood production are some of the main disturbances that favour the spread of miombo woodland by maintaining a sub-climax state (Lawton 1963; Boaler 1966; 1978; Chidumayo 1993). The reaction of miombo woodland species to gaps created by shifting cultivation and fire has resulted in opposing viewpoints in the literature, with some authors being of the opinion that miombo woodlands can be fire-climax communities (Lawton 1963; Malaisse 1978)

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while others believe that there is no evidence for fire sub-climax communities in miombo woodlands (Trapnell 1959).

Shifting cultivation is a widespread agricultural technique, mainly used for subsistence, where the original vegetation is removed, cut and burned, thereby opening gaps in the canopy layer, but the environment remains intact (Lawton 1982; Deshmukh 1986). If the stumps and larger roots are not removed in fallow land, a shrub savanna will tend in the direction of woodland again (Strang 1974), due to the vigorous coppice re-growth from stumps, and sucker regeneration from roots (Trapnell 1959).

The stumps of most of the trees remain (Trapnell 1959), as well as some fruit trees (Campbell 1987) or other special trees of cultural or medicinal value (Grundy *et al.* 1993). However, growing human populations can result in too short a fallow period so that the system can no longer sustain itself (Lawton 1982).

The regeneration of tropical pioneer trees usually occurs from fresh seeds or coppice shoots and root suckers (Deshmukh 1986). Regeneration from fresh seeds is, however, unusual in the miombo in Tanzania (Boaler and Sciwale 1966) and Malawi (Robertson 1984), where the regrowth of woody vegetation is mainly from suffrutices.

Boaler and Sciwale (1966) investigated succession on fallow land in Luba and Kabungu in Tanzania. There, woody regeneration after cultivation starts with an increase in the density of high grass. Consequently, for at least 10 years, fires are fiercer than in undisturbed woodland. The woodland regeneration may be burnt back until the re-growth is vigorous enough to survive fire (Lawton 1963). The grass competition then decreases as the saplings overtop it (Strang 1969) and the saplings produce a thicket that reduces fire intensity. The duration of this phase is between 10 and 20 years depending on the density of sapling growth (Boaler and Sciwale 1966). The invasion of grass occurs again in this stage when the saplings are tall enough to allow grass to grow underneath, until the balance between grass and woody regrowth

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is reached in mature woodland (80 to more than 100 years after the disturbance) (Boaler 1966).

Abbot and Homewood (1999) found that the commercialisation of firewood for fish smoking, which involved the cutting of the canopy species, has a much greater impact and was the main cause of the declining miombo woodland at Lake Malawi National Park. Similar studies have been done in Zambia on the deforestation of miombo woodlands for industrial and domestic firewood (Chidumayo 1987; Chidumayo 1989). Later studies have found that the coppicing ability and the presence of a seedling pool in the herb layer of cut trees guarantees prompt recovery (Chidumayo 1993).

Much research has been done on forest clearing for agricultural purposes and clear felling, although fewer studies have been done on the impact of small-scale changes in forest structure and the composition of species caused by products collected by rural communities (Hall and Rodgers 1986). There is also only limited information on the quantities and frequencies of NTFP harvesting that is considered sustainable (Grundy 2000). Firewood collected for subsistence usually consists only of small dead branches. This has less of an impact on the resources than the harvesting of building poles (Hall and Rodgers 1986; Muir 1990). More studies are needed to understand the influence of such disturbances on miombo woodland vegetation.

1.2.2 Conservation and sustainable use

Conservationists have in the past used an exclusive, preservationist approach to forest and woodland management, where the aim was to protect nature from any human exploitation (Vandergeest 1996; Meffe and Carroll 1997). Wherever this approach did not take into consideration the needs of local land users it has frequently been found to be ineffective (Fiallo and Jacobson 1995; Meffe and Carroll 1997). In Thailand, for example, conflicts between park managers and forest dwellers have increased to such an extent in some areas, so that all conservation efforts have failed (Vandergeest 1996).

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The non-involvement of local communities in forest management can cause them to have a negative attitude towards conservation efforts and the enforcement of conservation-related regulations (Heinen 1996). This was the case in the Budongo Forest Reserve in Uganda, where rural people have not been allowed officially to collect any products from the forest for many years (Obua *et al.* 1998). Similarly, in Nepal's Royal Chiwan Park, the communities struggle to survive and grow their crops because tigers and rhinos are protected in this area (Mishra 1982). However, in circumstances where species have a low geographical range and are more sensitive to human activity, such as forest-specific butterflies and snakes, the preservation of undisturbed forests is an important part of their survival (Chongo *et al.* 2001).

Social variables such as population density, degree of ethnic heterogeneity and economic opportunities (Heinen 1996), as well as anthropological, religious, educational and cultural issues (Meffe and Carroll 1997) are important factors for managers to consider in collaborative conservation management plans (Heinen 1996). Moreover, the decision to remove products from tropical forests should be assessed both in terms of their sustainability and their impact on the ecosystem (Boot and Gullison 1995). To ensure the conservation of biodiversity, it is necessary to incorporate harvesting practices and preferences for local species into management plans so that these plans can be better understood and more readily accepted by local communities (Lykke 1998). However, until the impact of harvesting NTFPs on species dynamics is understood, this strategy remains just a theory.

1.2.2.1 Strategies for sustainability

The primary management objective of any collaborative programme with local communities should be to encourage biodiversity conservation while still promoting a balanced use of non-timber forest products (Infield 1988; Neumann and Hirsch 2000). This sustainability is achieved when it is based on economic interests (Schröder 1998) as well as on the co-operation of local communities. This objective is attained through activities such as the environmental education, the creation of economic alternatives to a predatory use of natural resources, the long-term social and economic monitoring

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(Fiallo and Jacobson 1995), and the implementation of certification system (Lewis and Alpert 1997).

While monetary incentives for conservation can be used as a method of encouraging better practice, by itself is not a sustainable method. When the incentive funds run out, the risk of depleting natural resources is very high. Monetary incentives for biodiversity conservation should be used in parallel with other approaches (Bean 1997 in Meffe and Carroll 1997). In particular, local communities should actively participate in the management of natural resources. Kirubi *et al.* (2000) recognized the importance of this point. Referring to arid and semi-arid lands of Kenya, these authors assert that local communities can only really be included in management plans by participatory and holistic methods.

The goodwill and an active participation by local communities in the natural resources management is not enough to achieve the sustainability goal. It should be complemented by a research work on the local flora. Information on vegetation composition and tree-size class distribution can be used to develop a dynamic framework aimed at understanding what levels of disturbance could be sustainable, in terms of preventing the depletion of vegetation (Everard *et al.* 1995).

In general, the consensus is that cooperation between different institutions such as the state, local communities, researchers and the private sector is needed if conservation efforts are to be successful (Bean 1997 in Meffe and Carroll 1997; Obiri *et al.* 2001). This idea is particularly relevant in countries where the public sector lacks the capacity to manage woodland areas efficiently. By considering the dependency of rural communities on the products from the woodlands, researchers have recommended that the most effective way to manage these areas, so as to prevent the complete loss of resources, is to empower local communities (Dewees 1994), in planning, executing and monitoring the local flora conservation.

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1.3 Review of methods for woodland resource assessment

A review of methods to determine resource assessment and resource use is described in the following subsections.

Participatory research is the ideal process to overcome the shortfalls of documenting cultural data by recording plant use and considering biological aspects such as the collection of plant species for taxonomic identification (Prance 1991 cited by Alexiades 1996). Participatory rural appraisal (PRA) allows local communities to gain control of the research process, while the researcher takes on the role of a facilitator who creates channels for people's knowledge and creativity (Alexiades 1996). By encouraging local people to actively participate in the investigation using mapping, modelling and ranking processes and allowing them to take the lead in expressing and analysing information, they become more aware of their surroundings (Chambers 1997). This could mark the beginning of the involvement of local forest-dwellers in the process of woodland management. While local people can be involved in collecting data and in discussions of the interpretation of the results, it is also imperative to maintain the scientific rigour of the ecological methods used (Abbot and Guijt 1998).

A questionnaire is a common research tool used in social sciences, where the same questions are asked to all respondents (Babbie 2001). This is also utilised when studying the behaviour of people with regard to their use of natural resources and the quantification of products used (Grundy *et al.* 1993), land degradation (Ward *et al.* 2000), economic valuation and improvement of livelihoods in African countries (Turpie *et al.* 1999), and needs and attitudes of rural people to conservation issues (Obiri *et al.* 2001). Qualitative methods allow a variety of different research strategies and data collection techniques to be used. For example, data can be collected in the form of words or pictures. Quantitative methods, on the other hand, are used to collect data in the form of numbers. These methods are complementary (Neuman 1999), and it is important to crosscheck information with different people using different methods (Cunningham 2001).

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In the absence of any information about the type of vegetation, species composition, species distribution and vegetation structure, a wood species inventory is a tool that provides baseline information about the forest or woodland which can be incorporated into management planning (Philip 1994). For the ecology and management of non-timber forest products, it is crucial to know the level of disturbance and the level of product extraction from the forest, in order to minimize the degradation of the tropical forest (Peters 1996b).

1.4 Problem statement

Mozambique has about 52 million hectares of woody vegetation, including woodland, mangroves and man-made forests, which cover about 66.79 per cent of the entire territory (Saket 1995). It is estimated that about 4.5 per cent of the forest has been destroyed by deforestation in the period from 1970 to 1990 (World Bank 1996). For more than 16 years there was civil war in the country with people moving from the rural areas to safer parts around the cities and along the coast, causing a localised decline in forest and woodland resources (Saket 1994). Subsequently, during the period of transition to peace, people moved back to the rural areas, clearing the land for agriculture, which resulted in more widespread deforestation (World Bank 1996). Most of the people still depend on the forest and woodland for firewood, building materials and timber, as well as on the land for agricultural purposes (Saket 1994). With the trend to increase shifting cultivation within the forests all over the country, the rate of deforestation is expected to rise (Saket *et al.* 1995). In Mozambique's miombo woodlands, little is known about forest dynamics, disturbance regimes or life history of individual species.

Miombo woodland is the most extensive vegetation type in Mozambique and occupies an area of 19 158 000 ha or 24.33 per cent of the country. It makes an important contribution to the livelihood of the local communities and the economic potential of the country (Saket *et al.* 1995). Most of the natural resources are under free access without any effective control (World Bank 1996). The country has 17 forest reserves but information regarding reserve boundaries and resources is scant and often

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incomplete (DNFFB 1997). The lack of information on forest processes makes it difficult to know what level of utilisation is sustainable (Everard *et al.* 1995). Moreover, little is known about the impact of NTFP utilisation on forest resources (Padoch and Pinedo-Vasquez 1996) and on the structure and function of tropical ecosystems (Neumann and Hirsch 2000).

Until 1998, the forestry law in Mozambique did not provide for any participation of local communities in forestry and wildlife management planning. However, in 1999 a new law was approved and one of the national priorities is now to construct and implement management plans with the collaboration of local communities (DNFFB 1999). Both local communities and the state will beneficiate maintaining a conserved area as long as these areas will be under management plans. It is necessary not only to understand the mechanisms for sustainable management of natural resources, but also to contribute to enrich the knowledge that will improve collaborative woodland management, and increase rural livelihood strategy options.

1.5 Objectives of this study

The general aim of this study was to investigate how information on specific non-timber forest product can motivate local users to participate in joint forest management planning. This information will be used to develop guidelines for sustainable collaborative management in miombo woodland in Mozambique.

The specific objectives of this study was:

a. To prioritise different non-timber plant-derived forest products from miombo, which are used by local people.

b. To assess the impact of harvesting building poles of selected species on woodland structure.

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The hypotheses are that:

a. Local people selectively harvest plants from the woodland.

b. Local people are sustainably harvesting building poles of selected woody species.

The research questions to be answered was:

1. Which non-timber forest species and products are used by the people?
   i. Which social and economic benefits do non-timber forest products provide for local communities?
   ii. How important are NTFP's in people's lives?
   iii. Do local communities differ with regard to the species or plant parts harvested for particular purposes?
2. What impact does the harvesting of building poles have on woodland structure and species composition in miombo?
   i. Is there evidence that the harvesting of building poles of selected species influenced their size class distribution?

1.6 Overall thesis structure

The thesis comprises a general introduction followed by four chapters. The second chapter describes the study area and methods where the impact of non-timber forest product harvesting on resources is investigated in two sections: woodland use, and resource assessment. In woodland use section, the species and products used by inhabitants are collected, and in the second section, resource availability is studied by assessing population structure of selected species. In the third chapter the results are presented in two sections, namely woodland use focusing on five tree species used for building poles, and the population structure of these five species. In the fourth chapter the results regarding the value of the woodland species and the sustainability of the selected woodlands species is discussed. The fifth chapter gives conclusions and some guidelines for collaborative reserve management.

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2. Methods

Derre Forest Reserve is described in this chapter. In order to investigate how information on non-timber forest products can be used to incorporate the local community into joint forest management planning, the second part of this chapter is subdivided into two sections. In the first section, the methods, both qualitative and quantitative, used to document woodland use are described. In the second section an inventory of woody plants in the areas surrounding the three villages was studied so as to determine the impact of human resource extraction on the forest and on the dynamics of tree canopy populations.

2.1 Study area

Derre Forest Reserve (16,98° - 17,56° S; 35,78° - 36,27° E) is situated in Zambézia Province, towards the northern part of Mozambique, approximately 209 km northwest of Quelimane, the provincial capital (Fig 2.1). The closest administrative centre is Derre Administrative Post in Morrumbala District. The Reserve, which was gazetted in 1957, occupies 170 000 ha of woodland dominated by trees of the genus *Brachystegia* (Gomes-e-Sousa 1968). These trees form part of White's Zambezian miombo woodland (White 1983) and grow in association with other species such as *Julbernardia globiflora*, *Pterocarpus angolensis*, *Burkea africana* and *Dalbergia melanoxylon* (Saket 1994).

The road from Mocuba to Morrumbala forms the northern boundary of the Forest Reserve, which is limited by the Luala River in the East and the Lima River in the West. This woodland is located in the middle of a plateau with an elevation ranging from 200 to 500 m.a.s.l. The average annual rainfall in the region is 800 mm, with a summer wet season extending from November/ December until March/ April (Dejene and Olivares 1991). Mean daily temperatures were 23.5 ^{0}C for 16 years, at the

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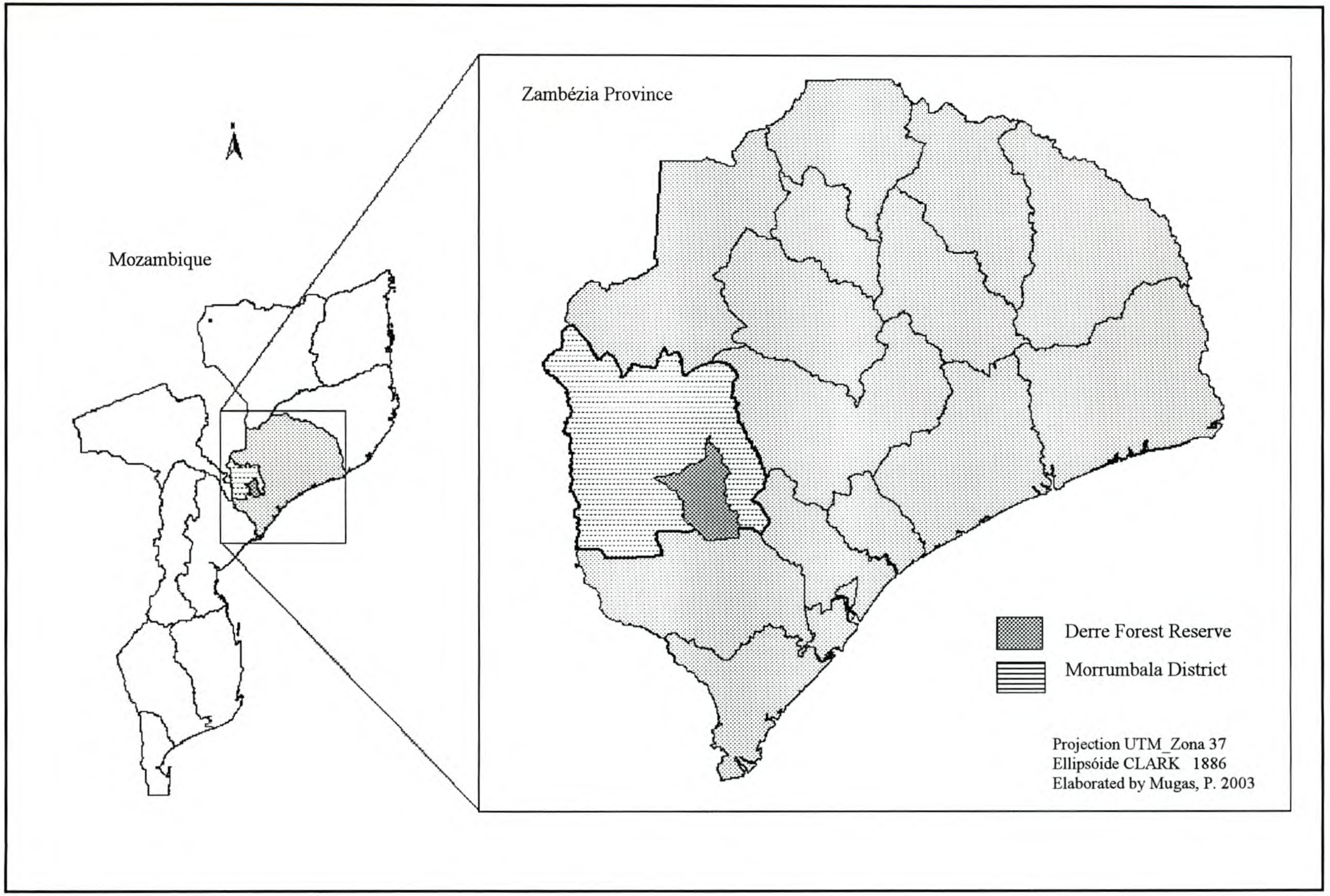

Figure 2.1 Derre Forest Reserve in Zambézia Province, eastern Mozambique.

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meteorological station at Morrumbala, approximately 90 km to the west of the Derre Forest Reserve (Kassam *et al.* 1981).

The Derre Forest Reserve has a long history of disturbance through human pressure (Gomes-e-Sousa 1968). Local communities have been living within the Reserve for an extensive period of time, practising itinerant agriculture and harvesting products for subsistence use. Additionally, the illegal harvesting of selected timber species (*Pterocarpus angolensis* and *Swartzia madagascariensis*), promoted by outsiders, has been uncontrolled in the past. No management plans have been implemented, and the impact of miombo product harvesting on vegetation composition and dynamics remains unknown.

The results from the most recent census show that the total population in Zambezia Province was 2 891 809 in 1997 (INE 1999). During the civil war in Mozambique, the human population within the study area was displaced. Some left the District and others moved from one place to another. Currently there are approximately 20 000 people living in the Reserve, many of whom practise the traditional slash and burn cultivation typical of miombo regions (see Lawton 1982; Stromgaard 1984). The common languages of the local inhabitants are Lóló (a mixture of the Chuabo and Sena languages), Irobe and Marendge. The Government's Provincial Forest and Wildlife Services in Quelimane administer this Reserve, and a local community-based organisation, ACODEMAZA[2], is also involved.

The houses built within the forest are scattered and grouped according to families. They are similar in the three villages, in general square or rectangular in shape and covered with mud on the walls. The mud prolongs the lifespan of the wall poles. The number of wall poles is usually less than the number of roof poles. The material used for walls and roofs is in most cases different. The diameter of roof poles is smaller than that of wall poles. Roof poles are mostly made of bamboo and raphia leaves divided in four parts, and covered with thatch. The structures are similar to those found in the

[2] Associação de Conservação do Meio Ambiente da Zambézia.

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miombo of eastern Tanzania (see Luoga *et al.* 2000), but differ from those found in Gazankulu (Liengme 1983).

For the first phase of this research, five villages were studied: Golombe, Gida, Arame, Matícula and Mpotho village. Due to time constraints, only three villages were studied for the second and third phases of the study. The criteria used to select the tree villages were the distance from the main road, the distance from the infrastructures, the proximity to the woodland, and the range of woodland products utilized. The latter three villages, Golombe, Arame and Mphoto, are located 24 km; 38 km and 35 km respectively from Derre Administrative Post (Fig. 2.2). The villagers of Arame have less access than the inhabitants of other two villages to the health post, school, market, transport and other facilities. Gida and Golombe, two of the villages inside the Derre Forest Reserve have quite similar conditions, and then only one was selected. The villages Matícula and Mphoto are both outside of the Derre Forest Reserve, and both of them are situated on both roadsides, with quite similar conditions. For that reason only Mphoto village was selected.

2.2 Data collection and analysis

The research was conducted in three phases. In the first phase, Participatory Rural Appraisal was applied to investigate which products and plant species from the woodlands were essential to local communities. For the second phase, a formal questionnaire was administered to collect quantitative data based on the products and plant species provided in the previous phase.

The last phase of the research was to compile an inventory of woody plants in the areas surrounding the three villages studied, so as to determine the impact of human resource extraction on the woodland and on the dynamics of tree canopy populations.

Data were collected to establish woodland use and to make an assessment of resources. In each of the following sections the application of the technique or method used is explained and linked to specific research objectives.

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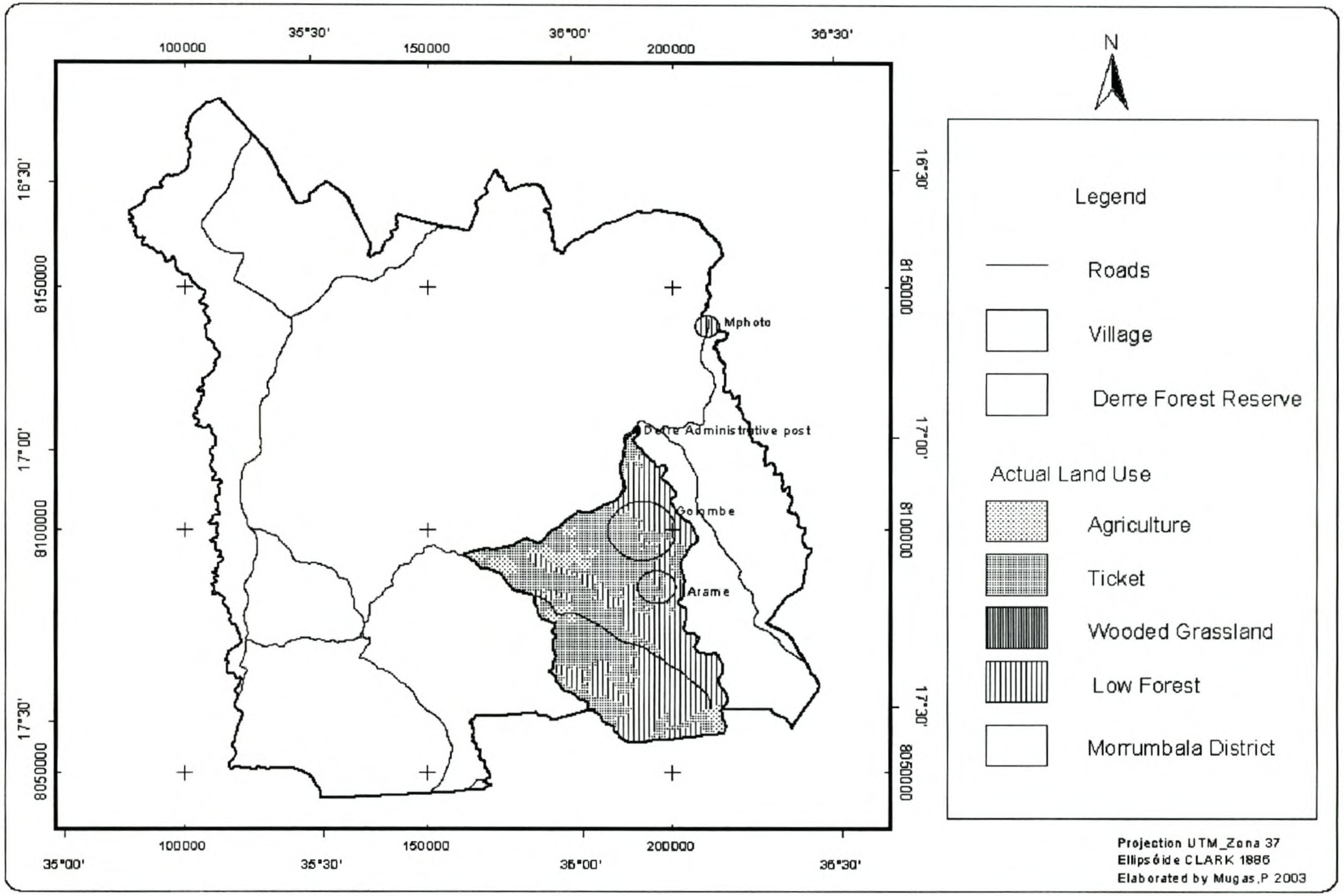

Figure 2.2 The three villages studied, Golombe, Arame and Mphoto.

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2.2.1 Woodland use

2.2.1.1 Participatory Rural Appraisal

Participatory data collection methods were used to document the range of uses and plant species of non-timber forest products. Participatory Rural Appraisal was carried out in five villages: three within the Forest Reserve and two outside. These were Golombe, Arame, Gida, Maticula and Mphoto respectively. The process took five days, one day per village. Participatory mapping, matrix ranking of product use and key informant interviews were used. Questions were asked in either Portuguese or Lolo, or both. The matrix ranking was done by drawing a table on the ground to determine the most important products used for a wide range of categories, as well as species preferences for these products.

This study focused on five of the most used tree species by the villagers, namely *Brachystegia boehmii*, *B. spiciformis*, *Pterocarpus angolensis*, *Terminalia sericea* and *Swartzia madagascariensis* (see Appendix 1). The future survival of these species depends on how they are harvested. These trees are used as building poles, for firewood, to make medicinal products, and to extract honey. From this group of five, four are trees of the canopy and three are valuable as timber species.

2.2.1.2 Questionnaire Survey

An investigation of human demographic trends in each village may help to predict the level of harvesting of building poles, to determine harvesting consequences and to predict the future use of NTFPs.

Based on the results of the participatory matrix ranking, four products and five plant species were selected as the focus of the questionnaire (Appendix 2). To document the trends of five species harvested, a survey was administered at random to inhabitants from three of the villages. Two of these villages were inside and one outside the Forest Reserve. These were Golombo, Arame and Mphoto respectively. Prior to administering the survey, one semi-structured meeting was held in each village in order

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to finalise and test the questionnaire (Appendix 2). Women, men, old and young, supplied answers.

A random sampling design was used to ensure a representative sample of the human population (Bulmer 1993). The absence of a "Sampling Frame" (list of households in this case) can be a problem in many developing countries (Bulmer 1993). To overcome this problem, the names of all families were taken during the first meeting, and each name was written on a piece of paper. These were placed in a bag and each person present at the meeting was at random asked to take one piece of paper out of the bag. The first 40 families' names collected in each village were the families chosen for the survey. Two teams, consisting of two people each, administered the questionnaire. All but one of those administering the survey was from the sample villages, and frequently the questions were asked in the local language, despite the questionnaire being in Portuguese.

The analysis was performed using Statistica' 99 and SPSS software. Data were imported into the worksheet from Microsoft Access and Excel. Not all data were normally distributed after transformation, and in such cases the Kruskal-Wallis ANOVA was used to test differences between villages (Zar 1999). The main parameters used for the analysis were the three villages, the number of people in each household, the number of products used for personal consumption, the number of years that pass between renewal of wall poles in the houses, and the number of wall and roof poles used per house by each household.

Assumptions:

- It was assumed that the number of persons per household can influence the size of houses and, in turn, the number of building poles used to construct the house.
- The second assumption refers to the high percentage of young people. This would significantly increase the number of new houses built and the size of new areas cleared for agricultural purposes, in the future.

To compare the strengths of the preferences that people showed for building poles of various species, the Chesson's selectivity index was used (Manly *et al.* 1993).

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2.2.2 Resource Assessment

To assess the impact of the harvesting of stems of the young woody species for construction poles on the woodland structure, adjacent to the three villages (Golombe, Arame and Mphoto) an inventory of woody plants was made before the start of the wet season. The inventory was planned on the basis of an existing topographic map (1: 50 000), a satellite image and geographic information system (GIS) facilities at the government Forest Inventory Unit, Maputo.

A random sampling design using a grid overlay was employed for statistical rigour, despite disadvantages, such as difficulty in locating the plots in the field and time spent travelling from one plot to the other (Peters 1996a). Plots were selected at random on a satellite image (Landsat TM) by using ARCVIEW software. A grid with 500 x 500 m divisions was applied to the image at the defined areas surrounding each village, and co-ordinates were taken at each point on the grid. The map co-ordinates were then corrected before being entered into a Global Position System (GPS) instrument so as to locate each plot. The data available to CENACARTA[3] from maps and satellite images is based on datum Tete, and the co-ordinates systems used by GPS are based on datum WGS84 (Sarkeala and Cuambe 2000). The difference in location obtained from these two systems varied from area to area or province to province. In Zambézia Province the difference is between 200 to 250 m (Sarkeala and Cuambe 2000). Those differences were taken into account and reducing the east co-ordinate by 52 m and the south co-ordinate by 231 m made the appropriate corrections from the map system to the GPS system. The plots fell into natural woodland under two management regimes: selective harvesting and fallow.

An inventory of woody plants was made from 23, 1-ha plots selected at random in the woodland adjacent to the three villages. Data were recorded in field data form (Appendix 3). The initial work plan considered 30, 1-ha plots, per each area in the vicinity of the tree villages. But because some plots fell in agricultural areas and had to be excluded, it reduced the number of plots sampled. Then the final sample was 23, 1-

[3] Centro Nacional de Cartografia e Teledetecção- Mozambique

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ha plots, of which six plots were measured in Golombe village, 10 plots in Arame village and seven plots in Mphoto village. The sampling intensity varied among the villages. It was 0.15 per cent for Golombe, 0.4 per cent for Arame and 0.5 per cent for Mphoto village (Fig. 2.3). Golombe was the village where some of the plots fell in agricultural areas. If time allowed, a larger sample for Golombe would be drawn.

Data were collected by two inventory groups of four persons each. In order to involve the local community in plant assessment, three people from each group came from the local village. They were taught the methods and collaborated in the identification of species by giving the local names and uses of existing species.

The plots were located and demarcated, each consisting of a permanent plot of 1 square hectare, divided into 25 sub-plots, each 20 x 20m, all the corners of each plot were demarcated (Synnott 1979; Peters 1996) (Fig. 2.4). Large sample units were chosen because they are more effective than smaller units in representing the variation, although they are more costly (Lawson *et al.* 1968; Philips 1994). Square plots were used to facilitate detection of spatial patterns (Campbell 1989). Diameter at breast height (DBH) of all trees and shrubs was measured with callipers at 1.30 m from the ground. Diameter at breast height is the commonly used measure in forestry ecology studies such as in static studies to compute cross-sectional area, dominance, and ground cover, and in dynamic, long-term studies to measure growth (Geldenhuys 1993; Philip 1994; Campbell 1989; Condit 1998; Lykke 1998; Cunningham 2001; Obiri *et al.* 2001).

In forest inventories, the minimum DBH measured is usually 10 cm, the assumption being that adults in the sample represent most juvenile tree species with less than 10 cm of DBH in the forest (Campbell 1989). However, a minimum DBH of 10 cm would have excluded individuals important to this study, as information on the abundance of small stems necessary in order to assess regeneration and population demography. Therefore, a minimum DBH of 1 cm was used here (Lykke 1998). The stems with more than 1 cm, but shorter than 1.3 m, were registered as a sapling. In each plot, each tree or shrub species was noted together with its local name and, where possible, identified with its scientific name. A list of local tree and shrub names

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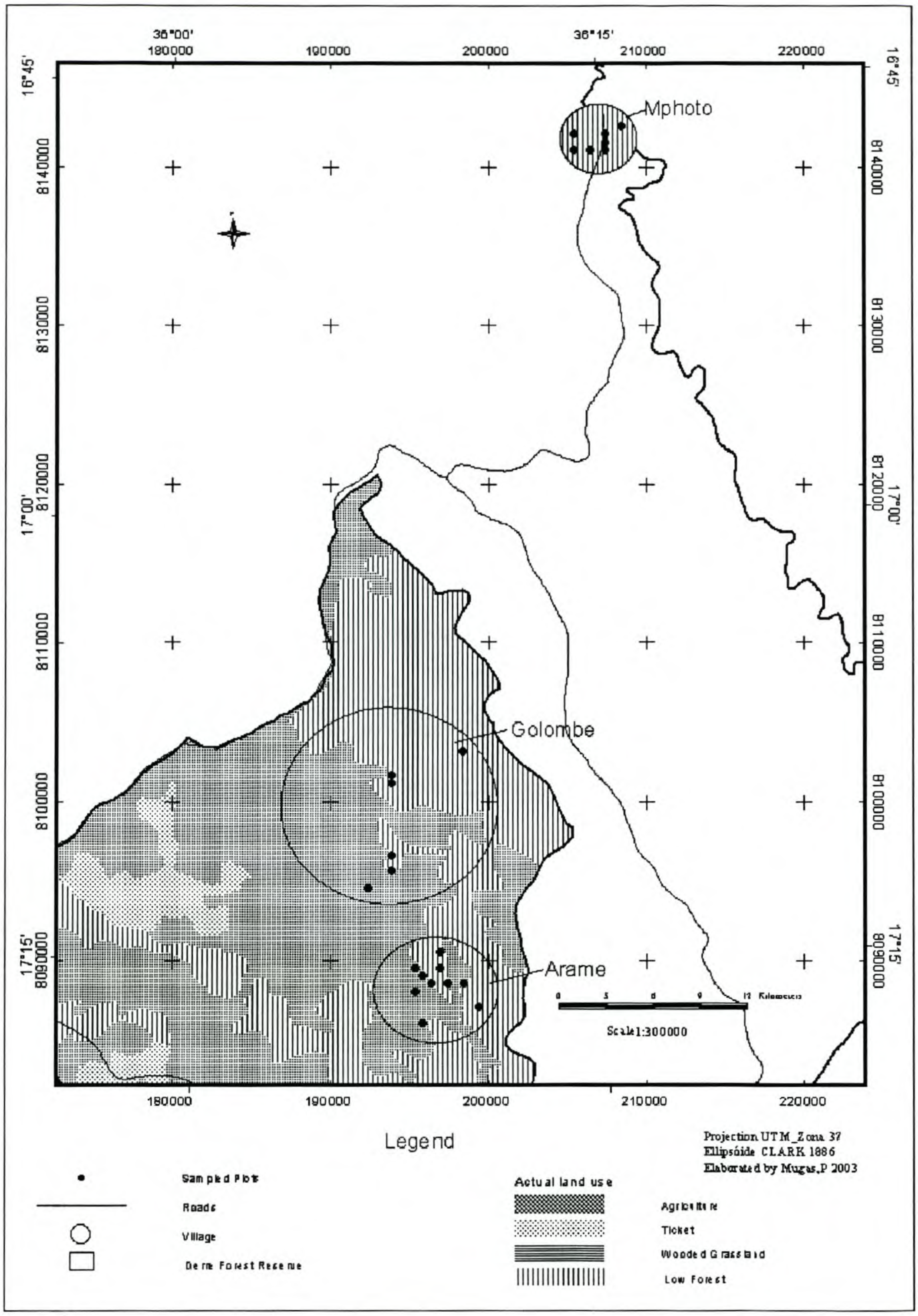

Figure 2.3 The sampled plots in the three villages, Golombe, Arame and Mphoto.

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and their Latin correspondent, is based on Gomes-e-Sousa (1966) and de Koning (1993) although, nomenclature follows Coates Palgrave (1983). In addition, the number of sprouting stems of each tree or shrub was counted, and observations on land use (woodland or fallow cropland) were made. The regeneration assessment was conducted after the wet season. In each plot a regeneration assessment was made using four 1 x 20 m transects within the 20 x 20 m sub plots. The number of tree seedlings (height < 1.5 m) of all species in each transect was counted.

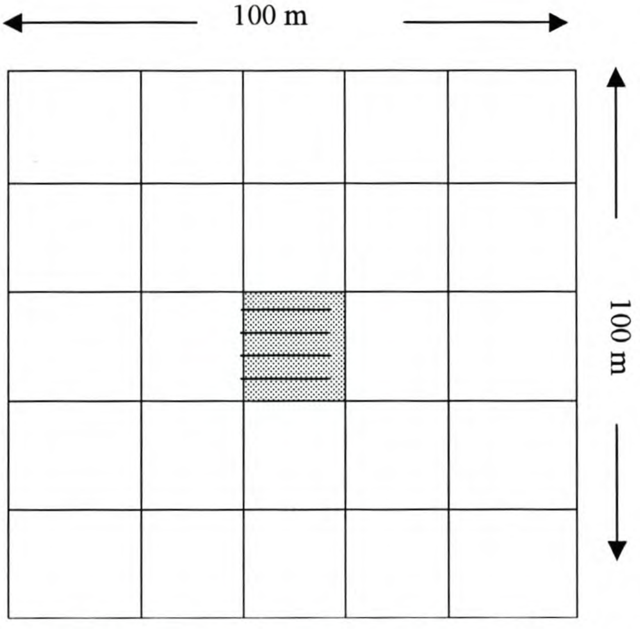

Figure 2.4 The size and shape of the sampling plot used for the resource assessment. The shaded area indicates the location of the plot used for regeneration estimates, done within one sub-plot in the centre as marked. Adapted from Alder and Synnott (1992).

2.2.2.1 Species composition analysis

Analysis of species composition was performed using Statistica'99 and Excel software. Data were imported into a worksheet from Microsoft Excel. From the non-parametric analysis, the Kruskal-Wallis was used to test differences between villages because not all data were normally distributed after transformation. The parameters used for the analysis were the number of species per hectare in each village, number of

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stems per hectare in each village, number of individual stems per hectare per selected species in each village (Muir 1990). The Berger-Parker Index measures the numerical importance or dominance of the tree species in woodland. The software used for calculating the Berger-Parker Index was "Species Diversity & Richness" (Henderson and Seaby 2001).

2.2.2.2 Population structure of selected species

The size-class distribution of the selected species was analysed in order to verify how the tree and stand respond to building poles harvesting (Geldenhuys 1993; Lykke 1998; Muir 1990; Cunningham 2001).

Size-class distribution of five species (*Brachystegia boehmii*, *B. spiciformis*, *Pterocarpus angolensis*, *Terminalia sericea* and *Swartzia madagascariensis*) was analysed. The DBH (cm) size class categories of 5 cm were used. The study was carried out for two categories of woodland use, namely selective harvesting and fallow land (approximately 15 years old), for Golombe and Arame villages and for selective harvesting only for Mphoto village.

A regression was calculated using the class midpoint as the independent variable and the number of individual stems transformed as the dependent variable for each selected species. The single number indicates the population structure of the five selected species as a result of size-class distribution slopes (Lykke 1998; Obiri *et al.* 2001).

The last analysis done was to compare the number of individual stems per hectare (6-20 cm DBH) in the sub-canopy and the number of individual stems per hectare (>21 cm DBH) in the canopy to analyse the spatial scale of regeneration of the five tree species (adapted from Obiri *et al.* 2001).

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3. Results

The results from the study of woodland use by local communities included analysis of qualitative data from the Participatory Rural Appraisal methods in five villages. The trends of the building poles harvesting are investigated using the results from the questionnaire of five tree species in three villages of the Derre woodlands. The species were identified as *Brachystegia boehmii*, *B. spiciformis*, *Terminalia sericea*, *Pterocarpus angolensis*, and *Swartzia madagascariensis*. In order to assess the impact of harvesting of the preferred five species that surround three villages where the survey was carried out, the results are presented by species composition, as well as population structure of five tree species.

3.1 Woodland use

3.1.1 Product use (qualitative data)

From the participatory appraisal, it was found that 46 woody miombo species were used in the five study villages for at least 29 different purposes (see Appendix 1). Five of these species (*B. boehmii*, *B. spiciformis*, *P. angolensis*, *T. sericea* and *S. madagascariensis*) were selected for further analysis because of their multiple uses and the unknown impact of their harvesting on the future survival of those hardwood trees species. These species are used for building materials, firewood, medicines, and other purposes (Table 3.1).

In general, *B. boehmii* was found be used for the greatest number of products, followed by *B. spiciformis*. A wide variety of species is used for building purposes in Derre (Table 3.2), and species use varies slightly from village to village. *Brachystegia boehmii*, *B. spiciformis* and *P. angolensis* were used for building poles in all villages, while *T. sericea* was used in all villages except Golombe. All villages used the two *Brachystegia* spp. for rope, due to the high quality of their fibre.

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Brachystegia spp. were commonly used for firewood in all villages. Only in Arame, Gida and Maticula were both *Brachystegia* spp. used for canoes. This suggests that only in these three villages were the rivers close to the forest. Three of the species were used for medicinal purposes: *P. angolensis* in all villages; *T. sericea* in Arame and Gida; and *S. madagascariensis* mainly in Arame and Matícula.

Table 3.1 Matrix ranking of product use of the five selected species in the five study villages, Derre.

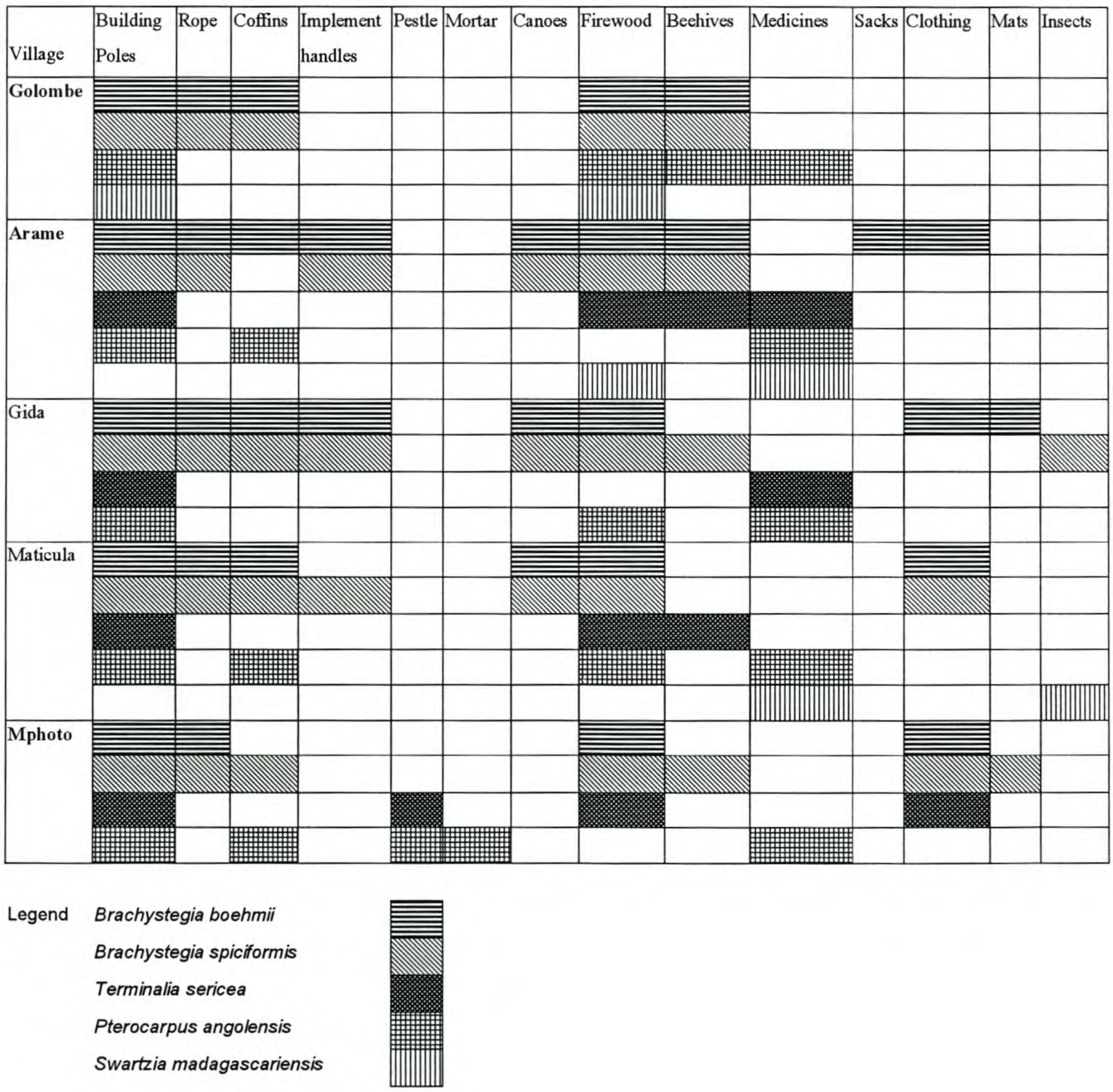

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Table 3.2 Species used for building purposes in the five selected villages, Derre. The local names vary as a result of the different languages used in the five villages.

Plant Species	Family	Local name
Annona senegalensis	Annonaceae	Matope, Muiebe
Antidesma venosum	Euphorbiaceae	Nanguareguare, Nanquaquare
		Bambu
Bauhinia thonningii	Caesalpinioideae	Mutete, Mussequesse
Bauhinia sp.	Caesalpinioideae	Pare
Brachystegia boehmii	Caesalpinioideae	Mombo
Brachystegia spiciformis	Caesalpinioideae	Murroto
Burkea africana	Mimosoideae	Mucarara, Carara,
Diplorhynchus condylocarpon	Apocynaceae	Nhatomboze, Mutombozi,
Julbernardia globiflora	Caesalpinioideae	Ntchenga, Tchenga, Muchenga
Millettia stuhlmannii	Papilionoideae	Pangire, Panga-panga, Banchire,
Pericopsis angolensis	Papilionoideae	Muanga
Pseudolachnostylis maprouneifolia	Euphorbiaceae	Mussolo, Sulo
Pterocarpus angolensis	Papilionoideae	Mulombue, Lombuá, Umbila
Strychnos madagascariensis	Loganiaceae	Theme, Muteme, Eteme
Swartzia madagascariensis	Papilionoideae	Samirete, Naquada, Pau ferro
Terminalia sericea	Combretaceae	Mssaissai, Ssaissai
Other unidentified species		(20)

From the species list, it can be seen that the forest also provides many other species suitable for building purposes (Table 3.2). Participants in informal meetings in five villages confirmed that the supply of building poles was not a limiting factor in their areas.

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3.1.2 Product use (quantitative data)

3.1.2.1 Village demography

Data for this section come from three selected villages, Golombe, Arame and Mphoto. Forty households or 13% of the population in Golombe, 34 households or 20% of the population in Arame, and 30 households or 8% of the population of Mphoto were interviewed. The median age of respondents was similar among the villagers: 40, 38, 39 years for Golombe, Arame and Mphoto, respectively. Adult men and women were included in this survey (Table 3.3).

Table 3.3 Number of questionnaire respondents by gender, in Golombe, Arame and Mphoto villages.

	Golombe		Arame		Mphoto	
	Frequency	%	Frequency	%	Frequency	%
Female	10	25	12	35	9	30
Male	28	70	20	59	19	63
Missing[1]	2	5	2	6	2	7
Total	40	100	34	100	30	100

[1] No answer for this particular question.

In general the age of respondents ranged between 17 and 60 years for all three villages. Men comprised the highest percentage of respondents in all the villages (Table 3.3). In Arame a higher percentage of females was surveyed than in the other villages, but in most cases both partners were present and either the husband or wife responded, depending on the question.

3.1.2.2 Household demography

In all three villages, there were more people younger than 30 years of age than there were in the category of people older than 30 years. Overall, 68% of the people were younger than 30 years, and 44% were younger than 18 years (Table 3.4).

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Table 3.4 Distribution by age and gender of household members in the selected three villages, Derre.

	Golombe n = 199				Arame n = 167				Mphoto n = 154			
Age (years)	Female	%	Male	%	Female	%	Male	%	Female	%	Male	%
> 60	4	2	9	5	7	4	8	5	3	2	3	2
30 - 59	28	14	25	13	19	11	15	9	23	15	23	15
18 - 29	17	9	20	10	27	16	28	17	18	12	13	8
< 17	45	23	51	26	36	22	27	16	37	24	34	22
Total	94	47	105	53	89	53	78	47	81	53	73	47

In Golombe the ratio of males to females surveyed is slightly higher than that of the other villages, but this difference was not great (Table 3.4). The number of people per household varied from one village to another, but the mean number of persons per household (5 in Golombe, 4 in Arame, and 5 in Mphoto village) did not differ significantly among the villages ($n = 100$; $H = 1.537$; $p > 0.05$).

3.1.2.3 Forest product use

In each of the three villages studied, inhabitants reported subsistence use of the following non- timber forest products: tubers, mushrooms, fruits, honey, reeds, poles (including bamboo), bark (fibre and medicines), firewood, raffia palm leaves and timber. The number of building poles used per household was similar between the three villages (Table 3.5).

Table 3.5. The median, minimum, and maximum number of wall and roof poles used per household, in three villages.

	Golombe	Arame	Mphoto	Golombe	Arame	Mphoto
		Wall poles	(Nº)		Roof poles	(Nº)
Median	100	120	100	150	140	140
Minimum	45	40	60	50	55	60
Maximum	260	180	280	260	252	250

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The number of wall and roof poles per house respectively did not differ significantly among the three villages (n = 96, H = 3.206, p > 0.05; n = 100, H = .326, p > 0.05). In Mphoto the variation is slightly higher than in the other two villages. Considering that the number of persons per household is similar, it was found that in Arame village 59 per cent of the respondents made their houses within the range of 110-180 poles per house. In this case where the woodland is closer, the accessibility is another factor that influenced the size of the houses.

Table 3.6 The frequency (f) and percentage (%) of respondents which used number of wall poles per house in four size categories in Golombe, Arame and Mphoto villages, Derre.

	Golombe		Arame		Mphoto	
Nº of poles	f	%	f	%	f	%
<= 80	15	38	9	26	6	20
81-109	11	28	4	12	10	33
110-180	6	15	20	59	8	27
181-280	5	13	0	0	4	13
Missing values[1]	3	8	1	3	2	7
Total	40	100	34	100	30	100

[1] No answer for this particular question.

The diameter preferred of wall poles also did not differ among the villages (n = 99, H = 5.704, p >0.05), with the average size being 10 cm (Table 3.7).

Table 3.7 The median size of wall poles in Golombe, Arame and Mphoto villages.

	Golombe	Arame	Mphoto
Median (cm)	10	10.35	10
Minimum (cm)	8	8	8
Maximum (cm)	12	15.7	12

The preferred species for building poles in all three villages was *T. sericea* (Table 3.8), but the percentage of available *T. sericea* was less than the other species, due to high use or low natural abundance. In Golombe village respondents stated that *T. sericea*

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and *B. boehmii* are the most-preferred species for building poles.

Table 3.8 Estimated percentages of five selected species preferred and percentage available for wall poles (8 –12 cm) for the five species in Golombe, Arame and Mphoto villages, Derre. Chesson's Selectivity Index gives a preference of wall pole species.

	Percentage preferred			Percentage Available			Selectivity Index		
Tree species	Golombe	Arame	Mphoto	Golombe	Arame	Mphoto	Golombe	Arame	Mphoto
Terminalia sericea	17.50	11.76	33.33	0.94	0.73	1.82	**18.65**	**16.15**	**18.36**
Brachystegia boehmii	17.50	20.59	0,00	12.12	11.72	2.85	**1.44**	**1.76**	**0.00**
Brachystegia spiciformis	10.00	5.88	10,00	2.47	5.50	19.58	**4.04**	**1.07**	**0.51**
Pterocarpus angolensis	10.00	2.94	13.33	5.63	6.29	1.95	**1.78**	**0.47**	**6.85**
Swartzia madagascariensis	2.50	5.88	0,00	1.54	2.32	1.43	**1.63**	**2.54**	**0.00**

Note: Percentage of preferred, percentage available and selectivity index refer to each village.

Terminalia sericea is not abundant in Golombe, and villagers did not mention their preference for this species in participatory surveys. But, the selectivity index reveals that they have a strong preference for *T. sericea*. The most preferred species in Arame was *B. boehmii*, while in Mphoto it was *T. sericea*. These differences could be a result of differences in species occurrence and between the villagers' choices. Nobody in Mphoto reported preference for poles from *B. boehmii* and *S. madagascariensis*. Incidentally, none of these species was abundant in Mphoto.

The Selectivity index varies from species to species and between villages. *Pterocarpus angolensis* was also considered a good species in Golombe and Mphoto. However the selectivity index above (Table 3.8) shows that use of *P. angolensis* was avoided in Arame (the Selectivity index was less than one). In Arame the respondents mentioned that because this species sprouts easily, and poles in the wall start to grow. For this reason they did not like it for building.

Brachystegia spiciformis was the least preferred species in terms of quality. *Swartzia madagascariensis* was mentioned as making poles of high quality, but only a few respondents reported that they preferred this species to the other four species. One possible explanation is that this species was not included as an option in the questionnaire, although it was mentioned under the category 'other'. Moreover, some

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respondents said that they like and use it. Another explanation is that it is a relatively slow-growing tree and rare in the woodland compared to other species. Wood quality is likely to be the major factor that influences the frequency with which villagers replace the poles of their houses (Table 3.9), due to their resistance to insects' attack and durability.

Table 3.9 Time intervals between replacement of wall poles in Golombe, Arame and Mphoto villages, Derre.

Time intervals	Frequency	Percent
2 - 3 years	27	26.0
4 - 5 years	6	5.8
6 - 8 years	28	26.9
> 9 years	41	39.4
Total	102	98.1
Missing[1]	2	1.9
Total	104	100.0

[2]No answer for this particular question.

Thirty nine per cent of respondents replace their wall poles every nine or more years. Since the lifetime of the wall depends on the quality of the species, people try to build their houses with the highest quality, most durable species. However, 52.9 per cent of the villagers replace their wall poles in intervals "less or equal" to 8 years. It suggests that these villagers may be choosing the trees closer to their homes or that they require less effort in obtaining and using being used as wall poles. These trees would fall in the category of less durable and lower quality species.

3.2 Availability of plant resources

3.2.1 Species composition

The number of plant species per hectare differs significantly among the villages ($n = 3$; $H = 7.036$; $p = 0.03$) (Figure 3.1). The species density was lower in Mphoto (outside the reserve) than at Golombe and Arame (inside the reserve).

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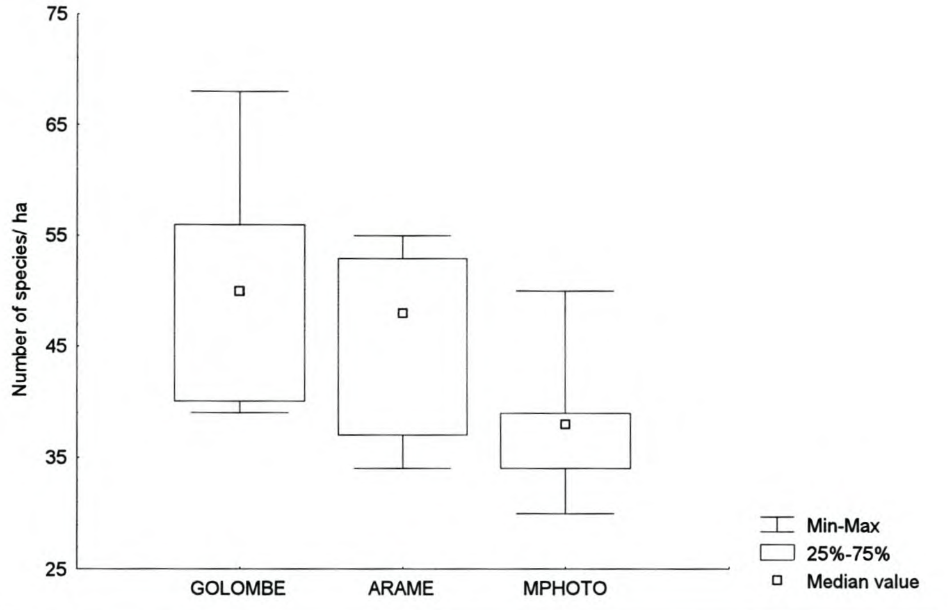

Figure 3.1 Number of woody and shrub species per hectare in the three selected study villages, Derre.

Species vary in their tolerance of fire and shade. The clear-felling system of clearing for agriculture (shifting cultivation) could also have an influence on the diversity of species inside and outside the Forest Reserve. The number of stems/ha did not differ significantly among the villages ($n = 23$; $H = 1.447$; $p > 0.05$). In Golombe the median of number of stems/ha is 968 (min. 378- max. 1781), in Arame 890 (min. 526- max. 1854) and in Mphoto 781(min. 545- max. 1027).

Species distribution within the woodland is patchy, typical of miombo woodland. The Berger-Parker Dominance Index showing the proportional importance of the most abundant species for Golombe was 0.16, for Arame it was 0.13, and for Mphoto it was 0.21. The dominant species in Golombe, and Arame is *B. boehmii*. In Mphoto *B. spiciformis* was dominant. Individuals of *P. angolensis* numbered less than 50 per hectare in Golombe, and even less in Arame, and Mphoto. *Terminalia sericea* was represented by fewer individuals in Golombe and Arame than in Mphoto.

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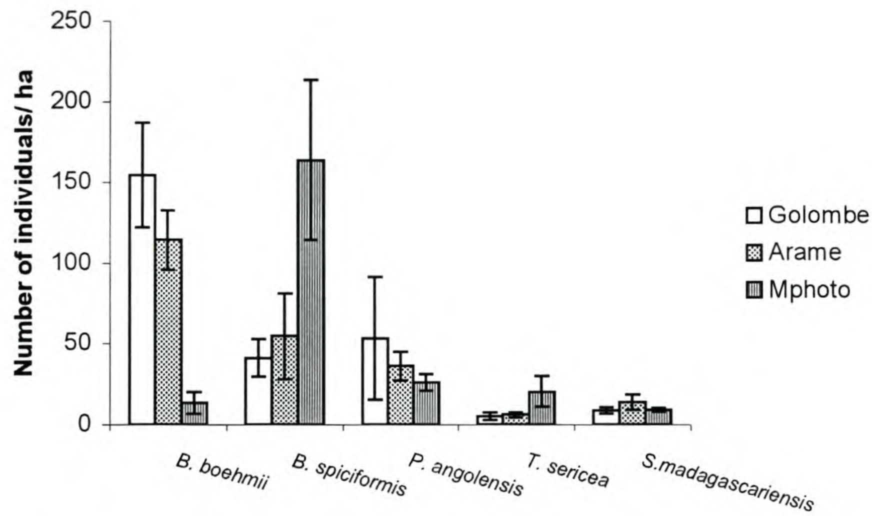

Figure 3.2 Number of individual stems per hectare of the selected species in each village. (Error bars indicate Standard error)

3.3 Population structure of selected species

The results of the size class distribution study are presented for the five selected species in the woodland surrounding the three villages. The selected species exhibited a negative exponential size-class distribution, with the exception of *T. sericea* and *S. madagascariensis* in Golombe on both fallow land and in woodland under selective harvesting (Figures 3.3 and 3.4 respectively). Both latter species exhibit bimodal and flat curves. Other exceptions are *P. angolensis* in Golombe woodland and *B. spiciformis*, showing both flat curves (Figures 3.5 and 3.6 respectively).

The differences in distribution of *T. sericea* suggest that Golombe area may not have the required environmental conditions for this species to establish and grow. The size class distribution (SCD) slope did not differ significantly from zero in the fallow lands of the two villages (Table 3.10). In Arame, *T. sericea* presented a negative exponential distribution in both land-use types, although there were more individuals present in fallow land than in forested land. Again the SCD slopes did not differ significantly from zero (Table 3.10).

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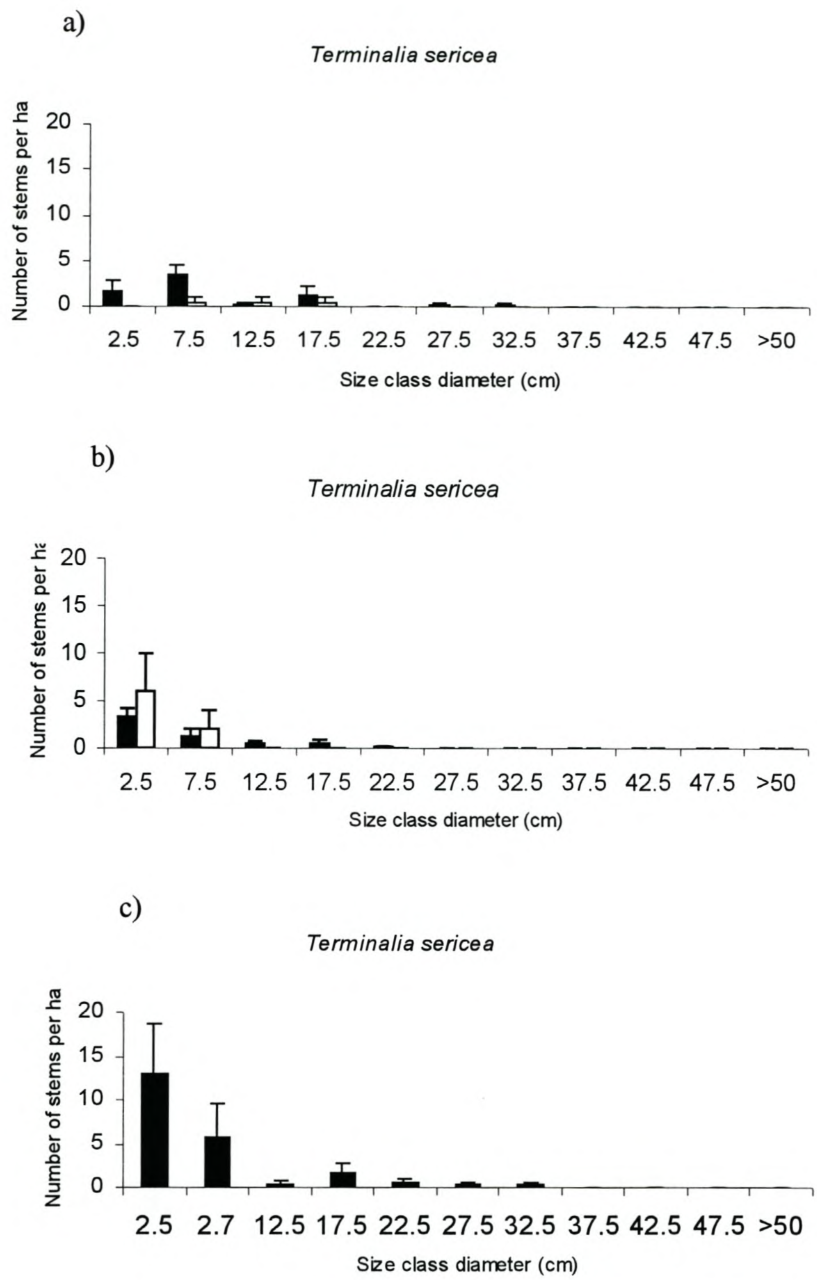

Figure 3.3 Size-class diameter distributions for ***Terminalia sericea*** in a) Golombe, b) Arame, and c) Mphoto woodlands. Open bars represent fallow land and shaded bars represent woodland. (Error bars indicate Standard error)

In Golombe and Mphoto the reduced number of individual stems in the third size class diameter, suggests that it is a result of building poles harvesting for *T. sericea*.

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Table 3.10 Regression slope values for the number of individual stems per hectare (log transformed) per size-class distribution (cm) for five species in woodland under selective harvesting and fallow land.

Species	Village	Slope	r2	*P-value*
Terminalia sericea	Golo Fallow	-0.001	0.22	0.11
Swartzia madagascariensis	Golo Fallow	-0.005	0.34	0.04
Terminalia sericea	Arame woodland	-0.005	0.50	0.01
Swartzia madagascariensis	Golo Woodland	-0.006	0.57	0.00
Terminalia sericea	Golo Woodland	-0.006	0.50	0.01
Swartzia madagascariensis	Arame Woodland	-0.007	0.66	0.00
Swartzia madagascariensis	Mphoto Woodland	-0.007	0.58	0.00
Terminalia sericea	Arame Fallow	-0.007	0.33	0.04
Pterocarpus angolensis	Golo Woodland	-0.009	0.91	0.00
Brachystegia boehmii	Mphoto Woodland	-0.009	0.62	0.00
Pterocarpus angolensis	Mphoto Woodland	-0.012	0.45	0.01
Brachystegia spiciformis	Arame Woodland	-0.012	0.67	0.00
Terminalia sericea	Mphoto Woodland	-0.014	0.52	0.01
Brachystegia spiciformis	Golo Fallow	-0.014	0.74	0.00
Pterocarpus angolensis	Arame Woodland	-0.018	0.76	0.00
Brachystegia spiciformis	Golo Woodland	-0.019	0.63	0.00
Swartzia madagascariensis	Arame Fallow	-0.021	0.70	0.00
Pterocarpus angolensis	Arame Fallow	-0.024	0.60	0.00
Brachystegia boehmii	Arame Fallow	-0.026	0.52	0.01
Brachystegia boehmii	Arame Woodland	-0.035	0.90	0.00
Brachystegia spiciformis	Mphoto Woodland	-0.039	0.70	0.00
Brachystegia spiciformis	Arame Fallow	-0.039	0.54	0.00
Brachystegia boehmii	Golo Woodland	-0.039	0.83	0.00
Pterocarpus angolensis	Golo Fallow	-0.039	0.70	0.00
Brachystegia boehmii	Golo Fallow	-0.044	0.86	0.00

Swartzia madagascariensis exhibited a flat curve in the Golombe area, with few individual stems in the two smallest size class diameters (Fig. 3.4). The population structure of *S. madagascariensis* differed between sites. The SCD slope did not differ significantly from zero in Golombe woodland and fallow land (Table 3.10).

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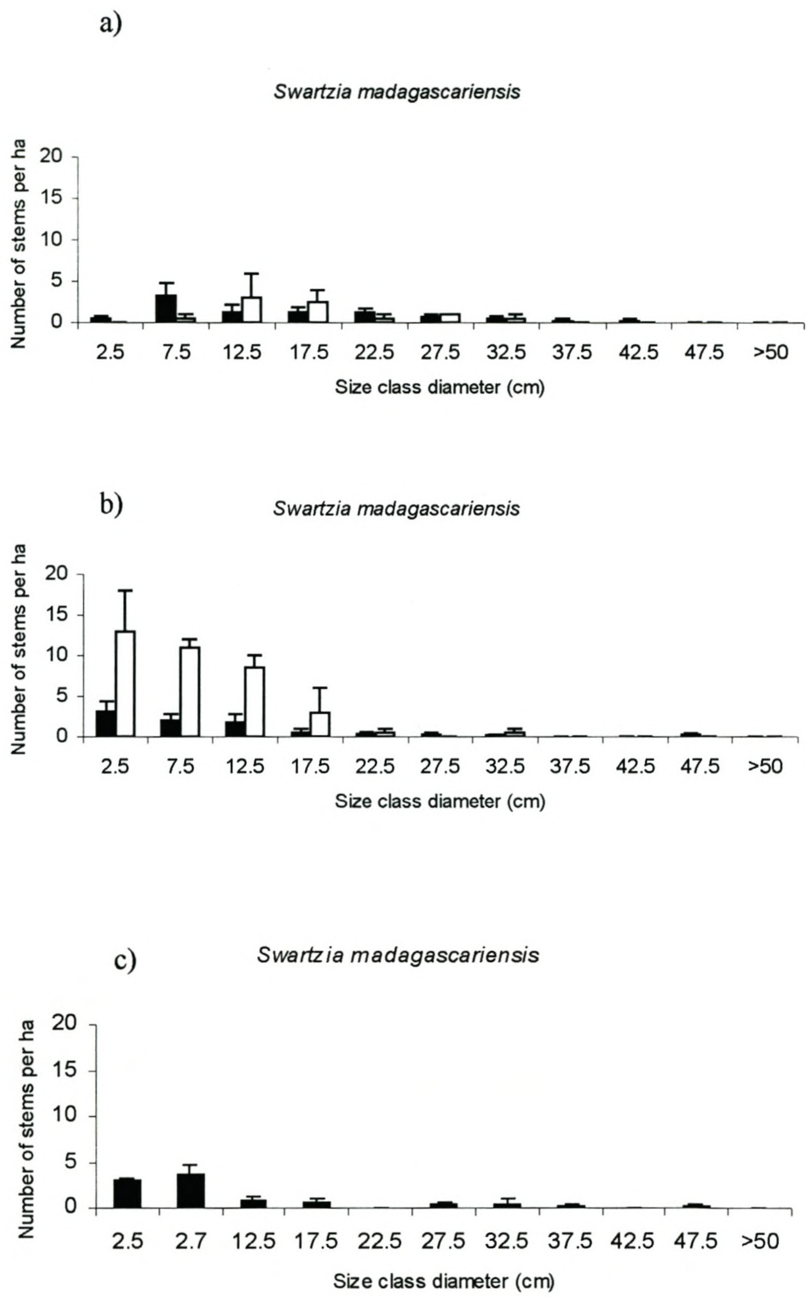

Figure 3.4 Size-class diameter distributions for ***S. madagascariensis*** in a) Golombe, b) Arame, and c) Mphoto woodlands. Open bars represent fallow land and shaded bars represent woodland. (Error bars indicate Standard error)

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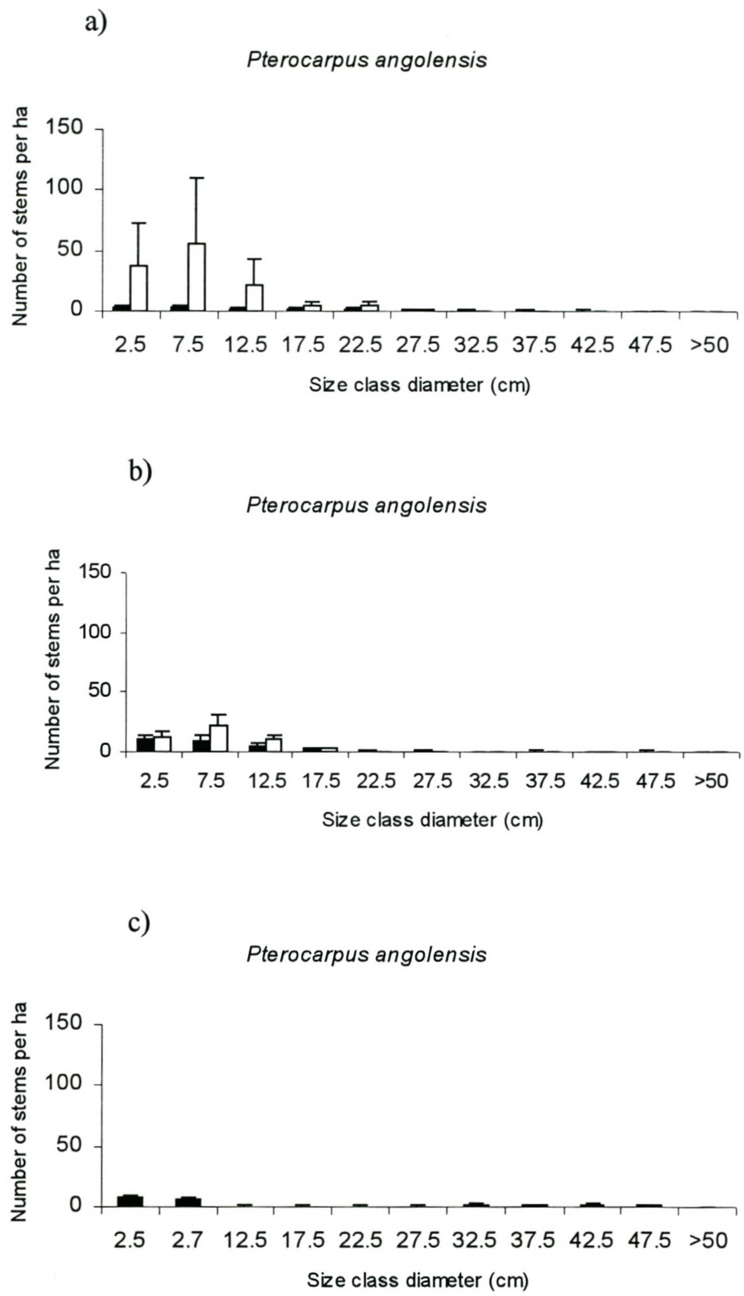

Figure 3.5 Size-class diameter distributions for ***P. angolensis*** in a) Golombe, b) Arame, and c) Mphoto woodlands. Open bars represent fallow land and shaded bars represent woodland. (Error bars indicate Standard error)

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In Arame *S. madagascariensis* showed a negative exponential size class distribution in woodland under both selective harvesting and fallow land (Figure 3.4). However in both land-use types it showed an absence of individuals in the largest size classes, indicating that, until recently, this species was logged in this village. This species is fire-tolerant and shade-intolerant. These characteristics could also influence its population structure, namely by favouring their recruitment.

Pterocarpus angolensis presents a negative exponential size class distribution in the fallow lands of Golombe village (Figure 3.5). In the woodland under selective harvesting, *P. angolensis* showed a flat size-class distribution in all the villages. In Mphoto, *P. angolensis* showed considerably fewer individuals in the size class mid point of 12.5 cm, which may be a result of selective harvesting for building poles.This species sprouts easily and is also a fire-tolerant and shade-intolerant species, and its behaviour suggests that when the land was left fallow, the increased light availability could have enhanced the regeneration of this species.

The species-condition combinations are displayed in order of increasing slope. Despite the variety of slope shapes for the same species (Table 3.10), all five species can exhibit a negative exponential SCD in favourable conditions. The slightly steeper SCD slopes occurred mainly in the two species, *B. boehmii* and *B. spiciformis*, which might be explained by the species ability to regenerate by both coppicing and seed germination.

Brachystegia spiciformis exhibited a mixture of negative exponential distribution and bimodal distribution in Golombe village, in woodland and fallow land respectively both graphs indicated evidence of harvesting of this species for poles (Figure 3.6). In both Arame, and Mphoto, this species exhibited negative exponential size class distributions for both land use types.

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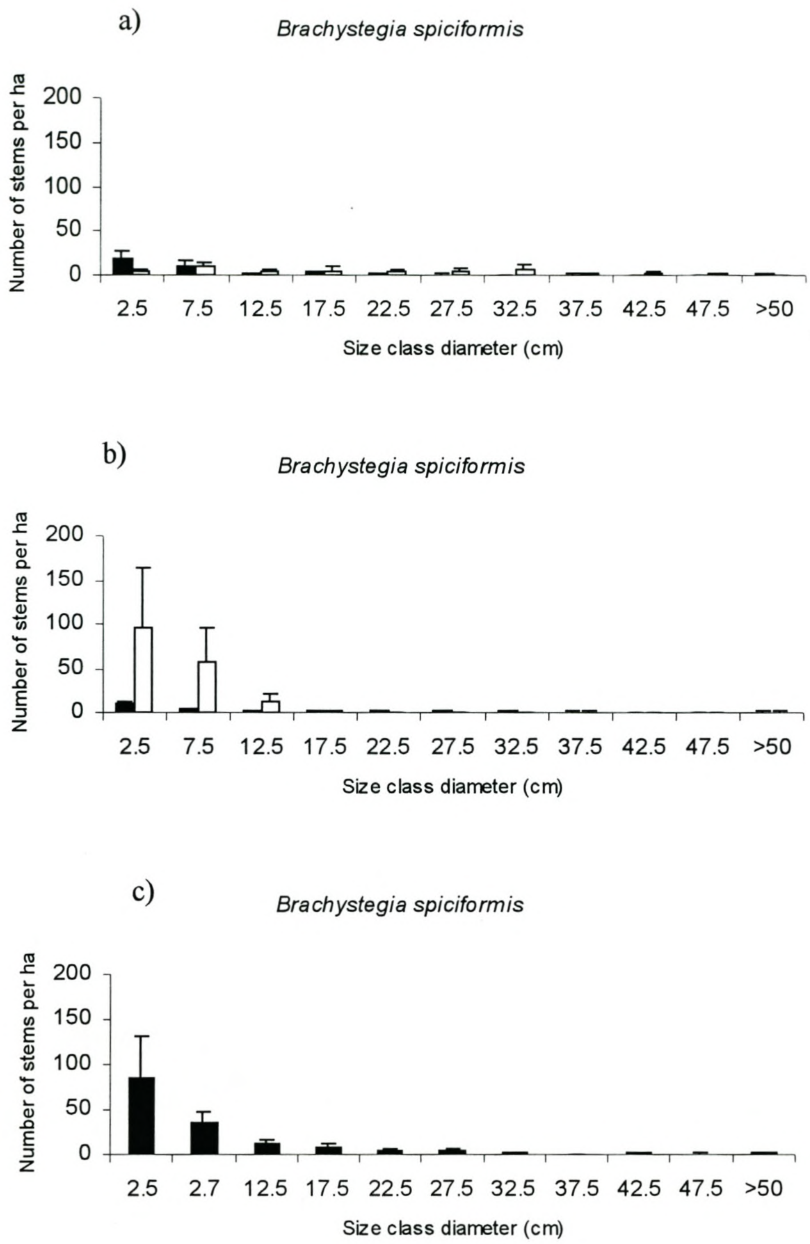

Figure 3.6 Size-class diameter distributions of ***B. spiciformis*** in a) Golombe, b) Arame, and c) Mphoto woodlands. Open bars represent fallow land and shaded bars represent woodland. (Error bars indicate Standard error)

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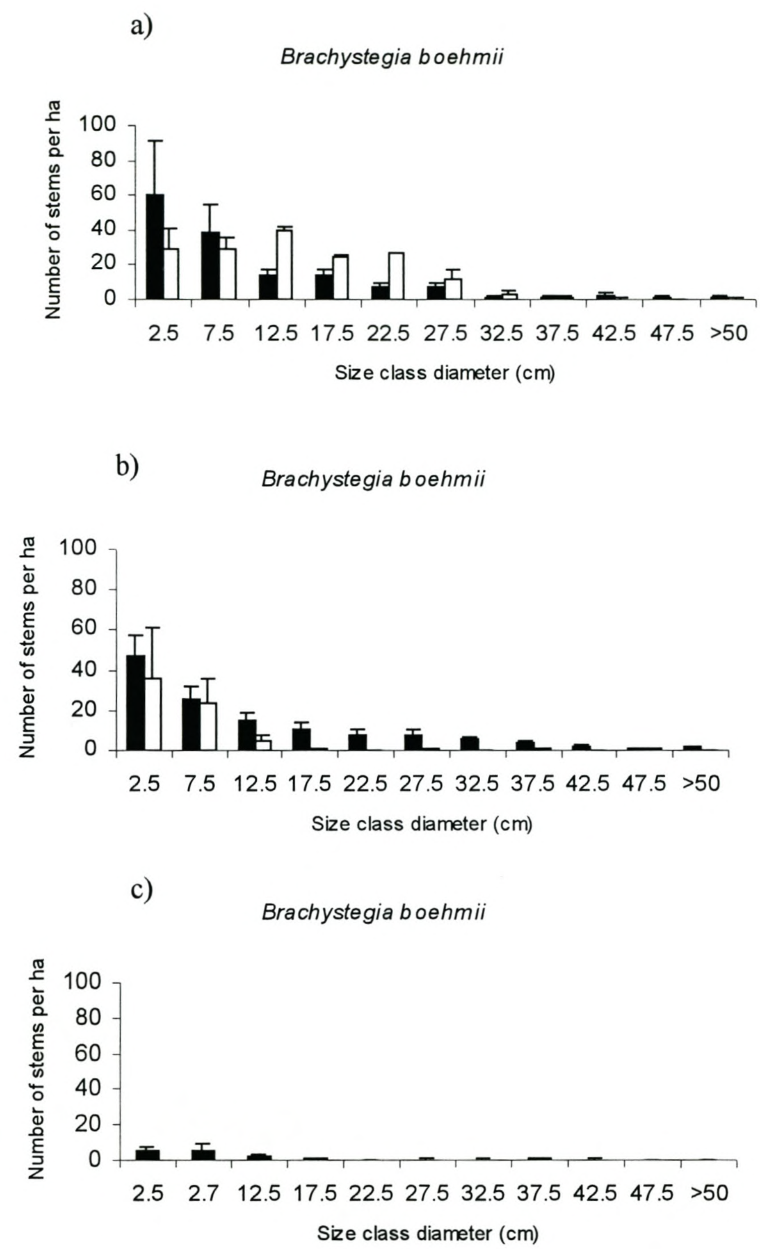

Figure 3.7 Size-class diameter distribution for ***B. boehmii*** in a) Golombe, b) Arame, and c) Mphoto woodlands. Open bars represent fallow land and shaded bars represent woodland. (Error bars indicate Standard error)

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Brachystegia boehmii exhibited a negative exponential size class distribution in both land-use types in Golombe village (Figure 3.7). This species has fewer individuals in Mphoto village than in the other villages. This species was dominant in the two villages inside the Derre Forest Reserve and the *B. spiciformis* was dominant in Mphoto village (Figure 3.8).

These results also are confirmed by comparing the mean frequency of stems in sub-canopy with the mean frequency of stems in canopy (Figure 3.8). Only *B. boehmii* growing in Golombe and Arame shows more than 40 individual stems per hectare in sub-canopy and more than 20 stems per hectare in the canopy layer.

Brachystegia spiciformis in Mphoto village shows more than 50 individual stems per hectare in sub-canopy and more than 12 stems per hectare in the canopy in Mphoto. The two species *T. sericea* and *S. madagascariensis* showed fewer individuals in the sub-canopy and canopy layers. This suggests that these two species should be harvested on a sustainable basis in the future.

Inside Derre Forest Reserve, there were more *P. angolensis* individuals with diameters < 20 cm in the sub-canopy than adult trees in the canopy layer. The future harvesting of this species requires control. Of these five species *B. boehmii* is the only species in Arame and Golombe villages that appears to be still abundant, while *B. spiciformis* is the most abundant species in Mphoto village.

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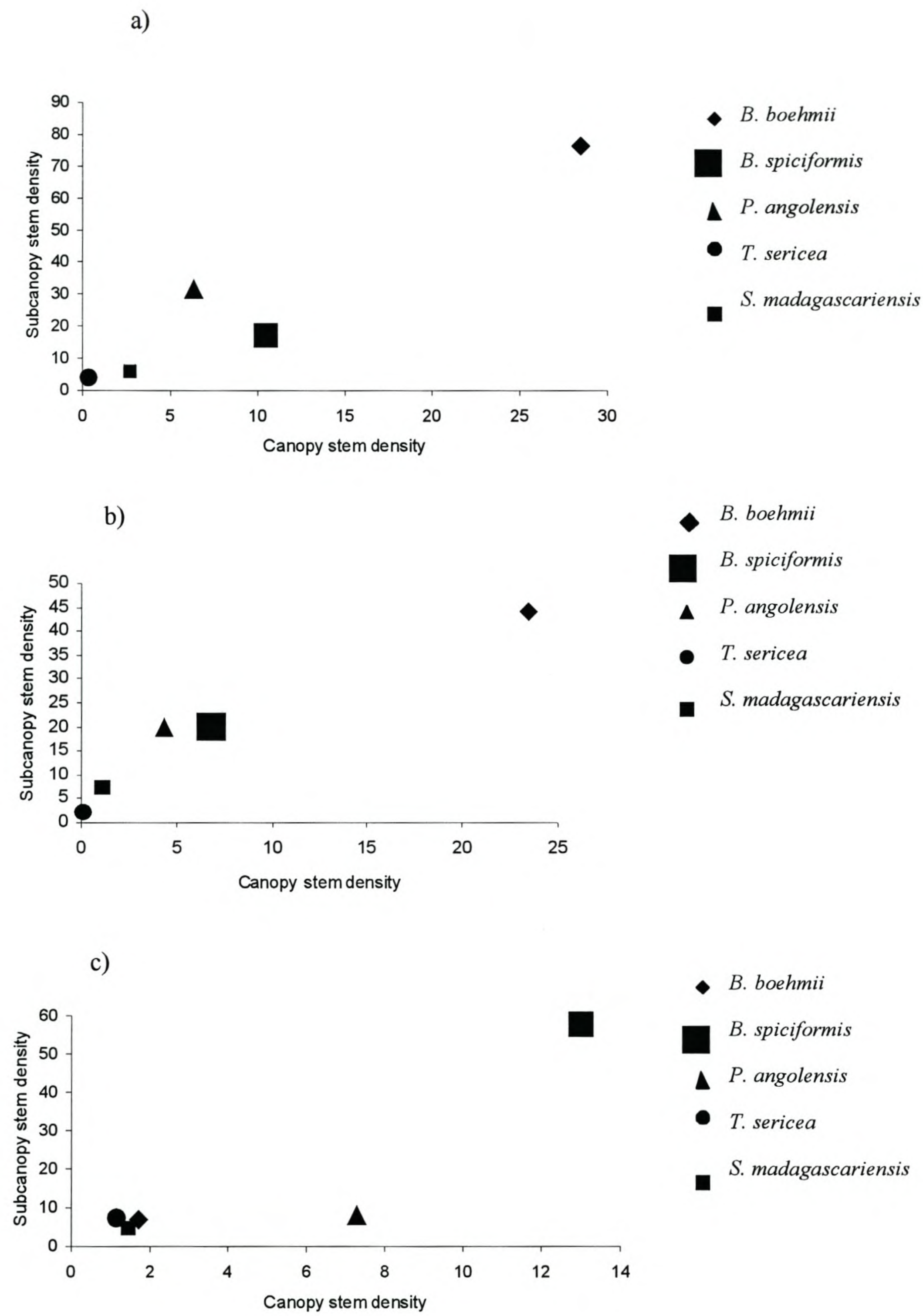

Figure 3.8 Scatter-plot of the relationship between the density of harvestable sub-canopy stems per hectare (number of individuals between DBH 6 - 20 cm), with canopy stem density per hectare (number of individuals for DBH ≥ 21 cm) for five selected species per each village, a) Golombe, b) Arame, and c) Mphoto woodlands. Axes units are number of stems per ha.

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4. Discussion

In this chapter the results obtained from the analysis of woodland use and availability of plants resources are discussed. The participatory survey was carried out as an initial investigation looking for obtaining information on forest products use as well as starting the involvement of local communities in this type of research. Besides participating in supervised management of Derre Forest Reserve, these communities should also benefit from the effects of this activity. Main factors influencing forest products use are also discussed.

The impact of preferred species used as building poles are discussed in relation to species characteristics, environmental factors and human factors. Finally based on the results obtained in this study, it is discussed how this information could be friendly used and understood by local communities in order to motivate them to become involved in the management planning. Local residents have an empirical knowledge about the five species as well as about the products derived from these species.

4.1 Woodland use

The results of the participatory appraisal showed that the local inhabitants in these remote villages use a variety of woody species in a number of different use categories (see Appendix1). Like two other miombo studies (see Grundy *et al.* 1993; Clark *et al.* 1996) this research showed that the dominant miombo species, *B. boehmii* and *B. spiciformis* are most often utilised, as they can provide building poles and firewood, as well as material for rope, beehives, sacks and clothing. Other species such as *P. angolensis*, *T. sericea* and *S. madagascariensis* also have multiple uses (see Table 3.1).

The range of uses of the plant species for non-timber forest products (see Appendix1) did not differ from those recorded in other studies in, amongst other places, Zambia, Zimbabwe, South Africa, and Malawi (Lawton 1982; Milton and Bond 1986; Infield

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1988; Grundy *et al*, 1993; Clarke *et al.* 1996; Campbell *et al,* 1997; Abbot and Homewood 1999). This outcome is supported by other research findings that emphasise the important role those woodland products play in the livelihoods of the rural poor.

Looking for developing guidelines for sustainable collaborative management this study showed that the combination of the following factors influenced the woodland use and building poles in particular:

4.1.1 Social and Culture

During this study specific attention was paid to building poles. When comparing the findings of this research with those from the literature, it was found that the people of Derre build more uniform houses with fewer poles than those found by other researchers in the region (see Muir 1990; Grundy *et al.* 1993).

According to the results of a questionnaire circulated in three villages, 44 per cent of the people interviewed were younger than 18 years old. This differs only slightly from national trends for 2000, according to which 44.6 per cent of the population was younger than 14 years old (I.N.E 2002). The results indicate that the number of houses to be built and replaced in the future will increase. The three villages can be considered similar in terms of age, gender and number of people per house (see table 3.4). However, this result has shown that the average number of persons per household (5 in Golombe, 4 in Arame and 5 in Mphoto) did not influence the size of the house itself (Table 3.6).

The size of stems used for poles (8-12 cm) is within a similar range found elsewhere (Hall and Rodgers 1986; Muir 1990). Generally, houses are rebuilt after approximately the same number of years (see Grundy *et al.* 1993; Luoga *et al.* 2000). This has shown that the durability of the poles is one of the determining factors here. Any differences, e.g. in preferred species and house styles, may be a result of dissimilarities in habits and cultures across regions. This should be taken into consideration when drawing up woodland management plans.

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4.1.2 Economic and quality of infrastructures

The survey has shown that the inhabitants of the three villages depend on woodland use products for their livelihood (see 3.1.2.3). This dependency suggests that there are similar rural situations in poor countries all over the world, where subsistence use increases with distance from towns or cities, intensified by the poor quality of infrastructures such as transport and communications (Bennett 1992; Medley 1993; Mwambo 2000).

Despite the fact that two of the villages are within a forest reserve, local people considered themselves free to collect any of the woodland products. According to the new forest law, subsistence usage of woodland products is still permitted (DNFFB 1999). Woodland products are used directly for consumption and not as a source of income. This survey has identified agriculture products as a source of income, which are complementary to woodland products. Therefore, there was no interest in comparing the economic value between agriculture products and woodland products. Data on agricultural products were not object of analysis of this study. Thus, it was not presented in this paper.

The fact that these villages are situated close to the woody resources may explain why people collect their own products, instead of buying it. No basic or raw materials such as building poles, firewood, rope, thatch, fruit tubers, mushrooms, reeds, honey and medicinal substances are bought or sold within the villages. Each family produces even their own implement handles. They do however sell or barter occasionally wild meat, pottery, mats, raphia furniture, sieves and crops. These findings confirmed the situation found in other studies when products such as wild fruits, poles, firewood or charcoal could be commercialised if the market existed locally (Campbell 1987; Chidumayo 1993). However, the distance from any market has so far discouraged large-scale commercialisation in Derre.

Honey is extracted as an indirect tree product. The inhabitants burn the tree when they find honey, as a traditional practice. Upgrading beekeeping practices could contribute

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to income generation and provide a food supplement to the people in Derre woodlands, as well as to reduce the damage to trees and the woodland in general by uncontrolled fire. Mushrooms are another wild product, which are seasonal. In Derre woodlands the inhabitants have the opportunity to preserve them by drying, thereby being able to eat them well beyond the rainy season.

In contrast to other African countries commercialisation of traditional medicines in rural Mozambique is still being developed on a small scale (Cunningham 1995). The increase in harvesting of many parts of these medicinal trees may pose a risk of changing the size class distribution in Derre Forest Reserve in the future.

4.1. 3 Selected species and building poles

The preference for certain species as construction material is likely to depend not only on the availability of the species, but also on its quality (e.g. termite resistance) (Milton and Bond 1986). The type of structures to be erected and the proximity of the woodland have also determined which of the selected species were harvested. The species used differ slightly from village to village, which suggests that if one species is not mentioned, its availability may be limited in that particular village.

The revealed species preferences indicated in the Participatory Rural Appraisal technique are supported by the results of the questionnaire survey, where the majority of respondents listed more than one species as being the best for building purposes. The shortfall of the preferred species and the availability of alternative species for building poles is a factor to consider in the management of species in Derre Forest Reserve (see Table 3.2, Figure 3.3, Figure 3.8).

The variety of species used for construction is greater than the number recorded by Grundy *et al.* (1993) in miombo woodland in Zimbabwe, perhaps because the number of species is higher in Derre. This is possibly due to the mosaic of vegetation types contained in miombo woodlands (Malaisse 1978; Campbell *et al.* 1988).

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For *B. boehmii*, *B. spiciformis* and *S. madagascariensis* this study shows that the species most in demand could be a result of its quality and its availability in the woodland. Preference for *T. sericea* and *P. angolensis* in some villages may have been related to their higher quality, based on their ability to resist to insect attacks, straightness and also durability, despite the scarcity of these two species. The monitoring of the species used will improve the species preferred by local communities. At the same time, it will contribute to collaborative woodland management. This approach will help the decision makers maintaining the conserved areas under management planning, at lower cost.

4.2 Availability of plant resources

The species found in the woodland next to the three villages in Derre, confirm the theory that the vegetation structure in miombo exhibits small-scale patterns (Campbell *et al.* 1995). For example, in Arame village there was less variation in the number of species per hectare, and fewer individuals of all five dominant species than in Golombe village, in Derre Forest Reserve.

A short description of each species growth habits and habitat preferences will help to discuss the factors that influenced the patterns found in this study:

- *Brachystegia boehmii* is an indicator of shallow soils with partial waterlogging or high water table (Chidumayo 1997).
- *Brachystegia spiciformis* is fire tender (Trapnell 1959). This species prefers deep, fertile soil and has a low tolerance for waterlogged soil (Grundy, 1995).
- *Terminalia sericea* is a shade intolerant species, that establishes only in open areas and never under trees (Yeaton 1988). Usually, it becomes rare in the mature miombo (Boaler and Sciwale 1966).
- *Swartzia madagascariensis* is fire tolerant (Trapnell 1959).
- *Pterocarpus angolensis* is a light demanding species and fire tolerant (von Breitenbach 1973; Vermulen 1990).

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This study has shown that there were differences in species dominance and composition in vicinity of the three villages. This is confirmed by other researchers who consider that miombo woodlands vary in species diversity and dominance (Trapnell 1959; Lawton 1978; Chidumayo *et al.* 1996). The reason of those differences could be related with past disturbance and soil characteristics (Campbell *et al.* 1995). Grundy (1995) found that species dominance varied according to soil quality and depth. As we can see from the short description each species has its growth habits that influence its occurrence in woodland. Soil moisture and nutrients as well as habitat preferences are other influencing factors (Frost 1996).

To draw guidelines for a sustained-use management of woodlands, it is crucial to know the ecological process of dominant tree species that maintain themselves (Geldenhuys 1993).

4.3 Population structure of selected species

In the general, in woodlands the processes are driven by mainly fire tolerance and browsing/grazing tolerance (Geldenhuys 1993). In the negative exponential distribution curve the recruitment and mortality on individual's tree species are balanced (Geldenhuys 1993). Usually the species that presents a negative exponential distribution curve are fire tolerant, and the recruitment is continuous if regular fires occur (Geldenhuys 1993). This concept is fundamental in order to define woodland management guidelines.

This study has shown different trends of the population structure for the five species *T. sericea, S. madagascariensis, P. angolensis*, *B. boehmii* and *B. spiciformis* in each of the three villages. It suggests that the patterns found were due to a combination of determining factors, such as species characteristics, environmental factors (e.g. soil) and disturbances factors (e.g. fire, agricultural practices and other human disturbances). However, size class distribution in this study, gave evidence that the species were being harvested for building poles.

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4.3.1 Selective harvesting for building poles

This study has found that the size class distribution of *Terminalia sericea*, *P. angolensis* and *S. madagascariensis* in Mphoto woodland showed the typical pattern of a species harvested for poles, with fewer individuals in the third size class (11- 15 cm) mid point. Consecutively, the next class diameters presented fewer individuals. Among all of the three species, only *T.* sericea showed reduced number in the third size class in all villages. This evidence has confirmed the preference of the inhabitants of the all three villages. This information on this particular species will help the decision makers and the local communities drawing up guidelines for monitoring of *T.* sericea for building poles. The selective harvesting of those tree species for building poles will require more attention in Derre woodlands (see Fig.3.8).

Brachystegia boehmii, despite the preference for use as building poles and other uses, displayed a negative exponential distribution in both land uses in the Golombe and Arame villages. The same picture was found for *B. spiciformis*, in Arame and Mphoto. The size class distribution for both species suggests that selective pole harvesting has had no impact on population growth. The large number of trees present indicates a low level of harvesting and this has shown that the people are more selective in terms of preferred size and quality of stems.

Agricultural practices, opening gaps by clearing land and fire are discussed as factors that have influenced the patterns found in Derre woodlands.

4.3.2 Agricultural practices and fire

The practice of leaving cleared and cultivated land to fallow for long periods of 15 years or more before recultivation has influenced vegetation structure in areas close to the studied villages. For example the negative exponential curve of *P. angolensis* (see Figure 3. 5) found in Golombe and Arame villages could mean that the recruitment showed by this species, resulted from the presence of fallow land, as indicated by Boaler (1966). The timing of fires is important, however, as *P. angolensis* has been

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found to show better growth when burnt later in the dry season (Trapnell 1959). In Mphoto village commercial logging takes place legally, then the use of *P. angolensis* should be monitored in this village, because there is actually no limit in it's harvesting.

For *Swartzia madagascariensis* in Arame village a negative exponential distribution curve found in fallow land compared to the flat curve in woodland under selective harvesting (see Figure 3.4), indicates that the increased recruitment resulted from the presence of fallow land (Trapnell 1959; Lawton, 1978). As in fallow land, fires are fiercer than in woodland under selective harvesting (Boaler and Sciwale 1966). This species showed more regeneration when burnt early at the beginning of dry season, June-July, than when protected from fire (Trapnell 1959). This species is in high demand for the manufacturing of furniture. No other studies of density and size class distribution could be found for comparison. So it is difficult to draw any given conclusions about the factors, which influence its survival and growth from the results of this brief study.

4.3.3 Selective Logging

To know the influences of stems harvesting on population structure of selected species is not enough. Many other factors such the behaviour of each species in their growth stages since the seedlings, saplings until adult phase (Trapnell 1959), as well the ability of the species to regrowth from coppice or root suckers must be established.

In Derre Forest Reserve, in Arame village the size class distribution of *S. madagascariensis* and *P. angolensis* showed evidence of past logging of large trees, given the absence or the low number of stems in the size class >36 cm. Therefore the selective logging could be one of the systems to achieve the required recruitment from either seedlings or coppice regrowth. Considering that both species are shade intolerant and fire tolerant, group tree felling may be a better option to get the expected regeneration. Due to different time preferences for fire, the monitoring of this species will require different management guidelines.

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4.3.4 Regeneration

This study has found that the five species have shown different levels of recruitment, where in general the fallow land presented better conditions for almost all species. The exceptions were *T. sericea* and *S. madagascariensis* in Golombe village with a scarce number of individuals in the size class < 4 cm of diameter. Other factors than fire and light could influence the recruitment. Dispersion, competition, soil, among others, will contribute to the small saplings growth. In this study the effect of browsing will not be discussed, although it is also a factor that influences the survival of saplings.

Considering that the regeneration of miombo species is through stump or root sucker shoots and from seed germination, this study could not confirm whether the origin of regeneration occurs under the same species or by sprouting root shoots for all species.

In this study, for example the level of recruitment of *P. angolensis* suggests that Arame woodland has desirable conditions for this species. Their shade intolerance and fire-tolerance has previously been thought to facilitate their regeneration (Geldenhuys 1993; Piearce 1993). Geldenhuys (1977) also suggests that due to the reasonably shallow rooting system of *P. angolensis* this species may be found on poorly as well as freely drained soil.

4.4 Sustainable collaborative management in miombo woodlands

This study gave information on species preferred by locals, products used and some findings of size class distribution of five most used trees that could be used as preliminary information, which the stakeholders could start using in their management actions.

In Derre woodlands the rural inhabitants have been using informal management for a long period. Empirical knowledge has been passed from parents to sons. The findings of this study could be the start of a collective thought process about conservation and use, but not the final answer for sustainable use of those five species.

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The fact that NTFPs could not be a source of income generation makes the advertising task more difficult for the Derre Forest Reserve management, when trying to persuade the rural communities to become part of the formal stakeholders. For this reason the participatory survey was applied in the beginning of this study. The Derre woodlands inhabitants started to think about woody and shrub resources and the relation between ecology of the five tree species and plant products used by them.

Shackleton and Scholes (2000), suggest that the main management actions with the involvement of the local woodland inhabitants are: fire monitoring; different methods of bush clearing; selective harvesting of resources; herbivore species mix; supplement feeding; fencing; and erosion control. Other management actions particularly for the miombo conditions, comprise: coppice management, harvesting practices monitoring; bush fallow system; managing demand for wood products and management of NTFPs (Chidumayo *et al.* 1996). This type of management activities would be more effective and less costly for the government. At the same time, it would beneficiate the rural communities.

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5. Conclusions and Recommendations

This study has shown that, through the use of woody species, miombo woodlands contribute to the livelihoods of the local communities living in Derre. The preferred species varied slightly between the three villages, as a result of differences in factors such as individual household preference, culture, plant availability and accessibility. In this study it was found that usually more than one species was used for one product. Most of the species are trees with multiple uses.

This study investigated the impact of building pole harvesting on woodland plant species and focused on five tree species, namely *Brachystegia boehmii*, *B. spiciformis*, *Terminalia sericea*, *Pterocarpus angolensis* and *Swartzia madagascariensis*. The information on size class distribution of these species indicated that response to disturbances differed among species and was probably related to their evolutionary history. An understanding of the life histories of these tree species would be a valuable basis for development of management guidelines for the Derre woodlands. The more knowledge on species characteristics and specific products is obtained, the better the understanding of the priorities and alternatives that can be recommended for certain species without threatening the customs and needs of local communities. This understanding will enhance a higher acceptance of application of forest management practices by the inhabitants.

The woodland provides for the basic needs of the inhabitants of the villages, as they do not have access to alternative products anywhere else close to their villages. The plant products harvested were used mainly for basic needs such as housing material, firewood, and medicine. This study has therefore shown that these products have economic value for the inhabitants. However, unsustainable usage of the species may have a negative impact on the plant resource base, resulting in economic loss for the users. In Derre woodlands the non-timber forest products have not been commercialised, therefore the local community does not generate income from such products. The products are also important for making medicines thus giving them

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social value. The religious value of NTFPs were not analysed in this study.

The most popular species for the majority of the products were woody species, with similar products used in the three villages. The choice of species within the local communities differed slightly according to the use of non-timber forest products. Nevertheless, villagers used the same common species for the purpose of the following: building poles, rope, firewood and medicine. A common demand in the three villages was for young stems of trees for use as construction poles and for the bark of *Brachystegia* sp. used for rope. This study suggests that the level of use of non-timber forest products was similar for all the villages (see Appendix 1).

The implication of potentially large and long-lived trees having multiple uses is that the species may become scarce as a result of higher harvesting intensities. Although in total more than 32 other species are used as building material, inhabitants still prefer the five species already mentioned. Monitoring the sustainable use of these five species could lead to the use of the main stem for best quality timber, and the branch wood for products of smaller pieces, as well as to an increasing harvesting of the lesser used tree species, as an alternative source of raw material.

The five plant species selectively used for building poles are all large trees with multiple uses. The number of wall and roof poles used per household was similar among villages and the number of persons per household did not influence the size of the house. The species used differed slightly from village to village. This suggests that the size of the house and species selected for construction may depend on the available stems in the forest and/or individual preferences in home construction.

In the miombo woodlands studied, the number of shrub and woody species per hectare differed significantly among the villages. This suggests that the miombo woodlands differ in composition and structure over a small scale as a result of the variations in physical environment and human disturbance. The species diversity in Mphoto was less than in the other villages. This could be due to soil conditions and other factors. This study suggests that the clearing woodland fallow land and consequent open land and periodic fires' could determine the level of recruitment of the species.

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The population structure of the five species *T. sericea*, *S. madagascariensis*, *P. angolensis*, *B. boehmii* and *B. spiciformis* showed different trends in each of the three villages. It suggests that the patterns found were due to a combination of determining factors. However size class distribution gave evidence that the species were being harvested for building poles in Mphoto villages.

This study has therefore provided evidence that the selective harvesting of the three above-mentioned species for building pole in the Derre woodlands is having a non-detrimental effect on recruitment and development.

This study has also provided some evidence that *Pterocarpus angolensis* and *Swartzia madagascariensis* can benefit from shifting cultivation and fire, which encourages coppice regeneration. However, more research is required to further validate this evidence.

5.1 Final recommendations

The local communities should take-part in woodland management decision-making, as the most preferred building pole species will be endangered if selective harvesting for poles is not monitored. This is especially true in the case of *Terminalia sericea.*

Use of *Terminalia sericea* and *Swartzia madagascariensis* for building poles must be monitored in the studied three villages, and the available alternative species should be utilized.

The local communities should take-part in woodland management decision-making to achieve the conservation of the valuable timber species, which are endangered by selective logging. This is especially in the case of *Pterocarpus angolensis* and *Swartzia madagascariensis* which are used for other purposes than for building poles.

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The use of *Pterocarpus angolensis* for building poles should be done on a sustainable basis in all villages. Alternatively, the other species could be used.

In order to reduce the harvesting of building poles, the introduction of mud blocks as a construction material in areas with suitable soil types is recommended. An additional advantage of using mud blocks is that these houses last longer than those constructed using wooden poles, although there is a need to develop research on the application of this recommendation.

Additional research on the behaviour of these species is recommended in order to answer to questions like 'why are there differences in canopy species between Golombe and Mphoto, or Arame and Mphoto, when the climate over relatively short distances is likely to be the same'. Other factors such as soil, combinations between species, shifting cultivation, fire, browsing and selective harvesting should be considered in this analysis.

The factors that influenced the higher presence of individuals *S. madagascariensis* in the Arame village than in the other two villages also requires investigation.

By involving the local communities, forest policy-makers will achieve improved and more cost-effective management. The presence of a management person will not be necessary, which will lower the management cost of this particular Derre Forest Reserve.

An improved beekeeping system could contribute to income generation, supplement the diet of local people and cause less destruction of the trees, which might not be burnt for honey collection anymore. The drying of mushrooms that is carried out in Mphoto could be implemented in Golombe and Arame villages. This would also improve the quality of the diet in these villages beyond the end of the wet season.

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Terminology

Climax – The presumed end point of a successional sequence, a community that has reached a steady state.

Community patterns in time – succession of non-seasonal, directional and continuous pattern of colonization and extinction on a site by species populations.

Interspecific competition – competition between individuals of different species.

Intraspecific competition – competition between individuals of the same species.

Livelihoods – means of living of local communities.

Local communities – Inhabitants who live close to and depend on the forest for their livelihood.

Miombo woodland – African woodland dominated by tree genera – *Brachystegia – Julbernardia* and /or *Isoberlinia.*

Niche – the limits, for all-important environmental features within which individuals of a species can survive, grow and reproduce.

Non-Timber Forest Products (NTFP) in this study are regarded as: vegetative plant structures (stem fibre, leafs, roots, bark, raw materials such as rattan, bamboo), reproductive propagules (such as fruits, oil seeds, nuts), plant exudates (resins, latex, gums), wildlife and wildlife products (Peters 1996b).

Patchy habitat – habitat in which there are significant spatial variations in suitability for the species under considerations.

Participatory Rural Appraisal – is an approach where different techniques such as Participatory Mapping, Matrix Ranking of Product Use and Key Informant Interviews are used in order to enable community members and outsiders to assess local conditions. Here the unit of analyses is a village.

Population dynamics – The change in the size and structure exhibited by a population over time (Peters 1996).

Population structure – The numerical distribution of individuals of differing size within a population at a given moment in time. (Adapted from Peters 1996).

Shifting cultivation – is the extensive agriculture system, where the most part of the trees are cut and the plants remains burned. The areas are abandoned after three or four years' farming because reduce in soil fertility under cultivation (Boaler and

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Sciwale, 1966).

Stable equilibrium – a level of a population or populations or of resources that is returned to after slight displacement from that level.

Suffrutices – perennial plants which aerial parts die each dry season, new shoots growing in the following year (Boaler 1966).

Sustainability- "seeks to meet the needs and aspirations of the present without compromising the ability to meet those of the future" (in WWF 1983).

Sustainable – "system for exploiting non-timber forest tropical forest resources is one in which fruits, nuts, latexes, and other products can be harvested indefinitely from a limited area of forest with negligible impact on the structure and dynamics of the plant population being exploited." (Peters 1996b).

Swidden – an area of land made cultivable by cutting or burning off the vegetative cover.

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Appendix 1. Species and uses in five villages, Golombe (1), Arame (2), Gida (3), Maticula (4) and Mphoto (5), in Derre, Mozambique.

Species	Poles	Rope	Coffin	Implements	Pestle	Mortar	Canoes	Firewood	Honey	Medicines	Sacks	Clothing	Mats	Insects	Thatch	Fruit	Furniture	Soap	Glue	Wine	Baskets	Broom	Hats	Nets	Cages
Annona senegalensis	1,3,4,5			2,3,5				1,3		1,2,3						1,2,3,4,5			3,4						
Bamboo	1,3,5		1					1													1	1,3			3
Brachystegia boehmii	1,2,3,4,5	1,2,3,4,5	1,2,3,4	2,3			2,3,4	1,2,3,4,5	1,2		2	2,3,4,5	3											3	
Brachystegia spiciformis	1,2,3,4,5	1,2,3,4,5	1,2,3,4,5	2,3,4,5			2,3,4	1,2,3,4,5	1,2,3,5			3,4,5	5	3										3	
Burkea africana	3,4							3						3,4											
Diplorynchus condylocarpon								2		2															
Flacourtia indica								2		1,2						1,2,5									
Hyparrhenia filipendula	1,2		1												1,2,3										
Hyphaene sp.	1	1															1			2	1,2		1,2		
Julbernardia globiflora				3				3																	
Milletia stuhlmanii	2							2		2,5							2,5	2							
Pericopsis angolensis	4,5							4,5	4,5	4							5								
Piliostigma thonningii										3				3											
Pterocarpus angolensis	1,2,3,4,5		2,4,5		5	5		1		1,2,3,4,5							1,2,34,5								
Raphia sp.			4										4				4								
Swartzia madagascariensis	1							1,2		2,4				4			2,4								
Terminalia sericea	2,3,4,5				5			2,4,5	2,4	2,3		5					2,3								
Ziziphus mauritiana																4									
Other 22 species	Various uses																								

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Appendix 2

Questionnaire

Derre Administrative Post ☐☐ ☐ 1/

1. Name of Interviewer -- 2/
   a. Village -- 3/
   b. Date of interviewee-------/------------/2000 4/

2. Household information

a. Name of Interviewee --- 6/
b. Age -- 7/
c. Woman ☐, Man ☐ --- 8/
d. Occupation? -- 9/
e. Education? ------------If yes, which class? --------------------------- 10/
f. Position in household? -- 11/
g. Name of household head? -- 12/
h. Woman ☐, Man ☐ --- 13/
i. Occupation? --- 14/
j. Education? ------------- If yes, which class? ---------------------- 15/
k. Number of persons now at the household? ------------------------ 16/
l. Number of persons work for household? ------------------------- 17/
m. Number of adults (> 60 years old) Female ☐, Male ☐ 18/
n. Number of adults (between 30 at 59 years) Female ☐,Male ☐ 19/
o. Number of adults (between 18 at 29 years) Female ☐, Male ☐ 20/
p. Number of children (less than 17 years) Girls ☐, Boys ☐ ------21/

2.1 Family income - Which are the family income sources?

Income sources		
Employment		22/
Forest products		23/
Agriculture products		24/
Others		25/

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3. Economic purposes

3.1Which of those products are uses for self-consumption?

Tuber		25/	Bamboo		31/
Mushroom		26/	Rope		32/
Fruits		27/	Firewood		33/
Honey		28/	Medicinal		34/
Reed		29/	Timber		35/
Poles		30/	Raffia		36/

3.2 How many units do you collect from the forest/day, and what time of year do you produce these articles?

Product	Quantity		Time of year	
Tuber		43/		57/
Mushroom		44/		58/
Fruits		45/		59/
Honey		46/		60/
Reed		47/		61/
Poles		48/		62/
Bamboo		49/		63/
Rope		50/		64/
Firewood		51/		65/
Medicinal		52/		66/
Timber		53/		67/
Raffia		54/		68/

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3.3 How much time you spent for collecting those products, and who collect?

Product	Time spent		Who collect?	
Mushroom		70/	Woman ☐, Man ☐	81/
Fruits		71/	Woman ☐, Man ☐	82/
Honey		72/	Woman ☐, Man ☐	83/
Reed		73/	Woman ☐, Man ☐	84/
Poles		74/	Woman ☐, Man ☐	85/
Bamboo		75/	Woman ☐, Man ☐	86/
Rope		76/	Woman ☐, Man ☐	87/
Firewood		77/	Woman ☐, Man ☐	88/
Medicinal		78/	Woman ☐, Man ☐	89/
Timber		79/	Woman ☐, Man ☐	90/
Tuber		80/	Woman ☐, Man ☐	91/

3.4 How much each item you produce, how much cost or change?

Product	**How much produce**		**How much cost**	**Change**	
Mat		92/			108/
Sieve		93/			109/
Chair		94/			110/
Bed		95/			111/
Table		96/			112/
Relax chair		97/			113/
Pottery plate		98/			114/
Pot		99/			115/
Implement handle		100/			116/
Hoe		101/			117/
Axe		102/			118/
Bow		103/			119/
		104/			120/
		105/			121/
		106/			122/
		107/			123/

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3.5 Where products are sold?

Within village		124/
Licuari		125/
Luale		126/
Derre Post		127/
Quelimane		128/

3.6 Which transport is used?

By foot ☐----------------------------129/
Bicycle ☐------------------------130/
Tractor ☐ -------------------------131/
Track ☐ ------------------------132/

3.7 How many units do you produce per year, How much each unit cost and how much transport cost?

Product	How many units you produce?		How much each unit cost		how much transport cost	
Maize		133/		140/		147/
Boer Beans		134/		141/		148/
Peanuts		135/		142/		149/
Cassava		136/		143/		150/
Chicken		137/		144/		151/
		138/		145/		152/
		139/		146/		153/

1 = Tin of 20 litres
2 = Bag of 50 Kg
3 = Tin milk

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4. For building poles

Listed below are various choices. Circle one number for each.

1. Best
2. Good
3. Less good
4. Least

4.1 Which species do your prefer?

a. Mombo -----------------------------1-------2-------3-------4------154/
b. Murroto ----------------------------1-------2-------3-------4------155/
c. Msaisai -----------------------------1-------2-------3-------4------156/
d. Umbila -----------------------------1-------2-------3-------4------157/
e. -----------------------------1-------2-------3-------4------158/

4.2 Which diameters do you prefer for walls?

a. < 5cm --159/
b. 6 – 11 cm --160/
c. > 12 cm ---161/

4.3 How often do you replace wall poles?

2 at 3 years		162/
6 at 8 years		163/
		164/
		165/

4.4 How often do you replace roof poles thatch?

Every year		166/
2 and 2 years		167/
		168/
		169/

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4.5 Which type of material you use for roof thatch?

	170/
	171/
	172/

4.6 How many poles are necessary for one middle house?

-- 173/
-- 174/
-- 175/

4.7 How many poles are necessary for roof?

--- 176/
--- 177/
--- 178/

4.8 which species sprout from the stem?

a. Mombo -------------- Yes ☐, No ☐-----------------------179/
b. Murroto ------------- Yes☐, No ☐-----------------------180/
c. Mssaissai ------------ Yes☐, No ☐-----------------------181/
c. Umbila ------------- Yes☐, No ☐-----------------------182/

4.9 Do you use poles from regrowth?

-------------------------- Yes ☐, No ☐--------------------------183/

4.10 Which species sprout from the roots?

a. Mombo ----Yes ☐, No ☐---184/
b. Murroto ----Yes ☐, No ☐---185/
c. Msaisai -----Yes ☐, No ☐---186/
d. Umbila ------ Yes ☐, No ☐---187/

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5. For firewood purposes

5.1 Which species you prefer?

a. Mombo --189/
b. Murroto ---190/
c. Mssaissai --191/
d. Umbila --192/

5.2 Do you use live wood? ---- Yes ☐, No ☐--------------------- 193/

5.3 How many times per week do you collect firewood from the forest? ---194/

5.4 mean weight of firewood removed from the forest per headload ? (Scale 25 kg)

---195/

5.5 Do you use any trees from your home garden? If yes which? ----------
----
--196/

6. For Medicinal Purposes

6.1 Do you use any of those species for medicinal purposes?

a. Mombo ------Yes ☐ , No ☐--------------------------------197/
b. Murroto ----- Yes ☐ , No ☐--------------------------------198/
c. Mssaissai ------ Yes ☐ , No ☐-----------------------------199/
d. Umbila ------ Yes ☐ , No ☐--------------------------------200/

6.2 Which materials do you use?

a. --------------------------------------Bark ☐----------------------201/
b. ------------------------- ------------ leaves ☐ -------------------------202/

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c. --Roots ☐----------------------203/
d. --------------------------------------Fruits☐ --------------------------204/
e. ---------------------------------------Sap ☐-----------------------205/

7. For honey purposes

Listed below are various choices. Circle one number for each.

1. Best
2. Good
3. Less good
4. Least

7.1 Is honey obtained from any of the following species?

a. Mombo ------------------------------1-------2-------3-------4-------207/
b. Murroto ------------------------------1-------2-------3-------4------208/
c. Msaisai -------------------------------1-------2-------3-------4------209/
d. Umbila -------------------------------1-------2-------3-------4------210/

7.2 How do you collect honey? --

-----211/

7.3 How many times can you collect honey from the same tree? ----------
----

212/

7.4 Do you use bark to make hives? ---

--213/

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8. For traditional practices

8.1 Do any special trees have religious or spiritual values? If yes which?
--214/
--215/
--216/
--217/

8.2 What happens if people break the rules? --------------------------------
----

218/

8.3 Could you cut these trees? --

--219/

8.4 Are there any places in the forest which are sacred? -------------------
----

---220/

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Appendix 3

Derre Post			Zambezia Province					
Name				Date		Plot Nº		
UTM ZONE	GPS E			GPS S				
Sub Plot Nº								
ID	Local Name	Scientific Name	DBH (cm)	Nº of Stems	Quality	Condition	Strata	Observ.