# TESTING THE FEASIBILITY OF COMMUNITY-BASED COPPICE MANAGEMENT FOR SUSTAINABLE FUELWOOD PROVISION IN RURAL SOUTH AFRICA

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## DECLARATION

I declare that this thesis is my own work, unless specifically mentioned and acknowledged in the text. It is being submitted for the Degree of Doctor of Philosophy at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any university.

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## ABSTRACT

As in other developing countries in Africa, unsustainable harvesting of fuelwood in South Africa has become a matter of concern among policy makers and researchers. This is despite the country having the highest electrification access in the continent, because the majority of rural households in communal woodland areas cannot afford to cook on electric stoves, due to high levels of poverty and unemployment,. Moreover, relevant institutions do not have the capacity to monitor compliance with harvesting rules, resulting in resource users harvesting livewood due to the scarcity of deadwood with almost impunity, despite this constituting an illegal activity under the traditional management rules. Other interventions such as woodlots have largely been unsuccessful in addressing the unsustainable harvesting problems. Thus, researchers have recommended that rotational coppice harvesting be implemented by the local institutions in partnership with local resource users as a potential strategy to sustainably provide fuelwood, while addressing incapacity problems in terms of the shortage of physical and human resources in the relevant institutions. The majority of South Africans using fuelwood reside in the savanna biome which covers 34% of the country. Savanna tree species generally coppice (resprout) easily and this provides an opportunity for rotational harvesting strategies, involving local resource users.

Although ecological data suggest that rotational harvesting of coppice regrowth can be sustainable, rotational harvesting of coppice has not gained popularity in South Africa, because of tenurial and institutional challenges in communal areas. Thus, whether or not rotational harvesting strategies are feasible in communal woodland is yet to be established. This thesis reports the findings of a study that assessed the implementation of a rotational harvesting scheme in selected rural communities. In order to investigate the ecological and socio-economic feasibility of community-based coppice management (CBCM), four communities across Limpopo and Mpumalanga Provinces (Thorndale, Peninghotsa, Homu and Makhuva) in South Africa were selected based on a set of criteria, and involved in a coppice management trial. The harvesting trial was implemented over a one year period by the local traditional leadership in partnership with local resource users and relevant government institutions, facilitated by the researcher. The trial was successfully piloted through one iteration of the adaptive management cycle in the first two villages. The intervention entailed rotational harvesting of specified stem size classes and species in blocks

(coupes), according to consensus-based rules that were enforced by local institutions in cooperation with resource users. The study period was not long enough to monitor the rotational harvesting of coppice *per se*, but enabled the creation of coppice stools and a community-based system for rotational harvesting of wood resources.

Both qualitative and quantitative methods were used in this action research study to assess fuelwood harvesting and use patterns, ecological sustainability, social feasibility, and the adequacy of local resource-governance systems to implement CBCM, over the course of the first year of the intervention. Data such as energy mix used in the households, time spent acquiring fuelwood, compliance with harvesting rules, perceived cooperation between institutions, and socio-economic information were collected using questionnaires. Data were collected in two survey periods, the first occurring in early January 2014 before the trial started, and the second one from April 2014, after it had started, to January 2015. The fuelwood resource base, coppicing, and wood harvesting patterns in the village communal woodlands were assessed before and during the trial in fixed 100 $m^2$ circular plots. Allometric equations were used to convert the observed density of stems and coppice shoots into wood biomass. The measured growth rates of coppice shoots were used to estimate the amount of time that would be required for shoots to reach the allowable harvest diameter of 4–9 cm, and hence the number of years required for one harvest rotation between coupes. These data, along with the measured rates of self-thinning of shoots and village wood demand, were used to make projections of fuelwood supply by coppice and unharvested stems in the village coupes over a number of harvest rotations. The effectiveness of management under traditional management rules and that of CBCM were assessed in focus group discussions, interviews and questionnaires with the local traditional leaders and key informant interviews with government rangers before and during the trial.

Levels of compliance by resource users with the agreed CBCM rules were high in Thorndale and Peninghotsa because they were given an opportunity to decide and agree on harvesting rules that were conducive to their harvesting practices. Although the intervention did not change the energy use patterns in the households in these villages, local resource users spent significantly less time acquiring fuelwood than they did prior to the intervention, thus reducing the opportunity costs of wood harvesting. There was a noticeable decline in the incidence of illegal harvesting of fuelwood by “outsiders” due to greater vigilance by resource users and community-based monitors as a result of the successful implementation of

CBCM in these villages. Based on the growth rate data averaged across species, coppice shoots would reach the harvestable diameter of 4 cm in 3 years in Thorndale and 4 years in Penninghotsa. The difference may be explained by species differences in these villages, e.g. *Terminalia sericea* which coppices vigorously was one of the predominant species recorded in Thorndale. The successful implementation of the trial in Thorndale and Pennighotsa in the first year of the intervention is attributed to a number of socio-economic factors, including relatively small and homogenous populations, innovative and adaptive local TAs which were flexible and had encouraged community participation and supportive resource users who had positive perceptions of their leadership and the project. This is in contrast to Homu 14B and Makhuva which were characterised by larger, more heterogeneous populations, inflexible leadership who were incapacitated by lack of physical resources, lack of transparency by the leadership, and negative attitudes and perceptions of resources users. This study demonstrates that community-based coppice management is potentially applicable and feasible for sustainable provision of fuelwood in communal areas, and identified under what conditions it is most likely to succeed.

*Keywords*: community-based coppice management, rotational harvesting, coppice shoots, local institutions, communal woodlands.

# DEDICATION

I dedicate this work to my late father Mackson Mbhazima Mathebula

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## LIST OF ABBREVIATIONS

| | |
|---|---|
| **ADMADE** | Administrative Management Design for Game Management Areas Programme |
| **CAMPFIRE** | Communal Areas Management Programme for Indigenous Resources |
| **CBCM** | Community-Based Coppice Management |
| **CDF** | Community Development Forum |
| **CPR** | Common Pool Resources |
| **CBNRM** | Community-Based Natural Resource Management |
| **DAFF** | Department of Agriculture, Forestry and Fisheries |
| **DEA** | Department of Environmental Affairs |
| **DLRRD** | Department of Land Reform and Rural Development |
| **JFM** | Joint Forest Management |
| **KNP** | Kruger National Park |
| **IEA** | International Energy Agency |
| **NGOs** | Non-profit Organizations |
| **NRM** | Natural Resource Management |
| **NTFP** | Non-Timber Forest Products |
| **SANCO** | South African National Civic Organization |
| **SPSS** | Statistical Package for the Social Sciences |
| **TA** | Traditional Authority (or traditional institution) |
| **LG** | Local Government |

## GLOSSARY OF TERMS USED

**Coppice shoot –** shoot growing from a tree stump or stool left after harvesting or burning (White, 1979).

**Coppice-with-standards system** – a coppice system in which a proportion of trees and shrubs are left to grow into larger size classes (White, 1979).

**Coupe –** area of coppice to be cut in any year (White, 1979).

**Sustainable harvesting –** harvesting such that the rate of biomass removed is less than or equal to the rate of biomass regeneration.

**Savanna –** ecosystem which is characterized by a continuous herbaceous layer and discontinuous woody layer (Scholes and Archer, 1997).

**Woodland –** defined as vegetation formations that are mostly dominated by trees, not to the extent of overlapping canopies and also not excluding other growth forms such as grasses or shrubs (Scholes, 2004).

**Rotational harvesting –** returning back to the first coupe after a certain amount of time to harvest regrowth.

# CHAPTER 1

## GENERAL INTRODUCTION AND LITERATURE REVIEW

### 1.1 INTRODUCTION

Fuelwood is the primary energy source for domestic purposes throughout the developing world, in both urban and rural communities (Von Maltitz and Scholes, 1995; Campbell *et al.*, 2003; Ejiqie, 2007; Madubansi and Shackleton, 2007). It will continue to be used in the short to medium term, given the low incomes and high unemployment rates in these communities, which constrain the ability of households to afford alternative energy sources and associated appliances (Gandar, 1997; Shackleton *et al.*, 2007b; Howells *et al.*, 2005). For example, a decade after the introduction of electricity, over 90% of households in villages in Bushbuckridge, Mpumalanga Province, South Africa, still used fuelwood for cooking and heating (Madubansi and Shackleton, 2007). The mean household fuelwood consumption rates in these communities had not changed between 1991 and 2002, even with a government allowance of 50 kWh free electricity per household per month. In the meantime, sources of wood continue to be depleted (Shackleton *et al.*, 2005; Damm and Triebel, 2008).

There is concern about unsustainable harvesting of fuelwood (Twine *et al.*, 2003a; Shackleton *et al.*, 2004a; Makhado *et al.*, 2009). Forest and savanna ecosystems are being rapidly degraded for the natural resources they provide because fuelwood is the primary, and often only, energy option for rural African households, local supplies are in high demand, often resulting in unsustainable harvesting (Twine *et al.*, 2003a; Shackleton *et al.*, 2004a; Lawes *et al.*, 2004). This has ecological and social costs. Interventions aimed at closing the "energy gap" or solving the "fuelwood crisis" have had little impact (Arnold *et al.*, 2006). Natural resource governance based on centralized governance or top down management has proved unsuccessful to sustaining these ecosystems (Prasad, 2007). Community involvement in resource management, known formally as community-based natural resource management (CBNRM), has gained favour as an alternative to resource management approach (Swatuk, 2005).

The capacity of savanna trees to resprout (coppice) after being damaged provides an opportunity for active management of coppice in indigenous woodlands to enhance fuelwood supply especially in Africa (see White, 1979; Kennedy, 1998; Shackleton, 2001; Kaschula *et al.*, 2005). This is because there is high dependence on fuelwood for primary energy uses (IEA, 2006), while the savanna biome constitutes almost half of the continent (Scholes and Walker, 1993; Higgins *et al.*, 1999). The potential exists to address the problem in savanna areas by taking advantage of the coppicing ability of savanna trees, in rotational coppice management systems involving local communities and institutions (i.e. community-based coppice management) (Kaschula *et al.*, 2005; Makhado *et al.*, 2009). However, most coppice studies in African savannas have been conducted in protected areas, to the exclusion of people (Shackleton and Clarke, 2007). The proposed community-based coppice management (CBCM) is informed by CBNRM. It is based on the hypothesis that by involving local people as part of the coppice management system, sustainable fuelwood provision can be achieved in communal woodlands. This thesis sets out to test this hypothesis by assessing the feasibility of CBCM.

This literature review thus starts by reviewing the use of fuelwood across Africa, and South Africa in particular, and the sustainability thereof. This is followed by a review of coppicing in savannas which provides a backdrop to a review of available data on possible coppice management systems in the South African context. The literature review ends with a review of the literature on local resource governance and institutions, but this occurs after reviewing among others, CBNRM as management strategy which is a context for locally-managed coppice systems in communal lands.

## 1.2 LITERATURE REVIEW

### 1.2.1 Patterns of use and commercialization of fuelwood

The vast majority of rural households in sub-Saharan Africa rely extensively upon fuelwood as their basic energy source (Kituyi *et al.*, 2001). For instance, in many parts of the region, more than 90% of the rural population relies on fuelwood and charcoal, with the average fuelwood load per day being around 20 kg (IEA, 2006). The daily amount consumed per household ranged from 8.2–23.2 kg in communal woodland areas assessed in South Africa (Shackleton and Shackleton, 2004b). However, the use of fuelwood in South Africa has changed little over the last few decades, despite increasing population pressures and changing socio-economic and environmental profiles (Madubansi and Shackleton, 2007). In Botswana, the poorest 40% of households use predominantly fuelwood for cooking despite having electricity paraffin and gas (Prasad, 2007). This is mainly due to low income and cost of connections as they are too poor to afford the modern energy sources (Prasad, 2007). Contrarily, in The Gambia reduction in fuelwood usage was observed as a result of improved access to kerosene and electricity (Prasad and Visagie, 2006). Generally, it is apparent that low income levels are accountable for the significant use of fuelwood over other sources (Masekoameng *et al.,* 2005). However, Africa has the lowest electrification rate in the world, excluding Egypt and South Africa (Adkins *et al.,* 2012). For example, it is estimated that less than 20% overall, and in some countries as little as 5%, of the population in Africa has direct access to grid electricity (Adkins *et al.,* 2012).

In terms of commercial opportunities resulting from local shortages, those with vehicles take advantage by collecting fuelwood from areas with high resource supply to sell in demand areas (Williams and Shackleton, 2002). For instance, Twine *et al.* (2003b) observed about 32 *bakkies* (pick-up truck) and five large trucks transporting wood from one village to be sold in another over a seven-day period in Bushbuckridge. The proportion of households purchasing fuelwood in such areas has increased in response to increased fuelwood scarcity in the local environment. Commercial harvesting is thus a response to fuelwood shortage (Gandar, 1997). Alternatively, those who cannot afford to buy fuelwood are coerced to obtain a greater proportion of energy requirements from other sources, such as paraffin, gas, electricity, (Shackleton, 2001). For example, villages around Giyani region, Limpopo Province, South Africa supplement wood with paraffin when wood is not available. Paraffin is also used in case of rainy conditions or when cooking or heating has to be done as a matter of urgency (Masekoameng *et al.*, 2005). Scarcity often results in an inflation of local prices, thus enticing increasing numbers of new traders in the market (Twine, 2005). Those who have vehicles can take advantage of the resource scarcity to satisfy the demand in the affected areas (Twine, 2005). Those who have vehicles can take advantage of the resource scarcity to satisfy the demand in the affected areas (Twine, 2005).

Households that remain reliant on biomass due to a lack of ability to access modern fuels, for financial or other reasons, could be considered to be in a state of “energy poverty” (Hughes *et al.*, 2010). This being the case it is imperative that supportive and adequate policies and strategies with vision and direction be developed for the fuelwood sector (Williams and Shackleton, 2002), to help promotes sustainable harvesting of fuelwood since the use of fuelwood is predicted to continue despite access to electricity in developing countries (IEA, 2006). In the context of South Africa, suggestion of having an increase in the amount of electricity subsidy has been made as one potential strategy that can ameliorate the pressure on the woodlands (Shackleton *et al.,* 2007a). While this appears to be a good suggestion, there should also be creation and accesses to job opportunities to enable local people to buy electric appliances because affordability to the cooking electric stoves is a hindering factor (Shackleton *et al.*, 2007b).

### 1.2.2 Ecological impact of fuelwood harvesting

The use of fuelwood has been blamed for many of the environmental problems in Africa (Gandar, 1997; Hofstad and Sankhayan, 2001). For instance, harvesting by removing the whole tree removes nutrients because the aboveground biomass serves as a significant reservoir for many nutrients. The results include soil damage by disrupting topsoil, mixing soil layers, creating deep ruts, or compacting soil layers contributing to soil erosion as the soil is left bare (Campbell *et al,* 2007). While deadwood is generally preferred over livewood for energy purposes (Shackleton and Prins, 1992; Gandar, 1997), its removal leads to loss of habitats for fungi, invertebrates and birds (Du Plessis, 1995; Mudekwe, 1997). For instance, a decline in number of cavity nesting birds in the Eastern Cape, South Africa has been linked with the harvesting of deadwood (Du Plessis, 1995). Nonetheless, in comparison to other environmental stresses caused by other activities, the removal of deadwood has slight impact in the ecology (Gandar, 1997). Clearing woodland for agricultural purposes has been indicated as having a more serious impact on the environment than that emanating from wood harvesting (Hughes *et al.,* 2010). Thus, it is apparent that fuelwood extraction is not the primary cause of deforestation (Gandar, 1997) because large trees which have an important regulatory role in maintaining the structure of ecosystem are generally not harvested (Gandar, 1997). Moreover, fuelwood harvesters select certain tree species and within those species harvest stems of about 4 cm in diameter (Luoga *et al.,* 2004; Neke *et al.,* 2004; Shackleton and Clarke, 2007) which are usually in the intermediate size class. The results of selective harvesting are thinning of canopy cover, reduction in stem density, changes in woodland structure and coppice productions from stumps (Higgins *et al.,* 1999, Shackleton, 2000; Shackleton and Clarke, 2007).

Other impacts that selective harvesting can have are the change in species composition, as cutting influences the survival and reproduction of preferred fuel species relative to less preferred species, and that species which do not coppice may disappear altogether from the ecosystem (Wurster, 2010). For instance, in Ghana, Osei (1993) found that an important fuelwood species used by 80 % of households in two villages during the past decade was no longer available, while in Nigeria, Burkina Faso, Mali, Niger and Senegal Kindt *et al.* (2008) found that farmed parkland and nearby ecologically equivalent forest had different species compositions.

Sustainable harvesting remains important to the ecosystem and humans that need it for various purposes. Thus, ways need to be developed in which the impacts of fuelwood harvesting are ameliorated. This would require consideration of fuelwood collection not only to maintain the resource, but also the species that rely on it (Du plessis, 1995). Ecological sustainability can be promoted through selectivity of the preferred stems in a coppice-with-standard management system (Gandar, 1997; Kennedy, 1998). However, in such a system it is recommended that harvesting should be done by hand because this would ensure that some deadwood remains insitu to serve its broader ecological functions, such a nesting sites for certain bird species, micro-habitats for small vertebrates and invertebrates, nutrient recycling, micro-sites for seed germination (Shackleton, 1998). For instance, the aforementioned author found that there would be an annual rate of deadwood production of about 1.5-2.0% of standing biomass from the pieces that would be too big for fuelwood harvesting. Nonetheless, the spectre of environmental degradation that could result from unsustainable wood use in areas of high human population densities should not be the basis for arguments against the potential for sustainable use in areas with lower population densities (Lawes *et al.,* 2004). Certain communities still have relatively abundant fuelwood stocks (Gandar 1994) meaning such areas can allow for harvesting strategies such as rotational harvesting strategies of coppice shoots.

### 1.2.3 Evidence and implications of unsustainable use

Fuelwood harvesting becomes unsustainable when it causes changes in the woodland biomass in the manner that the quality of fuelwood is diminished for a length of time that negatively impacts human well-being (Wessels *et al.,* 2013). For instance, increased harvesting has a significant impact on the vegetation, which in turn reduces local resource supply (Twine, 2005). This leads to women, as they are the main ones involved in domestic harvesting, to be forced to spend more time collecting fuelwood (William and Shackleton, 2002). On the other hand, collection time has a significant opportunity cost, limiting the opportunity for women and children to improve their education and engage in income-generating activities. For instance, in Tanzania, the average distance to harvesting area is high in the central region of Singida, at over ten kilometres per day, followed by the western regions near Lake Tanganyika, where it is greater than five kilometres per day (IEA, 2006). In communal woodlands in South Africa, a headload of fuelwood (35 kg) that previously took about two hours to collect now has a mean collection time of four hours in Mametja, a village in Limpopo Province (Twine *et al.*, 2003a). Consequently, many children, especially girls, are withdrawn from school to attend to domestic chores related to biomass use, reducing their literacy and restricting their economic opportunities (IEA, 2006). In addition to increase of collection times, change in species preferences, increases in the price of fuelwood well below that of other fuels has also been observed in villages around Bushbuckridge. This was associated with unsustainable harvesting of the fuelwood resource (Madubansi and Shackleton, 2007).

Intensive harvesting of fuelwood has other implications such as indirect health and economic impacts. In mopane woodlands it affects the abundance of the edible mopane caterpillars (the caterpillar of the *Imrasia belina* moth). In such areas mopane caterpillars are apparently declining as a result of increasing exploitation of *Colophospermum mopane* trees and a general increase in pressure on mopane woodlands in Zimbabwe (Roberts, 1998). The author also reports of the disappearance of the mopane caterpillars from parts of Botswana after heavy harvesting. Mopane caterpillars are a valuable non timber forest product (NTFP) that contributes substantially to rural economies and nutrition in mopane woodland areas (Ghazoul, 2006), meaning that the loss of mopane caterpillars means loss of protein to the local people.

The sustainability of fuelwood harvesting remains a highly topical issue, with important implications for both the environment and human well-being (Matsika *et al.*, 2013). For instance, it can have positive economic benefits (Williams and Shackleton, 2002) through providing entrepreneurial and employment opportunities to some households (Gandar, 1994; Twine *et al.*, 2003b). On the other hand, sustainable fuelwood harvesting can supply a relatively cheap, or even free, source of energy for cooking and heating at the households level (Williams and Shackleton, 2002) thereby representing a cost saving to the household and the state. The later indicates the value and the urgency to create new strategies and policies to improve the sustinablibity of the resource base. Although in theory, sustainable harvesting can be effected through harvesting of deadwood, and only by hand Mudekwe (1997) which is one of the current control measures by traditional authorities/institutions, this is no longer applicable in many areas in rural South Africa. This is because deadwood has been exhausted, leaving resource users with no choice but to harvest (Gandar, 1997; Kirkland *et al.*, 2007).

Models have been used to assess sustainability of harvesting given levels of supply and demand. In the 1970s, it appeared that fuelwood use was growing rapidly, and this could have major adverse impacts on the resource base thereby affecting the poor users (Arnold *et al.*, 2006). This perception of a 'fuelwood crisis' was further encouraged by a widespread prediction of the models that by the end of the century much of Africa (and other areas) would have been deforested to provide fuelwood for the poor. Although harvesting of fuelwood has substantial impacts on the woody vegetation the 'fuelwood crisis' predicted since the 1970s has not materialized (Dewees, 1989; Arnold *et al.*, 2006; Twine and Holdo, 2016). Based on relevant literature, this was because of an underestimate of the actual supply. For instance, the prediction was based on a stock and yield figures relating to forest resources whereas, most fuelwood in practice comes from woody plant resources other than forest such as farm trees and the communal woodlands which regenerate after harvesting by coppicing (Dewees, 1989; Arnold *et al.*, 2006; Twine and Holdo, 2016). Furthermore, in case of scarcity of fuelwood resource users switch to other energy alternatives (Arnold *et al.*, 2006; Matsika *et al.*, 2013). Resprouting response of savanna species after harvesting is a key attribute of savanna species that contributes to ecosystem resilience and productivity (Shackleton 2001; Neke *et al.*, 2006). Therefore, any future models of these systems should consider integrating coppice regeneration (Matsika *et al.*, 2013).

### 1.2.4 Coppicing in African savannas

The capacity of savanna trees to resprout presents an opportunity for optimizing wood production in a managed rotational coppice harvesting system (Shackleton, 2000; Kaschula *et al.*, 2005). Vegetative regeneration is a trait in savanna trees that facilitates persistence in environments prone to disturbances such as browsing, harvesting and fire (Nzunda *et al.*, 2008). In order to resprout after injury a plant needs surviving meristems and stored reserves to support growth (Vesk and Westoby, 2004). The ability of damaged tree to regrow from the remaining stump is a key attribute of resilience and productivity of savannas (Shackleton, 2000; Shackleton, 2001; Twine, 2005). Following damage or removal of the above ground parts, most savanna woody plant species resprout or coppice vigorously, growing new shoots from roots and stumps (Shackleton, 2000).

Coppice shoots grow faster than newly established seedlings of a comparable size, because they already have a well-established root system with stored reserves (Chidumayo, 1993). Furthermore, coppicing trees protect the soil since the large rootstock remains in place (Kennedy, 1998). Coppice regrowth or resprouting is supported by reserves stored in below-ground biomass, usually a well-developed, deep root system (Bond and Midgley, 2001). This makes coppice shoots less susceptible to drought stress and they can grow much faster than seedlings. Persistence through coppice may thus be more successful in terms of growth rates and survival than recruitment via seed or dormant seeds in the seed bank (Bond and Midgley, 2001) and significantly contribute to the recovery of a woodland canopy. For that reason, resprouting could play an important role in woodland management and restoration (Shackleton, 2000). The coppice response is observed mainly after disturbances such as herbivory, fire and fuelwood harvesting (Luoga *et al.*, 2004).

Fuelwood harvesting is one of the major sources of damage to trees outside of protected areas in Africa (Shackleton, 1998). After tree-cutting, there is rapid regeneration from coppice, root suckering and the large bank of suppressed saplings (Chidumayo, 1993). User preferences determine what species are to be cut and cutting for the purpose of fuelwood usually occurs on small stems or smaller branches of a large tree. Harvesting methods play an important role in stimulating or retarding coppice growth. For instance, a clean cut with a saw results in more vigorous coppicing than a jagged cut from an axe. Subsequent to cutting, coppice regrowth can be managed according to conventional silvicultural practices to enable those that remain to grow more vigorously (Shackleton and Clarke, 2007).

Fire is endemic to savannas and has long been used as a management tool in these ecosystems (Gandiwa *et al.*, 2011). Fire also has an impact on coppicing of savanna trees. Resistance to fire varies with species. Some species are able to resprout from underground organs after the destruction of their above ground biomass by fire, while others are reliant on seed for regeneration (Bond and van Wilgen, 1996). The ability of woody plants to repeatedly resprout after frequent burning is dependent upon carbohydrate reserves, which are replenished between burns (Hoffmann *et al.*, 2000). If a destructive fire occurs before dominant shoots attain a safe height to escape mortality, the process of sucker shoot domination reverts to the initial stage and stumps respond by producing an equal or larger number of replacement shoots (Chidumayo, 1998).

### 1.2.5 Coppice management for fuelwood production in Africa

Active management of coppicing native trees may provide a more appropriate method of achieving sustainable fuelwood production than interventions such as planting woodlots of exotic species, while simultaneously preserving the habitat and biodiversity potentials of indigenous vegetation (Kennedy, 1998). For instance, Twine and Holdo (2016) predicted in their model that coppice regeneration can compensate for the harvesting of stems for fuelwood in communal woodlands. However, an understanding of the regeneration mechanisms of the species in the savanna woodlands is a prerequisite for developing appropriate silvicultural management regimes (Oliver and Larson, 1996), thereby guaranteeing their contributions to natural resource management (NRM).

African studies exploring sustainable fuelwood production from coppicing are limited. In East Africa (Tanzania and Kenya) for instance, Kennedy (1998) reports how carefully managed use of indigenous trees can satisfy human resource needs without resorting to monocultures of imported plantations species after his coppicing study of Leleshwa (*Tarconanthus camphorates*, Compositae). This tree species serves as one example of an indigenous African species that is amenable to coppicing. It produces high density wood and charcoal of the type preferred by local residents, and since it is an indigenous plant, no input of labour or special propagation techniques are required. It offers a number of other advantages as a source of fuelwood. Maximum rate of regrowth for fuelwood is between five and eight years after coppicing. The coppicing results observed by the author suggest that the percentage of total stems represented by optimum diameter size for fuelwood (2-20 cm) is 19.1% after 54 calendar months, 31% after 74 calendar months, and 41.6% after 121 calendar months. These values allow woodfuel harvesting to be devised that achieves a balance between overall biomass yield and maximum resource allocation to stems of the preferred diameter classes. Additionally, maintenance of leleshwa on a coppicing basis supports a good land husbandry as the shrubs prevent soil erosion and protect nutrient status. The coppiced trees also provide shade and prevent soil desiccation.

A case study from Malawi's Central Region comparing fuelwood species representation in customary and reserved woodlands showed that the preferred firewood (*Combretum. apiculatum*, *Pericopsis angolensis* and *Combretum molle*) have maintained their status within the heavily utilised customary woodland community because of good coppicing abilities (Abbot and Lowore, 1999). This led to the suggestion that these species be managed for domestic firewood on a coppice rotation of 5 years upwards and recommends that national policies for fuelwood production develop mechanisms for incorporating the rural woodland users into the management process. In Tanzania, Luoga *et al.* (2004) found that despite high levels of harvesting of species such as *C. molle*, *P. angolensis* and *Julbernardia globiflora* in communal woodlands, tree densities were almost identical with those in the forest reserve as a result of the high levels of resprouting. Therefore, the authors recommended that the woodland should be managed using coppice rotation as a silvicultural system because most miombo specie resprout vigorously after cutting. In Namibia and Zimbabwe, Mushove (1997) indicated that *Colophospermum mopane* coppices readily, and that pole production from seedling takes twice as long as from coppice. Diameter of growth of *C. mopane* coppice was linear up to seven years, and weight gain over five years was around 1 t/ha/yr at a density of 10,000 shoots/ha. The desired stem diameter class (5-25 cm) was available within 5-10 years. In Zimbabwe, 20% to 80% of stumps had coppice shoots three months after cutting, with the best time to coppice being before the onset of the summer rains. However, little is known about the establishment, growth rate and mortality of the species (Mushove, 1997). In South Africa, a few coppice studies have been conducted which provide valuable basic coppice date for informing the management production. For instance, Gandar (1997) found that coppice shoots of *Terminalia sericea* can reach a usable size at about 3 cm diameter after three years. There were about 95 stems/ha in the size class 6-8 cm yielding 400-600 kg/ha/year. Depending on the treatment (single pruning, double pruning and unprunned), Shackleton (2001) gave an approximate rotation of 4-13 years for stems to reach a diameter of 6 cm of the same species. Twine (2008) found that the same species, *T. sericea* could reach 4 cm between 5-6 years under unmanaged conditions. After five months of harvesting in communal woodlands, under poor rainfall, Neke *et al*. (2006) found coppice biomass of 989 kg/ha/year.

### 1.2.6 Factors influencing coppicing responses

A number of factors influence the coppicing response of trees. These can be manipulated or selected to optimize coppicing in a coppice management system. These factors are reviewed below, drawing on literature relevant to the context of African savanna woodlands.

#### *1.2.6.1 Stem size*

Coppice production tends to increase with the size (diameter) of the cut stem for most savanna species (Shackleton, 2000; Shackleton, 2001; Kaschula *et al*., 2005; Neke *et al.,* 2006). Most savanna species produce the highest number of sprouts in the diameter range 15 to 35.5 cm (Handavu *et al.,* 2011). Shackleton (2001) showed that larger stems (>30 cm circumference) of the savanna trees species, *T. sericea* took longer to respond than smaller stems, but once they had recovered, they had the capacity to grow at a faster rate and produce more shoots. However, reports of decreasing survival of stumps and number of shoots per stump with increasing stump size exist for many ecosystems (Chidumayo, 1997). Chidumayo (1997) observed decreasing coppicing ability with increasing stem size in the Zambian Miombo woodland while Khan and Tripathi (1986) observed the same pattern in four sub-tropical forest tree species. This was attributed to the increase in bark thickness of larger stems that prevents the emergence of buds. Shackleton (2001) and Kaschula *et al*. (2005) found that harvesting larger stems maximized coppice production and biomass for *Dichrostachys cinerea* and *T. sericea,* On the other hand, for species such as *Albizia harveyi* and *C. collinum*, Kaschula *et al.* (2005) found that the size of individual shoots was generally unaffected by stump size in some species.

#### *1.2.6.2 Cutting height*

Increasing the cutting height appears to have a positive effect on the number of coppice shoots produced by savanna trees (Shackleton, 2000; Shackleton, 2001; Luoga *et al*., 2004; Kaschula *et al.,* 2005). Cutting of *Colophospermum mopane* at 100 cm above ground level in southern Zimbabwe was found to enhance coppice regrowth compared to cutting at 10 cm from the ground (Mushove and Muchichwa, 1996). *C. mopane* cut at a height of 100 cm produced the most and tallest coppice shoots compared to those cut at a height of 10 cm (Mushove, 1997). Stems cut at 50 cm above ground produced more shoots than stems cut at 20 cm in the large and medium size-classes of *T. sericea* (Shackleton, 2001). In communal woodland areas of South Africa, Kaschula *et al.* (2005) observed an increase in the number of shoots produced with increased cutting height for the three species, namely *D. cinerea, A. harveyi*, and *C. collinum.*

Selective harvesting options form the beginning of broader, integrated systems and are needed for successful management of coppice in savanna (Kaschula *et al.,* 2005). As such, the management application of this depends upon the management objectives of the area under consideration. If the objective is to minimise the rotation time between harvests for fuelwood purposes, a lower cutting height is advocated as this will result in fewer shoots, contributing to apical dominance. For instance, Shackleton (2000) found that *Englerophytum nalalense*, *T. sericea*, and *Peltophorum africanum* are sensitive to low cutting height with respect to resulting number of coppice shoots. Thus, stump height has a definite positive effect on sprouting height. However, cutting too high may on the other hand result in loss of sprouting vigour and poor growth (Luoga *et al.*, 2004); hence in the savanna woodland areas Shackleton (2001) recommend a cutting height of 50 cm which is neither too high nor too low.

#### *1.2.6.3 Pruning*

Pruning is a silvicultural prescription of removing branches or stems in order to improve tree form or wood quality (Camirand, 2002). Pruning of coppice has a significant impact on resultant coppice growth, including the number of shoots per stump, mean shoot length, and cumulative shoot length (Shackleton, 2000; Shackleton, 2001). In South Africa, Shackleton (2001) looked into the impact of single and double pruning treatments on coppice production of *T. sericea*. In the single prune treatment, one shoot was left uncut while two were left in the double prune treatment. Regrowth was monitored as the number of coppice shoots, the mean coppice shoot length and the cumulative coppice shoot length per cut stump over four growing seasons. Pruning the resprout resulted in a reduction in the time required before re-harvesting; with remaining resprout shoots growing more rapidly than those for the no-pruned plants. After four growing seasons, mean shoot length for the single shoot pruning treatment was 54% greater than for the no prune-treatment, whilst the double shoot pruning was 40% greater. The double-prune treatment provided two poles in only a slightly longer period, and the no prune treatment provided several poles in a period of approximately times that of the single prune *T. sericea*.

For practical use, Shackleton (2001) advises that, in areas of low fuelwood supply and high demand, pruning may be a viable option because it reduces the interval between harvests. At the opposite extreme of low demand and good supply, pruning would not be worth the added effort since there is sufficient wood supply between harvest intervals. A longer regrowth period, with ultimately perhaps a few more shoots, is a better strategy in this situation. However, post-harvest pruning is a more intensive management action than selecting tree size and choice of cutting height. Moreover, it requires repeated application until apical dominance is established. Significant amount of coppice growth for *C. mopane* could also be achieved by pruning coppice to one to two stems per root stock. This has been observed in Namibia (Mushove, 1997).

#### *1.2.6.4 Influence of species*

Coppice growth is an important species-specific trait that strongly influences fuelwood production and regeneration (Kaschula *et al.,* 2005). Coppice resource allocation strategies have been observed to vary between three species investigated in South Africa (*D. cinerea, C. collinum*, and *A. harveyi*). *D. cinerea* exhibited a 'quantity-driven' strategy, with the production of large numbers of relatively small coppice shoots with high length:diameter ratio (shoot taper function) (Kaschula *et al.,* 2005). *C. collinum* exhibited a 'quality-driven' strategy, characterized by the production of a relatively low number of larger coppice shoots. Coppice growth variables for *A. harveyi* were intermediate between those of the other two species, suggesting a strategy where allocation of resources to the number and growth of shoots is more balanced. In Miombo woodlands Luoga *et al.* (2004) highlighted that the coppicing effectiveness, mean number of shoots per stump, varied among species investigated. For example, preferred species, *Combretum molle, Julbernardia globiflora* and *Pterocarpus angolensis,* are good resprouters while *Spirostachys africana* is a very low/non-resprouter, with poor coppicing effectiveness. Therefore understanding of the relationship between species type and coppice response for individual species is important in managing any coppice systems.

#### *1.2.6.5 Other factors*

Edaphic factors also seem to play a role in influencing coppice response (Kaschula *et al.,* 2005). However, in savanna systems, there is little understanding of the importance of edaphic factors. For instance, in the Bushbuckridge region, soils are characteristically poor, comprising mostly potassic granites and granodiorites (Kaschula *et al.,* 2005). Given this, it is possible that the highly weathered nature of savanna soils, combined with the current lack of an active nutrient management programme within the harvested areas, will play a limiting role in the overall sustainability of coppice management (Kaschula *et al.,* 2005). Season of cutting also can influence the number of shoots produced by stump. Shoots produced following a summer cut have a shorter first growing season than those formed after a winter cut and the length of shoot is shorter. However, these differences are likely to disappear in subsequent years (Harmer, 2004). Kaschula *et al*. (2005) investigated coppice growth and resource allocation strategies in relation to (1) position along the landscape catena and (2) harvesting technique, for three savanna fuelwood tree species: *D. cinerea*, *A. harveyi* and *C. collinum*. Results from this study suggest that it is possible to maximize coppice growth (number, shape and size) by selective harvesting according to species, catenal position, and harvesting technique (cutting height and selection of stem size). Survival of the cut stem and growth rate of the resultant coppice shoots is also influenced by factors such the root shoot ratio after felling in addition to those already mentioned above ( species type, stem size and cutting height)  (Shackleton, 2000; Kaschula *et al.,* 2005).

### 1.2.7 Coppice management systems

Coppice management systems are not new, and date back to the Middle Ages in Europe (Gandar, 1997; Harmer, 2004). Advanced modern commercial coppice management systems exist in Europe today to produce wood for wood-chip biogas energy systems and craft industries.  However, due to the relative abundance of wood in savannas, especially in the recent past, systems for actively managing coppice have not been developed or applied in African savannas. There are two broad approaches to coppice management- size-based and area-based management. Within either system, there is a range of factors that need to be considered when deciding on harvesting techniques, in order to maximize coppice. Taking the general approaches and specific influencing factors into account, these are the recommended coppice management system for the context of this study.

#### *1.2.7.1 Size-based coppice management system*

A size-based coppice management system involves selective cutting of stems within a certain size range. Harvesting under this system is not restricted to a single cutting period or area (Shackleton and Clarke, 2007). Sustainability can be promoted through selectivity, i.e. if only certain types and sizes of wood are harvested from particular species, and trees are left to grow until they reach the required dimensions. This approach provides for harvesting of multiple products, and relies on simple observation for determining when re-harvesting can take place. Unlimited harvesting is permitted within a restricted stem size range. All stems with particular recommended size/s may be harvested to establish the coppice stump. When coppice shoots reach a usable size diameter of 2-3cm (Gandar, 1997), they should be pruned leaving two longest shoots. Through selectivity, other resources required such as pole production can also be achieved. This can done be done through leaving relevant species until it reaches diameter size for pole class (4 to <10 cm) (Luoga *et al.*, 2004). Coppice shoots and ingrowths into the harvestable size range from smaller stem size classes can be harvested when they reach a basal diameter of 6-10cm to stimulate new coppice shoot. All deadwood of any size may be removed (Gandar, 1997).

Coppice-with-standard can be applied in this system, with all stems, except for a few mature trees called “standards” harvested on a rotational basis. Gandar (1997) recommends protecting approximately ten standards per hectare, each with a diameter of at least 15cm, as seed sources. A coppice-with-standards system of management is preferred over complete felling because it helps to maintain regeneration and some structure of the vegetation (Shackleton and Clarke, 2007). This system offers multiple benefits. For instance, it is less expensive than seedling plantation, and large trees left as “standards” protect newly established seedlings, from natural origin. Besides helping regeneration, leaving certain proportion of grown trees standing may have several other benefits such as soil protection and improved water retention (Fuller *et al*., 2004), preserving genetic resources and woodland compositional diversity, and it permits greater carbon sequestration (Khazri and Lasserre, 2011).

#### *1.2.7.2 Area-based coppice management system*

In contrast to size-based coppice management systems, area-based systems involve harvesting which is restricted to a particular area (block or coupe) for specific period of time before moving to the next coupe. It is best suited to timber harvesting operations where there is little species selectivity and total volume is of greatest importance. No restriction is placed on harvesting size, and clear-felling may be applied in the most extreme examples. This system is applicable, for example, when harvesting firewood for charcoal industries. Regeneration is rapid, and can be managed according to the products required (Shackleton and Clarke, 2007).

The area of coupe/s available for harvesting per year equals the total usable area of the communal woodland divided by the number of years required for one harvest rotation cycle. One or more can be harvested per year as long as the combined area is proportional to the rotation time in years. Each coupe is harvested once per rotation cycle (Gandar, 1997).

#### *1.2.7.3 Comparison of size-based and area-based systems*

The above mentioned coppice management systems differ in their application approaches but both are applicable in communal savanna. Each has its strengths and weakness and these are summarized in Table 1.1. The choice of system used should be informed by the considerations of these strengths and weaknesses alongside purpose for which coppicing is undertaken and the capacity of the local institution to enforce it.

Table 1.1: Comparison of size-based and area-based coppice management systems (source, Gandar, 1997).

| Coppice system | Strengths | Weaknesses |
|---|---|---|
| **Size–based** | -Operationally simple<br>-Not too technical<br>-Easy to adapt in the light of resource monitoring (size class may need to be adjusted or selected tree marked for protection) | -Difficult to enforce<br>-Co-operation of villagers needed<br>-Harvestable size range may be under-represented in some woodlands |
| **Area-based** | -Relatively easy to enforce in coupes can be clearly demarcated<br>-Adherence to specific sites classes is less critical, but advisable<br>-Creates opportunity for complementary management of livestock and tree harvesting<br>-Easy to calculate sustainable yield | -Presupposes accurate knowledge of rotation times based on coppice growth rates<br>-More demanding institutionally and operationally<br>-Some coupes may become exhausted of firewood before the specified time to move to the next coupe |

### 1.2.8 Guidelines for coppice management for fuelwood

The studies reviewed provide some useful guidelines for coppice management for fuelwood. For example, Shackleton (2000) indicates that the first consideration should be which tree to cut based on which size. The survey of literature acknowledges that through a combination of easily applied management considerations and actions the resultant number of coppice shoots can be manipulated. Kaschula *et al.* (2005) provide a summary of management options for maximizing different aspects of coppice growth from common species in South Africa (see Table 1.2 below). These species are *D cinerea*, *A. harveyi* and *C. collinum* recommended as the most appropriate species for the production of coppice shoots suitable for fuelwood especially the last two species.

Table 1.2 Summary of harvest options to maximize growth (source Kaschula *et al.*, 2005).

| **Variable** | **Management action** | ***D. cinerea*** | ***A. harveyi*** | ***C. collinum*** |
|---|---|---|---|---|
| Species | -Harvest species suited to particular woodlands products | -Large number of small shoots<br>-Short length maximized relative to diameter.<br>-Best suited for browse and kindling | -Intermediate number of medium sized shoots. Best suited for kindling and fuel wood | -Small number of relatively large shoots. Best suited for timber and fuel wood |
| Catenal position | -Harvest trees growing on bottom lands | -Maximize shoot length (absolute and relative to diameter<br>-Maximize diameter of thickest shoot (marginal) | -No variable maximize shoot length | -Maximize shoot length (absolute and relative to diameter<br>No variable maximized |
| Harvesting technique | -Increase harvest height<br>-Harvest larger stem<br>-Harvest smaller Stems | -Maximize number of shoot<br>-Maximize shoot length and thickness<br>-No variable Maximized | -Maximize number of shoots<br>Maximize relative resource allocation in coppice growth | -Maximize number of shoots<br>-Maximize number of shoots<br>-Maximize resource allocation in coppice growth |

Similarly, Gandar (1997) provides more specific guidelines for savanna species including *T. sericea* which is the only species for which data can be used with confidence since it has been relatively well studied (see Shackleton, 2001; Twine, 2008). These guidelines are applicable in the savannas on granitic soils receiving 550-800 mm rainfall per years such as the central lowveld of South Africa. They are as follows: 1) All stems with a diameter of 6–15 cm should be harvested to establish coppice stools and initiate the coppice cycle; 2) All stems in this size class should be harvested over the period of one rotational cycle; 3) Coppice growth rates of stems smaller than 6 cm are too low; 4) Trees with stem diameter greater than 15 cm (called “standard”) will be needed for producing seed and creating-sub canopy habitants; 5) Preferable harvesting technique is a saw; 6) Between 50 to 100 large trees per hectare are left as “standards” as seed sources for natural regeneration; 7) For *T. sericea* “standards” should be 15 cm or more in diameter, and 4 m or more in height; 8) Cutting height should be 50 cm to optimize shoot survival and number of shoots produced; 9) Coppice shoots become harvestable when they reach a basal diameter of 6 cm, and are cut as soon as they reach this size; 10) Time taken for the whole cycle is expected to be 8 to 10 years; 11) Number of stems felled per year is proportional to 1/rotation time, such that the annual coppice production after one year rotation is equal to total potential production time; 12) Unpruned stems have two dominant harvestable shoots after seven years; 12) Smaller pruned shoots (pruning treatment) or secondary (after apical dominance is established in un unpruned treatment) used as kindling but are not included in the biomass calculations, and 14) Stem and shoot mortality rate is 5% per year.

### 1.2.9 Community-Based Natural Resource Management (CBNRM)

The origin of community based natural resource management (CBNRM) can be traced to the 1950s and 1960s when it was introduced as an approach to rural development and was made popular by the United Nations during a period when many countries in the less developed world were gaining independence and becoming decolonized (Catley, 1999). CBNRM is a participatory, collaborative process where the focus is on local communities managing their local natural resources. This practice has been associated with decentralized management approaches, which empower communities who are the main stakeholders in the management of their customary land and sea resources (Schwarz, 2009). Community-based natural resource management (CBNRM) is thus the most appropriate paradigm for coppice management in these contexts, as demonstrated by the case studies in section 1.2.10 below. For instance, CBNRM is motivated by the idea that if conservation and development can be simultaneously achieved, the interests of both could be served (Berkes, 2003). The reasons for advocating CBNRM and a move away from top-down/centralized management include the following: 1) it creates sense of ownership to local people who depend from the resource as the authority over the resource is devolved to the local people themselves who depend from it (forest, savanna or woodland, fisheries, wetlands etc.), and 2) access is restricted to legal users only, and benefits are shared between the legal users (Brandon and Wells, 1992).

Initially, CBNRM focused mainly on wildlife and its main impetus was to ensure that people living within areas rich in wildlife derive economic benefits, more especially employment and income. For instance, this is been noted from the widely known Communal Areas Management Programme for Indigenous Resources (CAMPFIRE) in Zimbabwe which is the pioneer of CBNRM in Southern Africa and CBNRM in Africa (EGSSAA, 2009). Since then, the initiative has expanded to include other natural resource types. Different names are used to refer to some form of CBNRM such as participatory forest management (Swatuk, 2005). In much of western and central Africa, CBNRM is interpreted by government authorities, donor agencies, and NGOs as benefit-sharing or outreach between national parks and adjacent communities (Roe *et al.,* 2009). In such instances communities are not empowered as authorized local resource managers but are involved principally as passive recipients of benefits controlled elsewhere. This form of outreach and benefit-sharing is also a characteristic of some protected area management in east African countries. In southern Africa, CBNRM is most clearly defined in terms of the devolution of rights to make management decisions, and capture benefits, in relation to resources located on communal lands. Nevertheless in all instances to some degree CBNRM involves co-management of resources between central authorities, local government, and local communities which share rights and responsibilities through diverse institutional arrangements (Roe *et al*., 2009). CBNRM programs take various forms of expressions e.g. participatory forest management, community wildlife management and community forest groups (Kellert *et al.,* 2000; Roe *et al.,* 2009).

The literature indicates that with a sense of ownership, local people are incentivised to look after the resource base and this can contribute to resource sustainability (Roe *et al*., 2009; Dawees, 2011). Examples exist, such as in Tanzania, where a degraded resource improved under some form of CBNRM, with the resource decline being reversed (Zahabu, 2007). Therefore, it is true that if utilized effectively, CBNRM provides a workable resolution to resource sustainability challenges in rural commons, but this is not always easy to apply (Kaschula *et al.,* 2005). However, the practical implementation of CBNRM initiatives has frequently fallen short of expectations. A number of reasons have been identified, which include a tendency for projects to be of short term in nature and over reliant on expatriate expertise; and a lack of clear criteria by which to judge sustainability or success in meeting conservation and marginalization of social groups (Hobley 1992; Sarin, 1995). However, in their review of CBNRM in Africa, Roe *et al.* (2009) found a number of studies documenting positive effects of these approaches to wildlife populations, e.g., CAMPFIRE in Zimbabwe, before the crisis occurred after 2000 (Mashinya, 2007) but there is a striking absence of similar well-documented studies on forest impacts. On the other hand, Dewees *et al*. (2011) warn against the assumption that decentralization, local management and returning control over woodlands to communities is the answer to all problems of management. They point out that in other cases giving customary authorities control over woodlands might mean transferring control over resource to local elite, who may use woodlands for immediate political or economic gain. Furthermore, they caution that sometimes the customary authorities might lack capacity to manage the resource.

### 1.2.10 Case studies of resource management involving local resource users

#### *1.2.10.1 Self-initiated local forest management in Nepal*

The degradation of *Shorea robust* (*Sal*) forests over the period of about 20 years occurred due to timber extraction, resettlement, large population and lack of control from the Forest Department (Agarwal, 1986). By 1987 the forest was destroyed. A forest management committee was established which restricted access to the forest at community level. Though the forest started regenerating, women had to go a long distance to collect fuelwood. Again the political instability in 1989-90 led to a new wave of destruction. While initial forest committees were dissolved, women initiated protection of the forest which resulted in quick regeneration of *Sal* coppices to the extent that species such as *Eugenia operculata*, *Terminalia chebula* and *Terminalia bellirca* were greatly affected. Finally, in 1991, Chuchekhola forest was handed over by the forest department to the community, to be managed according to the management plan jointly developed by the users and the foresters. This led to the establishment of the community forestry in 1992. While the indigenous management plan consisted mainly of complete protection from grazing, illicit cutting of fuelwood and fodder collections, the new management plan system introduced practices such as thinning and specific access regime among others. The access rules, the penalty structure and forest protection provision were presented in a written form and anyone cutting *Sal* trees could be fined $1.54, whereas anyone cutting *Terminalia tomentosa* would be fined $0.07. Village forest guards were appointed just as the case with previous community level system. Management practices such as selective logging were conducted according to specific management prescription in specific compartments and following particular schedule. For instance, fuelwood and fodder collection are collected on Tuesday from October and May. Species other than *Sal* can be cut for fuelwood, whereas only branches of *Sal* or coppices through thinning could be collected for fuelwood. Many of these are conducted in a form of groups. The main functions of the forest protection committee are to appoint forest watchers, arrange meetings implement rules and regulations and make decisions (Agarwal, 1986).

#### *1.2.10.2 Community Area Management Programme for Indigenous Resources in Zimbabwe*

The first CBNRM program in Africa was established in Zimbabwe in the early 1980s. In an effort to protect wildlife, particularly elephants, from unsustainable levels of poaching, the government of Zimbabwe set up the CAMPFIRE program. Under CAMPFIRE, authority over wildlife was given to the Regional District Councils (RDCs), administrative arms of government (EGSSAA, 2009). According to animal surveys, for example, Zimbabwe's elephant population under CAMPFIRE increased from 46,000 in 1980 to 90,000 in 2000 (Bond, 2001; Khumalo, 2003). These gains have occurred both on state reserves and in CAMPFIRE areas. After independence, 12 percent of the land in Zimbabwe was devoted to wildlife management, all in protected areas managed by the state. This percentage has increased to 33 percent since the establishment of CAMPFIRE through the inclusion of communal lands and private conservancies (Bond, 2001; Murphree, 2001; Khumalo, 2003). Furthermore, evidence from Zimbabwe showed that poaching, which was widespread prior to the introduction of CAMPFIRE, declined significantly once communities began to receive economic benefits. Community members were also exposed to education about conservation (Bond, 2001; Murphree, 2001; Khumalo, 2003). Local residents became watchdogs on their neighbours. Some Rural District Councils began to make public arrests of both subsistence and commercial poachers. Reviewers also state that the program contributed to the establishment of important new local governance systems linked to CAMPFIRE. The new institutions resulted in increased responsiveness and accountability and greater participation in distribution of benefits (Hasler, 1999). The author argued that through these institutions, CAMPFIRE communities learned more effective practices for collective management of their resources and for articulating their development needs.

CAMPFIRE achieved significant conservation and community development gains up through 2000. After 2000, however, the quality of local governance and the gains in community development collapsed at certain sites. Factors contributing to the failures included elite capture at the local level, the adverse effects of the national economic and political crisis, and the loss of capacity building and oversight that followed the withdrawal of the NGOs (Mashinya, 2007). As financial benefits ended up with district councils rather than with participating communities, the incentives to participate were weakened (Dawees *et al.,* 2011).

### *1.2.10.3 Participatory forest and woodland management in Africa*

Participatory woodland management is a strategy to achieve sustainable woodland/forest management by encouraging the management or co-management of forest and woodland resources by the communities living closest to the resources themselves (Roe *et al.,* 2009) and is used in different countries. For instance, one of the case studies selected from Tanzania support this. A village called Handei forest reserve, located in the Eastern Usambara mountains in Tanga region outside the Amani Nature Reserve (Zahabu and Malibwi, 2007) was brought participatory forest management by residents of Magambo-Miembeni village since 1996. The utilization of resources was confined to a buffer zone of 50 m from all sides of the forest boundary; the interior part of the forest was for protection without utilization, with other uses permitted in the buffer zone included: ecotourism, timber harvesting, collecting dry firewood, vegetables, mushrooms and collection of traditional medicines. The village had set down various by-laws on how and when these forest products can be utilized, to ensure proper utilization of forest products. A village committee responsible for all activities regarding the forest consisting of twelve members (four women and eight men) operated under the village government that managed the forest. It was also responsible for following up on legal issues pertaining to the management of the village forest reserve while reporting on a monthly basis to the village government, district forest officer and a local supporting organisation (the Amani Nature Reserve conservation office). The role of the district forest officer and the supporting organisation was to provide technical support to the forest committee and interpretation of policy guidance (Brockington, 2007).

The Tanzanian experience of village government has been defined as one of the most advanced community forestry in Africa. For instance, in the district of Iringa Lund and Treue (2008) found that decentralization had positively affected livelihood effects, including well-functioning local governance and benefits distribution systems. Nonetheless, Village Land Forest Reserve is best understood when looked at against the background of the country's village administrative structure, the new forest policy and legislation, the land policy and law (MNRT, 1998). This is because as much as the local population was heavily involved in implementation; they were not involved in planning and budgeting in the country (Chirenje *et al.,* 2013). Other countries in which CBNRM projects are advance include Botswana and Namibia ((Roe *et al*., 2009).

In Ghana 200,000 hectares of forest have been demarcated under the Community Resource Management Area Policy of 2000 and this gives participating communities full authority to control access and harvesting of resources within their management area, thus reducing the illegal activities in the areas under this type of management. In Niger and Mali, community based woodland management programmes are involved in fuelwood marketing by associations under sustainable harvesting of resources, and rehabilitation of degraded woodlands (Roe *et al*., 2009).

In South Africa, CBNRM has much legislative recognition and being appreciated of, as an approach that can reduce poverty in the country. These include among others: the National Forests Act (84 of 1998) and White Paper on Energy Policy (DME, 1998). The Act provides opportunities for access to resources for communities, development of community-public sector partnerships, community forestry and joint management of state forests (Fabricius *et al.*, 2004). It also recognizes the important role of forest and woodland resources in people's livelihoods. The National Forest Act makes a distinction between woodlands and forests, thus paves the way for participatory woodland management through a locally managed coppice system that has been recommended in communal woodland areas (Neke, 2004). The Act also calls for cooperation between rural councils or their equivalents, local co-coordinating bodies, and Community Development Facilitators to ensure that forestry programmes fit into local development programmes (Fabricius *et al.*, 2004).

At a municipal level, since 1998 each municipality, including rural districts, has to prepare and regularly update a local Integrated Development Plan, although capabilities to do so are weak in many areas. These plans set the foundation for sustainable resource use through the zoning of parcels of land for specific purposes. The new Tenure Reform and Rights Act Communal Land Rights Act (11 of 2004) means that some of the uncertainties regarding fuelwood resource tenure and access may be resolved when it is adequately implemented (Shackleton *et al*., 2007a). Nonetheless, despite these notable local and national achievements, fundamental challenges to CBNRM remain in African countries. Overall, there remain relatively few cases of communities obtaining formal authority over lands and the natural resources found on those lands. Centralized control over natural resources persists despite the ubiquitous change in the rhetoric over land and resource management. In some cases, ix trends point more towards central consolidation of the right to use and allocate valuable resources such as wildlife and timber (Roe *et al*., 2009).

### 1.2.11 Relevant local institutions

Various institutions are relevant in the management of forest and woodland ecosystems across Africa (Mamimine and Mandivengerei, 2001; Kirkland *et al.*, 2007). In South Africa these include the traditional leadership, The Department of Agriculture, Forestry and Fisheries and the Department of Environmental Affairs (Gandar, 1997). The Department of Agriculture, Forestry and Fisheries is the custodian of the forest resource in the country but it does not have the sufficient resources to monitor communally owned forest let alone its own forest (von Maltitz and Shackleton, 2004). Similarly, the Department of Environmental Affairs is hindered by shortage of human and financial capacity on its monitoring and compliance enforcement mandate, to ensure sustainable utilization of woodland and forest resources (Shackleton *et al.,* 2004). Thus far, cutting of livewood has been reported in communal areas such as Bushbuckridge areas, Mpumalanga province and Giyani region, Limpopo province (see Gandar 1997; Kirkland *et al.,* 2007; Makhado *et al.,* 2012). Nonetheless, governments have a major role to play in CBNRM as it is among others, the main capacity developer at the local level (Fabricius, 2004). CBNRM is a costly exercise (Fabricius *et al.,* 2004), for instance, most CBNRM programmes are initiated in areas with high poverty in the region (Harrison *et al.*, 2014). Capacity remains a widespread problem in many governments in southern Africa (Jones, 2004), e.g. officials do not have vehicles to get into the field (Jones, 2004); also they are not trained in working with people (Jones, 2004; Fabricius and Collins, 2007). However, more attention in the region has been on formal CBNRM (Shackleton and Shackleton, 2004; Turner, 2004). This type of CBNRM requires a high quality capacity building component and a clear exit strategy (Jones and Erdmann, 2013).

### 1.2.12 Local resource governance

Governance is about how power is exercised, and how important decisions in a society are made. It refers not only to institutions, but also to the performance of these institutions (Lutz, 2004). Across the continent, traditional authorities (TAs) continue to play a role in NRM with varying degrees of legitimacy and control (Shackleton *et al.*, 2002). In South Africa, access to natural resources on communal land is controlled by chiefs and headmen (Gandar, 1997). Historically, a system of laws and permits was put in place in order to regulate the harvesting of resources, particularly live trees, and guilty offenders could face paying fine or doing community service in communal lands found mainly in former homelands area (Twine, 2005). Some of the police duties according Gandar (1997) would include: 1) Control of tree cutting and bark stripping, 2) Checking other environmental regulations, e.g. fishing licenses, 3) Dealing with crime in the community, 4) Guard the tribal authority court, and, 5) Patrol the resource to ensure only legal harvesters harvest the allowed volume. The revenue goes directly to the tribal authority (TA) and the tribal police are paid according to the number of transgressors they confiscated. The chiefs were given a budget by the homeland governments to employ police who were responsible for apprehending offenders. Although flawed, this system of resource management by TAs exercised a degree of control on resource harvesting and moderated the impact of humans on the resource base.

After 1994, the TAs started sharing responsibility with village level local governance structures (community development forums), district municipalities, and provincial authorities. This has resulted in lack of clarity on the role of the TAs in the new dispensation, budget cuts by government, internal corruption, and inefficiency all contributed the weakening of their control (Kirkland *et al.,* 2007). The TAs have become increasingly weakened and marginalized in their role of managing natural resources in the lowveld and this has become particularly evident since the first democratic elections in South Africa in 1994 (Mamimine and Mandivengerei, 2001; Twine, 2005). The weakening of authority and responsibility over natural resources management by TAs is mainly because of the loss of control of the communal lands to modern institutions of governance. This characterise many countries African countries including Zambia (Mamimine and Mandivengerei, 2001).

Due to lack of capacity and resources, local government has not adequately supported or replaced the TAs in resource management (Cousins *et al.,* 2007; Twine, 2005). Nevertheless, in theory, traditional resource management institutions still exist (Twine, 2005) and have the capacity to determine whether or not natural resources under their jurisdictions are actively managed sustainably (Cousins *et al.,* 2007). The capacity of the TA is critical given recent government policy to devolve responsibility for the management of natural resources to local communities; TAs (tribal chiefs) are key stakeholders in this process (Phadima and Lawes, 2000). TAs are headed by tribal chiefs who preside over a council of headmen (*indunas*) and other designated councillors. They are not elected but inherit their positions and where necessary, they appoint headmen to represent them in the villages under their jurisdictions (Gandar, 1997). This is the pattern elsewhere in Africa where land tenure is communal (Roe et *al*., 2009) and has been used to govern rural landscapes, resources and people since before the colonial era. It continues even today, impacting how rural households access a variety of environmental resources and development opportunities thus far (King, 2004).

In their case study, Phadima and Lawes (2000) found that recent changes in government policy in South Africa had created a participatory role for communities in managing natural resources. At issue is the ownership, power relations (relative to other local stakeholders and in relation to forest resources) and influence of TA (the chiefs and headmen) on the management of natural resources. Ezemvelo KwaZulu-Natal Wildlife (EKZNW) currently manages the Ongoye forest in Zululand, South Africa, and is willing to engage in cooperative management with the community, but to some extent is deterred from doing so by the authoritarian approach of the chiefs. Furthermore, the powerful chiefs affect the participatory role that the community currently plays, and the community has indicated that they would like more involvement in making management decisions. However, the community's willingness to control the forest was intrinsically linked to their interest in accessing and using forest resources and not necessarily with the sustainable management of these resources. The power and influence of the chief was seen by the community as restricting user access and control of forest resources. Thus, in terms of the conservation of the forest, the chief*'s* dominant role was vital. The authors suggest that in creating any future participatory management institution it will be necessary to balance community opinion against their respect for TAs in developing a suitable committee structure for meaningful conservation of the forest so that usage patterns continue to be sustainable.

Today, land administration reform is both behind schedule and is contested. In some cases local government officials are of the opinion that they can allocate land although this is not legally the case (Cousins *et al*., 2007). Thus, different perceptions exist about who governs the resource. While local government councillors have perception that it was their role to regulate natural resources in their wards, this is not the case, and under the new legislation neither Local Government (LG) nor the TA's, are directly responsible for NRM as their primary function. The key function of LG is one of service delivery while that of the traditional leadership is to focus on customary law, and is otherwise largely facilitatory in nature. This is in itself a grey area since words such as 'promote', 'assist', 'support', 'recommend' are used, and none of them actually confer authority (Cousins *et al*., 2007).

In Botswana, Sharma (2011) reports that after independence; democratically elected bodies established by statutes of parliament replaced the tribal councils. Land Boards established through the Tribal Land Act in 1970 took away the exclusive authority of chiefs for allocation of tribal land and this has constrained relationship as the chiefs had lost their exclusive authority over tribal land. They however, have now reconciled to the changed situation and are involved in district level development planning and implementation. They also contribute towards protection, management, and allocation of natural resources by lending support to the Community Based Organizations (CBOs) in the concerned districts. Similarly, in Namibia exclusion of traditional leaders from conservancy committees was counterproductive at first, resulting in conflict, until these leaders were co-opted onto the committees. TAs among the Miao people in China played an important role in limiting abuses of devolution policies by local bureaucrats and traders, and maintaining traditional forms of forest protection and access. In several cases, e.g., in Namibia, traditional leaders were provided an *ex officio* role, for instance, as patrons on committees (Shackleton *et al.,* 2002).

## 1.2 RESEARCH RATIONALE

The unsustainable harvesting of fuelwood from savanna ecosystems has become a matter of concern among policy makers in South Africa, as it is in other African countries (Norton-Griffiths and Southey, 1995; Shackleton and Williams, 2002; Lawes *et al.,* 2004; Manjate, 2006). In response to the perceived problem of unsustainable harvesting, interventions such as woodlots, solar panels, and fuel efficient stoves have been employed by various government agencies and non-profit organizations (NGOs) to reduce pressure on the savanna resource, but have been largely unsuccessful (Bembridge, 1990; Shackleton and Williams, 2002). For instance, many woodlots failed, not only in South Africa, but also in the entire region, mainly because the species planted in such programmes, e.g. *Eucalyptus* spp. are not well regarded as a fuelwood species (Shackleton *et al.*, 2004b). Little consideration has been given to manage harvesting of coppice as a strategy to contribute towards solving the fuelwood problem in savanna biome despite the potential it carries to do so (Shackleton, 2000; Shackleton, 2001; Shackleton and Williams, 2002; Shackleton *et al.,* 2004a; Shackleton *et al.,* 2007a). Savanna tree species generally resprout easily, providing an opportunity for rotational coppice harvesting, thereby enhancing supply of fuelwood to local communities (Shackleton *et al.*, 2004a; Shackleton *et al.*, 2007a; Damm and Triebel, 2008). It takes advantage of the regeneration capacity of trees to produce new shoot growth from the stump or root crown if cut or damaged (Harmer, 2004). Thus, it has the potential to provide a more appropriate method of achieving sustainable fuelwood production while simultaneously preserving the habitat of indigenous woodland (Kennedy, 1998). Coppice management involving resource users and local institutions has, as a consequence, been proposed to be an appropriate intervention to promoting sustainable fuelwood harvesting of the savanna resource supply (Gandar, 1997; Shackleton, 2000; Shackleton, 2001; Twine 2005; Neke *et al.*, 2006; Makhado *et al.*, 2009). However, despite this recommendation, no South African studies have been conducted to investigate the feasibility of such an intervention and its potential therefore remains unknown.

This occurs despite, 1) fuelwood remaining the dominant energy source for cooking and heating across communal woodland areas in South Africa, 2) the availability of ecological data and evidence showing that sustainable rotational harvesting of coppice shoots is possible (Shackleton, 2001; Twine, 2009), 3) growing concern about the sustainability of fuelwood harvesting (Twine *et al.*, 2004a; Neke *et al.*, 2006), 4) legislative support for expanding renewable energy sources such as biomass (Shackleton *et al.*, 2007a), 5) the lack of expected results from government and NGOs interventions (Shackleton *et al.*, 2007a), and, 6) there are opportunities for payment for ecosystem services (PES). PES are some of the most innovative instruments focused on balancing growth and environmental impact are originating in developing countries and are viewed as a way of promoting new livelihoods and generating more sustainable growth of natural resources in communities. They incentivise landowners and communities to maintain intact ecosystems, restore the natural environments of degraded land, and use natural resources sustainably (TIPS, 2012). It is against this backdrop that this study was proposed and conceptualized. In filling this identified gap, this study explored the feasibility for locally managed rotational harvesting of coppice regrowth as a source of sustainable renewable energy for fuelwood provision.

## 1.3 AIM AND OBJECTIVES

The aim of this project is to pilot a community-based coppice management system in selected rural villages in order to assess the ecological and social feasibility, and consequent opportunities and obstacles for community-based coppice management (CBCM) in South Africa.

The specific objectives of the study are:

1. To assess fuelwood harvesting and use patterns before and during the harvesting trial
2. To examine the ecological feasibility of the community-based coppice management
3. To assess the social feasibility of CBCM in terms of community compliance, cooperation, perceptions and attitudes.
4. To assess the capacity of local governance systems to successfully implement community-based coppice management
5. To evaluate opportunities and obstacles within the ecological and social domains in order to assess the feasibility of CBCM, and develop a set of guidelines and framework for the CBCM implementation thereof.

## 1.4 CONCEPTUAL FRAMEWORK OF THE STUDY

The implementation of woodland management strategies is affected by both environmental and socio-economic factors (Johann, 2007), but their influence on a coppice management system in communal woodlands remains poorly understood, since such a system has never been implemented (Neke, 2004; Shackleton and Clarke, 2007). Locally managed coppice systems have been recommended for communal woodland areas in South Africa as a potential strategy for sustainable provision of fuelwood (Neke, 2004; Kaschula *et al.,* 2005; Makhado *et al.,* 2009; Matsika *et al.,* 2013) as elsewhere in Africa (see Kennedy, 1998; Musvoto *et al.,* 2006; Shackleton and Clarke, 2007; Mapaure and Ndeinoma, 2011).

This study was guided by a conceptual framework that considered the implementation of sustainable CBCM to be directly affected by number of internal drivers. These internal drivers are: 1) resource supply (with coppice shoot production, as a subset of resource supply; 2) resource users; 3) village consumption patterns; 4) local traditional institutions; and 5) management system (Figure 1.1). The management system would influence the project directly through decisions such as the length of the harvesting period and the size of the demarcated harvesting blocks, called coupes. On the other hand, the internal factors are in turn also considered to be directly or indirectly influenced or affected by the implementation of the project in a feedback loop. For instance, the number of shoots from which biomass would be derived for future supply of fuelwood would be affected by the density of the stumps or coppice stools created when harvesting fuelwood during the trial, the higher the stem density the higher the number of coppice shoots and this can to a certain degree translate to more biomass and vice versa. Village consumption patterns would affect the usage of fuelwood, where the majority of local people depend entirely on fuelwood for cooking the majority would use fuelwood during the trial. Opportunity costs would be reduced because during the harvesting trial local resource users would be permitted to harvest livewood from coupes. This is because, although harvesting of livewood occurs under traditional management rules given the scarcity of deadwood (Gandar, 1997; Kirkland *et al.,* 2007), local resource users harvest them, but not in nearby places, for fear of being caught (Shackleton, 1993). Policing or patrolling conducted by local resource users in partnership with local institutions would be more effective leading to improvement in the adherence to harvesting rules.

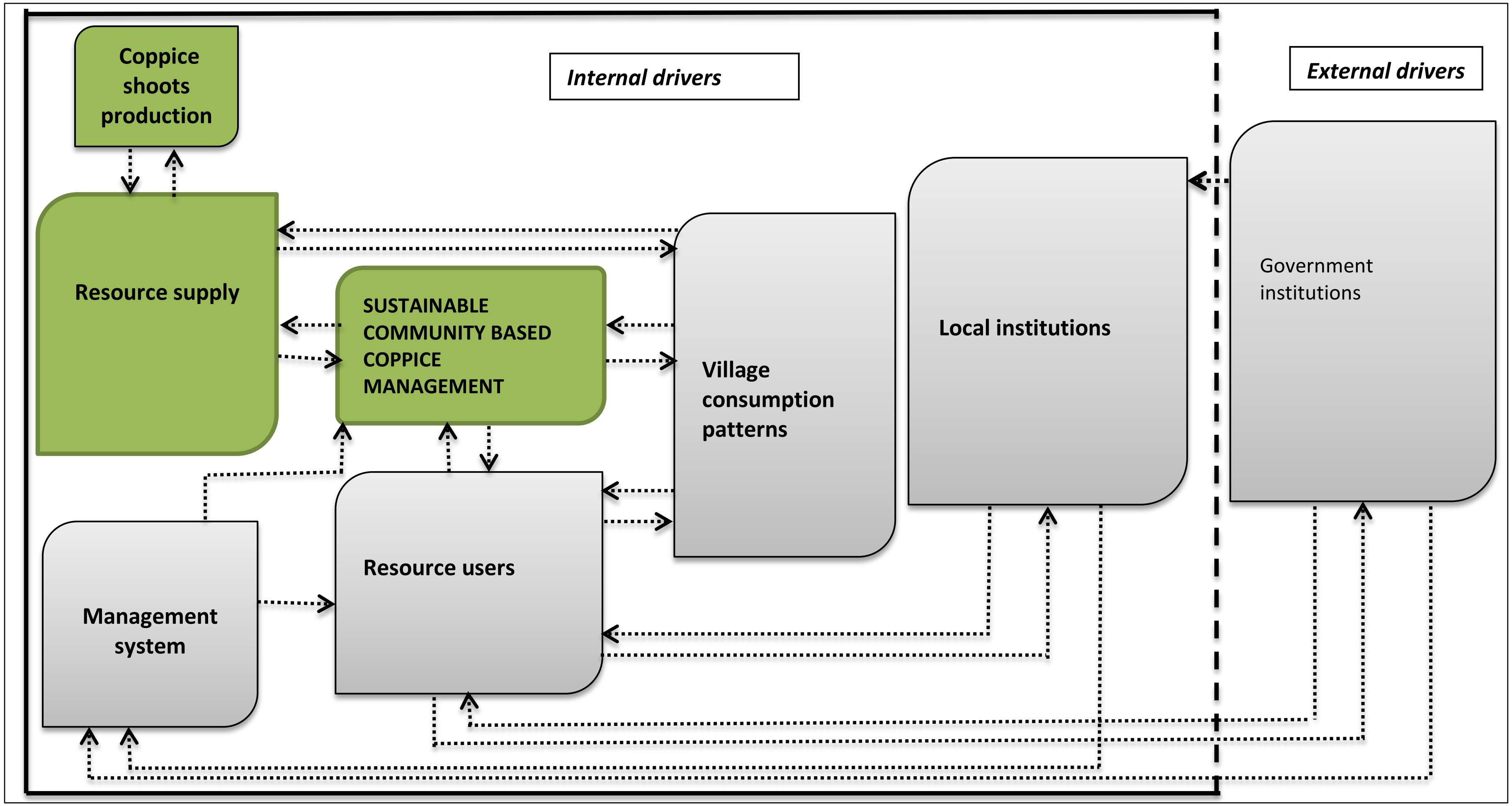



Figure 1.1: Conceptual framework for factors hypothesized to influence the feasibility of implementing sustainable community-based coppice management in study villages.

The conceptual framework also considered CBCM to be indirectly influenced by external drivers, which are the government institutions. Their influence occurs through developing policies and enforcing legislation that impact harvesting and the consumption behaviour in the CBCM areas. In almost the same manner, local institutions affect the management system of the CBCM since those involved in the system would have to prescribe rules that do not contravene with those of the relevant Acts, e.g. National Forests Act, 84 of 1998, which prohibits harvesting of protected species such as C*ombretum imberbe*. However, the local traditional and the governmental institutions, especially DEA, would also be affected indirectly by the project, in a feedback loop, because it has a monitoring mandate (Von Maltitz and Shackleton, 2004). For instance, the enforcement capacity would be strengthened because of policing undertaken by local resource users during the harvesting trial. This can increase the amount of fuelwood used per annum because local resource users in the study villages would not compete with outsiders for fuelwood resource nor fear the rangers but harvest freely within the agreed rules. Independent of the project, a direct relationship exists between resource supply and village consumption patterns since they affect sustainability (Shackleton *et al.,* 2007a). The dashed boxes in the conceptual framework are the quantifiable variables that help explain the extent of the influence of each factor and each driver on sustainable CBCM

## 1.5 STUDY APPROACH

This study uses an applied or action research approach. Action research is not about learning why people do certain things, but rather how people can do things better and change their certain approaches to have a positive impact on what they intend to achieve (Ferrance, 2000). Furthermore, it is also learning by doing with participants. In order to assess the ecological and social feasibility of the CBCM intervention in communal woodlands, the local traditional institutional leadership in selected pilot villages implemented the harvesting trial in partnership with the local resource users and the relevant governmental institutions. However, although there were four villages approached for this feasibility study, the full feasibility assessment was only possible in two villages where the project occurred in its entirety (details of the reasons in chapter 5 and 6). Nevertheless, insights were also drawn from the two villages in which it was not successfully implemented as these also yielded valuable insights. This feasibility research occurred over a period of a year with the researcher playing the role of facilitator. However, a Phd study is not long enough to assess a rotational coppice harvesting system over a whole rotational cycle, e.g., three or four years which would have been required in this study based on the growth rates. Thus, the researcher could only assess key components of CBCM such as feasibility of harvesting stems in coupes based on the preferred diameter size class, compliance with agreed harvesting rules and cooperation among relevant institutions, and make inferences about future prospects for the successful continuation of CBCM in these villages.

Ecological and socio-economic baseline data were collected in January 2014 and January 2015. The same households from which the socio-economic baseline data were collected in the initial stages of the project were revisited to collect the socio-economic data again in order to assess if there were changes associated with the intervention such as the type of energy used for cooking and heating, time spent getting to the harvesting areas, compliance with harvesting rules and others. Two separate focus group discussions were held with the local resource users (women, men and youth) and the local traditional leadership to assess their perceptions and attitudes and the perceived efficacy of CBCM. Similarly, two separate interviews were undertaken with the senior rangers (conservation officer) in the local department to also assess their perception and attitudes towards the project and the perceived efficacy of CBCM. The insights emanating from the study was synthesized to make recommendations for future implementation of CBCM and also applying them to broader CBNRM theory.

## 1.6 SCIENTIFIC CONTRIBUTION

This study sought to assess the ecological and social feasibility of community-based coppice management in the South African context using an action-research approach. This study is novel because it is the first, as far as can be ascertained, to do such an assessment in Africa by implementing a community-based coppice management trial in partnership with selected local communities and their leadership. Information exists on the coppicing ability and potential rotation times for some African savanna tree species and general guidelines have been proposed for locally managed rotational harvesting of coppice for fuelwood in this context. However, no published studies have assessed the success of an actual community based-coppice management system in the continent. In giving an example, in Botswana White (1979) had proposed the implementation of a coppice-with-standards system based on ecological data for, e.g., *Terminalia sericea* in the woodland of the Matsheng villages, but there are no subsequent reports or evaluations of the implementation by the local communities (Gandar, 1994) similar to elsewhere in the continent (Shackleton and Clarke, 2007). Furthermore, in South Africa, although the ecological feasibility is fairly well established in communal woodlands, it exists mainly from one region, Bushbuckridge, in Mpumalanga Province. This study expands the spatial coverage of coppice research in the lowveld region of South Africa by extending north into Limpopo Province, and predominantly rural province dominated by savannas. On the other hand, data on the socio-economic feasibility of CBCM in South Africa and the rest of the region is totally lacking (Shackleton and Clarke, 2007).

In this context, the study has important contributions to make to theory and the practical implementation of coppice management communal woodland areas in the continent. It provides new data and insights needed to implement CBCM while also providing the basis for assessing feasibility of CBCM in other contexts. The findings are used to develop a framework and set of guidelines for implementing community based management of wild coppice for sustainable fuelwood production. The ultimate product is the creation of a local model for managing coppicing which may be scaled up to other rural areas for improved resource management and energy security. The study also has a contribution to make to community-based natural resource management (CBNRM) theory more broadly, from the lessons that could be learnt.

## 1.7 STRUCTURE OF THE THESIS

This section gives the structure of the study (Figure 1.2). The research chapters of this thesis are written in the format of scientific papers to be submitted in internationally accredited scientific journals.

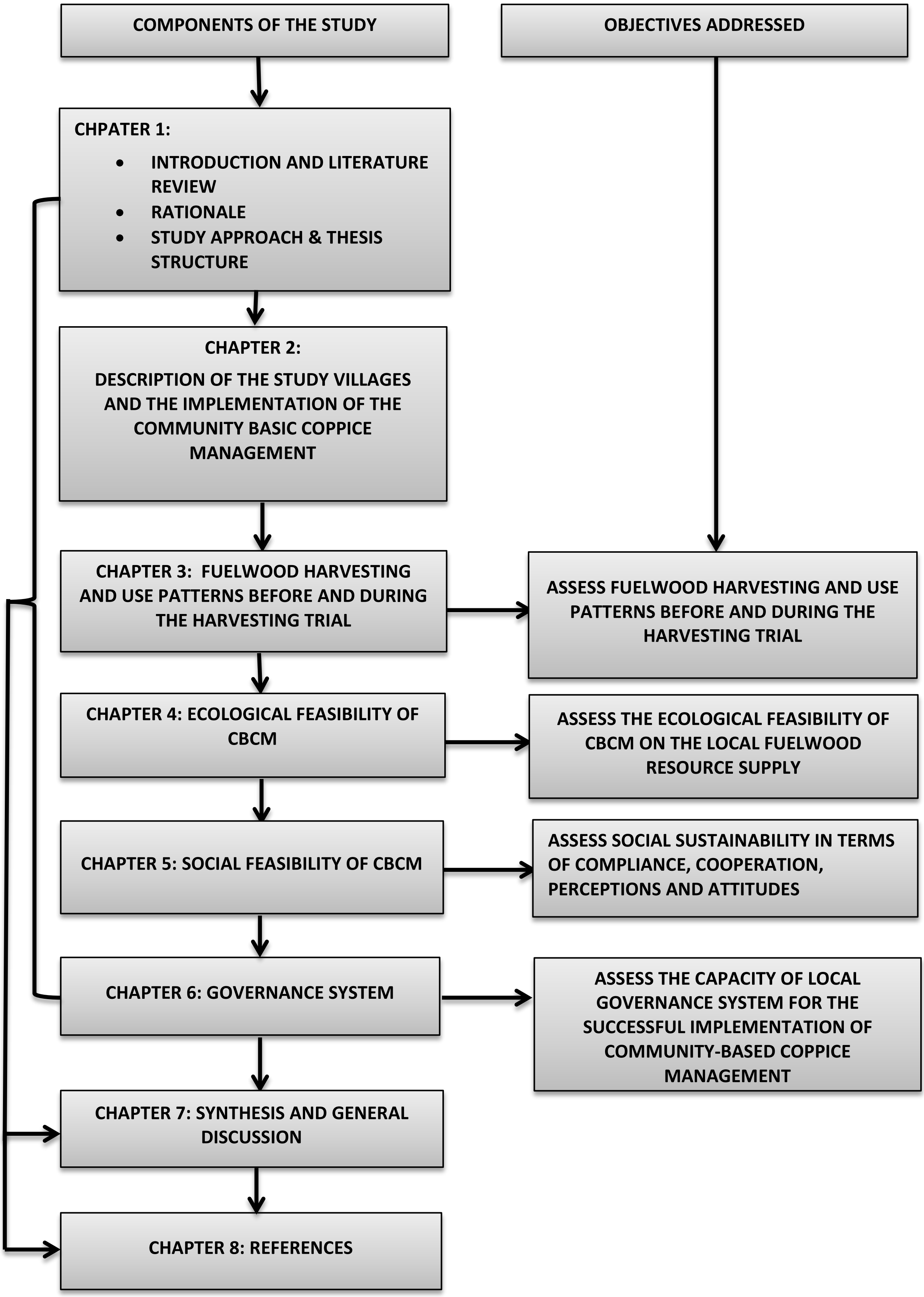



Figure 1.2: Study structure for testing the feasibility of community-based coppice management for sustainable fuelwood provision in rural South Africa.

Following this introductory chapter, Chapter 2 describes the study villages, the trial implementation process of the whole project across the study villages, siting of plots and the reflection of the researcher as the project facilitator during the project implementation period. Chapters 3 to 6 each focuses on a specific research objective (Fig.1.2). Detailed descriptions of the study methods are presented in each of the data chapter (chapter 3, 4, 5 and 6), which follow after chapter 2. The concluding chapter which is chapter 7 provides a synthesis of the findings from all the data chapters.

# CHAPTER 2

## DESCRIPTION OF THE COMMUNITY-BASED COPPICE MANAGEMENT INTERVENTION IN STUDY VILLAGES

This chapter gives the criteria that were used to select the study villages, and explains the process followed by the researcher in securing their support, cooperation and involvement in CBCM. This is followed by a description of the implementation process based on the adaptive management project cycle and how the project implementation measured against the project cycle. It also gives a description of the geographic, socio-economic, and ecological setting of each study village.

### 2.1 VILLAGE SELECTION CRITERIA

The following criteria were used to select villages in which the intervention was piloted:

- Cultural homogeneity: Tsonga-speaking rural communities in former homeland areas were selected in order to factor out the influence of cultural differences on results.
- Degree of degradation of surrounding savanna/woodlands: Preference for working with communities whose communal woodlands were still relatively intact, rather than heavily degraded with fuelwood scarcity. Google Earth was also used to assess relative woodland cover.
- Availability of data on woody plant species present in the area.
- Traditional leadership buy-in to implement the project in partnership with the local resource users and other stakeholders because they are the custodians of the natural resources in communal lands, and are thus central to locally-managed coppice systems. Furthermore, in the southern African context, it is critical that initial engagement is carried out through traditional authorities (TAs) in order to gain their approval (Dyer *et al.*, 2014).
- Varying village population size to enable comparisons (two villages with less than 1 000 inhabitants and two villages with population size greater than 1 000).

The villages that were chosen as per the selection criteria were Thorndale in Mpumalanga Province, and Peninghotsa, Homu 14B and Makhuva in Limpopo Province. In the woodlands surrounding Thorndale village, Neke (2004) reported densities of tree species, such as *Combretum apiculatum* being higher in the communal land than in the adjacent protected area. In Peninghotsa, Anthony and Bellinger (2007) reported the woodland to be relatively less disturbed compared to other villages. Makhado *et al.* (2009) refer to Makhuva as one of the villages with a high density of woody stems in the local municipality, while for Homu 14B, the search was based on scholars' recommendations and Google Earth. Ideally, the researcher had wanted two villages per province, but he was not successful. The researcher approached Peninghotsa in Limpopo Province after he had unsuccessfully approached various TAs in Mpumalanga. For instance, after approaching the Amashangane Traditional Authority in Mpumalanga, the local leadership wanted the project but indicated that it had to be piloted in all the villages falling under their TA, which was beyond the scope of the study. In another potential study site in Mpumalanga (Manjenje TA), the local leadership indicated that most of the woodland is privately owned.

## 2.2 STUDY VILLAGES

### 2.2.1 Thorndale

Thorndale village (Figure, 2.1) is a small village situated in Bushbuckridge local municipality, Mpumalanga Province, South Africa (31°28'E; 24°30'S) (Dovie *et al.*, 2002). The total number of households is 126, while the population size is 514 (Statistics South Africa, 2011). The female population size is 287, constituting 56% of the total village population. There are few formal employment opportunities, high levels of migrant labour and agricultural potential is limited by aridity (Dovie *et al.*, 2002). There is intermittent access to potable water, pumped from a borehole and distributed to public taps. There are few households involved in off-farm income generation activities. Male migrancy to urban centres is common. Apart from teachers of the village primary school and a few workers of the Manyeleti Game Reserve, there is no formal employment within several kilometres of the village. Refer to Table 2.1 and Appendix 14 for more socio-economic information of this village. This remoteness limits exposure to and participation in the formal cash economy and employment opportunities. Hence, a greater reliance on the local resource base for resources such as fuelwood, thatch grass, construction materials, fruits, medicinal plants, bushmeat and reeds from the woodland (Dovie *et al*., 2002). For instance, fuelwood is the most important woodland resource with 90% of households using it as their primary energy source (Dovie *et al*., 2002).

The village and surrounding land is under communal tenure. It is categorized into arable and residential plots, and communal rangelands where residents are allowed free access for grazing livestock and harvesting resources such as fuelwood. The area of the woodland surrounding the village is 1 247 ha (Google Earth Pro). Thorndale borders the Manyeleti Game Reserve which is a provincial reserve and is remote from major centres of commercial activity, with limited access to social infrastructure.

Mean annual rainfall in Thorndale is approximately 550-600 mm, most of which is received between October and April, usually in the form of convectional thunderstorms. Mean annual temperature is approximately 22° C (Neke *et al.*, 2006; Shackleton, 1993). The topography of the study region is gently undulating. Soils are underlain by granitic gneiss with local intrusions of gabbro. Vegetation of the region is broadly classified as Mixed Lowveld Bushveld and is dominated by species of the *Combretaceae* (Bredenkamp and Van Rooyen, 1996).

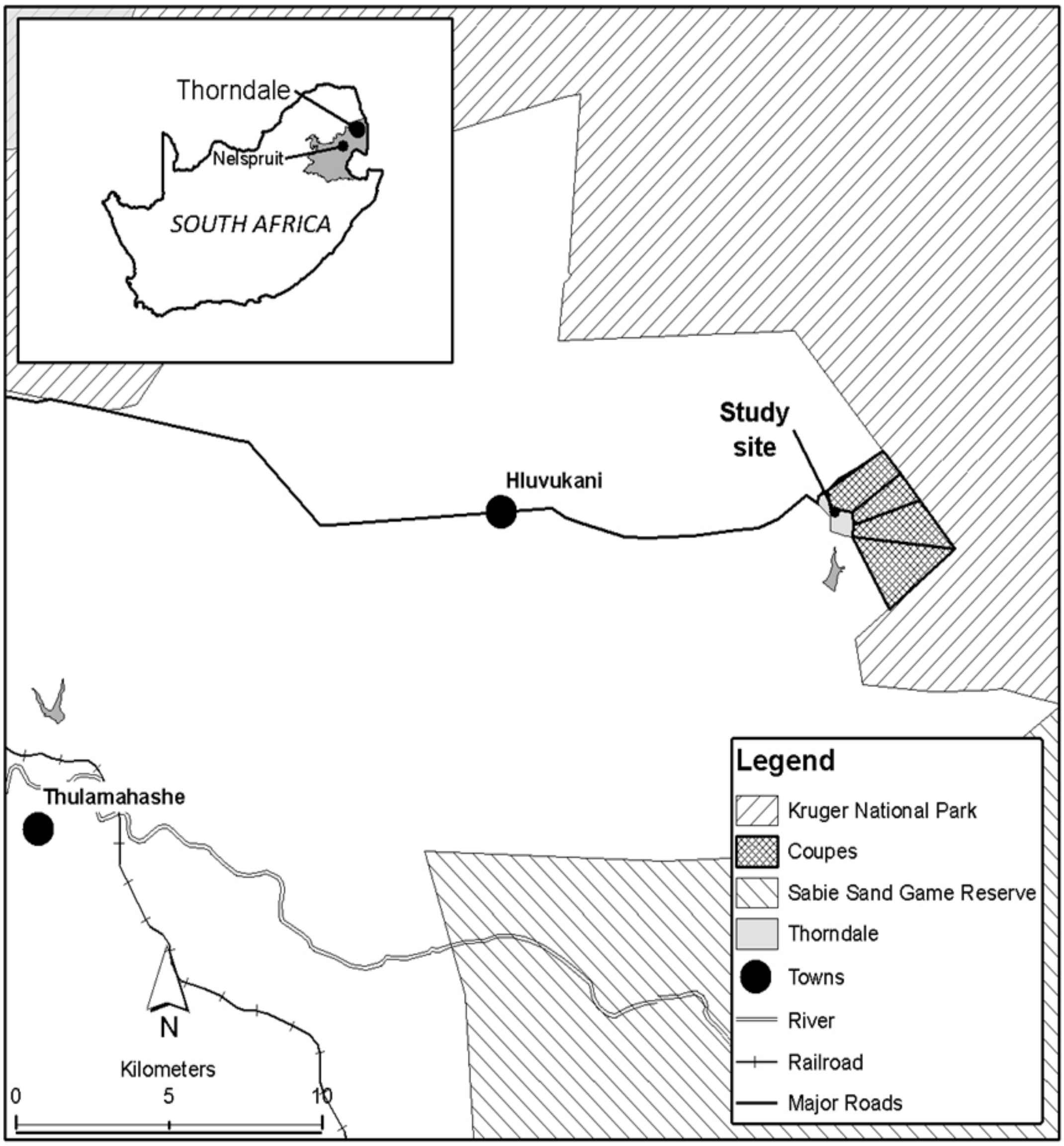



Figure 2.1: Map showing the location of Thorndale village in Mpumalanga Province, South Africa.

### 2.2.2 Peninghotsa

Peninghotsa is a small village (Figure 2.2) situated in the Shingwedzi and Letaba river catchments adjacent to the western border of the Kruger National Park (KNP) in the Thulamela municipality of Limpopo Province (23°01’15"S; 30°50’14”E). The total number of households in the village is 210, while the population size is 802 (Statistics South Africa, 2011). The female population size is 455, while that of men is 345, meaning that the female population constitute 57% of the village population. In this village, livelihoods are primarily land-based and consist of arable agriculture, animal husbandry, and harvesting of natural resources (Anthony and Bellinger, 2007). The village experiences high unemployment (Anthony, 2006). Refer to Table 2.1 and appendix 14 for more socio-economic information of the village.

The village is under communal tenure. The area of the woodland surrounding the village is 1 700 ha (Google Earth Pro). The woodland area surrounding the village still consists of relatively sizeable bushland areas with biodiversity largely intact, especially between the Shingwedzi and Klein Letaba rivers (DWAF, DEAT and WRC, 2001). The vegetation consists primarily of *Colophospermum mopane* and *Combretum* spp. woodlands (Anthony and Bellinger, 2007). The village experiences a mean annual precipitation of 440–560 mm, and is characterized by slightly undulating plains containing villages with built-up land, surrounded by areas for subsistence farming (Anthony and Bellinger, 2007).

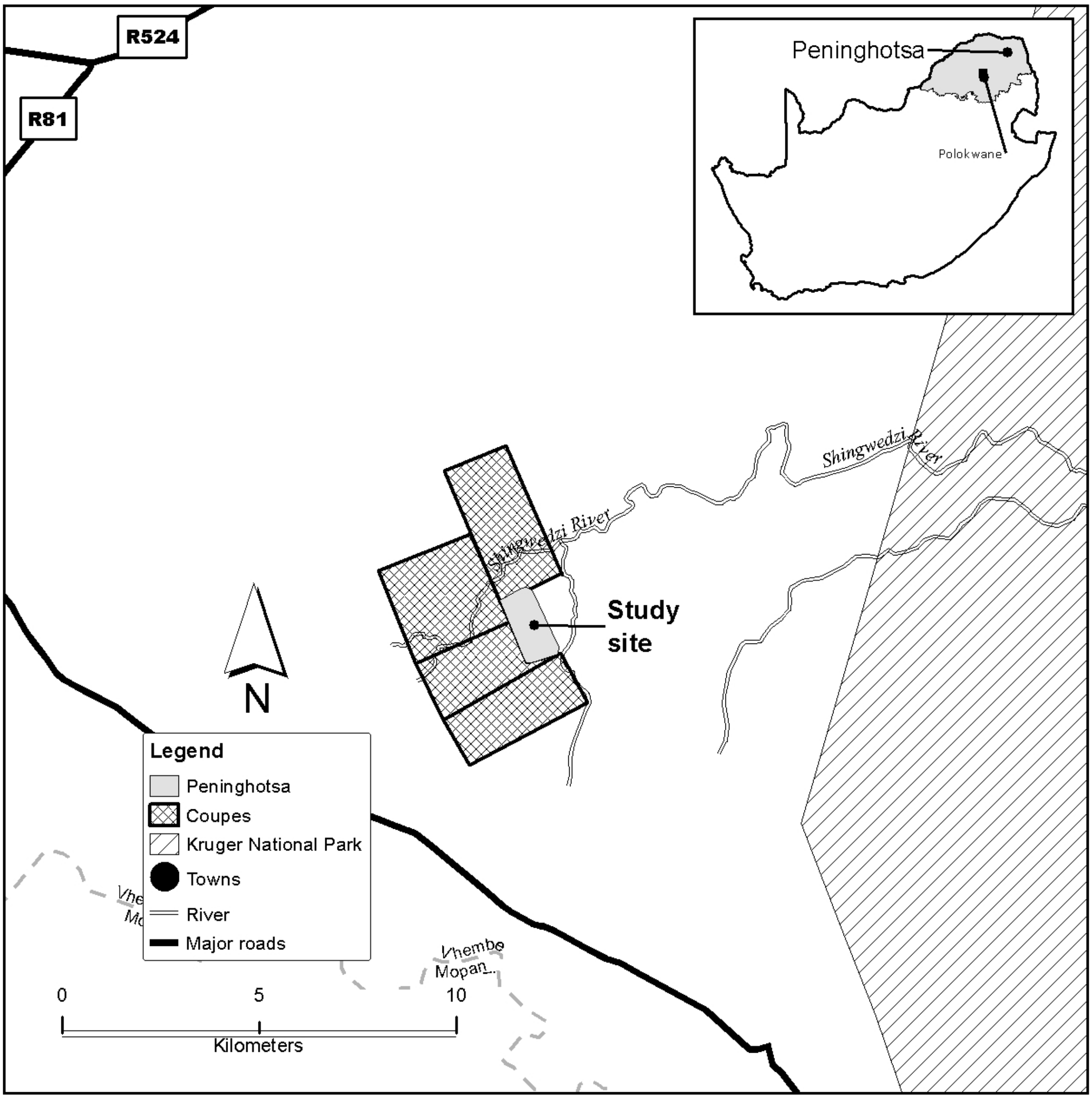



Figure 2.2 Map showing the location of Peninghotsa village in Limpopo Province, South Africa.

### 2.2.3 Homu 14B

Homu 14B is a large village (Figure, 2.3) located in the heart of Limpopo Bushveld, under Greater Giyani Municipality on the northern bank of the Klein Letaba River west of Kruger National Park (23° 19' 0"S; 30° 43' 0"E). It is situated near Giyani town, which was established in the 1960s as the administrative centre for Gazankulu homeland. It is now the administrative capital of Mopane District Municipality. The total number of households of the broader Homu village, including other sections, Homu 14 A and C is 1 914, and the population is 3 012 (No population break down based on gender could be done because these statistics included other parts of the broader Homu area) (Statistics South Africa, 2011). The number of the household in the village portion to which the project was delegated was estimated to be around 420, and no population size was found from this number. Refer to Table 2.1 and appendix 14 for more socio-economic information of the village. The majority of the people in this village similar to other villages under the municipality depend on government grants such as old age pension, subsistence agriculture, and on harvesting woodland resources for household nutrition and income generation. For instance, it is estimated that 80% of people in the villages depend on fuelwood for cooking and heating (Makhado *et al.,* 2009). The majority of people especially the females are unemployed, illiterate and live below the poverty line (Makhado *et al.*, 2009).

The land tenure system is communal. Although the size of total Homu area, including Homu A and B, is large (1 500 ha), the size of the woodland which surrounded the village portion which was set aside/considered for the project was 300 ha (Google Earth Pro). The climate of the Greater Giyani Municipality is characterized by low rainfall and high temperatures. The mean annual rainfall in the Greater Giyani Municipality is 386 mm and the temperature varies from a minimum of 15 °C in winter to a maximum of 29°C in summer (South Africa Weather Service, 1980-2003). Normally, Giyani receives about 421mm of rain per year, with most rainfall occurring mainly during mid-summer. The monthly distribution of the average daily maximum temperatures ranges from 23.9°C in June to 31°C in January. The region is cold during July when the mercury drops to 8°C on average during the night.

The vegetation is classified as the lowveld mopane savanna, while the underline geology of the area is characterized by the metasediments of the Giyani Greestone belt stone with common rocks such as granite, sandstone, shale and basalt (Makhado *et al.,* 2009).

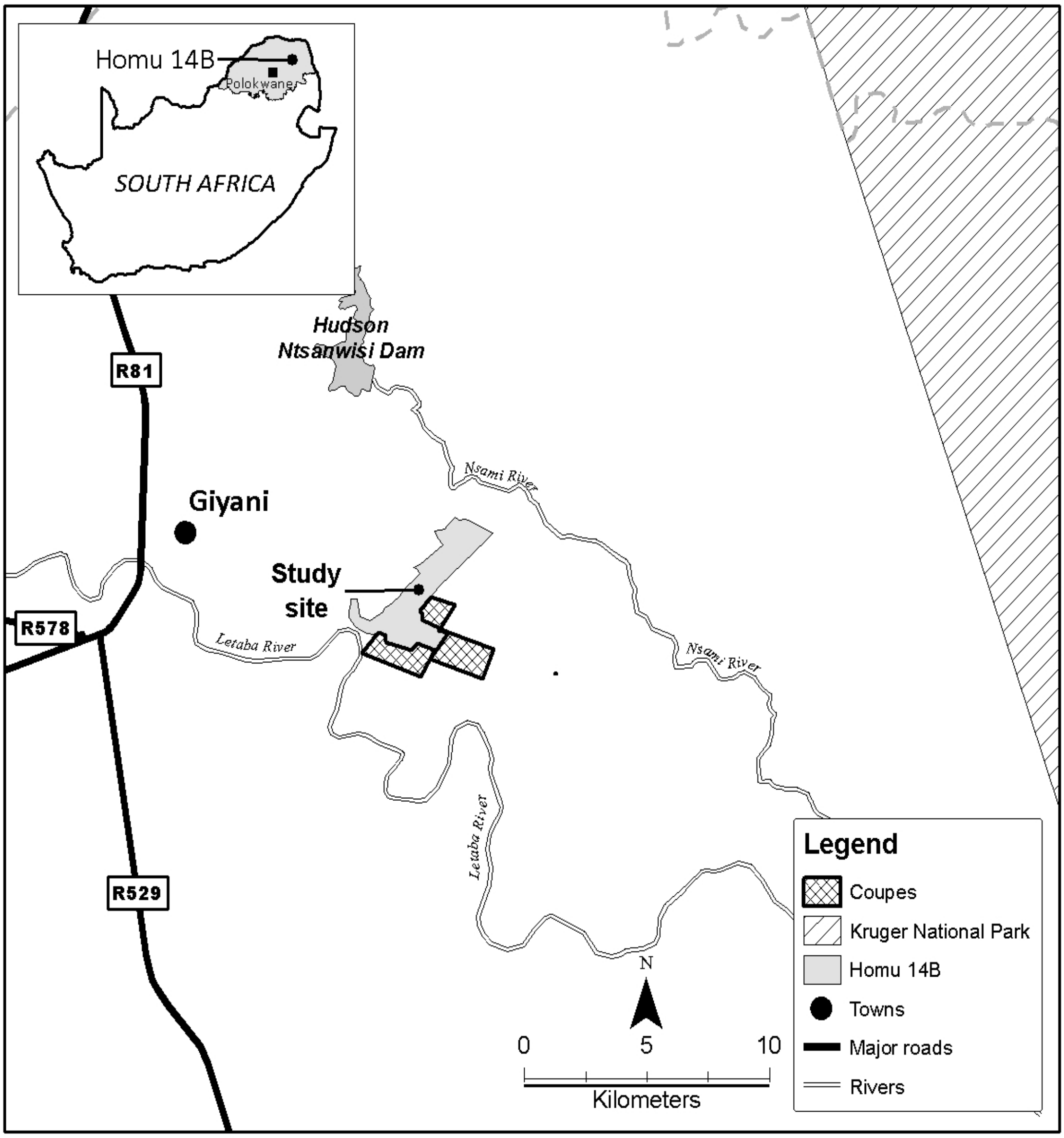



Figure 2.3: Map showing the location of Homu 14B village in Limpopo Province, South Africa.

### 2.2.4 Makhuva

Similar to Homu 14B, Makhuva is a large village (Figure, 2.4) also located in the Greater Giyani Municipality in the north-eastern part of the Limpopo Province (23° 35' 0"S; 30° 58' 0"E) and the village is under communal tenure. The total number of households is 885, while the population size is 3 606 (Statistics South Africa, 2011). The female population size is 1 970, constituting 55% of the village population in Makhuva. Similar to Homu 14B, Makhuva also has high number of employment with the majority depending on government grants as in other villages under the same municipality (Makhado *et al.*, 2009). Refer to Table 2.1 and appendix 14 which gives more socio-economic background information acquired from Statistics South Africa and through questionnaire distributed by the researcher. Makhuva is located in the same municipality with Homu 14B, thus, it shares the similar weather, climate and vegetation to that of Homu 14B (Makhado *et al.*, 2009). In this village no measurement of the woodland surrounding the village was done because the project was terminated early- after three months of the implementation. This was because of reasons such as the absence of chief to give a go-ahead to the study since he had granted the study permission. However, there was also high polarized views among local people which suggested the need for more meetings before getting their buy-in.

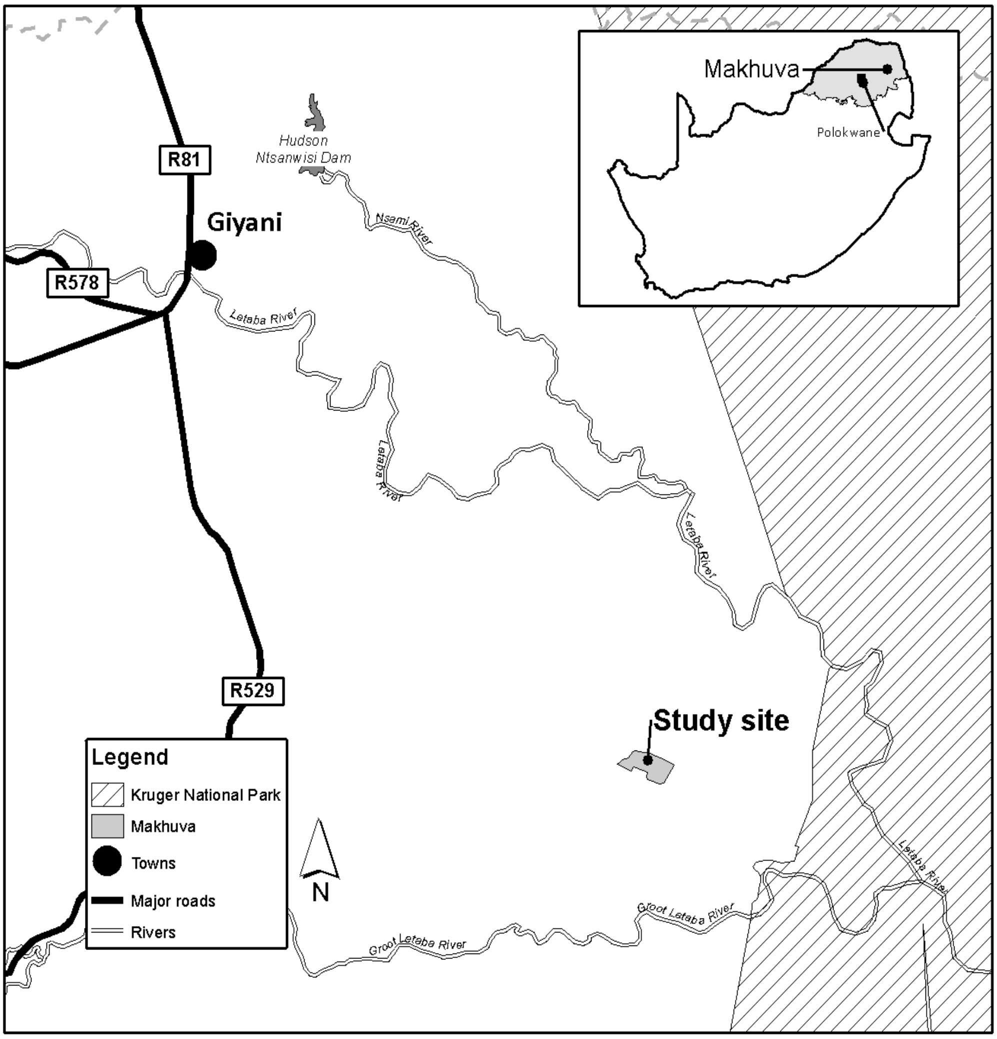



Figure 2.4: Map showing the location of Makhuva village in Limpopo Province, South Africa.

Table 2.1: Socio-economic information of the study villages (Statistics South Africa, 2011).

| Variable | Thorndale | Peninghotsa | Homu 14B | Makhuva |
|---|---|---|---|---|
| **% of HH members (permanent and migrant)** | | | | |
| 1-5 | 73.30 | 50 | 57.10 | 48.30 |
| 6-10 | 23.30 | 46.70 | 42.90 | 43.30 |
| > 10 | 3.30 | 3.30 | 0 | 8.30 |
| **Permanent household Mean total (±SE)** | 3.64 ±0.38 | 4.97 ±0.50 | 4.53 ±0.21 | 5.0 ±0.21 |
| **Migrant Mean total (±SE)** | 1.78 ±0.24 | 2.5 ±0.33 | 1.8 ±0.23 | 2.0 ±0.22 |
| **% of HH receiving government grant** | | | | |
| Child grant | 66.66 | 60 | 67.14 | 78.33 |
| Old age pension | 23.33 | 20 | 8.57 | 13.33 |
| **% of HH with access to electricity** | (1st) 90% (2nd) 100 | 100 | 100 | 100 |
| **% of HH receiving free basic electricity (FBE)** | 16.70 | 13.30 | 0 | 18.30 |
| Do not qualify (The income is higher) | 6.70 | 10 | 18.60 | 8.30 |

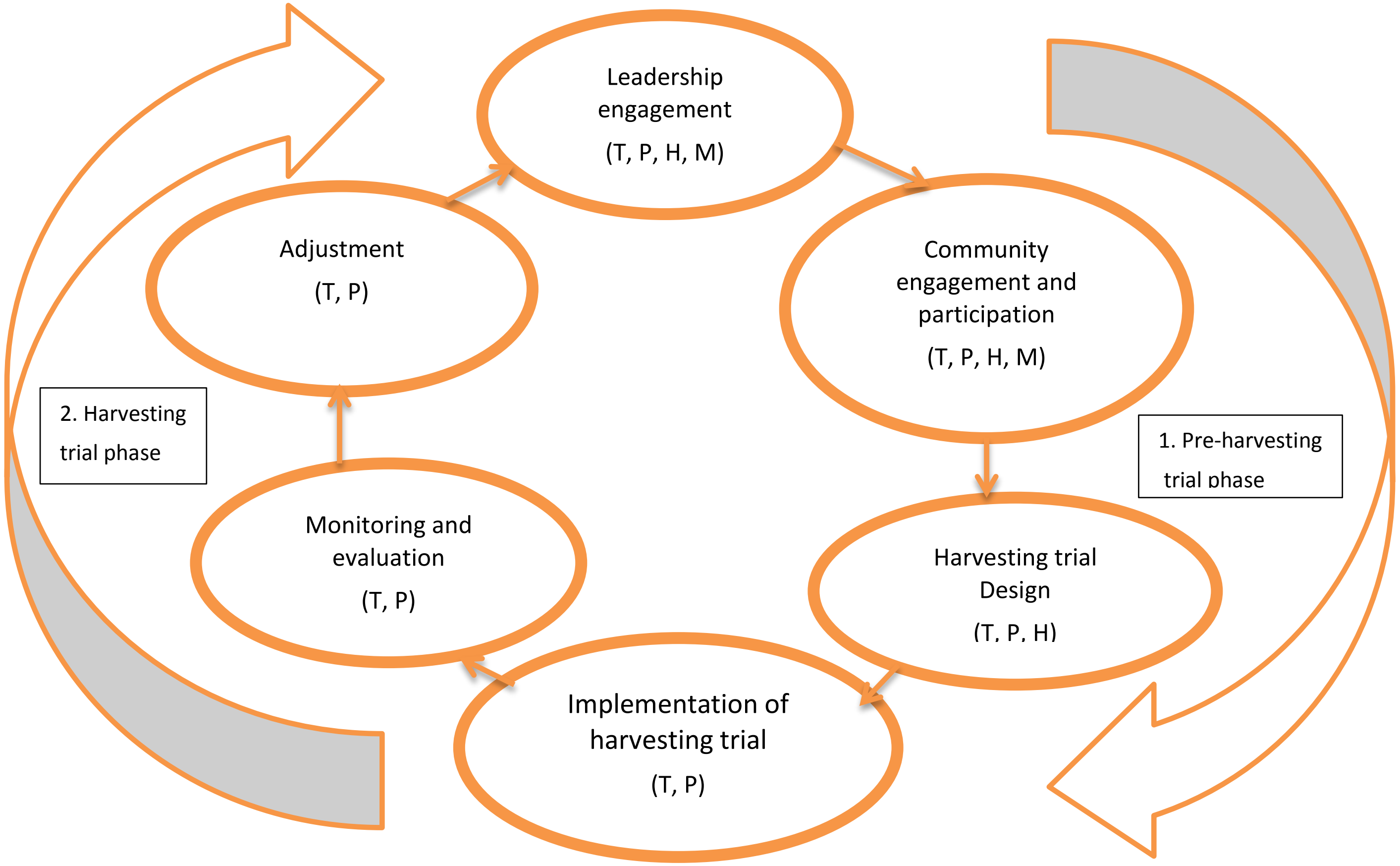
## 2.3 PROJECT IMPLEMENTATION CYCLE

The researcher used the accepted adaptive management project cycle (see Allan, 2007) to guide the project implementation process and modified it for his study project (Figure 2.5). Six stages were formulated: leadership engagement, community engagement, participatory harvesting trial design, implementation of the harvesting trial, monitoring and evaluation, and adjustment.

In the first stage, the starting assumption was that local TA are the most appropriate institutions to govern CBCM. Hence, the researcher approached the TA – the chief and/or headman - to present and discuss the project concept. This was to seek their buy-in to have the project piloted in their villages by them, in partnership with the local community and other relevant institutions, while the researcher played a facilitatory role. This was done first because traditional institutions are usually responsible for natural resource management, law enforcement and dispute resolution at the local level (Clarke and Gillespie, 2008), and this was no exception in all the study villages. Therefore, the initial engagement with them was done not only to gain their approval, since this is also critical in communal area (Dyer *et al.*, 2014), but also because their involvement were going to be essential in CBCM.

After discussing the project with chief and/or headman, the local Department of Environmental Affairs (DEA) and the national Department of Agriculture, Forestry and Fisheries (DAFF) were approached to present and discuss the project and get their opinions, because there were relevant government institutions for natural resource management (NRM) at provincial level. Having secured the support and buy-in from the traditional and government institutions, the next stage was to engage with the particular study communities. The researcher initiated the process by presenting and discussing the proposed project with village residents at an open community meeting called by the chief and/or headman. Community engagement and participation was an on-going process throughout the pre-harvest and harvest phases, and therefore, indicating it as a stage only marks the commencement of this process. For instance, the community members participated in the designing of the harvesting rules for the harvesting trial, which has been indicated as the next stage. This stage was only applicable in villages where the harvesting trial was implemented. During this stage, local resource users were allowed by the headmen in Thorndale and Peninghotsa to design harvesting rules in a community meeting which were employed during the implementation of harvesting trial stage.

Aspects pertaining to demarcation of coupes, their number and rotation times were dealt with by the headman. Therefore, in the implementation stage, the headmen were responsible for deciding upon the harvesting coupe in which to start harvesting and also the harvesting period before local resource users shifted to the next coupe. The next stage was the monitoring and evaluation stage, in which the headmen, the local resource users and the researcher monitored the performance of the project, including the community participation and compliance, stakeholder attitudes, and the growth of coppice shoots after every three months for a period of nine months. The adjustment stage was the last stage. In this stage, project aspects that community and the leaderships felt needed to be changed were discussed in a community meeting and were implemented by the leadership. For instance, these included replacing patrol committee members in Thorndale who had left patrol activities due to job opportunities in the nursery in Kruger National Park and restricting women to patrol only from nearby places. Details about each stage in the project cycle have been given below under the implementation description of the respective study villages.




*T = Thorndale*
*P = Peninghotsa*
*H = Homu 14B*
*M = Makhuva*

Figure 2.5: Project cycle showing the processes followed during the community-based coppice management in the study villages

## 2.4 IMPLEMENTATION PROCESS IN THORNDALE

### 2.4.1. Leadership and community engagement

In Thorndale, the researcher initially approached the chief of the Mnisi TA at his traditional institution office to present and discuss the project with him. Through his approval, the project would be piloted in one of the villages that he was in charge of by the local people and the researcher would play the role of a facilitator in the process. The chief accepted the project at once after the presentation. However, he requested that the researcher present the project to his headmen, expecting that those who were interested in piloting the project would do so in their villages. All of the headmen (13) showed interest in piloting the project in their villages after the researcher presented it. However, since only one village was required from the TA, Thorndale village was selected because it met the study requirements, e.g. it was a relatively small village, with communal woodlands that were comparatively less degraded than all the villages under this TA. Having accepted the project, the headman in Thorndale requested that the researcher presents it before residents of the village in a public meeting for their views and endorsement. However, before this happened, the researcher engaged with key relevant government departments for their opinion, endorsement and support. These included the local DEA, DAFF and the conservation unit in the local municipality. All government officers showed interest and undertook to be part of the project implementation over the twelve month period of the feasibility study. Contacts were exchanged with all officers to enable communication regarding community meetings in which the researcher had to present the project concept as per the headman’s request.

During the project presentation that the researcher gave in a community meeting following the permission of the leadership, everyone in attendance supported the project (see attendance statistics in Chapter 6). For instance, this was evidenced by community members applauding after the researcher finished presenting the project, and also by the lack of people who were against the project in the meeting after the programme director (who was a member of the headman council) requested that those who did not support the project could show it by raising their hands which demonstrated flexible leadership. Aspects of commercial harvesting mainly by outsiders and the incapacity problems by the local traditional and government institutions were key issues raised during the meeting, and thus, there was an expectation that through partnership with local resource users these problems would be addressed. Officers from the local municipality and DAFF were available, while an apology was given by the officers from the local DEA. After the community meeting, contacts were exchanged between the local leadership and the government departments' officers to enable communication regarding dates of the next community meeting aimed at discussing the rules of the harvesting trial. The researcher also informed officers from DAFF of the other study villages located in Limpopo Province, Peninghotsa, Homu 14B and Makhuva, because they were from the national office which was also in charge of these villages (Limpopo and Mpumalanga).

### 2.4.2 Harvesting trial design

#### *2.4.2.1 Designing of harvesting rules*

Harvesting rules were designed in the second community meeting, following the project endorsement in the first one. Before allowing the community to decide on rules, the headman gave prescriptions within which rules had to occur. He proposed that species such as *Dichrostachys cinerea* be harvested indiscriminately because it hindered grass growth which provides grazing for livestock in the village. *D. cinerea* is a thorny tree species and one of the common encroachers of South African savannas. It is umbrella shaped and forms an impenetrable canopy that constrains browsing by large mammalian herbivores. Moreover, it also suppresses the herbaceous layer and reduces rangeland carrying capacity and livestock production (Richter *et al.*, 2001). All fruit trees species, such as *Sclerocarya birrea*, were to be avoided during the harvesting trial

The headman allowed community members to formulate harvesting rules. However, he emphasized that women should decide on harvesting rules since the project related more to them than it did to men. Therefore, discussion about harvesting rules, and their finalization, was left entirely up to women who were present in the meeting. During this process, the researcher played a facilitatory role, ensuring that the project rules were within the legal framework of the relevant Acts, such as the National Forest Act 84 of 1998. These included giving a list of all protected species, such as *Combretum imberbe* and *Sclerocarya birrea* which were prohibited by the National Forest Act, as it was harvesting of all species for commercial purposes (National Forest Act, 1998). The researcher also gave technical information regarding recommended cutting height to be considered during the harvesting trial stage to enhance their coppicing abilities, as recommended by the coppice literature (see Gandar, 1997; Shackleton, 2001; Kaschula *et al.,* 2005). Below are the rules as designed by women in the community meeting and enforced during harvesting trial after being endorsed by the leadership, the community at large, and the relevant government institutions:

- Harvesting only for domestic purposes;
- Harvesting days - Fridays and Saturdays from 06:00 am to 5:00 pm;
- Harvesting quotas to be carried only by wheelbarrows or on the head;
- Using machete as cutting equipment (no chain saw);
- Indiscriminate harvesting of *D. cinerea* permitted (all size classes);
- Avoiding fruit bearing trees and protected species;
- Cutting height of 50 cm from the ground (local metric used – knee height);
- The upper stem harvesting diameter cut-off was 8 cm (the researcher used a beer bottle of 750 ml as a local metric, to illustrate what was indicated as the preferred diameters from the diameter size demonstrations by women. They all agreed that it was roughly the highest size mark of the woody stems they prefer since they used machete which cannot be used to harvest large trees); and
- The lower stem harvesting diameter cut-off was 4 cm. Woody stems with a diameter of 1-4 cm are usually saplings (see Luoga *et al.*, 2004), and the researcher thus recommended that they be avoided for continuous recruitment of the woody stems into class covered their preferred woody stems. In trying to use local metrics, local resource users indicated that they would not harvest woody stems of the size of the first toe and/or combined two fingers and less. Although the researcher found this to be subjective, it was considered close enough to guide them in avoiding saplings during the harvesting trail, especially because these local metrics represented the higher end of the woody stems in the sapling phase.
- To ensure that every village member was aware of these rules, the researcher documented them in a leaflet using the local language which was distributed by the local leadership (Appendix 2).

It was agreed that if local resource users were found breaking the above harvesting rules, they would be brought before the headman who would exercise his own discretion regarding the severity of the punishment. Therefore, during the trial aspects about how rule violators should be punished did not change as this was the case in the traditional management system.

#### *2.4.2.2 Implementation of harvesting trial, management, monitoring and adjustments*

The commencement of the harvesting trial occurred after the headman announce in a community meeting to which all the stakeholders were invited. In the first project meeting, there was a total of 49 community members, which constituted 9.5% of the village population (514). In terms of gender-based attendance, 31 members were female and this represented 11% of the total female population (287). Eighteen men attended, representing 7.9% of the total male population (227). Four cattle grazing camps of different sizes were available and later used as harvesting coupes. The size of the biggest coupe was 410 ha, while those of the last three were 319 ha, 308 ha, and 210 ha, respectively. Combined, they made a total communal woodland area of 1 247 ha. However, only three of these camps were considered for the harvesting trial because of a boundary conflict involving the fourth one. The headman requested that harvesting start on the biggest coupe, which was the first coupe from the western side of the village. In order to ensure compliance, the community suggested that it should be everyone’s responsibility to police each other’s harvesting practices against the set rules and to report violators to the patrol committee team or directly to the headman. However, for management purposes, the researcher suggested that it would be important to select a particular number of local resource users who would have the primary responsibility to undertake policing while reporting to the headman on daily basis. This view was supported by the headman and the local people who suggested that women should constitute the majority in the team because they were the ones who harvested fuelwood for domestic purposes. Furthermore, it was suggested that people who wanted to be in the team should volunteer. Many people wanted to be part of the team but there was a suggestion that by the community that 15 resource users would be good. Therefore, although every community member had a policing mandate, this patrol committee team undertook conducted patrols in all coupes every day and worked under the leadership of the headman. Accountable to the headman, the team had to report to him after undertaking patrols, therefore, together with the headman, the patrol committee constituted the project management system. As already mentioned, offenders were brought before the headman if found by the patrol committee team who had to exercise his own discretion regarding the severity of the punishment.

The headman of Thorndale decided on a harvesting period of six months in the first coupe. However, initially, he had proposed a harvesting period of three months, but changed it after the researcher indicated that this time was too short for woody stems to recover. Although the researcher had recommended a harvesting period of one year, the headman recommended the six months period in one coupe for the trial, because he wanted to find out if local resource users would comply if he directs them to harvest in the next harvesting coupe since this observation would not happen in a one year period. Therefore, he suggested that he would consider a one year harvesting period after the feasibility study period in the future. Therefore, after six months, the headman stopped harvesting in the first harvesting coupe and directed local resource users to harvest in the second harvesting coupe. He announced this in a community meeting after discussing with the patrol committee team, as together they constituted the management system of the CBCM. However, recommendations proposed by the community members before the leadership were considered as seen by them adapting the project accordingly. For instance, the leadership summoned a meeting after a request was made by the community that a meeting be held to find replacements of the two patrol committee members after they had left their monitoring duties due to job opportunities in the Kruger National Park. Ironically, it was through their involvement in the project that they secured nursery jobs following their exposure to the botanical knowledge gained during the project.

Measuring the progress against the project cycle in this village, the project completed one full project cycle and the harvesting trial was implemented as demonstrated as demonstrated by the letter “T” which represents Thorndale in the legend being available across all the implementation stages (Figure 2.5). However, local people, the chieftaincy and government officers were interested in engaging in the project beyond this trial period.

## 2.5 IMPLEMENTATION PROCESS IN PENINGHOTSA

### 2.5.1 Leadership and community engagement

Unlike in all other study villages, in Peninghotsa, the project was not presented to the local chief at the Madonsi TA, but rather to the headman who informed the chief about it. This was because after the researcher approached the headman to inform him about the request to have the project piloted in his village, he made the decision to give permission for the project implementation by himself before approaching the chief. The headman indicated that he would inform the chief of the decision to accept the project through a report to whom all headmen made every Tuesday. After this, the headman requested that the researcher present the project before the community members whose endorsement would mean that the project was welcome in the community. However, before this, as in Thorndale, the researcher engaged officers from government institutions, the provincial DEA and DAFF, for their views, endorsement and support where possible such as on issues of permit application since it was required in this village (Appendix 1). Officers from DAFF were already aware of the project since this was a national office and the researcher had informed them of this village. The senior officer (ranger) in the provincial DEA approved the project after a number of meetings. The officer also requested that the researcher apply for a harvesting permit and have written consent for the harvesting trial which meant that the researcher needed to approach the provincial Department of Land Reform and Rural Development as the department that had the title deed for the communal woodland of the village. As in Thorndale, contacts were exchanged with the approached officers from all government institutions to inform them of the date for the first community meeting where the researcher had to present the project to the community members, as recommended by the headman as he was the one providing the leadership at the village level.

### 2.5.2 Harvesting trial design

#### *2.5.2.1 Designing of harvesting rules*

There were similarities in some aspects such as rules to those observed in Thorndale. For instance, rules were designed and agreed upon in the second community meeting while the headman also prescribed certain rules before allowing the community to decide on rules pertaining to harvesting access during the harvesting trial. These included permitting indiscriminate harvesting of *D. cinerea* because of its encroachment in the communal woodland and prohibiting the harvesting of all fruit trees. However, unlike in Thorndale where *Combretum apiculatum* was the predominant species, here it was *Colophospermum mopane*. Since this tree species is the host species for edible mopane caterpillars (*Gonimbrasia belina*), the headman prohibited its harvesting. Therefore, with few exceptions, many rules were the same (Appendix 3) as those in Thorndale because of the national rules from the National Forest Act 84 of 1998, and the technical support from me which are described below:

- Harvesting only for domestic purposes;
- Harvesting days - Saturdays and Sundays from 05:00 am to 5:00 pm
- Harvesting quotas to be carried only by wheelbarrows or on the head;
- Using machete as cutting equipment (no chain saw);
- Avoiding fruit bearing trees and protected species;
- Indiscriminate harvesting of *D. cinerea* permitted (all size classes).
- No harvesting of *C. mopane*;
- Cutting height of 50 cm from the ground (local metrics used – knee height); and
- The upper stem harvesting diameter cut-off was 8 cm and the lower cut-off was 4 cm. Similar local metrics to those in Thorndale were used for illustrating the upper and lower cut-offs.

As in Thorndale, regarding the punishment after breaking agreed harvesting rules in CBCM, it was decided that the headman was the only person who could decide the extent of punishment similar to traditional natural resource management (NRM). Therefore, similar to Thorndale, decision on the severity of the punishment of the offenders did not change with the intervention also in Peninghotsa.

#### *2.5.2.2 Implementation of harvesting trial, management, monitoring and adjustments*

Unlike in Thorndale, there were no pre-existing cattle camps in Peninghotsa. The headman divided the communal woodlands into four harvesting blocks but their areas were not equal. The biggest coupe had an area of 498 ha, while the last three had areas of 462 ha, 404 ha and 336 ha. Combined, these coupes made a total area of 1 700 ha. In the absence of a fence, communal boundary fences, trails, grave sites and roads were used as features to mark the harvesting coupe boundaries. Like in Thorndale, harvesting started after the announcement was made in a community meeting by the headman. Officers from the government departments could not attend the launch meetings and cited capacity-related problems as the main reasons as in the first community meeting (discussed in details in chapter 5). However, the researcher gave them the minutes of the meeting after it was over, while giving the local leadership their contacts to enable communication between them regarding support and assistance. A total of 64 people attended the meeting, representing 9.1 % of the population of 702.

In regards to patrolling, similar to Thorndale, every community member was primarily responsible for policing and reporting offenders. Following the same recommendation the researcher made in Thorndale, a dedicated team of local resource users who had to conduct policing were voluntarily selected, and the number of patrol committee team in this village was of 20. Emphasis was again made that women should constitute the majority since the project related to them more. Uncertain of the harvesting period, the headman asked the researhers how long harvesting should occur in one coupe. The researcher indicated that it could last for a period of one year, depending on the size of the coupe. However, since the researcher indicated the experience with Thorndale, the headman considered harvesting for a six month period for similar reasons. "*We would be happy to see if our people can respect this rule since it is new*," he said. Therefore, after six months, the headman directed local resource users to use the next harvesting block. Aspects related to the need to adjust the project were discussed in the community meetings held fortnightly in the presence or absence of project issues. For instance, a suggestion was made that the female patrol team members be restricted to conducting patrols within the vicinity of the village because they were more vulnerable to attacks by defiant fuelwood vendors.

Similar to Thorndale, this village completed the full project cycle as indicated by the letter "P" in the legend indicated across all the implementation stages (Figure 2.5). The project also continued beyond the harvesting trial period. The researcher and the rangers supported the local resource users to apply for permit extension which was given for six months, although the community wanted for one year. The challenge was to continue after it expired because local people wanted to continue indefinitely.

## 2.6 IMPLEMENTATION PROCESS IN HOMU 14B

### 2.6.1. Leadership and community engagement

Similar to Thorndale, the researcher initially presented the project concept before the chief at Homu TA office who upon approval delegated it to one of the four headmen. Similar to

Thorndale and Peninghotsa, the headman requested that the researcher presents the project concept before the community members. Government officers from DAFF were already aware since the forestry sector is a national competence with the departmental offices based in the same region in which Peninghotsa was located. Therefore, it was only the local officers from the provincial department of the local environmental affairs and the local municipality which had to be approached since the village was in a different municipality. However, although an office dealing with conservation issues existed, the officers indicated that they only covered issues of conservation surrounding the graveyards; therefore, they considered the project irrelevant to their mandate.

In the first community meeting at which the project concept was presented following the request of the headman and the council, there were no representative available from the local DEA and DAFF for similar reasons as in other villages (capacity challenges). In contrast to the other villages mentioned above, local people in this village were divided between those who wanted the project and those not in the first meeting (details in chapter 6). However, although the project completed a twelve month period, due to differences in this village, actual harvesting of fuelwood based on the project rules did not occur (or harvesting trial did not occur). This was despite harvesting coupes having been demarcated for harvesting. It is important to indicate that in this village, eight community meetings were held to secure participation of local resource users while other project activities were undertaken alongside such, as coppice shoots monitoring in the field, because there was an expectation that there would be an increase in the number of resource users participating in the project, which was not the case since the opposite happened. Statistics to measure the attendance in the portion of the village could not be obtained from Statistics South Africa because the available one included other Homu village sections, Homu 14 A and C, and could not be differentiated which was 3 012. However, based on this number the meeting that had better attendance had 51 members representing 1.69% of the total population.

### 2.6.2. Harvesting trial design

#### *2.6.2.1 Designing harvesting rules*

A pattern similar to that from the headmen in Peninghotsa and Thorndale regarding the harvesting of *D. cinerea* was observed in Homu 14B. The headman also prescribed that *D.*

*cinerea* be harvested destructively because it negatively affected the growth of grasses required for grazing by their livestock. "*There is no grass for our cattle because this tree is all over and grasses do not grow under it. We have been telling our people to harvest it even before*," said the headman. He elaborated, "*Even before the project, when we see our people harvesting that tree we did not punish them. We punish them when we find them harvesting mopane*." Harvesting of *C. mopane* was prohibited for similar reasons mentioned in Peninghotsa. Although like the other leadership, there was an acknowledgement that women should make harvesting rules, this could not be carried out due to the lack of interest by the majority of the community members. For instance, due to poor attendance in meetings, it was suggested that designing rules would be futile because only a handful of resource users would be aware of such rules. Therefore, although the project completed a full project cycle, harvesting continued under the traditional rules in this village during what was supposed to be a harvesting trail period over the twelve months of the CBCM.

Measuring the progress against the project cycle, the project in this village reached the harvesting trial design. However, this stage did not involve designing of rules by local resource users because of poor attendance e.g. less than 10 community members attended the community meeting in which rules were supposed to be designed. Hence, against the project cycle, this village only reached the harvest trial design which is indicated by the relevant letter, "H". Therefore, harvesting trial design in this village was reflected by three coupes of 134 ha, 92 ha and 74 ha respectively, which were set aside, adding up to a total of 300 ha.

## 2.7 IMPLEMENTATION PROCESS IN MAKHUVA

### 2.7.1. Leadership and community engagement

Similar to Thorndale and Homu 14B, the researcher presented the project before the chief at the Makhuva TA who subsequently requested him to come back to present it before the local people in a community meeting. Since Makhuva was under the same municipality and the local DEA with Homu 14B, officers from these institutions were already aware and only needed to be informed of the CBCM meeting in this village. Three community meetings were held in this village. The most attended meeting in this village had 81 community members which represented 2.2% of the 3 603 total population. In terms of gender, female attendance was 55, representing 3% of the total 1 970 female population, while male attendance was 22 representing 1.3% of the 1 633 total male population. Similar to Homu 14B, people were divided between those who supported the project and those who did not. Rangers/officers from the DEA only attended the third meeting and cited capacity problems as a major problem in the department. While more community engagements were required and recommended by the local headmen, it was agreed with the chieftaincy that the village would be dropped from the current trial due to time constraints faced by the researcher, but that it could possibly be revisited in future. This occurred while the project had progressed into the second stage; the community engagement and participation. This conclusion was made after a period of three months during which three meetings were held as already had been indicated. Therefore, against the legend which demonstrates the progress each study village has made it has been represented by the letter “M” occurring in only the two implementation stages (Figure 2.5).

## 2.8 SITING VEGETATION MONITORING PLOTS IN COUPES

After the local leadership agreed to implement the project, they designated harvesting coupes for the intervention. Vegetation monitoring plots were sited through systematic sampling in the coupes for ecological assessment before and during the trial. Transect walks with research assistants, the headman and/or his delegates were undertaken in each study village in order to become familiar with the dimensions of the village communal woodlands and the designated coupes of the study villages (refer to chapter 2), which were subsequently geo-referenced using a Garmin hand-held Global Positional System (GPS). Plots in coupes were aligned along three linear transects away from the settlement periphery, last household or field, north, south, east and west depending on local reasons such as boundary conflicts. Circular vegetation monitoring plots are commonly used in vegetation studies (Gage and Cooper, 2010), and are easier to create in the field, requiring only a stake at the centre stake and a tape measure (Tiner 1999). In this study, circular vegetation monitoring plots having a radius of 5.64 m, equating to an area of 100 $m^2$, were used. During the siting of plots, the tape measure was first stretched from the centre of plot which was marked with a metal stake and recorded by GPS so that it would be easy to return to it to each plot for data collection and monitoring in the future. The boundary of each circular plot was demarcated through tying strings on tree branches on the boundary edge. The “far” plots were sited near the boundary demarcating the end of the communal woodland area. The bigger the size of the coupe, the greater the number of plots sited in order to promote better representivity. In order to promote objectivity, a rule was designed that maximum of six plots would be sited when the distance between the last household or field and the boundary marking the communal end in the coupes was 800 m and less, and nine plots when the distance was more than 800 meters but less than 1 600 m. Across the study villages, the distance of the near plots from the settlement area varied between 200 m to 500 m depending on the distance from the last field or stand marking the edge of the settlement. Based on the size of the coupes, 27 plots were sited across three coupes in Thorndale (410 ha, 319 ha, 210 ha, excluding the last one with 308 ha, which was not considered because of boundary conflicts), 36 in Peninghotsa (498 ha, 462 ha, 404 ha and 336 ha), and 21 in Homu 14B (134 ha, 92 ha and 74 ha). The area of each coupe was calculated using Google Earth Pro. This was done after the local headmen had demarcated the harvesting coupes. As procedure, the researcher used Google Earth Pro (Polygon tool) to outline and measure the area of each harvesting coupe.

## 2.9 ETHICAL CONSIDERATIONS

All human interaction, including the interaction involved in human research, has ethical dimensions (NHMC, 2015). As required by the University of The Witwatersrand to ensure the research was ethically acceptable, the researcher had to apply and be given Human Research Ethics Clearance prior to going to the field or undertaking surveys. This was because the significant portion of data was derived through focus group discussions, interviews and workshops, which indicates that these data gathering techniques remain the most common techniques used in gathering qualitative data in CBNRM. Securing university ethics clearance enhanced the legitimacy of the researcher in the study villages. For example, in a public meeting in Makhuva, a community member wanted to know if ethics clearance was obtained from the institution similar to during conducting interviews. For instance, the researcher presented the ethics clearance certificate that he received (Protocol number H121110) which had indicated the title of the project and to ask participants how long they were willing to take part in the surveys. The permission was obtained from the relevant TAs to do this research (both implementing the intervention and conducting the interviews and focus groups).

Consent to participate in research was voluntary and based on sufficient information and adequate understanding of both the proposed research and the implications of participation in it (NHMC, 2015) and this was made clear in the beginning of data gathering techniques. No respondent had declined to be interviewed nor withdrew in the middle of the interviews which implies that most resource users in communal woodland areas would be comfortable giving relevant information to project facilitators or managers in the CBCM area. This would be useful because such information would help them improve or enhance their understanding regarding local resource users and the all relevant aspects.

## 2.10 REFLECTION OF THE RESEARCHER ON THE FACILITATION PROCESS

The researcher played the simultaneous roles of researcher and facilitator in this project. This had a positive influence on communication and his legitimacy with project participants throughout the project across the study villages. For instance, in Thorndale, the local people were excited in having the researcher since he belonged to the ethnic group similar to that of the local people. Thus, during community meetings it was easy for the researcher to read communication made through gestures or non-verbal communication, and also the conversation of local people about the project. The researcher did not need interpreters during the survey because he spoke the local language. The local people and the chieftaincy also did not have any language barrier to express themselves. For instance, in trying to encourage the researcher after attending a number of meetings where the local community members did not come, the headman had this to say in Homu 14B: "*Do not worry things will be fine, finally. It is like when you find a woman and you propose, and she loves you at once, you must know she will not stay in the marriage. The one who takes time to agree to your marriage is the one who will stay in the marriage*", said the headman. In Makhuva, the legitimacy of the researcher as the project facilitator was questioned because he used public transport when going to the village: "*Where is the car from the university or the government with a badge*", said one community member.

The fact that the researcher shared ethnicity with the local resource users and the chieftaincies, and was from a rural area facing similar problems which CBCM sought to address, had a number of implications. For instance, respondents had to be honest because they knew the researcher would know if they were not honest in certain aspects, such as indicating that there were adequate amounts of fuelwood. However, this was also a challenge to the researcher because he had to listen to what they had to tell regardless of whether in his experience this was understandable or not. The researcher also encountered challenges associated with local politics especially in Homu 14B and Makhuva where not only ordinary local people but also those in the leadership would tell him of what should happen in the village if the project had to be successful. However, the researcher was able to overcome such challenges by sticking to what the local leadership would tell him in community meetings or during discussions with the council members, regarding aspects of fuelwood harvesting

# CHAPTER 3

## FUELWOOD HARVESTING AND USE PATTERNS BEFORE AND DURING THE HARVESTING TRIAL

### ABSTRACT

The majority of people in communal woodlands in South Africa continue to use fuelwood as the primary energy source for thermal uses such as cooking and space heating because they cannot afford alternative energy sources such as electricity. Due to the scarcity of deadwood and the lack of adequate number of rangers to enforce rules, harvesting for commercial purposes is rife and this has resulted in the unsustainable harvesting of fuelwood in such areas. This has resulted in the recommendation of locally managed coppice system as one of the strategies carrying potential to address fuelwood harvesting problems in the savannas since species coppice vigorously after harvesting in such areas. However, such a system has not been implemented, despite related policies also supporting community based approaches in addressing natural resource management (NRM) problems such as fuelwood. This chapter examines the impact of community-based coppice management (CBCM) on household consumption patterns and fuelwood harvesting. Household interviews were conducted in four study villages using a questionnaire before and during the harvesting trial in order to gather data on fuelwood harvesting and consumption patterns, such as energy mix, species preference, and distance travelled. Households were randomly sampled in the study villages as follows: 30 in Thorndale, 30 Peninghotsa, 70 in Homu 14B and 120 in Makhuva. Although the implementation of the CBCM did not alter the consumption patterns, the project promoted better access, lifted pressure on preferred yet dominant species and those with socio-economic value, while reducing the opportunity costs. For instance, local resource

users spent significantly less time getting to the harvesting area and harvesting, with significant shift in fuelwood consumption having been observed during the trial.

## 3.1 INTRODUCTION

Throughout the developing world in both urban and rural environments, fuelwood is the primary energy source for domestic purposes (Von Maltitz and Scholes, 1995; Campbell *et al.,* 2003; Ejiqie 2007; Madubansi and Shackleton, 2007). In South Africa, over 90% of rural households continue to depend on fuelwood despite electrification of their households (Madubansi and Shackleton, 2007; Twine *et al.,* 2003a). This is primarily due to the prohibitive costs of electric appliances and the power they consume (Twine *et al.,* 2003b; Shackleton *et al.,* 2007b). Therefore, although paraffin, candles, batteries and electricity are also used, they are primarily used for lighting (Davis, 1998; Howells *et al.,* 2005; Lloyd, 2014). As a result, fuelwood is widely used as a cheap or free alternative to more costly energy sources such as electricity (IEA, 2006; Shackleton *et al.,* 2002, Twine *et al.,* 2003a; Shackleon *et al.,* 2004) because of unemployment and high poverty levels in rural areas (Mitchell, 2004).

Nevertheless, although fuelwood collection is ‘free’ (Lloyd, 2014) monetarily, it is a time-consuming and exhausting task, especially for women and children who are mainly responsible for domestic fuelwood collection (Shackleton *et al.,* 2004; IEA, 2006). For instance, in the central region of Singida, Tanzania, the average distance travelled for fuelwood collection is over ten kilometres per day (IEA, 2006). In South Africa, time spent and distance travelled for fuelwood collection varies extremely, depending on local context (see Banks *et al.,* 1996; Masekoameng *et al.,* 2003). For example, Twine *et al.* (2003b) found that a headload of fuelwood (35 kg) that previously took about two hours to collect now has a mean collection time of four hours in villages around Mametjia, Limpopo Province, while around Giyani in the same province, harvesters took three to six hours to harvest (Liengme, 1983). However, in cases of scarcity, wealthier households buy alternative modern fuels like gas, paraffin and electricity (Maphiri, 2009). Furthermore, they may also have other resources at their disposal, such as trucks or donkey-carts, enabling them to collect and transport fuelwood resources more efficiently (Twine *et al.,* 2003b).

There is much debate surrounding the potential and actual sustainability of wood harvesting in rural communities (Shackleton *et al.,* 2004a). However, harvesting for fuelwood does not amount to complete clearance of woody biomass, as some of the species are preferred to others. Moreover, it is also unrealistic to expect people who rely on fuelwood for their daily energy requirements to abstain from utilizing wood because it has been shown that their activities may negatively impact on regional biodiversity (Du Plessis, 1995). This is true especially because with the ongoing high demand for firewood, collection consists of cutting even the live or green coppice of a previously harvested tree stump in communal lands, but not in any coordinated way that enhances fuelwood production (Avohou *et al.,* 2011; Matsika *et al.,* 2013).

Fuelwood is a renewable resource, and thus there is potential to have live stems harvested and managed sustainably in savanna areas (Shackleton *et al.,* 2004a). Rotational harvesting strategies have been recommended to ensure that harvesting of such trees are done in a manner that would not alter the production and sustainability of the ecosystem (Shackleton, 1993). Such initiative can be implemented in the form of community-based natural resource management (CBNRM). This is because CBNRM models work to strengthen locally accountable institutions for natural resource use and management, enabling local groups of people to make better decisions about the use of natural resources (Roe *et al.,* 2009). Therefore, through CBNRM local resource users can work in partnership with local institutions to initiate a coppice system which is aimed at the production of fuelwood and small or medium sized material up to pole size (Von Maltitz and Shackleton, 2004). Moreover, it is an active management strategy necessary when pressure becomes much more on the resource base (Dewees, 1989) such as those in Bushbuckridge region. For instance, in such a system, the woodland can be divided into coupes that are big enough to allow for a continuous cutting cycle to be established such that by the time the last coupe is cut, the first is ready for re-harvesting by local resource users. The number of felling coupes is equal to the number of years it takes for the cut trees to produce coppice shoots and reach harvestable size (Shackleton and Clarke, 2007).

Coppice regrowth can be manipulated and this has been suggested as a possible management technique to allow continued harvesting of wood for fuel and construction from savanna woodlands (Shackleton 1993, Kennedy, 1998, Shackleton 2000, Shackleton, 2001; Neke *et* *al.*, 2006). To this end, rotational harvesting of coppice shoots involving local resource users has been recommended in many African countries as a promising strategy to promote sustainable harvesting of fuelwood. These include Kenya, Sudan, Malawi, Zimbabwe, Namibia and Namibia (Kennedy, 1998; Abbot and Lowore, 1999; Nygård *et al.*, 2004; Shackleton and Clarke, 2007) and South Africa (Gandar, 1984; Shackleton, 2000; Shackleton, 2001; Gandar, 1997; Williams and Shackleton, 2002; Neke, 2004; Kaschula *et al.*, 2005; Makhado *et al.*, 2009; Matsika *et al.*, 2013). However, for tenurial and institutional reasons rotational harvesting strategies have yet to be implemented (Neke, 2004; Shackleton and Clarke, 2007). This is despite the regulations that prohibited harvesting of livewood during the apartheid era in the former homelands remaining in force today, although they do not keep abreast with reality, such as increasing population (Shackleton, 1993). For instance, there is concern about the sustainability of intensive cutting of trees for fuelwood purposes in communal areas (Twine *et al.*, 2003, Kaschula *et al.*, 2005, Neke *et al.*, 2006, Shackleton *et al.*, 2004; Makhado *et al.*, 2009), since in villages such as those around Bushbuckridge, 93% of demand is met by harvesting of livewood due to acute shortages of deadwood (Shackleton and Shackleton, 2000). Furthermore, this is also despite technical recommendations from silvicultural system trials backing this recommendation in communal areas (Shackleton, 2001; Twine, 2008) and the willingness of rural communities to engage in CBCM (see Neke, 2004). In the context of the above this chapter sought to investigate the impact of CBCM on fuelwood harvesting and use patterns by quantifying these before and during implementation of CBCM.  This chapter thus sets out to answer the following questions:

- To what extent is fuelwood used by the households before and during the intervention?
- How does the fuelwood harvesting access and the species preference change with the implementation of CBCM, and how does this compare and contrast with fuelwood harvesting access and the species preference under traditional harvesting rules?
- To what extent are the preferred fuelwood species in the size classes selected with the intervention?

## 3.1 METHODS

### 3.1.1 Sampling procedure

A survey method involving interviews based on a structured questionnaire was used to gather data on the types of energy used and the associated factors, e.g. fuelwood harvesting and the use patterns from the sampled households before and during the harvesting trial. The first interviews were undertaken in January 2014 before the harvesting trial, which started in the same months, while the last one occurred in January 2015. Although the harvesting trial did not happen in Homu 14B, data were collected similar to Thorndale and Peninghotsa because the project ran throughout a year period. The same households were interviewed in both survey rounds. In order to be not bias in the sampling process, random selection of households approach from Shackleton (2007) was adopted, where the municipal planning maps with erf numbers was obtained from the local municipalities of each study village. Random samples of potential households were drawn and subsequently considered for the household energy survey. The sample size was between 11% and 24% of the total village households, as follows: Thorndale (126 households) n=30, (Peninghotsa (210 households) n=30) (Homu 14B (420 households) n=7), and Makhuva (885 households) n=120). Data were collected data on both weekdays and weekends so as not to be biased against people possibly being away for work. If nobody was at a randomly drawn household, the neighbouring household in succession was considered until a successful interview was conducted.

### 3.1.2 Household interviews

The household interviews for the first survey occurred before the harvesting trial or during the earlier phase in case of Homu 14B and Makhuva, since harvesting was not implemented. Therefore, it covered aspects of consumption patterns and fuelwood harvesting under the traditional management rules. Such experiences included the differences in the type of energy mix used, amount of fuelwood used daily, time spent acquiring fuelwood, financial costs of buying fuelwood and species preference ranking. The same households that were sampled randomly before the harvesting trial or in the first survey were returned to towards the end of the project period to assess the impact of CBCM on fuelwood harvesting and use patterns. Since the first survey occurred before the harvesting trial, it provided baseline information, while the second interviews provided information about the impacts of CBCM on fuelwood harvesting and the use patterns since this occurred towards the end of the harvesting trial, which was about 11 months. However, unlike other information such as the use of electricity, daily fuelwood consumption was collected on three occasions, with the one occurring in winter, July 2014, since the major two survey rounds had occurred in the same season, summer, January 2014 and January 2015 (Figure 3.1). The aim for collecting daily winter consumption was to account the influence of winter season. However, ideally, consumptions for both summer and winter data before the intervention would have been collected, but this was not possible due to time constraints. Therefore, this means that during the harvesting trial daily fuelwood consumption were collected twice, including the one for winter, which was collected in July 2014. The socio-economic data were also collected for the surveyed households such as aspects of employment and income, education, government grants, number of the household members, permanent and migrant members, and gender among others.

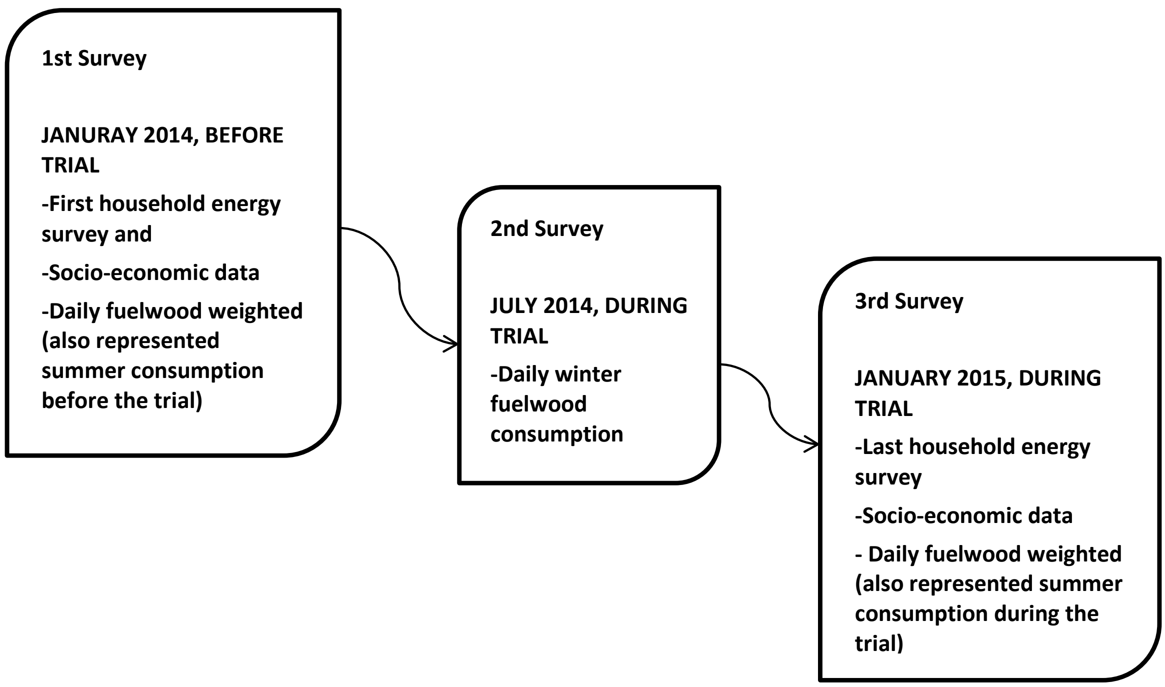



Figure 3.1: Time series by which the household interviews based on questionnaires were administered to the sampled households.

In order to measure daily fuelwood used, the respondents were requested based on their estimates, to set aside the fuelwood daily amount used (that covered all cooking and heating activities). This amount was used to calculate the total village fuelwood consumption per annum. This was done by initially multiplying the mean daily fuelwood amount recorded during the survey, by the total number of households using fuelwood in the village. Then, the subsequent value was multiplied by 243 (total summer days September-April) and 123 (total winter days May-August) to get the consumption over a one year period. If people used fuelwood while the household had access to electricity, the researcher inquired the reasons behind this. In case households used electricity for cooking and heating on occasional basis such as once a week or a month, they were classified in the same category as those using fuelwood on fulltime basis. In order to determine the correspondence between the species preference as reported by the local resource users during the survey rounds and the harvesting in the fields, the frequencies with which each species stems were mentioned during the survey and that of harvesting in the plots during the ecological survey based on stumps of different size class categories in the plots were assessed (see proportions, Appendix 4, 5 and 6), 0.1–0.9 cm, 1–3 cm, 4–9 cm, 10–19 cm and >20 cm. Circular plots which were sited in coupes were used for monitoring harvesting during the trial, and radius of each plot was 5.64 m, equivalent to100 $m^2$. The number of the plot per village differed depending on the number of and the size of coupe. The legal stem size as agreed during the community meeting was 4–8 cm which was within the intermediate size class category, 4–9 cm. Although the higher cut-off of the intermediate size class category was a little higher to that of the legal size class, the difference was considered to be negligible. In order to determine the species ratios or the relative abundance of the species in the field, the percent of the harvested species (stumps) was divided by that of the unharvested ones in both the survey periods to see if this changed with the intervention (Appendix 7, 8 and 9).

### 3.1.2 Data analysis

All statistical analyses were done using Statistical Package for the Social Sciences (SPSS) version 23. The following frequencies were analysed using chi-square test: 1) Resource users accessing fuelwood through harvesting, harvesting and buying and buying only before and during the trial, 2) Harvesting from the woodlands and the fields, 3) Buying from local fuelwood vendors or non-locals, 4) Preferring certain species, 5) Harvesting frequencies between the two survey rounds, and 6) Harvesting seasons. The categories of the independent variable, survey period (1$^{st}$ survey and 2$^{nd}$ survey) were put in the columns of the crosstab table, and those of the dependent variable in the rows (e.g., three nominal variables, harvest, buy and harvest and buy). For parametric statistics, all means were tested for normality using Shapiro-Wilk test before analysis, while T-test was used to determine if the time spent acquiring fuelwood during the harvesting trial or second survey was different from that of the first survey or before the trial. Analysis of variance (ANOVA) was used to determine the difference in the mean amount of fuelwood amount used on daily basis gathered in winter and that of two summers, January 2014 before the trial, and January 2015 during the trial.

## 3.2 RESULTS

### 3.2.1 Use of different energy sources

Fuelwood was the most widely used energy source in all four study villages in the first and second survey rounds with more than 80% across the study villages using it (Table 3.1). The dominant uses were for cooking, space heating and water heating and this did not change over the observation period. Electricity was also used for thermal purposes before and during the harvesting trial by 3-20 % of the households across the villages. Almost all households used electricity for lighting over the observation period. Other energy types used for lighting were paraffin and candles. However, they were mainly used by non-electrified households in the first survey round as this had changed in the second survey round after such households were electrified, especially in Thorndale. Nonetheless, in Peninghotsa, certain households continued using candles despite access to electricity. The proportion of sampled households using electricity for cooking increased in Thorndale and Peninghotsa during the harvesting trial. In Mkhuva, household changes in energy mix could not be assessed because only one survey round was conducted, since the project did not proceed beyond the initial phase.

Table 3.1: The proportion (%) and the frequencies (in brackets) of households using particular energy forms for cooking, space heating, water heating and lighting across study villages (Peninghotsa, Thorndale, Homu 14B, and Makhuva).

| Village | Thorndale | | Peninghotsa | | Homu 14B | | Makhuva |
|---|---|---|---|---|---|---|---|
| | 1st survey | 2nd survey | 1st survey | 2nd survey | 1st survey | 2nd survey | 1st survey |
| **Fuelwood** | | | | | | | |
| Cooking | 93.33% (28) | 83.33% (25) | 96.66% (29) | 93.33 %( 28) | 81.42% (57) | 80.00% (56) | 90.83% (109 |
| Space heating | 93.30% (28) | 86.66% (26) | 93.33% (28) | 93.33 % (29) | 81.42% (57) | 80.00% (56) | 90.00% (108) |
| Water Heating | 96.70% (29) | 93.33% (28) | 96.66% (29) | 93.33 (28) | 91.44 (64) | 81.42% (57) | 86.66% (10 |
| Lighting | 0% (0) | 0% (0) | 0% (0) | 0% (0) | 0% (0) | 0% (0) | 0% (0) |
| **Electricity** | | | | | | | |
| Cooking | 6.67% (2) | 16.67% (5) | 3.34% (1) | 6.67 (2) | 18.58% (13) | 20.00% (14) | 9.17% (11) |
| Space heating | 3.33% (1) | 10.00% (3) | 3.34% (1) | 6.67 % (2) | 17.14% (12) | 20.00% (14) | 8.33% (10) |
| Water heating | 6.66% (2) | 16.66% (5) | 6.66% (2) | 10.00% (30) | 22.85% (16) | 21.42% (15) | 13.33% (14) |
| Lighting | 90.00% (27) | 100% (30) | 100% (30) | 100% (30) | 98.57% (69) | 100% (70) | 95.00% (114 |
| **Paraffin** | | | | | | | |
| Cooking | 0% (0) | 0% (0) | 0% (0) | 0% (0) | 0% (0) | 0% (0) | 0% (0) |
| Space heating | 0% (0) | 0% (0) | 0% (0) | 0% (0) | 0%(0) | 0% (0) | 0% (0) |
| Water heating | 0% (0) | 0% (0) | 0% (0) | 0% (0) | 0% (0) | 0% (0) | 0% (0) |
| Lighting | 6.67% (2) | 0% (0) | 0% (0) | 0% (0) | 3.34% (1) | 1.42% (1) | 6.66% (8) |
| **Candles** | | | | | | | |
| Lighting | 16.66% (5) | 0% (0) | 13.33% (4) | 6.66 (2) | 5.71% (4) | 0% (0) | 11.66% (14) |

### 3.2.2 Fuelwood access and harvesting sources

During the harvesting trial in Thorndale and Peninghotsa, access to harvesting of livewood to initiate a coppice cycle was restricted to local resource users in coupes. The patrol committee team undertook patrols to ensure that harvesting by outsiders did not occur as before, while ensuring that harvesting by the local resource users was based on the agreed rules.

More than 70% of the resource users reported acquiring fuelwood through harvesting in all of the study villages in both survey rounds (Table 3.2). During the second survey, an increase in those who acquired fuelwood through harvesting was recorded, with a decrease in those who obtained it through purchasing in all the study villages. More than 80% of local resource users harvested fuelwood from the communal woodland, with only few harvesting in their own fields (Table 3.3). The fact that this did not change significantly over the observation period was not surprising because few people harvested from their own field before the trial. However, as reported by the resource users, there was a shift from purchasing from local fuelwood vendors before the harvesting trial to purchasing from non-local vendors during the harvesting trial in Thorndale and Peninghotsa. Nonetheless, statistical tests could not be done in Thorndale and Peninghotsa because the sample size of those who purchased fuelwood were too small. Therefore, it was only done for those in Homu 14B where results showed insignificant changes (Table 3.4). In Makhuva, this could not be observed because the project did not complete the project implementation circle of twelve months period for the reasons already indicated in chapter 2.

During the second administration of the questionnaires (during the trial) in Peninghotsa, one of the female respondents who admitted being a fuelwood vendor was concerned about the prescribed fuelwood harvesting access, although she expressed her support to the project. She indicated that harvesting twice a week negatively affected her business unlike before the CBCM. For instance, she said that she had to hire other people and also requested her children to help her harvests a greater amount on the prescribed days to meet fuelwood purchase orders placed by her customers. The reason for doing fuelwood vending business, she said, was that she could not find work for more than ten years, despite being in possession of a national teaching diploma.

Table 3.2: Ways by which local resource users acquired fuelwood in the first and second survey periods.

| Village | Thorndale | | Peninghotsa | | Homu 14B | | Makhuva |
|---|---|---|---|---|---|---|---|
| | χ (1)=3.452, *p*= 0.178) | | χ (1)=4.793, *p* =0.091) | | χ (1)=2.324, *p*=0.283) | | |
| **Fuelwood acquisition** | **1st survey** | **2nd survey** | **1st survey** | **2nd survey** | **1st survey** | **2nd survey** | **1st survey** |
| Harvest | 72.40% (21) | 89.30% (25) | 72.40% (21) | 88.90% (24) | 75.00% (48) | 69.20% (45) | 78.33% (94) |
| Buy | 17.20% (6 ) | 10.70% (3) | 17.20% (5) | 11.10% (3 ) | 20.30% (13) | 18.50% (12) | 11.66% (14 |
| Harvest and buy | 6.90% (2) | 0% (0) | 10.30% (3) | 0 % (0) | 4.70% (3) | 12.30 % (8) | 6.66% (8) |

Table 3.3 Sources of fuelwood harvesting across study villages in the first and the second survey periods.

| Village | Thorndale | | Peninghotsa | | Homu 14B | | Makhuva |
|---|---|---|---|---|---|---|---|
| | χ (2)=0.004, *p*=0.952) | | χ (2)=0.362, *p*=0.547) | | χ (2)=0.311, *p*=0.577) | | |
| **Sources** | **1st survey** | **2nd survey** | **1st survey** | **2nd survey** | **1st survey** | **2nd survey** | **1st survey** |
| Woodland | 95.70% (22) | 96.00% (24) | 80.00% (22) | 83.3 % (23) | 98.00% (50) | 96.20% (51) | 83.30% (100) |
| Field | 4.30% (1) | 4.00% (1) | 10.00 % (3) | 6.7% (1) | 2.0% (1) | 3.80 (2) | 2.50% (3) |

Table 3.4: Fuelwood vendors from which local people purchased fuelwood in the first and second survey periods

| Village | Thorndale | | Peninghotsa | | Homu 14B χ (2)=0.880, *p*=0.348) | | Makhuva |
|---|---|---|---|---|---|---|---|
| **Fuelwood vendors** | **1st survey** | **2nd survey** | **1st survey** | **2nd survey** | **1st survey** | **2nd survey** | **1st survey** |
| Local fuelwood vendors | 100% (6) | 33.30% (2) | 100% (7) | 50.00% (1) | 76.90% (10) | 90.90% (10) | 84.20% (16) |
| Non-local | 0% (0) | 66.70% (1) | 0% (0) | 50.00% (1) | 23.10% (3) | 9.10% (1) | 15.80% (3) |

### 3.2.3 Species preference

Species preference was assessed for only the three most preferred species in the study villages (Table 3.5). In Thorndale, *Combretum apiculatum* was the most preferred species, followed by *Acacia nigrescens* and *Dichrostachys cinerea* before and during the harvesting trial. A significant shift in the species preference pattern was observed in Peninghotsa during the harvesting trial. *C. apiculatum*, which was indicated as the second most preferred species after *Colophospermum mopane* before the harvesting trial was indicated as the most preferred species during the harvesting trial, followed by *D. cinerea* and *A. nigrescens*. *C. mopane* was not indicated as one of the top three most popular species during the harvesting trial. In Homu 14B, no significant changes in the species preference pattern was observed, with *C. mopane* being indicated as the most preferred species, followed by *C. apiculatum* and *D. cinerea* in the first and second survey rounds. In Makhuva, *C. mopane* was also indicated as the most preferred species, followed by *C. apiculatum* and *Sclerocarya birrea*, which was surprising since the latter is a protected species as per National Forest Act No. 84 of 1998. However, the fact that people have resorted to harvesting of *S. birrea* indicates that there is shortage of fuelwood in Makhuva as this has been reported in villages where fuelwood is very scarce.

Species preferences were influenced by factors such as accessibility, ability to burn longer and give good coals, and drying quickly, among others. In Peninghotsa, Homu 14B and Makhuva, the preference of *C. mopane* was based on both its accessibility and the ability to give good coal, while in Thorndale it was *C. apiculatum* which was selected based on the similar factors.

Table 3.5: The three most preferred species as indicated during the household energy surveys in the first and second survey rounds (%-percentage and f=frequency, in brackets).

| **Thorndale** $\chi^2$ (13)=9.827, *p*=0.708 | | | | **Peninghotsa** $\chi^2$ (13)=43.463, *p*<0.001 | | | | **Homu 14B** $\chi^2$ (8)=4.048, *p*=0.853 | | | | **Makhuva** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1st survey** | **% and f** | **2nd survey** | **% and f** | **1st survey** | **% and f** | **2nd survey** | **% and f** | **1st survey** | **% and f** | **2nd survey** | **% and f** | **1st survey** | **% and f** |
| *C. apiculatum* | 39.65% (23) | *C. apiculatum* | 40.00% (16) | *C. mopane* | 42.10% (24) | *C. apicultum* | 48.90% (23) | *C. mopane* | 39.30 % (48) | *C. mopane* | 45.87% (50) | *C. mopane* | 76.51% (101) |
| *A. nigrescens* | 34.48% (20) | *A. nigrescens* | 35.00% (14) | *C. apiculatum* | 35.08% (20) | *D. cinerea* | 31.91% (15) | *C. apiculatum* | 40.16 (49) | *C. apiculatum* | 40.36 (44) | *C. apiculatum* | 19.69% (26) |
| *D. cinerea* | 25.86% (15) | *D. cinerea* | 25.00% (10) | *D. cinerea* | 22.80% (13) | *A. nigrescens* | 19.14% (9) | *D. cinerea* | 20.49% (25) | *D. cinerea* | 13.76% (15) | *S. birrea* | 3.78% (5) |
| **Total** | **100% (58)** | | **100 % (40)** | | **100% (57)** | | **100% (47)** | | **100% (122)** | | **100% (109)** | | **100% (132)** |

An assessment of the species preference ratio was undertaken in order to measure the species preference in relation to its abundance in the field (Table 3.6, 3.7, and 3.8). In Thorndale, although *C. apiculatum* was harvested at a rate higher than its relative abundance before and during the harvesting trial, this occurred at a lesser rate in the latter period. On the contrary, *D. cinerea* was harvested at a rate higher than its relative abundance during the harvesting trial, which was not the case before the intervention. In Peninghotsa, *C. mopane* was harvested at a rate lower than its relative abundance before and during the harvesting trial, but this occurred at a lower rate during the harvesting trial. In contrast, *C. apiculatum* was harvested at a rate higher than its relative abundance before and during the harvesting trial, but this occurred at a much higher rate during the harvesting trial. Other species that were harvested at the rate relatively higher than their abundance before the harvesting trial included *Philenoptera violacea* which was also notable since it is also a protected species as per National Forest Act No. 84 of 1998 and *S. birrea*. In Homu 14B, harvesting in the second survey was only recorded for *A. nilotica* and *C. mopane*. Harvesting of *C. mopane* was different from the first survey, in which it was harvested at a rate much higher than its relative abundance. *A. nilotica* was harvested at a rate higher than its relative abundance in the second survey but it was not harvested in the first survey. Fruits trees such as *S birrea* and *Euclea divinorum* were not harvested in either of the survey rounds.

Table 3.6: Species preference ratio in Thorndale (<1= harvested at a rate lower than its relative abundance; 1= harvested equal to relative abundance; >1= harvested at a rate higher than its relative abundance; - =no stumps).

| Species | 1st survey | 2nd survey |
|---|---|---|
| *Combretum apiculatum* | 3.03 | 1.51 |
| *Acacia nigrescens* | 1.21 | 1.43 |
| *Terminalia sericea* | 0.73 | 1.34 |
| *Dichrostachys cinerea* | 0.74 | 4.20 |
| *Dalbergia melanoxylon* | 1.10 | 0.44 |
| *Combretum hereroense* | 0.53 | 1.92 |
| *Pterocarpus rotundifolius* | 2.52 | 0.58 |
| *Peltophorum africanum* | 0.85 | 0.36 |
| *Ziziphus mucronata* | 0.70 | - |
| *Euclea divinorum* | 0.34 | - |
| *Grewia monticola* | 0.45 | - |
| *Philenoptera violacea* | 0.98 | - |
| *Gymnosporia senegalensis* | 0.77 | - |
| *Acacia nilotica* | - | 0.56 |

Table 3.7: Species preference ratio in Peninghotsa (<1= harvested lower than relative abundance; 1= harvested equal to relative abundance; >1= harvested at a rate higher than its relative abundance; - =no stumps).

| Species | 1st survey | 2nd survey |
|---|---|---|
| *Colophospermum mopane* | 0.72 | 0.34 |
| *Combretum apiculatum* | 2.17 | 4.57 |
| *Dichrostachys cinerea* | 0.79 | - |
| *Acacia nigrescens* | 0.34 | 3.18 |
| *Peltophorum africanum* | 2.99 | - |
| *Philenoptera violacea* | 3.00 | - |
| *Dalbergia melanoxylon* | 7.21 | - |
| *Pterocarpus rotundifolius* | 0.93 | - |
| *Sclerocarya birrea* | 3.96 | - |
| *Gymnosporia senegalensis* | 12.5 | - |
| *Ehretia amoena* | - | 2.22 |
| *Grewia monticola* | - | - |

Table 3.8: Species preference ratio in Homu 14B Species preference ratio in Homu 14B (<1= harvested lower than relative abundance; 1= harvested equal to relative abundance; >1= harvested at a rate higher than its relative abundance; - =no stumps).

| Species | 1st survey | 2nd survey |
|---|---|---|
| *Colophospermum mopane* | 2.16 | 1.29 |
| *Acacia nilotica* | 0.31 | 9.25 |
| *Combretum apiculatum* | 0.25 | - |
| *Dichrostachys cinerea* | 0.12 | - |
| *Acacia nigrescens* | 0.54 | - |
| *Ziziphus mucronata* | 0.22 | - |
| *Securinega virosa* | 0.25 | - |

### 3.2.4 Species selection

Frequencies with which species were harvested were assessed during the ecological survey in Thorndale, Peninghotsa and Homu 14B. In Thorndale, *C. apiculatum* was the most harvested species followed by *Acacia nigrescens* and *D. cinerea* (the latter had equal stump number with *Terminalia sericea* in the first survey) before the harvesting trial. However, during the harvesting trial this changed. While *C. apiculatum* remained the most harvested species, it was followed by *D. cinerea*, with *A. nigrescens* becoming the third most harvested species (Appendix 4). In Peninghotsa, the most harvested species was *C. mopane*, followed by *C. apiculatum* and *D. cinerea* before the harvesting trial while *C. apiculatum* was the most harvested species during the harvesting trial followed by *C. mopane* and *A. nigrescens* (Appendix 5). *C. mopane* was also the most harvested species followed by *D. cinerea* and *C. apiculatum* in Homu 14B in the first survey, while in the second survey only two species were harvested and these were *C. mopane* and *A. nilotica* (Appendix 6). Other species harvested, although not indicated as preferred, included *Dalbergia melanoxylon* and *Pterocarpus rotundifolius* in Thorndale, *Ziziphus mucronata* in Peninghotsa.

### 3.2.5 Size selection

Before the harvesting trial most recently cut stems in the vegetation plots were in diameter size classes 4–9 cm and 10–19 cm across the study villages (Figure 3.2). However, during the harvesting trial in Thorndale, there was a significant decrease in the harvesting of stems within diameter size class 10–19 cm and an increase in harvesting of stems within diameter size class 4–9 cm during the trial (second survey) $\chi^2$ (4)=30.353, $p<0.001$) (Figure 3.2A) (pooled data). The total number of harvested stems across total number of plots was 102 before and 81 during the harvesting trial. Similarly, in Peninghotsa, there was a significant decrease in harvesting of stems within diameter size class 10–19 cm and an increase in harvesting of stems within diameter size class 4–9 cm during the second survey $\chi^2$ (3)=38.155, $p<0.001$) (Figure 3.2B). The number of harvested stems recorded before and during the harvesting trial were 81 and 59 respectively. In Homu 14B, only two stems were harvested in the monitoring plots (one each in diameter size class 4–9 cm and 10–19 cm), while 89 were recorded in the first survey, therefore, no statistical test was conducted (Figure 3.2C).

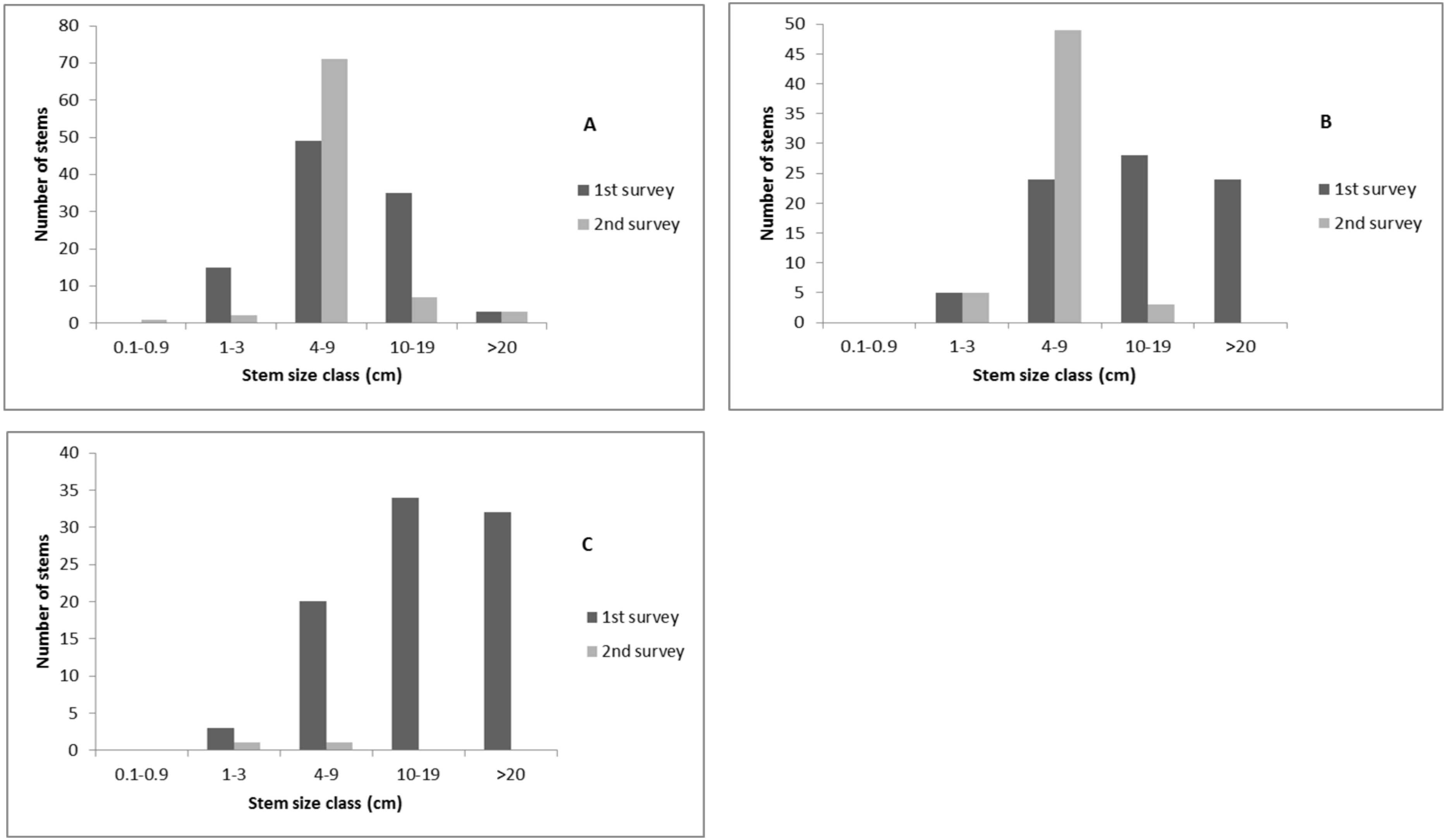



Figure 3.2 Harvesting per stem diameter size class in the first and second project phase in, A) Thorndale, B) Homu 14B and, C) Homu 14B in both survey periods.

### 3.2.6 Time costs

In both Thorndale and Peninghotsa, mean time spent getting to the harvesting areas decreased during the trial, but only significantly so in Peningotsa, e.g. by mean of 30.62 minutes ($p$<0.001). The actual harvesting time decreased significantly in both villages, by an average of 120.62 minutes in Thorndale and in 89.17 minutes in Peningotsa ($p$<0.05 in both villages) (Table 3.9). In contrast, the time spent getting to the harvesting area in the woodland increased insignificantly in the second survey in Homu 14B (Figure 3.9). However, it was in Makhuva where resource users spent the most time getting to the harvesting areas in the first survey round (more than four hours).

During the harvesting trial, although many resource users continued to harvest twice a week, this increased slightly in Thorndale, contrary to Penighotsa, where many resource users significantly reduced their harvesting frequencies to twice a month. In Homu 14B, there was an insignificant reduction in those who harvested twice a week in the second survey round. In terms of harvesting season, there was a substantial shift from restricting harvesting only in winter to harvesting in any season in Thorndale and Peninghotsa, but it was in the former where the shift was significant. On the contrary, this was not the case in Homu 14B, with many resource users having increased harvesting frequencies insignificantly in winter during the second survey round.

Table 3.9: Comparing and contrasting the time spent getting to harvesting area and harvesting, collection trip frequencies and harvesting seasons, as observed in the first and second survey periods in Thorndale, Peninghotsa, Homu 14B and Makhuva. Superscripts represent significant differences.

| **Village** | **Thorndale** | | **Peninghotsa** | | **Homu 14B** | | **Makhuva** |
|---|---|---|---|---|---|---|---|
| | **1st survey** | **2nd survey** | **1st survey** | **2nd survey** | **1st survey** | **2nd survey** | **1st survey** |
| | *t*(23)=1.842, *p*=0.078 | | *t*(23)=4.129, *p*<0.001 | | *t*(57)=-1.744, *p*=0.087 | | |
| **Time spent getting - to harvesting areas (minutes)** | 40.80[a]±4.05 | 33.47[a]±2.56 | 70.20[a]±6.87 | 39.58[b]±2.97 | 39.32.72[a]±2.85 | 41.98[a]±2.93 | 89.53±1.11 |
| | *t*(23)=3.448, *p*<0.05 | | *t*(23)=2.360, *p*<0.05 | | *t*(58)=-1.155, *p* =0.253 | | |
| **Time spent- harvesting fuelwood (minutes)** | 225.85[a]±20.07 | 105.23[b]±20.07 | 243.75[a] ±35.30 | 154.58[b]±17.20 | 245.08[a]±18.97 | 266.94[a]±17. 65 | 251.83±12.02 |
| **Harvesting frequency per household** | $\chi^2$ (6)=5.983, *p*=0.425) | | $\chi^2$ (7)=14.531, *p*<0.05) | | $\chi^2$ (3)=4.367, *p*=0.498) | | |
| 1-2x/week) | 33.3% | 46.7% | 46.7 | 26.7 | 40.0 % | 35.7% | 34.2% |
| <1/month) | 30% | 10% | 13.3 | 4.3 | 28.6% | 21.4% | 16.7 |
| 1-2x/month) | 16.7% | 26.7% | 26.7 | 36.7 | 1.4 % | 15.7% | 19.2% |
| 3-5x/week) | 10% | 0% | 0 | 6.7 | 5.7% | 4.3% | 20.8 |
| N/a | 10 % | 16.7% | 13.3 | 20 | 12.9 % | 15.7% | 9.2% |
| **Harvesting season** | χ2 (3)=11.022, *p*<0.05) | | χ2 (2)=3.564, *p*=0.313) | | | | |
| Winter | 67.6% | 30 % | 46.7% | 26.7 % | 47.2% | 50% | 21.7% |
| Summer | 10% | 6.7% | 10.7 % | 6.7% | 7.1% | 2.9% | 5.8% |
| Any season | 20% | 40.3% | 26.7% | 46.7 % | 31.4% | 2.9% | 63.3% |
| N/a | 13.3% | 20 % | 16.7 % | 20 % | 14.3% | 19.1% | 9.2 |

### 3.2.7 Fuelwood consumption

Daily fuelwood consumption values were remarkably consistent between the study villages (Table 3.10). Daily winter consumption was significantly higher than daily summer consumptions for both summer periods, summer before the harvesting trial and summer during the harvesting trail in Thorndale and Peningotsa ($p$<0.001). The daily summer and winter values were used to derive an estimate of the annual total village consumption (Table 3.11), but in Makhuva the total village consumption did not include that of winter because the project was terminated. During the last survey, few households were found without fuelwood piles in Thorndale during the estimation of the daily fuelwood consumption.

Table 3.10: Comparing and contrasting the household fuelwood consumption per different seasons (winter consumption was collected during the harvesting trial, since the project started in January 2014). Means with different superscripts are significantly different from each other.

| **Thorndale** | | | **Peninghotsa** | | | **Homu 14B** | | | **Makhuva** |
|---|---|---|---|---|---|---|---|---|---|
| ($F(2.82)=7.529$, $p<0.001$ | | | ($F(2.82)=8.009$, $p<0.001$ | | | ($F(2.186)=23.392$, $p<0.001$ | | | |
| **1st survey** | **2nd survey** | **3rd survey** | **1st survey** | **2nd survey** | **3rd survey** | **1st survey** | **2nd survey** | **3rd survey** | **1st survey** |
| **Summer: January 2014** | **Winter: June 2014** | **Summer: January 2015** | **Summer: January 2014** | **Winter: June 2014** | **Summer: January 2015** | **Summer: January 2014** | **Winter: June 2014** | **Summer: January 2015** | **Winter: January 2014** |
| $9.19^{a}$kg ±0.81 | $12.69^{b}$ kg ±1.05 | $10.49^{a}$kg ±0.83 | $8.12^{a}$ kg ± 0.97 | $11.76^{b}$ kg ±1.09 | $8.66^{a}$ kg ±0.67 | $9.90^{a}$ kg ±0.07 | $11.20^{b}$ kg ±0.09 | $8.08^{a}$ kg ± 0.04 | 13.60 kg ±0.41 |

Table 3.11: The total annual village fuelwood consumption per year were extrapolated from the household data.

| **Thorndale** | | **Peninghotsa** | | **Homu 14B** | | **Makhuva** |
|---|---|---|---|---|---|---|
| **1st survey** | **2nd survey** | **1st survey** | **2nd survey** | **1st survey** | **2nd survey** | **1st survey** |
| 462 t | 491 t | 694 t | 706 t | 1 371 t | 1 242 t | 2 611 t |

## 3.3 DISCUSSION

### 3.3.1 Use of different energy sources

Fuelwood was the most widely used energy for cooking, space heating and water heating while electricity was mainly used for lighting in all study villages. This did not change over the study period, with only a slight increase in those who used electricity to cook in Thorndale and Peningotsa. The slight increase in the proportion of those who used electricity can be explained by the fact that some of the households received electricity during the trial period. This means that those who could afford electric appliance and electricity bills also had the option of using it for cooking. Nonetheless, this indicates that CBCM did not alter the energy consumption pattern in the trial villages, but promoted access to fuelwood. In Homu 14B, lack of change in use of electricity explains almost no change in the use of fuelwood.

High unemployment rate and menial jobs reflected by the majority of those who were employed working as labourers, e.g., in Makhuva may be the reason for the majority of the resource users using fuelwood for thermal purposes throughout the CBCM period (see Appendix 14), since like other local resources, its use is affected by the socio-economic characteristics of the community (Twine, 2004). For instance, electrical appliances are needed for thermal uses while they cannot afford them, and this has been found to be a limiting factor to access modern energy in rural villages (Twine and Moshe, 2003; Twine *et al.*, 2003b). The findings are in agreement with those of Campbell *et al.* (2003), Davis (1998) and Ouedraogo (2006) that income is a major determinant of energy transition. This was evidenced by the relatively higher number of people using electricity for cooking and space heating in Homu 14B which is explained by the relatively higher number of those who in their employment status worked as professionals (see Appendix 14). This is because they can afford electric cooking appliances and monthly service fee.

The continued use of fuelwood for meeting fuelwood energy needs across the study villages indicates that wood will remain the dominant energy in rural areas despite electrification mainly due to lack of affordability. In further substantiating this, in four villages in Bushbuckridge region, in Mpumalanga Province, Madubansi and Shackleton (2007) found that after 11 years of electricity access and receiving free basic electricity (FBE) households continued cooking using fuelwood. The slow uptake to electricity in communal woodlands suggests that finding strategies that can contribute towards the sustainable use of fuelwood should remain a high priority, the result from this study demonstrate that CBCM is one of such strategies that can promote sustainable harvesting of fuelwood to meet the village demand (chapter 4). At the same time, the absence of change in the use patterns of fuelwood during the harvesting trial despite access to electricity suggests that CBCM should be implemented in both villages with and without electricity alike. This is because over 60% of rural households are still unelectrified (Madubansi and Shackleton, 2007) implying that CBCM would be an important resource management option in communal woodland areas. Thus, although there has been an emphasis on electricity (Shackleton *et al.*, 2007a), it is evident that if energy planning was based on the sound knowledge of the local energy use patterns, it should consider fuelwood energy in communal areas agreeing with the Shackleton *et al.*, (2007b). This is especially true because its impact has been significantly less than was originally expected (Lloyd, 2014). Therefore, this does not only demonstrate the relevance of CBCM, but also the sense of urgency with which CBCM should be implemented. This is because the number of households will continue to use fuelwood to some extent for decades to come (Madubansi and Shackleton, 2007), while deadwood in communal woodland which are the ones permitted to be harvested under the traditional NRM are scarce as also acknowledged by the local resource users in this study (chapter 6) and in other villages (see Mathye, 2002; Kirkland *et al*., 2007).

### 3.3.2 Fuelwood access and acquisition

Access to common property resource under communal ownership in communal woodlands is defined with respect to community membership (Heltberg, 2002), and this was strengthened during the harvesting trial in Thorndale and Peninghotsa. For instance, through the involvement of local resource users in undertaking patrols, harvesting problems by outsiders were reported to have been addressed leaving local resource users being the ones harvesting in coupes. Thus, this suggests that in other villages where harvesting of fuelwood and other common property resources such as poles and grasses which have become open access (see Kirkland *et al.,* 2007) could be resolved through CBCM.

Lack of significant difference on acquiring fuelwood through harvesting before and during the harvesting trial demonstrates that resource users in communal areas will continue to harvest livewood in the woodlands either under CBCM or traditional management rules because of the scarcity of deadwood, because they harvest deadwood out of necessity (Gandar, 1997). That resource users who in the first survey acquired fuelwood through both harvesting and buying switched mainly to acquiring fuelwood through harvesting during the harvesting trial in Thorndale and Peninghotsa illustrates that given a choice, their most preferred way of acquiring fuelwood was harvesting rather than buying. This means that some households might have been forced to purchase fuelwood since this happens when there is local scarcity or an inability to collect sufficient quantities. Similar findings have been found by Madubansi and Shackleton (2007) in rural villages in Mpumalanga Province where households purchased fuelwood in response to increased fuelwood scarcity as did Kirkland *et al.* (2007) in the villages of the same province. It is evident that acquiring fuelwood under traditional management rules means that an extra financial burden is put on the already impoverished resource users if the findings are anything to go by. For instance, through harvesting, local resource users risk being arrested by transgressing rules which (limit harvesting to dead wood only) involve fines. Ironically, given the scarcity or absence of dead wood as acknowledged by resource users across the study villages (chapter 6), they are bound to transgress such rules thereby having to pay money for such fines. Thus, since, the poor households spend the majority of government grants income on food and other basic necessities in the households (Guthrie, 2002), it means they are further impoverished. Alternatively, those who fear being arrested are bound to acquire fuelwood through purchasing from fuelwood vendors. For that reason, the enforcement of traditional rules coupled with scarcity of deadwood in rural areas is exacerbating poverty among resource users. This indicates a dilemma in which resource users find themselves in communal woodland areas in South Africa under traditional NRM, especially as reflected by high unemployment rate with many resource users receiving government social assistance child grants and old age pension in the study villages (Chapter 2, Table 2.1).

The fact that resource users bought from both local fuelwood vendors and non-local fuelwood vendors in the second survey implies that harvesting for commercial purposes occurred before and during the harvesting trial. Howver, that it was less during the trial indicates that CBCM would be more effective in addressing commercial harvesting problems than traditional NRM (chapter 5 and 6). Yet, this also means that those who depended on harvesting for selling, especially the poor were negatively affected, because closure of access to harvesting through community management efforts is likely to have a stronger effect on them (Arnold *et al.,* 2003; Cooke *et al.,* 2008). For instance, they use open access to access generate income from natural resources such as fuelwood (Arnold *et al.*, 2003) similar to this study findings in Peninghotsa. For instance, failing to find employment, a woman who was trained as teacher, possessing a national teaching diploma entered into the fuelwood vending industry. This also demonstrates that local fuelwood harvesters would circumvent harvesting rules to continue harvesting for commercial purposes even in the CBCM area. Related findings have been found by Shackleton *et al.,* (2006) in the Eastern Cape Province, in South Africa where some of the fuelwood vendors acknowledged to have started selling fuelwod because they could not find jobs despite completing matric. Moreover, in Malawi, Hara (2004) found that most people derived livelihoods from selling fuelwood and from fishing after being unable to find work in the formal sector. While there was a proposal aimed at limiting access to the fishery co-management, fishers did not support such a proposal and the reason for this was that they regarded such measures as denying others in desperate economic situation the chance to derive livelihoods from fishery. Therefore, the inability of the general economy to act as a sink for excess labour has been found to have an effect on the sustainability of the fishery co-management project in the country. This indicates that CBNRM programmes do not solve all the problems in the programme area, meaning that CBCM should not be implemented in isolation with other projects aimed at reducing poverty in communal woodlands agreeing with (Von Maltitz and Shackleton, 2004). Further, and by implication, this means that the extent to which CBCM can be sustainable in providing energy to the poor will be determined by the macro-economic situation in South Africa since as it is the primary force of a country as seen in Bangladesh (Akther *et al.*, 2010).

Commercial harvesting has been recommended as carrying potential to address poverty. In some regions such as in Orissa state in India, *sal* woodland and forests have regenerated after harvesting through joint forest management (JFM) and can make a significant contribution to the economy of local communities, besides meeting their basic needs for fuelwood. This is due to low population density while the region is rich in forest (Singh, 2001). Moreover, in Chimaliro and Liwonde forest reserves under the pilot forest co-management program in Malawi, Jumbe and Anglsen (2006) found that a community forestry program protected the poor households from extreme poverty. However, they also found that in areas where forests were the main source of livelihood, complementary interventions such as supplementary sources of income were required alongside forest co-management program to provide poor households if such programmes were to be successful. This would reduce pressure on forests and stimulate greater participation among forest-dependent households. Nonetheless, Luoga *et al.* (2002) found that commercial use of woodland resources in Tanzania has resulted in the depletion of the most saleable species. In South Africa, and through CBCM, commercial harvesting would not feasible because local communities do not have property rights (chapter 5). Yet, even if government could give communities such rights, other conditions such as market access and forest timber value would dictate (Ribot *et al.,* 2010). Furthermore, the findings (chapter 5) indicate that the supply of fuelwood from certain villages will not even meet the domestic village demand as seen in Homu 14B and possibly in Makhuva, based on the size of the population although no ecological assessment was done.

Nonetheless, livewood is harvested from legally sources, e.g. private lands (game reserves) in regions such as Bushbuckridge (Madubansi and Shackleton, 2007), based on agreed contracts between fuelwood vendors and the parks (Gandar, 1997). This proposes that household members who cannot harvest due to labour shortages or problems in CBCM villages can buy from fuelwood vendors harvesting legally from the woodland sources, thereby creating employment. However, to achieve this, there should be mechanisms that would need to be used to differentiate those fuelwood bundles bought from fuelwood vendors harvesting legally and those not, with strong measures taken against those buying from non-legal sources. Nonetheless, it is evident that there would be limitation to this because not all villages are located around parks where such harvesting contracts between parks and local people exist (see Gandar, 1997). Furthermore, the structure, dynamics and viability of fuelwood markets have been little studied in South Africa (Madubansi and Shackleton, 2007) with the number of households involved in fuelwood trade being unknown (Williams and Shackleton, 2002). As such given this knowledge gap, it is clear that more work would be required to understand its feasibility and sustainability prior to considering this as an option for resource users who might be forced to purchase due to physical scarcity in the CBCM area. This is particularly true given that more conservation areas also do not permit harvesting (Madubansi and Shackleton, 2007).

### 3.3.3 Species preference

A significant shift in species preference only occurred in Peninghotsa, where *C. apiculatum* was indicated as the most preferred species during the harvesting trial replacing *C. mopane*. This could be due to the prohibition of harvesting of *C. mopane* during the trial, because it is a host species for mopane caterpillars (*Imbrasia belina*). If harvesting of *C. mopane* is prohibited by the local leadership across mopane woodland areas because of its socio-economic value, it would be highly unlikely that the village energy demand can be met by other species because it is by far the dominant species in such areas (Lock 1989). This would limit the scope of CBCM implementation especially because it has been recommended in mopane woodland villages such as Homu 14 area, Mapayeni, Zaba, Mbaula and Makhuva (Makhado *et al.,* 2009). Such a potential negative impact can be demonstrated by the size of the mopane woodland which covers about one third of the total land area with an estimated 23,000 $km^2$ of mopane woodland occurring in the Limpopo and Mpumalanga Provinces (Mapaure, 1994). Furthermore, the impact could also be regional, since locally managed coppice system has been recommended in the entire region (Musvoto *et al.,* 2006; Mapaure and Ndeinoma, 2011). For instance, in southern Africa, mopane woodland is estimated to be covering 555,000 $km^2$ and it is the dominant vegetation type (southern Angola, northern Namibia, northern Botswana into Zimbabwe, and central and northern Mozambique, in southern Zambia and Malawi (Makhado *et al.,* 2009). This is true particularly because with the decreasing densities of mopane woodlands, affecting the abundance of mopane caterpillars, coppicing have been recommended to occur with more stems in the 1-3m height class, (Greyling and Potgieter, 2003). *C. mopane* coppices readily implying that harvesting of mopane caterpillars can also occur with fuelwood harvesting through CBCM. Furthermore, although mopane caterpillars were reported to be available, this occurred despite harvesting also of large trees by outsiders. Therefore, this suggests that through CBCM the production of mopane caterpillars can be enhanced because only local resource users would be allowed to harvest them based on the stems in the intermediate size class and not large trees which were less harvested during the trial.

In terms of species preference ratio, it was *D. cinerea* that changed noticeably in Thorndale during the harvesting trial. For instance, its harvesting occurred at a rate higher than its relative abundance but in a manner that was higher than all the other species for which their harvesting was also higher than their relative abundance. This means that although *C. apiculatum* was the most preferred species in both survey rounds, local resource users had less harvesting pressure on it similar to *C. mopane* in Peninghotsa during the harvesting trial while that of *D. cinerea* increased enormously. This also indicates that local people complied with harvesting rules since an emphasis was made during the rules-design meeting that *D. cinerea* must be harvested indiscriminately.

By implication, this finding also means that the implementation of CBCM in communal areas will not only address aspects of fuelwood problems, but it can also contribute towards addressing other pressing environmental problems such as bush encroachment. In the context of CBCM, for example, this would mean harvesting and maintaining invasive trees in the coppicing phase. Thus, this also means that through CBCM other invasive plants (alien) that the government is spending funds to eradicate them through “Working for Water” Programme (Lloyd, 2014) can be harvested in communal areas and used for fuelwood purposes.

### 3.3.4 Size class selection

The presence of stumps (Appendix 4 and 5) in diameter size class 4–9 cm and coppice shoots (chapter 5) demonstrates that, although local resource users have been harvesting *C. mopane* trees for fuelwood, this has been in a manner that promotes the growth of new shoots since the stumps are for small plants in Peninghotsa and Homu 14B. This may be the reason for the continued availability of mopane caterpillars in these villages because new coppice shoots emerged which can host them. This implies that even if harvesting of *C. mopane* is not restricted in the future implementation of CBCM in mopane woodland areas, its harvesting will not have negative impact on the production of mopane caterpillars as was thought by the headmen. However, local leadership will need to be educated about this, suggesting that the acceptability of CBCM without the prohibition of *C. mopane* will mainly depend on the understanding of the local chieftaincy. On the other hand, the continued availability of mopane caterpillars in such area will also be subject to compliance of the resource users after such an understanding, since *C. mopane* trees were also harvested during the harvesting despite its harvesting prohibition during the trial. Nevertheless, its harvesting in the second survey was lower than that of the first survey round, and also in a manner that was recommended which indicates that its conservation will be more effective under the CBCM intervention than under traditional NRM. Therefore, their availability will continue. For instance, by containing the harvesting of *C. mopane* to a coupe, mopane caterpillar production in the other coupes might even increase because *C. mopane* trees were harvested illegally all over before anyway. Since mopane woodlands are an important source of income and food for rural people across the southern Africa region (Mapaure and Ndeinoma, 2011), through the implementation of CBCM, such positive socio-economic impact can be enhanced in the region, because of the greater security of the resource base. However, this suggest the need to have more research undertaken in order to determine if mopane caterpillars prefer large mature trees or if they also use coppice shoots.

The fact that *S. birrea* was the third most preferred species after *C. apiculatum* in Makhuva was surprising because it is a protected species as per National Forest Act No. 84 of 1998. Therefore, that it was not harvested during the harvesting trial in Peninghotsa suggests that local resource users are more likely to respect rules that they participated in determining, than those imposed upon them by government institutions This suggests that there is such a shortage of good wood at Makhuva that people have resorted to this species. Yet this implies that through complying with harvesting rules that prohibited harvesting of fruit trees such as *Sclerocarya birrea* (marula), and with greater resource security, CBCM can also contribute towards poverty reduction and prevent loss of useful fruit species (Shackleton, 1993; Gandar, 1997). For instance, some of the resource users in Thorndale indicated support for the project because it would also enhance the protection of *S. birrea* species from which they collected marula fruits and supplied companies making products from them, thereby making livelihoods. Similar findings have been found by Wynberg *et al.* (2002) in Bushbuckridge where communities supplied marula fruit products to two large commercial enterprises. One was a private corporation producing an internationally marketed cream liqueur based on the fruit pulp, and the other was an employment creation initiative developing several products based on marula fruit juice, pulp, kernels and oil. Therefore, that *S. birrea* was not harvested in Thorndale might have also been due to its economic importance to the resource users.

A significant shift from harvesting stems in diameter size class 10–19 cm to those in diameter size class 4–9 cm in Thorndale and Peninghotsa indicates that local resource users can comply with rotational harvesting strategy rules. This is critical considering that restriction of cutting livewood is becoming less practicable (Shackleton 1993). While harvesting of stems in diameter size class 10–19 cm also occurred, this might have been for commercial purposes during the trial because women are limited by harvesting tools to harvest large trees because they use machete (Abbot and Lowore, 1999). Furthermore, large-diameter fuelwood is not favoured even when available because it requires splitting before use (Mudekwe, 1997; Abbot and Homewood, 1999). Similar findings have been found in Malawi by Abbot and Lowore (1999) where men usually use axe to harvest bigger sizes while women use machete harvesting branches and stems between 3–8 cm diameters. This implies the relevance of

CBCM in communal woodlands because coppice shoots rarely grows beyond the pole size (White, 1979).

Harvesting of *C. apiculatum*, *D. cinerea* and *A. nigrescens* in Thorndale showed correspondence between the reported preferences during the household survey and harvesting frequencies as recorded during the ecological survey in the field (Appendix 4). Contrarily, there was no correspondence for *C. mopane*, because although it was not indicated as one of the three most preferred species during the harvesting trial, it was the second most harvested species after *C. apilculatum* (Appendix 5). One possible explanation for this is that local resource users might have feared to acknowledge harvesting it because by doing so, they would be revealing non-adherence to agreed rules, since its harvesting was prohibited. Although less, this means that even under CBCM there would be those who will not comply with harvesting rules. In Homu 14B, while they were only two species harvested in the second survey- *C. mopane* and *A. nilotica*, it was surprising for the latter because it was not indicated as one of the most preferred species in both survey rounds. Therefore, this suggests that its harvesting would have been for other purposes other than those of fuelwood. For instance, in certain areas in India, *A. nilotica* has been found to be used for fencing such as in farmland (Choudhury *et al.*, 2005).

### 3.3.5 Time spent on fuelwood acquisition

Local resource users spent more time getting to the harvesting area and actual harvesting in the period before than during the harvesting trial. Given a choice deadwood is preferred over livewood (Gandar, 1997; Williams and Shackleton, 2002), which provides evidence of the scarcity of fuelwood because if they were harvesting in nearby they would spend less time before the trial. Similar findings have been found by Mathye (2002) in a village called Mbokota, in Limpopo Province where local people travelled long distance and spent more time because of scarcity of fuelwood as did Kirkland *et al.* (2007) in villages in Mpumalanga Province, and Kumar and Hotchkiss (1988) in Nepal. Reports of increased time spent harvesting fuelwood have also been made in most parts of southern Africa (Makhado *et al.*, 2009). The fact that resource users travelled long distances and spent more time harvesting fuelwood before the trial implies that harvesting was not done in the vicinity of the village to minimise their chance of being caught. This is true especially in Thorndale and Peninghotsa where the headman and the civic association were said to conduct patrols and compliance monitoring to ensure people harvested deadwood (chapter 5). The implication for this is that in areas where there is some level of effectiveness of patrols by the relevant local institutions, coupled with the scarcity of deadwood, local resource users face an increasing opportunity costs. In case of scarcity it is mainly the poor who travel long distance and spent more time harvesting because fuelwood is freely available (Williams and Shackleton, 2002). Since women and children are ones involved in domestic harvesting, this limits their opportunities to improve their education because valuable time and effort is devoted to fuel collection instead of education putting them into grip of poverty (IEA, 2006).

The time spent in both getting to the harvesting area and doing the harvesting was significantly reduced in Thorndale and Peningotsa, demonstrating that the implementation of CBCM can reduce opportunity costs in terms of time spent on acquiring fuelwood. This can help save time that can be used for other valuable activities such as education, and this can lift the local resource users out of poverty, as with decent jobs resource users can receive better income thereby enabling them to move up the energy ladder as seen in Homu 14B, where those who were educated did not use fuelwood. Accordingly, this also suggests that CBCM might not be considered as a permanent NRM strategy since with increased income resource users can switch to modern energy sources such as electricity. However, opportunity costs are affected by resource density (Robinson and Kajembe, 1999), which means that the extent to which CBCM can contribute towards reducing them (time spent travelling and actual harvesting) will vary from village to village depending on the resource density of stems in such a village. Similar findings has been found in this, for instance, in Thorndale, where the resource density was high from the stems in the most preferred size classes, local resource users spent less time harvesting than in all the study villages. Similar findings have been found by Van’t Veld *et al.* (2006) in India where in villages with Joint Forest Management and relatively high levels of biomass, women collected more fuelwood from the commons and spent less time doing so.

### 3.3.6 Fuelwood consumption

In Thorndale, during the harvesting trial, a pattern emerged in which many local resource users increased harvesting to twice a week. This is probably because, during the harvesting trial local resource users agreed to harvest only twice a week, which also shows compliance to the agreed rules. In Peninghotsa, many resource users significantly reduced their harvesting frequencies to twice a month which shows that they had control over time seen by skipping certain weekends.

The fact that many resource users shifted from harvesting in winter to any time regardless of the season provides evidence for this because households choose to collect fuelwood in a manner that minimises the cost to the household (Cooke, *et al.,* 2008). Seasonality is important to household labour allocation decisions (Cooke, *et al.*, 2008) suggesting that had resource users preferred harvesting during the winter period or months they would have indicated this during rules-design meeting. Therefore, although harvesting is likely to be greater during the winter period when additional fuel is needed to counter the cold (Dovie *et al.,* 2004), it seems to occur mainly under traditional NRM where rules are imposed on resource users. This is illustrated by an increase in harvesting in winter in Homu 14B contrary to Thorndale and Peninghotsa where harvesting trial took place. A finding further supporting this (not mentioned above) was through a woman in Peninghotsa who indicated that harvesting permitted only on weekends made it easy for them because their daughters were available. This she said also resulted in their daughters having longer time to study during holidays because fuelwood would be available in winter unlike during the traditional NRM where they would wait for winter to harvest. This also indicates that CBCM will have a positive impact on the safety of the resource users since harvesters are vulnerable to attack by criminals and wild animals (Prasad, 2006). This is because they will coincide they harvesting on weekends and harvesting from the same place e.g. coupe as requested by the headman. The fact that there were few households which were found without fuelwood piles in Thorndale during the estimation of the daily fuelwood consumption. From such households, respondents indicated that they saw no need to have fuelwood piles as before because they could harvest freely on any weekends they wanted. This means that the project brought a sense of fuelwood security in terms of both fuelwood availability and access among local resource users.

### 3.4 CONCLUSION

This study has indicated that the majority of people in communal woodlands continue to use fuelwood as the primary energy source despite access to electricity. This means that approaches such as CBCM in such areas are relevant and urgently required if sustainable harvesting of fuelwood is to be achieved. This is because the traditional management rules defy the reality that deadwood are scarce or no more and that the village energy demand can be met by harvesting of livewood, which could be done in a controlled manner. With harvesting access limited only to the local resource users, there would be socio-economic benefits emanating from the increase in mopane caterpillars and marula trees thereby contributing to poverty reduction since these products are harvested and sold. This proposes that if energy programmes in South Africa and elsewhere consider integrating approaches such as CBCM into their programmes they will promote sustainable harvesting of fuelwood while this would also have other socio-economic spin-offs through greater resource security against outsiders. Although commercial harvesting occurred, it did so at a reduced rate in the second survey round, with harvesting pressure lifted on the predominant species which demonstrates the effectiveness of CBCM in comparison with traditional NRM. Nonetheless, a follow-up study would be required in the CBCM area to determine the effectiveness of CBCM in addressing local commercial harvesting. This is because it is possible that in the absence of job creation, numbers of resource users engaging in commercial harvesting might increase, thus threatening the sustainability of the CBCM.

# CHAPTER 4

## THE ECOLOGICAL FEASIBILITY OF THE COMMUNITY-BASED COPPICE MANAGEMENT INTERVENTION


### ABSTRACT

Due to scarcity of deadwood, livewood, including coppice shoots, is usually harvested in communal woodlands. Since the majority of people depending on fuelwood reside in savannas, the possibility of rotational coppice management for more sustainable fuelwood supply has been recommended in such areas. This is because savanna species generally coppice easily, providing an opportunity for rotational harvesting. However, the focus on coppice studies has been on plantation forestry despite data demonstrating that coppice systems could be feasible in communal areas. Ecological sustainability is central to any successful community-based coppice management intervention in communal areas. This study assessed the ecological feasibility of a community-based coppice management (CBCM) intervention in the two study villages. Local resource users harvested stems between 4 – 9 cm rotationally, in coupes over a period of one year to initiate a coppice cycle. The mean biomass derived from new coppice shoots, was used to extrapolate fuelwood supply over a rotation of four years. In Thorndale and Peninghotsa, current fuelwood stocks would provide adequate supply of fuelwood, and managed coppice regrowth alone could meet the village demand from the 8$^{th}$ year in Thorndale. In Peninghotsa, this would occur from the 12$^{th}$ year. The amount of biomass from the pre-existing coppice would also be sustainable over a four period in Thorndale and Peninghotsa. By implication, this means that CBCM would be ecologically feasible particularly in villages with small population size where resource users have access to intact woodlands.

## 4.1 INTRODUCTION

The savanna biome covers 12% of the global land surface (February and Higgins, 2010), and 40% of Africa (Scholes and Walker, 1993). Savannas provide a number of ecosystem services to society, including fuelwood (Shackleton, 2000; Scoones, 1993), which is used as a primary or secondary energy source by over 80% of rural and urban inhabitants in southern Africa (IEA, 2002). However, in rural areas across Africa, the supply of fuelwood is becoming a pressing environmental management problem (Kennedy, 1998; Twine and Holdo, 2016). With an increase in human population densities (Shackleton *et al.*, 2008) and shortage of deadwood (Kirkland *et al.*, 2007), prohibiting harvesting of livewood is becoming less practicable (Shackleton 1993). Coupled with the absence or scarcity of deadwood, live trees are now being harvested for fuelwood in countries such as Tanzania (Kideghesho and Msuya 2010) and South Africa (Shackleton 1993; Du Plessis, 1995; Gandar, 1997; Kirkland *et al.*, 2007; Makhado *et al.*, 2009), to mention a few. Even so, fuelwood is a renewable resource and thus has the potential to be harvested and managed sustainably (Shackleton *et al.*, 2004a; Shackleton *et al.*, 2007a).

Savanna tree species generally coppice easily, providing an opportunity for rotational harvesting (Shackleton *et al.*, 2004a; Shackleton *et al.*, 2007a). Additionally, coppice shoots grow faster than newly established seedlings, because they already have a well-established root system with stored reserves (White 1979; Chidumayo, 1993; Tredennick and Hanan 2015). This would increase sapling-to-adult tree recruitment rates for postharvest saplings (coppice shoots) relative to regular saplings (Tredennick and Hanan, 2015). For these reasons, a locally managed coppice system is regarded as one of the potential fuelwood supply-side approaches that can contribute to sustainable provision of fuelwood (Williams and Shackleton, 2002; Shackleton *et al.*, 2004a; Gandar 1984; Grundy 1995; Kennedy, 1998; Shackleton 2001; Kaschula *et al.*, 2005). A coppice system is based on the biological fact that after cutting, savanna tree species usually regenerate vegetatively, by growing shoots either from the stump or from the root system (Szabó *et al.*, 2015). Therefore, the same tree can be harvested many times on a short rotation without losing its ability to grow new shoots (Szabó *et al.*, 2015). However, coppicing potential for woodland management has been under-acknowledged to date in Africa (Kennedy, 1998).

Coppicing is a common practice in Europe, characterizing much of the Mediterranean forest landscape today and has contributed significantly to the survival of rural communities by sustainable supply of fuelwood (Szabó *et al.*, 2015). Thus, coppice shoots can be a valuable fuelwood source in arid and semi-arid regions of Africa where fuelwood supply is already limited (Kennedy, 1998; Shackleton, 2000; Shackleton, 2001; Neke, 2004). For instance, under a rotational harvesting strategy, coppice shoots can be managed according to conventional silvicultural practices to enable those that remain to grow more vigorously (Shackleton and Clarke, 2007). Simple management actors, such as changing the height of cutting and pruning of post-harvest coppice shoots, can accelerate regrowth rates and hence reduce the harvest intervals (Shackleton, 2001). Furthermore, coppicing offers potential to manage woodlands in a controlled manner, minimising damage to natural habitats and preserving soil fertility, because rootstock is not removed while exposure of the underlying soil to wind and rain action is minimised (Kennedy, 1998).

Much attention has been paid to woodlots as potential solutions to fuelwood shortages in Africa (Shackleton *et al.*, 2004b) and have been successfully implemented in some cases, e.g. in Ethiopia (see Jagger *et al.*, 2003). However, woodlot programmes are expensive to establish (Shackleton *et al.*, 2008), and have generally not lived up to their potential in their response to fuelwood supply in southern Africa including South Africa (Ham and Theron 2001). Furthermore, they result in the loss or decreased availability of other important ecosystem products provided by multiple-use woodlands, such as edible fruits (Shackleton *et al.*, 2004b).

The absence of managed rotational harvesting of coppice regrowth represents a lost opportunity in South Africa, since savannas cover approximately 34% of the country (Shackleton *et al.*, 2007a), providing fuelwood to about 70% of the rural households (Shackleton 1993). Furthermore, like in most communal woodlands elsewhere (Chidumayo, 2002; Musvoto *et al.*, 2007), the savanna woodlands in South Africa are currently under increasing pressure from over-exploitation (Twine *et al.*, 2003b). The implementation of a rotational harvesting strategy of coppice regrowth can promote sustainable fuelwood supply provided harvest intervals are adequate for the savanna ecosystem to recover from the last harvest, e.g. ecological rotation (Von Maltitz and Shackleton, 2004). However, such knowledge is not yet established. This is because while data exist on coppicing of savanna trees across Africa, providing the basis for piloting a managed coppice system in theory, e.g.

in Kenya (Kennedy, 1998), Botswana, (White, 1997), and South Africa (Shackleton, 2000; Shackleton, 2001; Kaschula *et al.*, 2005; Neke *et al.*, 2006; Twine, 2008), there are no published empirical data on rotational harvesting involving local resource users in partnership with local institutions. On the other hand, most of the data on savanna tree growth and coppice comes from the central lowveld of South Africa, where one of the study villages, Thorndale, is located. This chapter seeks to examine the ecological feasibility of a community-based coppice management (CBCM) system in selected rural communities in the lowveld region of South Africa by answering the following questions:

- How much of the standing stock is effectively available for fuelwood harvesting, and how does the density of stems in different size classes compare and contrast before and after intervention?
- How many years would coppice shoots take to reach basal diameter of 4 cm as preferred size class for fuelwood (Luoga *et al.*, 2002; Neke *et al.*, 2006).
- What is the contribution of coppice regeneration to the total biomass stock and the fuelwood supply, and will the supply of wood by coppice meet village demand in a rotation of four years?
- To what extent is fuelwood harvesting of coppice shoots under CBCM ecologically sustainable?

## 4.2 METHODS

### 4.2.1 Quantifying the standing biomass and the density of woody plants

In order to quantify the standing biomass and determine stem densities in the sited plots (refer to Chapter 2), the following parameters were measured in the plots sited in the designated coupes: 1) stem diameter of all species (all stems for multi-stemmed trees) and the stumps, with the diameter measurements occurring above basal swelling when one was evident or as close as possible, 2) cutting height, 3) number of new and old coppice shoots (in cm) and, 4) basal diameter and the length of each coppice. Data on old stumps and coppice shoots were collected in January 2014 during the siting of plots before the harvesting trial, while new stumps and coppice shoots were collected from April, making it easy to distinguish old stumps and shoots from new ones. However, colour and freshness of the harvested stump surface were used to estimate when harvesting occurred (Luoga *et al.*, 2002). Tree species were identified through the assistance of the research assistants and a local expert fully conversant with tree species in the local village. Where uncertainty existed in the identification process, a specimen of the bark and leaf was taken for identification using the field guide

Callipers were used to measure diameters of all stems while a tape measure was used to measure their lengths. All stems and stumps in the 100 $m^2$ plots were measured. In order to monitor the ingrowth of uncut tree stems into the next size class categories, the measurements of uncut stem diameters were taken twice, the first one before the harvesting trial, in January 2014 during the siting of plots, and the last survey in January 2015 (indicated as $1^{st}$ and $2^{nd}$ survey on figures). Therefore, the number of stems that recruited into the next class were evident since there was an increase to the number recorded before the trial, similar to those which grew out into the next class. Monitoring of harvesting, the growth of new coppice shoots and the old ones occurred at an interval of three months, April 2014, July 2014, October 2014 and January 2015 over a period of nine months. In Homu 14B, although the trial was not implemented, ecological data were collected to determine the supply in villages with large population since this fell in that category.

Below are the size class categories used that were adapted from Luoga *et al.* (2004), which were used to categorize data collected on stems in the plots:

- 0.1 to 0.9 cm: considered to represent new regeneration by ‘seedlings’ or “coppice shoots” (referred to here as root suckers);
- 1 to 3 cm: ‘saplings’;
- 4 to 9 cm: ‘poles’;
- 10 to 19 cm: ‘small reproductive trees’; and
- > 20 cm: ‘large reproductive trees’.

Below are the functional diameter categories that were for data on coppice shoots. Unlike those of the primary stems above, three categories were used for coppice shoots because usually, coppice shoots do not beyond the pole size or become indistinguishable from ordinary stems of that size (White, 1979). When measuring the coppice shoots, the exact measurements were taken and assigned them in the relevant diameter class category as follows:

- 0.1 to 0.9 cm
- 1 to 3 cm: ‘saplings’; and
- 4 to 9 cm: ‘poles’.

In order to determine the mean number of stems per hectare, the means per plot were multiplied by 100, with the subsequent value multiplied by the number of hectares of each coupe to determine the total distributions of stems in the coupes. For the distributions of the stems in the entire communal woodland area (number of hectare), the hectare value was multiplied by the total woodland area. To determine the amount of standing biomass for fuelwood supply and their removal, uncut and cut stems, original and coppice shoots, were converted to biomass using the allometric equations in Nickless *et al.* (2011). These equations, listed below are used to convert biomass of stems for savanna ecosystems. In this study they were preferred over other equations such as that of Tietema (1993) because they recognize differences of the biomass associated with different species type, e.g. fine-leafed and broad-leafed species which were common in the communal woodlands of the study villages. The following equation was used for fine-leafed species which included *Dichrostachys cinerea*, *Albizia harveyi* and all *Acacia* species, e.g. *Acacia nilotica*, *Acacia nigrescens*:

$$\mathrm{Ln}\,(M)=a+b\ln(D)$$

where Ln is natural logarithm, a and b are constants: -3.35 and 3.09 respectively, and D is stem diameter. Since stem data were captured based on diameter size classes, the equations were applied to determine the amount of biomass emanating from stems in different size classes.

The equation used for broad-leafed species, which included species such as *Colophospermum mopane*, *Euclea divinorum* and all Combretum species (*Combretum apiculatum*, *Combretum imberbe*, *Combretum collinum*, and *Combretum hereroense*), was:

$$\ln\,(M)=a+b\ln(D)$$

where ln is natural logarithm, a and b are constants: -3.47 and 2.83 respectively, and D is stem diameter.

The stem density and the associated biomass density in different classes were compared and analysed to determine if there were significant differences among stems in different size class categories. The comparison of stems among different size classes was undertaken within the survey of each study period, before and during the harvesting trial. Before analysis, all means were tested for normality using Shapiro-Wilk test, and if they were not normally distributed they were log transformed to fit assumptions of normality. One way analysis of variance (ANOVA) was used to determine whether there was a significant difference between the mean number of stem and the biomass in the size class categories before and during the harvesting trial. Significant differences between the stems in the size class categories were identified using Tukey's *post hoc* test.

### 4.2.2 Extrapolated supply of fuelwood in coupes

Fuelwood harvesting would be considered unsustainable if it caused persistent changes in the woodland biomass such that the quality of fuelwood is diminished for a length of time that negatively impacts human well-being, resulting in a decline in social and economic capital (Shackleton *et al.*, 1994; Scholes 2009). Determining the harvest rate from the stems was based on the removal of the stems only in the range of 4–9 cm. This is because it was only the stems in this size class which were allowed for harvesting to meet the village demand while creating coppice stools for rotational harvesting during the trial, meaning that harvesting of biomass in other size classes reflected incompliance with harvesting rules during the trial. Harvesting during the trial lasted for six months in each coupe, which meant that harvests could only be assessed in two coupes, coupe 1 and 2. Thus, in order to estimate the amount of biomass that would have been removed if harvesting continued over twelve months, the observed harvest was in each coupe multiplied by 2. On the other hand, in order to determine the harvest rate in coupe 3 and 4 where harvesting did not occur, the average of the two observed harvests from the two coupes, coupe 1 and 2 was used. In Homu 14B, assessing the sustainability was not possible because there was no harvests to determine the village demand since harvesting continued under traditional rules of prohibiting harvesting of live trees.

From the stems that were harvested in the harvestable size classes in coupe 1 and 2 in Thorndale and Peninghotsa (including those harvested for commercial purposes), the supply of biomass was predicted from the emerging coppice and the unharvested stems in the legal size class. Two scenarios were used in the supply predictions of fuelwood based on coppice shoots, the first one was based on firstly harvesting coppice shoots to meet the village demand and shift to the primary stems if the amount of the coppice shoots did not meet the village demand. On the other hand, the second scenario focused on only harvesting the primary stems to meet the demand, while noting the subsequent coppice production and the time period from which the amount from the coppice shoots would meet the village demand. Comparison of the biomass amount that would emanate from these scenarios was also made. The same amount of biomass from the ingrowth recorded after a year in the harvestable size class was added in the biomass of unharvestable stems over the rotations because it was assumed that the amount would remain the same.

The predictions of the biomass supply from new coppice shoots were based on harvested stems of the preferred sizes. As procedure to predicting the biomass supply from coppice shoots, the mean stem diameter values were derived from the growth rates recorded in April 2014, July 2014, October, 2014 and January 2015 from coupe 1 and 2. The quarterly growth rates of new coppice shoots were derived by subtracting the diameter values recorded in the previous interval or quarter by those in the following quarter, e.g. those recorded in April were subtracted by those recorded in July. The difference or the subsequent values reflected the growth rates of the coppice shoots between the monitoring intervals. To predict an average diameter of new coppice shoots over a one year period, the mean growth rate, diameter values were multiplied by 12 months. To determine the associated biomass supply in plots in the prediction, the subsequent extrapolated mean diameter value was converted into a biomass value, and multiplied by the number of coppice shoots recorded in each plot. In order to express the supply per a hectare basis, the predicted supply from the plot was multiplied by 100, and by the total number of the hectares of each coupe to determine the total biomass supply. To predict the supply after four years, the extrapolated biomass supply after a year in each of the two coupes was multiplied by 4, while an average from the two was used for the prediction in coupe 3 and 4. To get estimate the amount of coppice shoots biomass supply for a year period, the recorded biomass amount of coppice noted over a six months period was multiplied by 2, since it was assumed that if the observed harvest had doubled so would be the predicted supply of biomass from coppice shoots. The two equations, both broad-leafed and fine-leafed were used when multiplying the biomass value since the projection emanated from coppice shoots from species in these species types, to ensure that there was correspondence between stem size and the associated projected biomass supply. The predicted amount of biomass supply was converted from kilograms to tonnes to assess the total biomass supply in each coupe versus the village demand, since the village demand data was recorded in tonnes.

In the extrapolation process, aspects that can affect the supply of biomass such as dieback and self-thinning were factored in in each coupe (Figure 4.1). For instance, self-thinning is relevant to coppicing trees (Luoga *et al.,* 2004), in order to factor it in, the mean number of old coppice shoots that had reached the harvestable class, 4–9 cm in the last monitoring month, January 2015 were used as a benchmark. This is because it was expected that the mean number of new coppice shoots after a year would be high, but it would decline by the same number (%) observed from the old coppice shoots in the intermediate class after self-thinning which starts after a year. Consequently, even the supply that would emanate from coppice shoots that were not recorded from some stumps because harvesting occurring towards the end was accounted for after. This is because recruitment and mortality were assumed based of the differences between the high mean number of new coppice shoots per stump of new coppice shoots and the low mean number of old coppice shoots per stump. Self-thinning differs with vegetation types (Weller, 1987), and to ensure that the self-thinning rule applied was relevant in the village, the mean number was calculated per village. Similar approach was also used to account for the health of stumps which would die over time.

To establish ecologically sustainable harvesting levels, information needs to be gathered on population density, size class structure and the yield characteristics in order to select the species or resource groups based on user requirements (Lawes *et al.,* 2004). The effective resource base is on the preferred species and preferred morphological types (Neke *et al.,* 2006). In this regard, from the standing stock, the effective supply emanated from the most preferred species which had to be more than 50% of the standing stock population. The extrapolated supply would be considered to be sustainable provided there would be adequate supply of biomass in all coupes to meet the village demand since this would enable local resource users to harvest at least one year in each coupe. For tractability, zero growth in the human population was assumed for the projection period, following Twine and Holdo (2016).

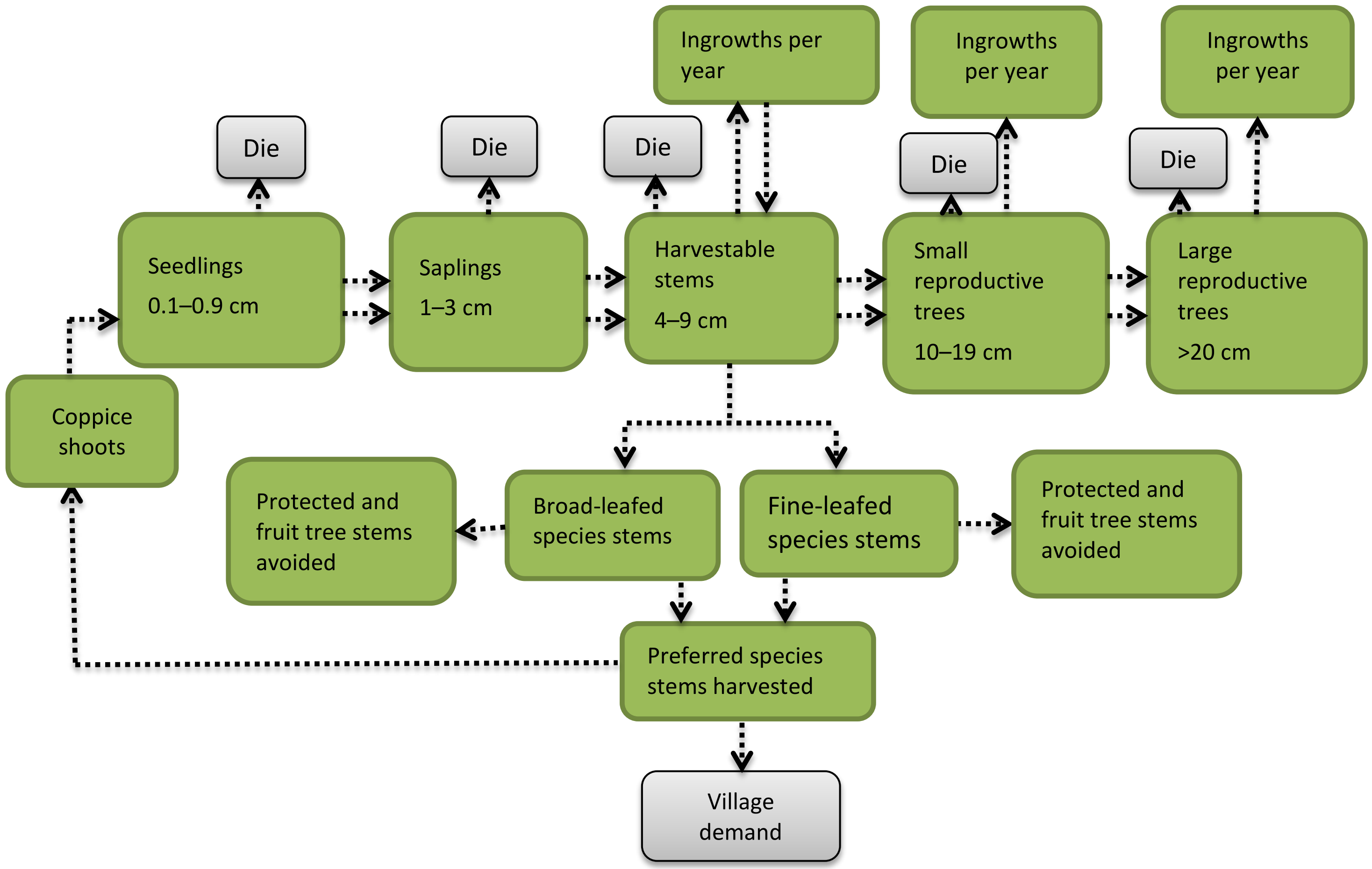



Figure 4.1: Graphic representation of how the supply was derived and affected by different factors.

## 4.3 RESULTS

### 4.3.1 Stem density of total standing stock

In Thorndale, stem density in the smallest size class was significantly higher than those in other size classes before the harvesting trial ($p$<0.05). For instance, before the trial there were more than 3 500 ha stems and about 2 500 ha during the trial. However, this changed during the intervention with a significant increase in the number of stems in the next size class, the saplings (Figure 4.2) This means that stem density in the small size classes (0.1-0.9 and 1–3 cm) were significantly higher than those in the intermediate and large size classes during the intervention. Similar results were recorded in Peningotsa ($p$<0.001). In Homu 14B, the number of stems in the small and intermediate size classes was higher than those in the large size classes (e.g. more than 1000 ha) ($p$<0.001). The only change in the second survey was a significant increase in the number of stems in the sapling size class (1–3 cm), since those in the smallest and intermediate size classes remained significantly higher than those in large size classes.

The size class distribution of stems “near”, “mid” and “far” plots were also assessed (Table 4.1). The distributions in the number of stems did not differ significantly between the “near”, “mid” and “far” plots in both survey periods, except in Peninghotsa for the woody stems in the size class 1–3 cm, which significantly increased during the trial period.

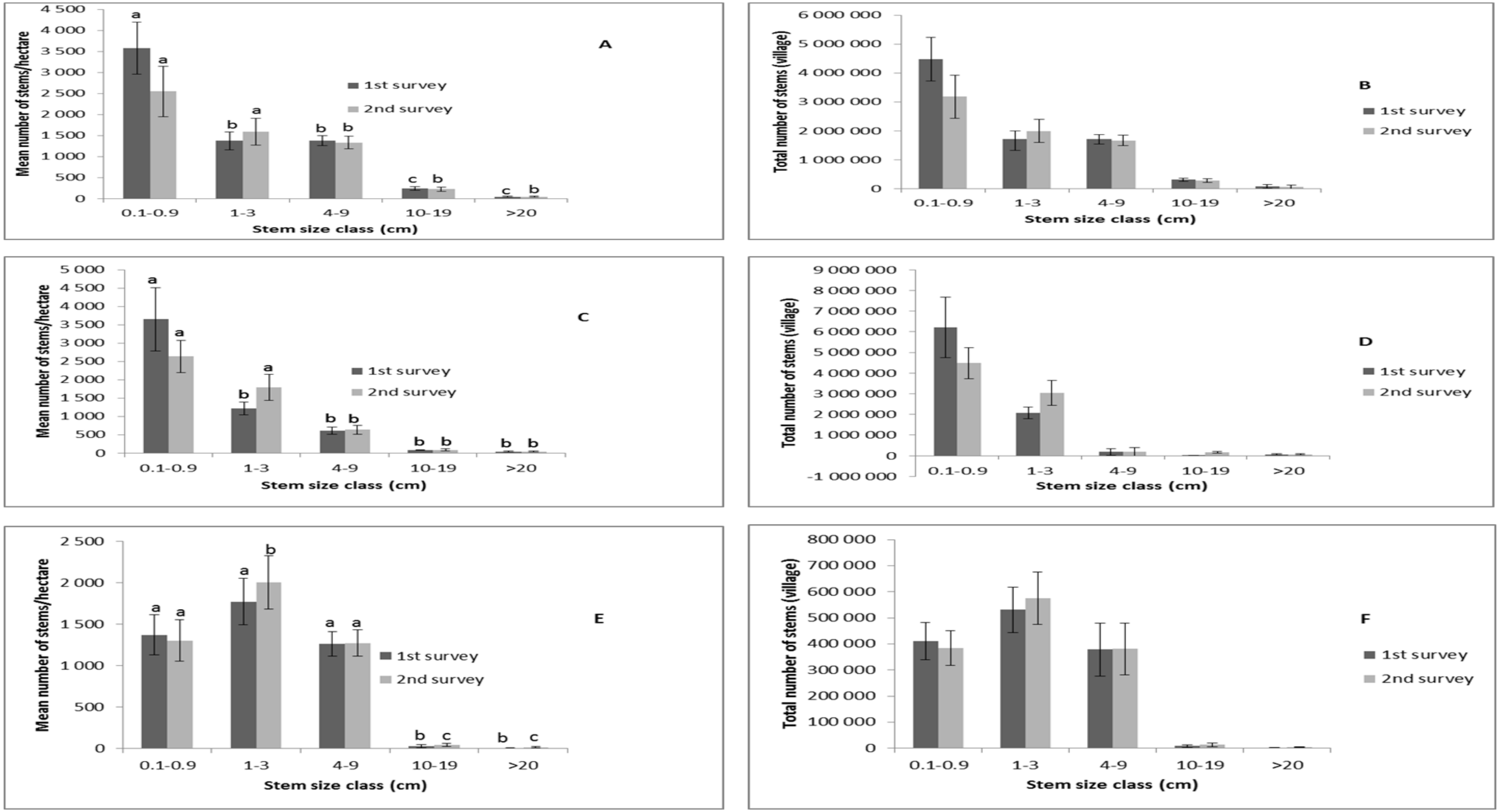



Figure 4.2: Mean number of stems per size class (within each survey period) per hectare and extrapolated to village level in Thorndale (1 247 ha) (A & B), Peninghotsa (1 700 ha) (C & D), and Homu 14B (300 ha) (E & F) (Bars with different letters indicate significant differences).

Table 4.1: Distribution of uncut woody stems (per plot) per size class from near, mid and far plots of the village settlement (Different letters indicate significant differences between distance within survey rounds).

| Diameter | Near<br>1$^{st}$ survey | <br>2$^{nd}$ survey | Mid<br>1$^{st}$ survey | <br>2$^{nd}$ survey | Far<br>1$^{st}$ survey | <br>2$^{nd}$ survey |
|---|---|---|---|---|---|---|
| **Thorndale** | | | | | | |
| | 1$^{st}$ ($F$(2,27)=1.826, $p$=0.180) | | | 2$^{nd}$ ($F$(2,27)=0.407, $p$=0.670) | | |
| 0.1-0.9 | 26.90$^{a}$±8.12 | 35.60$^{a}$± 14.41 | 50.90$^{a}$±14.12 | 25.00$^{a}$± 7.29 | 27.44$^{a}$±4.07 | 15.11$^{a}$±7 |
| 1-3 | 10.20$^{a}$±2.33 | 14.50$^{a}$± 5.47 | 20.36$^{a}$±4.50 | 21.72$^{a}$±6.30 | 9.88$^{a}$±2.74 | 10.66$^{a}$±4.77 |
| 4-9 | 9.60$^{a}$±3.20 | 12.90$^{a}$± 3.43 | 11.36$^{a}$±1.57 | 16.90$^{a}$± 2.40 | 6.55$^{a}$±0.94 | 9.77$^{a}$±1.46 |
| 10-19 | 1.90$^{a}$±0.83 | 2.50$^{a}$±0.81 | 3.27$^{a}$±0.85 | 2.72$^{a}$±0.73 | 2.22$^{a}$±0.57 | 1.44$^{a}$±0.41 |
| >20 | 0.60$^{a}$±0.33 | 0.50$^{a}$±0.26 | 0.72$^{a}$±0.23 | 0.72$^{a}$±0.23 | 0.22$^{a}$±0.14 | 0.22$^{a}$±0.14 |
| **Penighotsa** | | | | | | |
| | 1$^{st}$ ($F$(2,33)=0.716, $p$= 0.496) | | | 2$^{nd}$ ($F$(2,33)=0.242, $p$=0.786) | | |
| 0.1-0.9 | 20.91$^{a}$±3.44 | 18.83$^{a}$± 5.4 | 52.33$^{a}$±23.90 | 25.50$^{a}$± 8.67 | 36.33$^{a}$±8.99 | 34.91$^{a}$± 8 |
| 1-3 | 7.33$^{a}$±2.39 | 11.00$^{a}$± 3.81 | 17.66$^{b}$±3.55 | 23.25$^{a}$±6.79 | 11.83$^{b}$±2.41 | 19.50$^{a}$±7. |
| 4-9 | 3.83$^{a}$±0.76 | 3.83$^{a}$± 1.24 | 3.66$^{a}$±0.73 | 9.08$^{a}$± 2.80 | 2.00$^{a}$±0.50 | 5.00$^{a}$±1.95 |
| 10-19 | 0.58$^{a}$±0.25 | 0.75$^{a}$±0.35 | 0.50$^{a}$±0.15 | 0.83$^{a}$±0.57 | 0.75$^{a}$±0.25 | 1.50$^{a}$±0.60 |
| >20 | 0.25$^{a}$±0.17 | 0.25$^{a}$±0.17 | 0.25$^{a}$±0.17 | 0.50$^{a}$±0.28 | 0.83$^{a}$±0.32 | 0.50$^{a}$±0.26 |
| **Homu 14** | | | | | | |
| | 1$^{st}$ ($F$(2,18)=0.102, $p$=0.383) | | | 2$^{nd}$ ($F$(2,33)=0.013, $p$=0.987) | | |
| 0.1-0.9 | 18.57$^{a}$±4.65 | 12.85$^{a}$± 3.95 | 12.14$^{a}$±4.43 | 13.57$^{a}$± 4.67 | 10.57$^{a}$±3.44 | 12.57$^{a}$± |
| 1-3 | 10.42$^{a}$±2.19 | 15.57$^{a}$± 2.15 | 21.00$^{a}$±5.84 | 20.71$^{a}$±4.39 | 23.85$^{a}$±4.89 | 25.28$^{a}$± |
| 4-9 | 5.42$^{a}$±1.74 | 8.14$^{a}$± 2.43 | 7.14$^{a}$±2.57 | 10.85$^{a}$± 3.90 | 11.71$^{a}$±3.30 | 13.28$^{a}$±1.76 |
| 10-19 | 0.14$^{a}$±0.14 | 0.28$^{a}$±0.28 | 0.42$^{a}$±0.42 | 1.14$^{a}$±0.45 | 0.71$^{a}$±0.47 | 0.42$^{a}$±0.42 |
| >20 | 0.60$^{a}$±0.33 | 0.50$^{a}$±0.26 | 0.72$^{a}$±0.23 | 0.72$^{a}$±0.23 | 0.22$^{a}$±0.14 | 0.22$^{a}$±0.14 |

The supply of fuelwood from the standing stock, from the primary stems was assessed (Table 4.2). The contributions of coppice shoots to the standing stock were also assessed and also those that were removed or harvested (Table 4.3 and 4.4) (see pre-existing shoots in Peninghotsa Figure 4.3 A) In Thorndale, the amount of wood biomass in the largest size classes was significantly higher than those in other classes before the harvesting trial. However, those in the intermediate and the second largest size classes were also significantly higher than those in the small size classes (see resource density in the intermediate size class in Thorndale Figure 4.3B). This did not change with the implementation of the project. In Peninghotsa, the amount of biomass in the largest size class was significantly higher than those in other size classes which like in Thorndale did not change with the intervention. In

Homu 14B, the amount of biomass in the largest and intermediate size classes was significantly higher than those in other size classes in both survey periods.

The total village consumption in Thorndale was 462 t before and 491 t during the trial. With the biomass supply in the harvestable size of the primary stems class being 7 482 t before the trial and 6 696 t during the trial means that local resource users consumed only 6.17% and 7.33% of the resource base in the two respective periods. The amount contributed by coppice shoots from old shoots in the harvestable size class before the trial was 1 970 t and 2 157 t, during the trial representing the contribution of 26.32% and 32.21% in the two respective periods. In Peninghotsa, the village demand in the first survey was 694 t and 706 t in the second survey. Therefore, the supply being 8 415 t in the first survey and 7 307 t in the second survey means that the village demand was only 8.24% and 9.66% of the resource base in both surveys. The coppice contribution was 3 077 t in the first survey and 3 944 t in the second survey, meaning that they contributed 36.56% and 53.97% of the resource base in the respective survey period. In Homu 14B, the village demand was 1 371 t in the first survey and 1 242 t in the second survey. With the supply being 2 220 t recorded in the first survey and 2 600 t in the second survey means that the village consumed 61. 75% and 47.76% from the effective resource base in the two respective survey periods. The coppice shoots biomass was 1 778 t, in the first survey and 267 t in the second survey, meaning that they contributed 80% in the first survey and 10.26% in the second survey.

A B


Figure 4.3: A) Pre-existing coppice shoots of *C. mopane* in Peninghotsa. B) Resource density in the intermediate size class in Thorndale.

Table 4.2: Amount of standing woody biomass per diameter size class per plot, extrapolated to a hectare and the entire communal woodland area of the study villages (Different letters indicate significant differences).

| **Diameter** | **Per plot (kg) 1$^{st}$ survey** | **2$^{nd}$ survey** | | **Per hectare (t) 1$^{st}$ survey** | **2nd survey** | | **Communal woodland (t) 1$^{st}$ survey** | **2$^{nd}$ survey** |
|---|---|---|---|---|---|---|---|---|
| **Thorndale** | | | | | | | **(1247 ha)** | |
| | 1$^{st}$ ($F(4, 145)$=2, 174, $p$<0.05) | | 2$^{nd}$ ($F(4, 145)$=1, 583, $p$<0.05) | | | | | |
| 0.1-0.9 | 0.96$^{a}$±0.02 | 0.68$^{a}$± 0.01 | 0.1-0.9 | 0.09 | 0.07 | 0.1-0.9 | 112 | 75 |
| 1-3.9 | 8.51$^{a}$±1.34 | 14.92$^{a}$± 2.69 | 1-3 | 0.85 | 1.49 | 1-3.9 | 1 060 | 1 858 |
| 4-9.9 | 59.98$^{b}$±10.5 | 53.7$^{b}$± 9.7 | 4-9 | 6.00 | 5.30 | 4-9 | 7 482 | 6 696 |
| 10-19 | 99 68.7$^{b}$±11.3 | 70.7$^{b}$±14.8 | 10-19 | 7.00 | 7.07 | 10-19 | 8 729 | 8 816 |
| >20 | 399.4$^{c}$±100 | 353.8$^{c}$±101 | >20 | 39.94 | 35.33 | >20 | 49 805 | 44 057 |
| **Total** | | | | | | | **7 482** | **6 696** |
| **Peninghotsa** | | | | | | | **(1700 ha)** | |
| | 1$^{st}$ ($F(4, 175)$=6,089, $p$<0.001) | | 2$^{nd}$ ($F(4, 175)$=5, 398, $p$<0.001) | | | | | |
| 0.1-0.9 | 0.16$^{a}$±0.03 | 0.10$^{a}$±0.02 | 0.1-0.9 | 0.01 | 0.01 | 0.1-0.9 | 17 | 17 |
| 1-3 | 2.26$^{a}$±0.68 | 4.74$^{a}$±0.84 | 1-3.9 | 0.22 | 0.47 | 1-3 | 374 | 799 |
| 4-9 | 49.50$^{a}$± 7.90 | 42.98$^{a}$±6.55 | 4-9 | 5.15 | 4.29 | 4-9 | 8 415 | 7 307 |
| 10 | 55.95$^{a}$±20.36 | 56.25$^{a}$±21.62 | 10-19 | 5.59 | 6.00 | 10-19 | 9 503 | 10 200 |
| >20 | 537.19$^{b}$±208 | 501.75$^{b}$±206 | >20 | 53.71 | 15.84 | >20 | 91 307 | 26 928 |
| **Total** | | | | | | | **8 415** | **7 307** |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Homu 14B** | | | | | | **(300 ha)** | | |
| | 1st ($F(4, 100) = 5{,}119$, $p<0.001$) | | 2nd ($F(4, 175) = 8, 763$, $p<0.001$) | | | | | |
| 0.1-0.9 | $0.39^{a}\pm0.09$ | $0.34^{a}\pm0.08$ | 0.1-0.9 | 0.03 | 0.03 | 0.1-0.9 | 9 | 9 |
| 1-3 | $18.4^{a}\pm2.90$ | $24^{a}\pm 3.30$ | 1-3 | 1.84 | 2.40 | 1-3 | 552 | 720 |
| 4-9 | $74.6^{b}\pm12.0$ | $86.8^{b}\pm12.20$ | 4-9 | 7.46 | 8.68 | 4-9.9 | 2 220 | 2 600 |
| 10-19 | $24.30^{a}\pm7.7$ | $28.09^{a}\pm8.7$ | 10-19 | 1.50 | 2.0 | 10-19 | 729 | 842 |
| >20 | $64.45^{b}\pm63.4$ | $78.44^{b}\pm63.5$ | >20 | 6.44 | 2.20 | >20 | 1 934 | 2 353 |
| **Total** | | | | | | | **2 220** | **2 600** |

Table 4.3: Biomass from the old coppice shoots in the communal woodland (Different letters indicate significant differences).

| Diameter | Per plot (kg) 1st survey | 2nd survey | | Per hectare (t) 1st survey | 2nd survey | | Communal woodland (t) 1st survey | 2nd survey |
|---|---|---|---|---|---|---|---|---|
| **Thorndale** | | | | | | **(1247 ha)** | | |
| | 1st ($F(2, 87)=7, 816$, $p<0.001$) | | 2nd ($F(4, 175)=8, 157$, $p<0.001$) | | | | | |
| 0.1-0.9 | $1.50^{a}\pm0.38$ | $2.55^{a}\pm1.07$ | 0.1-0.9 | 0.15 | 0.25 | 0.1-0.9 | 187 | 312 |
| 1-3.9 | $15.85^{b}\pm2.84$ | $17.32^{b}\pm 3.10$ | 1-3 | 1.58 | 1.73 | 1-3 | 1970 | 2157 |
| 4-9 | $0.00^{a}\pm0.00$ | $0.00^{a}\pm0.00$ | 4-9. | 0. | 0 | 4-9 | 0 | 0 |
| **Total** | | | | | | | **1 970** | **2 157** |
| **Peninghotsa** | | | | | | **(1700 ha)** | | |
| | 1st ($F(2, 105)=7, 176$, $p<0.001$) | | 2nd ($F(2, 105)=2, 827$, $p<0.001$) | | | | | |
| 0.1-0.9 | $2.60^{a}\pm0.55$ | $4.24^{a}\pm0.90$ | 0.1-0.9 | 0.26 | 0.42 | 0.1-0.9 | 324 | 524 |
| 1-3 | $18.17^{b}\pm7.07$ | $20.24^{b}\pm7.87$ | 1-3 | 1.81 | 2.02 | 1-3 | 3 077 | 3 434 |
| 4-9. | $0.00^{a}\pm0.00$ | $0.00^{a}\pm0.00$ | 4-9 | 0 | 0 | 4-9 | 0 | 0 |
| **Total** | | | | | | | **3 077** | **3 434** |
| **Homu 14B** | | | | | | **(300 ha)** | | |
| | 1st ($F(2, 59)=4, 816$, $p<0.05$) | | 2nd ($F(2, 59)=14, 656$, $p<0.001$) | | | | | |
| 0.1-0.9 | $6.48^{b\,c}\pm1.16$ | $8.94^{a}\pm1.38$ | 0.1-0.9 | 0.64 | 0.89 | 0.1-0.9 | 201 | 267 |
| 1-3 | $59.25.18^{b}\pm7.17$ | $18.82^{b}\pm7.37$ | 1-3 | 4.42 | 2.38 | 1-3 | 1778 | 562 |
| 4-9 | $0.00^{a}\pm0.00$ | $0.00^{a}\pm0.00$ | 4-9 | 0 | 0 | 4-9 | 0 | 0 |
| **Total** | | | | | | | **1 778** | **562** |

Table 4.4: Harvested biomass per diameter size classes from coppice shoots in study villages (Different letters indicate significant differences).

| Diameter | Per plot (kg) 1st survey | Per plot (kg) 2nd survey | | Per hectare (t) 1st survey | Per hectare (t) 2nd survey | | Communal woodland (t) 1st survey | Communal woodland (t) 2nd survey |
|---|---|---|---|---|---|---|---|---|
| **Thorndale** | | | | | | | **(1247 ha)** | |
| | 1st ($F(2, 87)=3, 659$, $p<0.05$) | | | 2nd ($F(2, 87)=4, 370$, $p<0.05$) | | | | |
| 0.1-0.9 | $0.72^{a}\pm0.29$ | $0.27^{a}\pm0.10$ | 0.1-0.9 | 0.07 | 0.02 | 0.1-0.9 | 87.29 | 25 |
| 1-3 | $13.84^{b}\pm7.03$ | $3.06b\pm1.73$ | 1-3 | 1.38 | 0.30 | 1-3 | 1721 | 374 |
| 4-9 | $0.00^{a}\pm0.00$ | $0.00^{a}\pm0.00$ | 4-9 | 0 | 0 | 4-9 | 0 | 0 |
| **Total** | | | | | | | **1 721** | **374** |
| **Peninghotsa** | | | | | | | **(1700 ha)** | |
| | 1st ($F(1, 105)=5, 074$, $p<0.001$) | | | 2nd ($F(2, 105)=3, 905$, $p<0.05$) | | | | |
| 0.1-0.9 | $0.57^{a}\pm0.21$ | $0.52^{a}\pm0.21$ | 0.1-0.9 | 0.05 | 0.05 | 0.1-0.9 | 85 | 85 |
| 1-3 | $13.13^{b}\pm4.10$ | $3.04^{b}\pm3.82$ | 1-3 | 1.31 | 0.60 | 1-3. | 2 227 | 517 |
| 4-9 | $0.00^{a}\pm0.00$ | $0.00^{a}\pm0.00$ | 4-9 | 0 | 0 | 4-9 | 0 | 0 |
| **Total** | | | | | | | **2 227** | **517** |
| **Homu 14B** | | | | | | | **(300 ha)** | |
| | 1st ($F(2, 60)=4, 881$, $p<0.05$) | | | 2nd ($F(2, 60)=1,203$, $p<0.05$) | | | | |
| 0.1-0.9 | $3.08^{a}\pm1.37$ | $0.52^{a}\pm0.21$ | 0.1-0.9 | 0.30 | 0. | 0.1-0.9 | 300 | 15 |
| 1-3 | $29.22^{b}\pm15.13$ | $41.80^{b}6.82$ | 1-3 | 2.92 | 4.18 | 1-3 | 876 | 125 |
| 4-9 | $0.00^{a}\pm0.00$ | $0.00^{a}\pm0.00$ | 4-9 | 0 | 0 | 4-9 | 0 | 0 |
| **Total** | | | | | | | **876** | **125** |

### 4.3.2 Assessment of rotational harvesting strategy and sustainability

The mean monthly increase in diameter from April 2014, July 2014, October 2014 and January 2015, was 0.12 cm in Thorndale and 0.11 cm in Peninghotsa. When multiplied by 12 months, the mean stem diameter value in Thorndale would increase to 1.44 cm, which would be the growth in terms of diameter per year. This would translate to 5.76 cm after four years. In Peninghotsa, the monthly mean stem diameter would reach 1.32 cm after one year, and 5.28 cm, after four years. After converting the mean stem diameter to biomass (in order to determine the biomass supply), the subsequent mean biomass from 1.44 cm was 0.10 kg for fine-leafed species and 0.08 kg for broad-leafed species. In Peninghotsa, the mean stem diameter of 1.32 cm translated to 0.08 kg for fine-leafed species and 0.06 kg for broad-leafed species. In order to determine the biomass supply from one year to four years, the mean biomass value was multiplied by the number of new coppice shoots recorded per stumps in the plots in each coupe, after accounting for self-thinning in stumps. For instance, the mean number of new shoots per stump during the harvesting trial in Thorndale was nine. Based on the mean number of the old coppice in the harvestable shoots which was four, means that over time the coppice shoots would reduce to four per stump, representing 56 % dieback. In Peninghotsa, the mean number of new shoots per stump was eleven per stump during the trial, while the mean number of old coppice shoots in the harvestable size class was five meaning that the projected coppice shoots would decline to five coppice shoots per stump representing a dieback of 55%. Therefore, in the extrapolation process, demonstrated below with the projected biomass over a one year period (Figure, 4.4 and 4.5), the self-thinning rule of 56% and 55% were applied. Regarding, the need to account for the new stump dying overtime, the researcher removed the number of stumps equivalent to 11% in Thorndale and 15% in Peninghotsa which were the % of the old stumps observed dead.

In Thorndale, the effective resource based consisted of the following species, *Combretum apiculatum*, *Dichrostachys cinerea*, *Acacia nigrescens Terminal sericea*, while in Peninghotsa, theses were *Combretum collinum*, and *Colophospermum mopane*, *C. apiculatum* and *D. cinerea*. These species constituted much of the observed harvest during the harvesting trial to meet the village demand (Table 4.5).

Table 4.5: Observed harvest, i.e. biomass removed in the harvestable size class during the harvesting trial, on a rotation of six months (x2=harvest observed in six months were multiplied by 2 to get an estimate of the total harvest over a one year period).

| **Village** | **Coupe number and size** | **Plot (kg)** | **Hectare** | **Total harvest in coupes (t)** |
|---|---|---|---|---|
| **Thorndale** | Coupe 1 (410 ha) | 7.58±1.74 | 0.75 | 307 (x2 – 614) |
| | Coupe 2 (319 ha) | 8.92±3.2 | 0.89 | 283 (x2 – 566) |
| **Peninghotsa** | Coupe 1 (498 ha) | 8.29±3.57 | 0.82 | 408(x2 – 816) |
| | Coupe 2 (404 ha) | 9.16±3.68 | 0.91 | 367 (x2 – 737) |

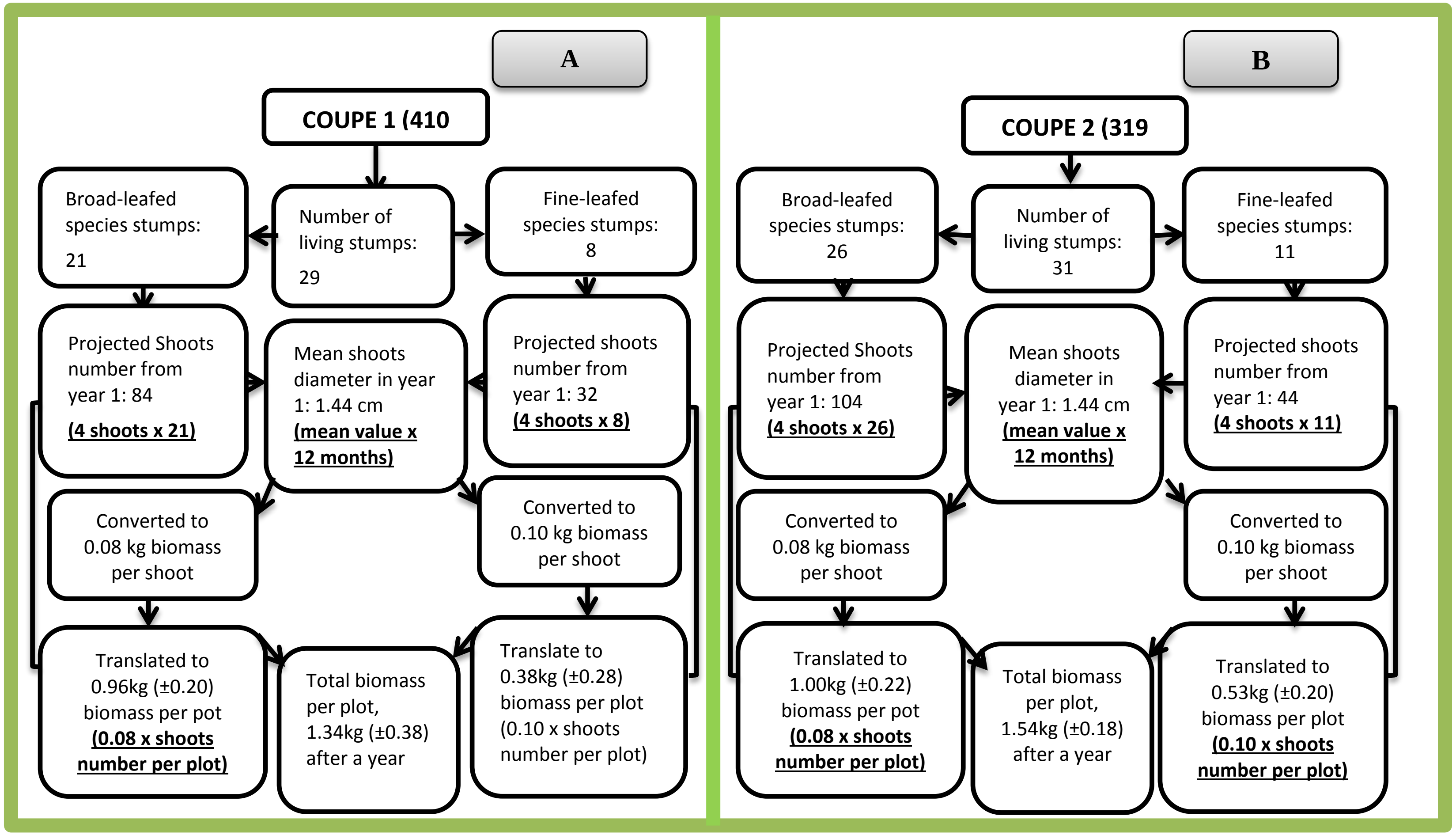



Figure 4.4: The extrapolation process and the biomass supply projected over a one year period in Thorndale (A, coupe 1 and B, coupe 2).

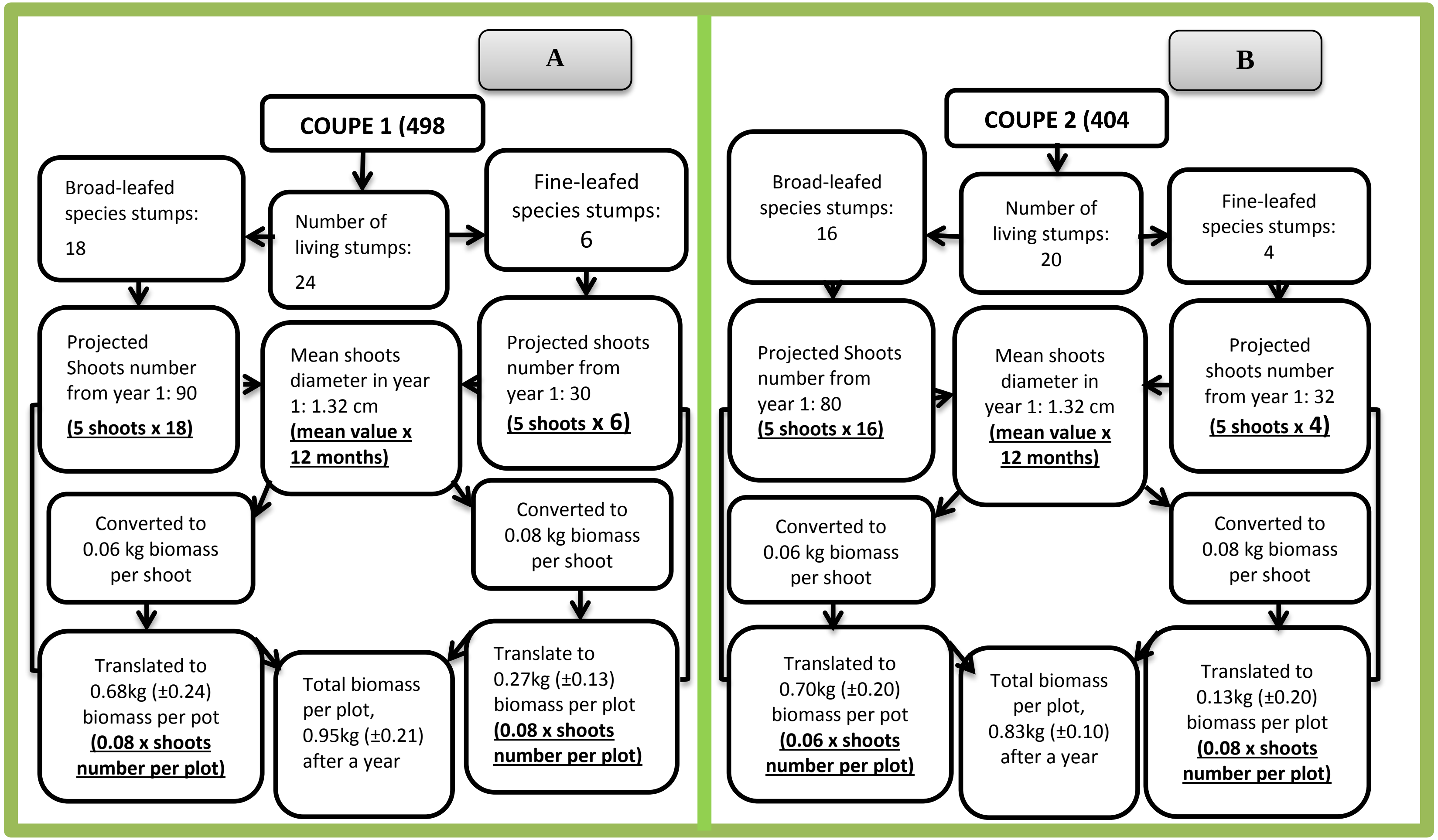



Figure 4.5: The extrapolation process and the biomass supply projected over a one year period in Peninghotsa (A, coupe 1 and B, coupe 2).

Table 4.6: Extrapolation of coppice production from one to four years in Thorndale in coupe 1 (x2=multiplied by 2 because the observed harvest from which the shoots emanated was also multiplied by 2 meaning the number of coppice shoots would double).

| **Variable: Year** | **Mean coppice biomass per plot (kg)** | **Per hectare (t)** | ***Coupe* 1 410 ha (t)** |
|---|---|---|---|
| 1 | 1.34±0.38 | 0.13 | 53.30 (x2 – 107) |
| 2 | 2.68±0.76 | 0.26 | 106.6 (213) |
| 3 | 4.02±1.14 | 0.39 | 159.9 (320) |
| 4 | 5.36±1.52 | 0.52 | 213.2 (427) |

Table 4.7: Extrapolation of coppice production from one to four years in Thorndale in coupe 2 (x2=multiplied by 2 because the observed harvest from which the shoots emanated was also multiplied by 2 meaning the number of coppice shoots would double).

| **Variable: Year** | **Mean coppice biomass per plot (kg)** | **Per hectare (t)** | ***Coupe* 2 319 ha (t)** |
|---|---|---|---|
| 1 | 1.54±0.36 | 0.15 | 47.85 (x 2 – 96) |
| 2 | 3.08±0.72 | 0.30 | 95.70 (192) |
| 3 | 4.62±1.08 | 0.45 | 143.5 (288) |
| 4 | 6.16±0.96 | 0.60 | 191.4 (384) |

Table 4.8: Extrapolation of coppice production from one to four years in Peninghotsa in coupe 1 (x2=multiplied by 2 because the observed harvest from which the shoots emanated was also multiplied by 2 meaning the number of coppice shoots would double).

| **Variable: Year** | **Mean coppice biomass per plot (kg)** | **Per hectare (t)** | ***Coupe* 1 498 ha (t)** |
|---|---|---|---|
| 1 | 0.95±0.29 | 0.09 | 44.82 (x2 – 90) |
| 2 | 1.90± 0.58 | 0.18 | 89.64 (180) |
| 3 | 2.85±0.87 | 0.27 | 134.4 (270) |
| 4 | 3.80±1.16 | 0.36 | 179.2 (360) |

Table 5.9: Extrapolation of coppice production from one to four years in Peninghotsa in coupe 2 (x2=multiplied by 2 because the observed harvest from which the shoots emanated was also multiplied by 2 meaning the number of coppice shoots would double).

| **Variable: Year** | **Mean coppice biomass per plot (kg)** | **Per hectare (t)** | ***Coupe* 2 404 ha (t)** |
|---|---|---|---|
| 1 | 0.83±0.27 | 0.08 | 32.32 ( x2 – 65) |
| 2 | 1.66±0.54 | 0.24 | 64.64 (130) |
| 3 | 2.49±0.81 | 0.36 | 96.96 (195) |
| 4 | 3.32±1.08 | 0.48 | 129.2 (260) |

In the predictions of biomass supply, based on coppice shoots, two scenarios were used (Figure 4.6 and 4.7). In the first scenario, local resource users would have to firstly harvest coppice shoots, shifting to the harvestable primary stems, if the demand is not met by the coppice shoots. In the second scenario local resource users would have to firstly harvest primary stems to meet the demand, shifting to the coppice shoots if the village demand is not met by the biomass amount from primary stems in the allowable size class. Under the first scenario, there would be adequate amount of biomass from coppice shoots alone from the 8$^{th}$ year across all the coupes to meet the village demand of 491 t. Similarly, in Peninghotsa, the project would also be sustainable, but, it would take longer, from at least 12 years, depending on the coupe for the village demand (706 t) to be met entirely by the coppice shoots. Based on the observed patterns which also included commercial harvesting (816 t in coupe 1 and 737 t in coupe 2). Under the second scenario, and over the same period, 8$^{th}$, the amount of coppice shoots would be higher than that emanating from the first scenario by 54%, 52% and 51% in coupe 1, 2 and 3 respectively in Thorndale. In Peninghotsa, unlike in the first scenario, in the second scenario, the amount of coppice shoots would meet the village demand in the 12$^{th}$ year, and would be higher than that of the first scenario by 58%, 38%, 50% and 30% in coupe 1, 2, 3 and 4 respectively. However, the yield would occur after exhausting the primary stems in the last three coupes.

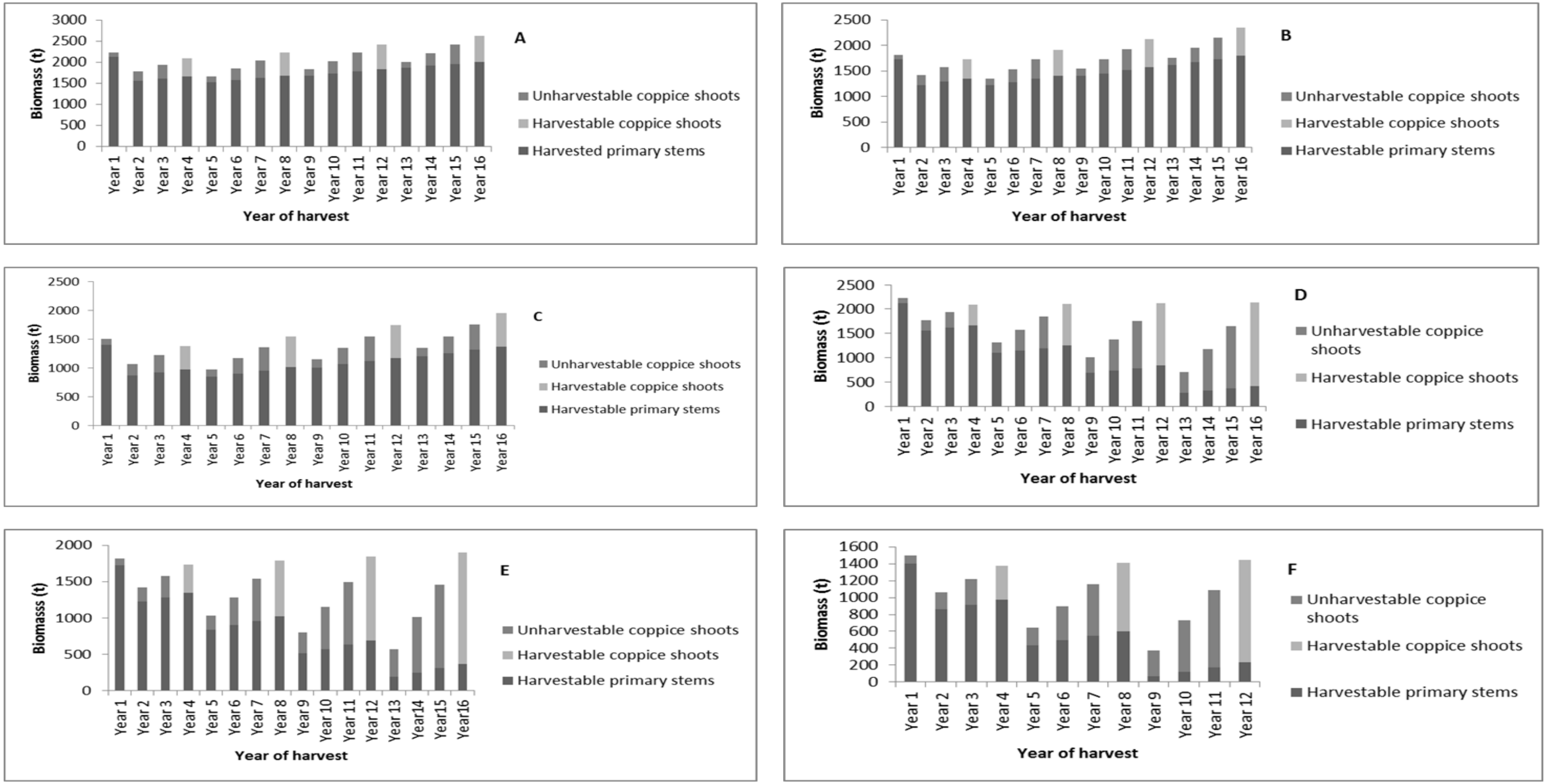
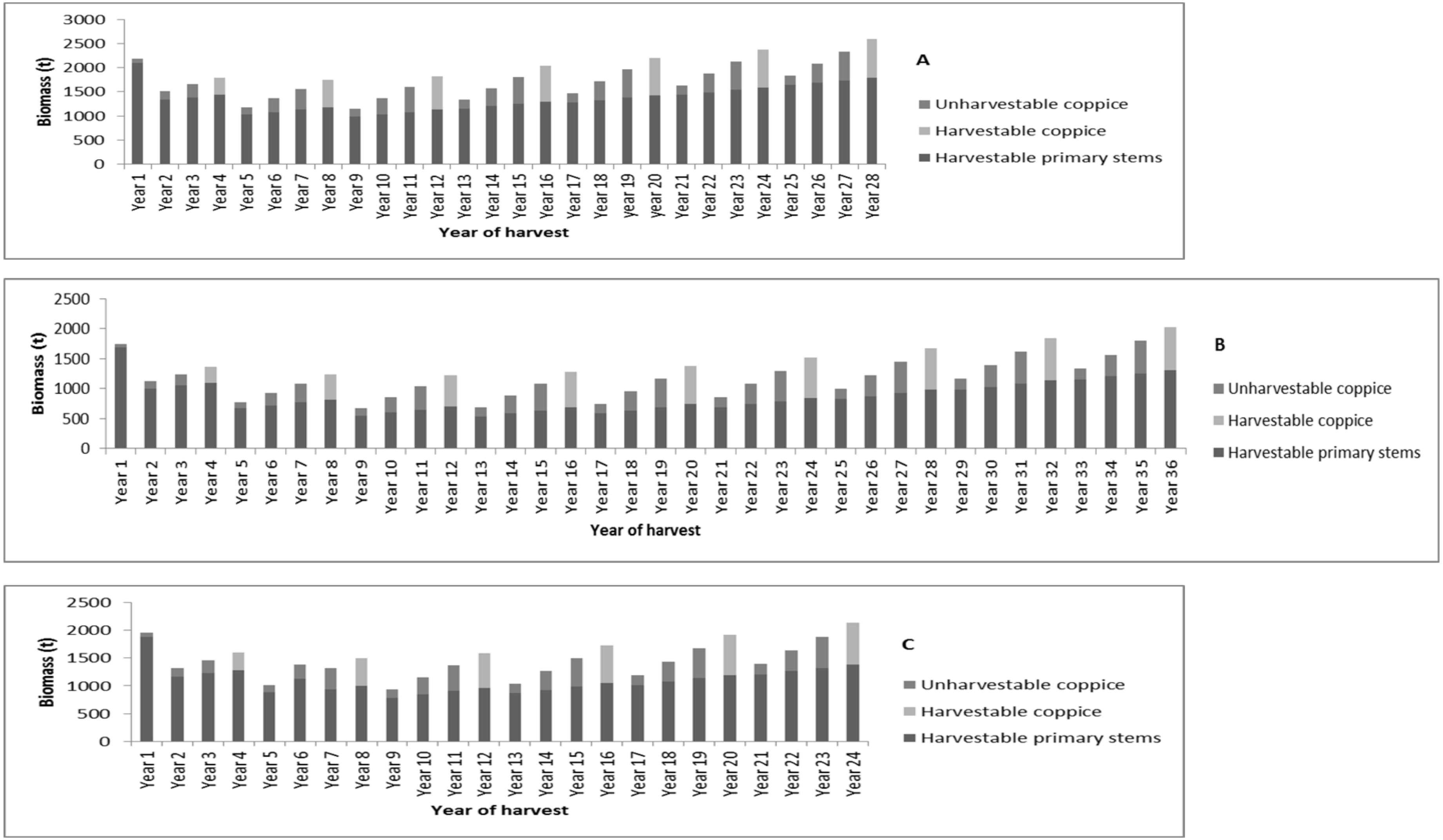



Figure 4.6: The predicted supply of fuelwood based on a scenario where the local resource users first harvest coppice shoots and harvest the primary stems in case the supply from coppice does not meet the village demand over the harvest rotations of four years, in Thorndale (A, coupe 1, B, coupe 2 and C, coupe 3) and the second scenario where they first harvest primary stems before shifting to coppice shoots (D, coupe 1, E, coupe 2, F, coupe 3)


A
Biomass (t)
Year of harvest
Unharvestable coppice
Harvestable coppice
Harvestable primary stems
B
Biomass (t)
Year of harvest
Unharvestable coppice
Harvestable coppice
Harvestable primary stems
C
Biomass (t)
Year of harvest
Unharvestable coppice
Harvestable coppice
Harvestable primary stems

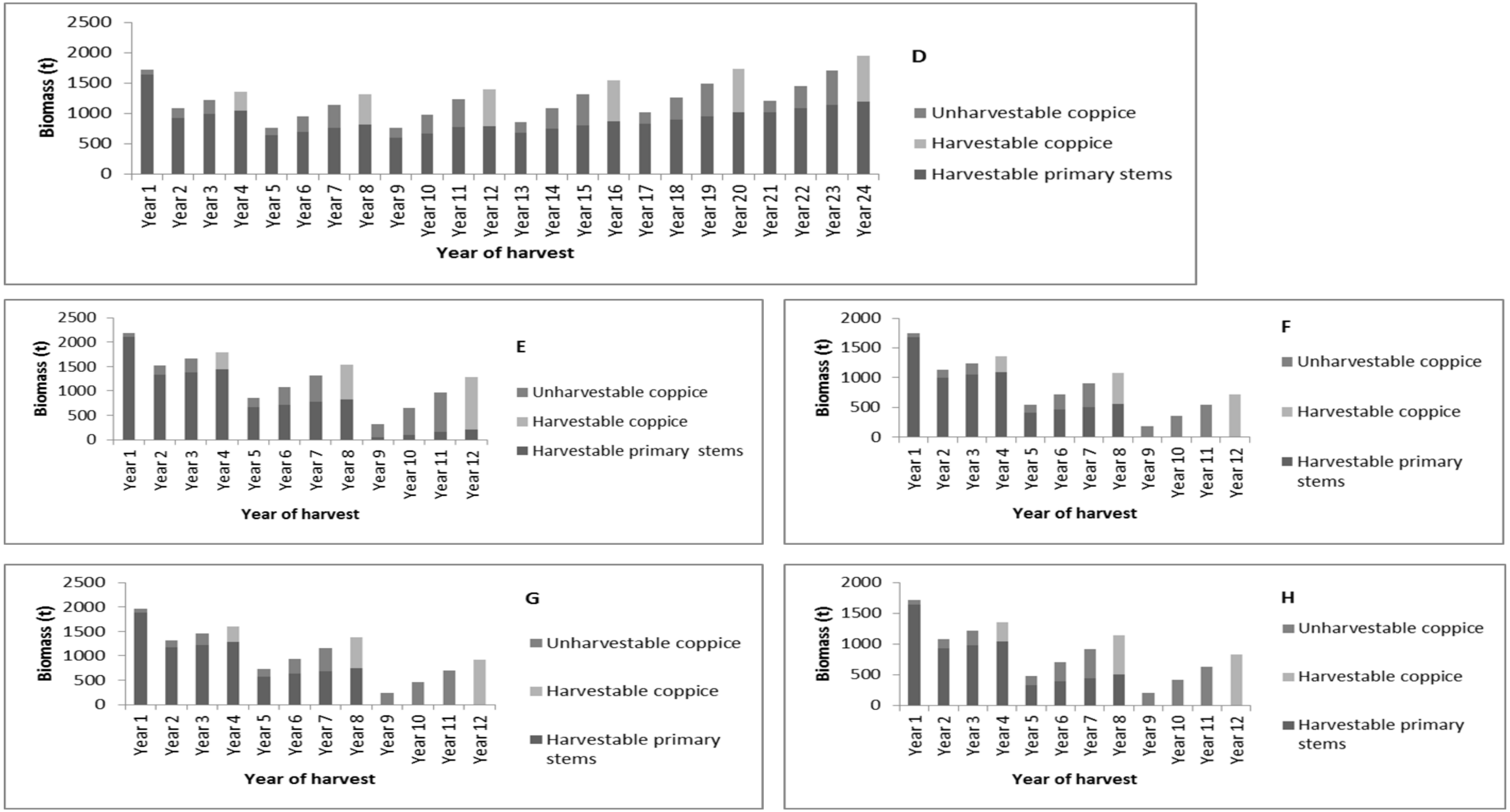



Figure 4.7: The predicted supply of fuelwood based on the scenario where the local resource harvest coppice shoots to meet demand and only switch to the primary stems if the demand is not meet from coppice shoots over the harvest rotations of four years, in Peninghotsa (A, coupe 1, B, coupe 2 and C, coupe 3, and D coupe 4) and the second scenario where resource users had to exhaust primary stems before switching to coppices (D, coupe 1, E, coupe 2, F, coupe 3 and G, coupe 4).

## 4.4 DISCUSSION

### 4.4.2 Standing biomass and resource density

There was a similar pattern in the total standing stock observed in Thorndale and Peninghotsa, which was different from not in Homu 14B. This can be explained by the differences in the effectiveness of traditional management systems in the villages since in Thorndale and Peninghotsa there was some level of effectiveness in enforcing harvesting rules. There was a greater stem density in the smallest size class and fewer stems in the intermediate and large size classes in both survey periods. Such an observation represents an inverse J-shaped size class structure/profile which is usually considered as an indicator of self-replacing populations and an ecosystem with stable populations (Virillo *et al.,* 2011). This is also demonstrated by the density of the saplings increasing significantly during the harvesting trial which can also explain a slight increase in the density of stems in the intermediate size class. This is because there was a little decrease in the number of stems in the intermediate size class despite the removal of stems by harvesting in this size class implying that through CBCM, saplings can be expected to grow into adult trees. This is true especially if their harvesting can prohibited as a matter of policy as it has been the case in this study. For this reason, the fact that changes in growth rate of saplings lead to a major change in tree cover in the past and in the future (Bond, 2008), means that the high density of saplings would translate into more tree cover in communal woodland areas because they recruit to trees (White, 1979).

Lack of significant difference in the density of the stems across the plots at the communal woodland level indicates that there was a uniform distribution of stems in different size class categories across the communal woodland of the study villages. Yet this may also indicates compliance by local resource users because harvesting of saplings was prohibited during the trial, which was a recommendation made by the researcher, unless they were harvested for other purposes. On the other hand, lack of significant increase in the number of stems in the harvestable size class across the study villages may be accounted by the fact that large trees grow slowly (Shackleton, 1997). This is because certain stems in the other last end of the harvestable size class, 4–9 cm could be regarded as large trees based on Shackleton, (2001) classification categories of small, medium and large trees (small, 2–4 cm, medium and large >9 cm). Furthermore, this can also be due to that harvesting of stems occurred in this size class. Prohibiting harvesting of large trees in the large diameter size class, 10–19 cm and >20 cm indicates that through CBCM large trees would be protected in communal woodland areas. This can allow them to grow and provide important habitant such as pollen production and other services for many species, after dying naturally (Ruger *et al.*, 2008). For instance, deadwood provides among others nests, roost sites, food and shelter (Du Plessis, 1995). Thus, this also suggests that the supply of biomass through CBCM will enhance the ability of the savanna ecosystem in providing such ecosystem services. This is also illustrated by that harvesting of fruits trees was recorded only before the harvesting trial despite their harvesting prohibition as per relevant Act. For instance, their harvesting stopped during the harvesting trial. Thus, this means that local extension of fruit trees which have been reported, i.e. in villages around Bushbuckridge (Gandar, 1997) can be prevented through CBCM thereby continuing to offer other ecosystem products such as fruits. This is because the supply of fuelwood would come only from the preferred species. Furthermore, based on the extrapolated biomass supply not all of preferred stems would need to be harvested since the biomass coppice yield could be adequate to meet the village demand from the 8$^{th}$ period in Thorndale in either of the two scenarios.

Although trees in the largest size class had more biomass than trees in the smaller size classes despite their low stem density, it is only the biomass from the harvestable size class that would determine if the standing stock and the resource density could permit for ecological sustainability of rotational harvesting in communal woodland areas. As seen this is primarily because women are the ones who harvest for domestic purposes and do not harvest large stems since they not favour large-diameter fuelwood even when available because it requires splitting before use (Mudekwe, 1997; Abbot and Homewood, 1999).

The availability of old coppice shoots across the study villages indicates that coppice shoots are an important part of the standing stock in communal woodland, but also that they can be a sustainable source of fuelwood. This is because the associated biomass amount although assessed at the communal woodland level was higher than that of the village demand. Thus, this could allow for rotational harvesting without including the unharvested original stems and the ingrowths. As a result, this indicates that in certain villages rotational harvesting can commence on the already existing coppice which are already being harvested in communal woodland areas. For instance, Matsika *et al.* (2013) have found that local people harvested coppice shoots to meet their fuelwood in communal woodlands similar to Homu 14B as found in this study.

With regard to self-thinning of coppice shoots, the density of coppice shoots emanating from new stumps would be high in the first two years since each stump would have a mean number of nine coppice shoots in Thorndale and eleven in Peninghotsa, based on the self-thinning rule derived from old coppice shoots. However, since shoots monitoring was done for nine months, after a year there would be a decline to four coppice shoots per stump in Thorndale and five per stump in Peninghotsa, since self-thinning usually starts after this period (Shackleton, 1997; Shackleton, 2001). For instance, Moyo *et al.* (2016) recorded a decline in the coppice shoots of *Terminalia sericea* between September 2011 and September 2012, there was over 50% reduction in the number of shoots in all treatments.

### 4.4.3 Fuelwood supply in coupes

The project would be sustainable under both the scenarios used in the predictions in Thorndale and Peninghotsa, demonstrating that rotational coppice harvesting strategies are ecologically viable in certain communal woodlands. The emergence of coppice shoots after all the primary stems have been harvested and projected it indicates that under moderate harvesting levels in a rotational system, demand can be met from coppice regeneration.

Less biomass amount removed to meet the village demand in coupe 2 suggests that there was less harvesting for commercial harvesting in the last six months of the feasibility period. Yet, this also indicates that with less harvesting it would take longer for the amount of coppice shoots to meet the village demand because there would be less number of stumps from which coppice shoots can emanate for future fuelwood supply. For instance, based on the observed harvest in coupe 2, the required biomass amount that could meet the village would be achieved on the 36$^{th}$ year period. However, of the two scenarios, the first scenario indicates the reality because coppice shoots are harvested in communal woodland (Matsika *et al.*, 2013) and primary stems (Gandar, 1997; Kirkland *et al.*, 2007), indicating that fuelwood demand is met by harvesting coppice shoots and primary stems. That the prediction from both scenarios indicates that over time there would be enough biomass from the coppice shoots to meet the village demand justifies studies (see Shackleton, 2000; Shackleton, 2001; Shackleton *et al.*, 2004a; Twine, 2009) which recommended rotational harvesting of coppice shoots as a potential source of sustainable fuelwood harvesting. Similar findings have been found by Twine and Holdo (2016). However the amount of coppice shoots predicted might be an underestimate because the prediction was based on the number of shoots that emanated from the small and large coppice stools. For instance, although grouped in the same diameter class 4–9 cm stems in the higher end, e.g. 9 cm are large stumps and large stumps produce more coppice shoots than small ones (Shackleton, 2001; Kaschula *et al.,* 2005). Moreover, the biomass from ingrowth in the harvestable size class recorded in January 2015 might also be an underestimate. This is because the recruitment of saplings to adult trees is mainly affected by the amount of rainfall (Vadigi and Ward 2013), while the amount of rainfall received over the one year poriond was below average in 2014 across all the two provinces (Mpumalanga and Limpopo) (DAFF, 2015). Recording more ingrowth in the small diameter size class, 1–3 cm and less in the large classes, 10–19 cm and >20 cm, indicates that there would be a continuous supply of biomass from the seedling recruitments, while for those in the harvestable size class indicate that the biomass removed for fuelwood supply would be compensated for on annual basis. On the other hand, lack of ingrowth in the large classes, despite some of the stumps being more than five years old shows that harvesting of large trees should be avoided because it would take time to recover biomass loss of large trees. However, in a coppice-with-standards management system, large trees with a stem diameter of 15 cm and above serve as reproductive “standards”, and are not supposed to be harvested (Gandar, 1997) and that such trees were mainly harvested before the trial demonstrates that local people can comply with a coppice-with-standards management system in a CBCM system.

The fact that the projected stem growth in Thorndale could also allow for harvesting every three years means that even in the exclusion of the fourth coupe, which was excluded because of boundary conflicts with the neighbouring the project, would be sustainable (Chapter 6). The differences in the projected growth of coppice shoots between the two villages can be due to factors such as species biology and edaphic factors since they are known to affect coppicing ability of savanna species (Kaschula *et al.*, 2005). For instance, the predicted growth of coppice shoots was 1.44 cm a year, and would be 5.76 cm over a period of four years, while 4.32 cm over a period of three years. Therefore, since the number of coupes, should be equal to the number of years it takes for the cut trees to regenerate and reach harvesting size (Shackleton and Clarke, 2007), 4 cm would be reached in three years. In Peninghotsa, the predicted growth would reach 4 cm over a four year period meaning that rotation harvesting had to occur after every four years although this might be an underestimate. Related findings have been found by Shackleton (2001) who recorded 6 cm growth of coppice shoots for *Terminalia sericea* on large diameter stems > 9 cm, not pruned after a five year period which shows that fuelwood can be supplied in a short rotation in a coppice system. Similar to this study Shackleton (2001) indicated that the observed growth was a conservative estimate because of drought which was the severest drought on record for that region (54% of the mean). Yet this indicates the relevance of CBCM in communal woodland areas, because it means that the supply of fuelwood through CBCM would be less affected by the scarcity of rainfall, since coppice shoots depend on trees with already established root systems. Therefore, with communal woodland areas located in semi-arid region, it means that other supply strategies such as woodlot programmes would be negatively affected since seedlings need enough rainfall to germinate (Neke, 2004). Nonetheless, the growth of coppice shoots is affected by other factors such as soil conditions and nutrients availability suggesting that in other contexts the growth of the coppice shoots of the similar species might differ. This is true particularly because the predicted growth is based on the average growth of coppice shoots of the observed species (Kaschula *et al.,* 2005).

The general decline in the number of seedlings across the study villages shows that the sustinability of CBCM will be affected by the extent to which seedlings of different species recruit. However, seedlings establishment in many contexts are a rare occurrence, requiring sufficient rainfall (Neke, 2004), suggesting that the decline might also be explained by the low rainfall received in the study villages. Nonetheless, seedlings are also vulnerable to other factors such as livestock trampling, competition with grass for limited soil water and nutrients, and herbivory by mammals and insects (Higgins *et al.,* 2000). Thus it is evident that an understanding of these disturbances and even those affecting less common species especially the protected ones should be established to enhance the recruitment of seedlings into adult size classes. This is because the project cannot be considered sustainable if it has negative environmental impact (Auld 1995). This is true especially because sprouters have a threat of increased adult mortality which could be due to habitat alteration or changing growing conditions (Bond and Midgley, 2001). Therefore, this suggests that seedling recruitment is needed to establish new populations to some degree (Auld, 1995) in the CBCM area.

The death of new stumps in the supply of fuelwood in CBCM would not be a problem because stumps are prone to fungal infection when they are too low. At 50 cm from the ground stumps are neither too low nor too high; therefore, they are less vulnerable to disturbances such as fire and browsing (Shackleton, 2001). Therefore, this suggests that reduction of the stumps using the death % recorded from the old stumps might be an over estimate because new stumps were created randomly by harvesting under the traditional rules, meaning that the supply of biomass might also be an underestimate since the chance of the new stumps to survive would be high at 50 cm from the ground.

Harvesting of coppice shoots especially in Homu 14B, demonstrates that in the absence or scarcity of deadwood, local people will continue to defy traditional rules prohibiting harvesting of livewood, especially due to weak leadership and social organization issues as this was evident in this village. For instance, it was only in this village where the headman did not conduct patrols. However, that the supply was able to meet the village energy demand confirms the relevance of CBCM in communal woodlands, while harvesting of coppice shoots indicates that coppice shoots will continue to be harvested whether under CBCM rules or not, but that it would be in an unplanned manner under the traditional management rules. Nonetheless, with less resource security, such harvesting would be prone to over-exploitation by both local people and the outsiders, because there is high incompliance with rules under the traditional management rules. Ironically, harvesting of coppice shoots also reflected this in Homu 14B, because the local leadership recommendend harvesting of *D. cinerea*, which *per se* demostrates an appreciation by the local institutions that deadwood are scarce. On the other hand, the fact that local people were able to meet their fuelwood needs from harvesting of coppice shoots may have discouraged them to engage in CBCM, because they already met their fuelwood from coppice shoots for which the project promoted with the only difference being that harvesting would have to occur in a controlled manner in coupes

## 4.5 CONCLUSION

The study demonstrated that rotational harvesting can provide a sustainable supply of fuelwood in communal woodland villages in South Africa since the savanna species coppice vigorously, without any need of technical support to the local leadership in the process. The average growth of 4 cm of coppice shoots over a four year period means coppice shoots grow relatively fast, therefore, they can provide adequate amount of fuelwood to meet the village demand from each coupe in a rotation of four years. However, it is evident that the ecological sustainability could happen in villages with small user community and sufficient woodland in reasonable condition since the contribution of coppice shoots in such areas could be enough to meet the village demand as seen in Thorndale and Peninghotsa. The general decline in the number of seedlings, suggests that the implementation of CBCM would need to monitor seedling recruitment to ensure continuous supply of new plants by addressing the disturbances affecting them. The impact of re-harvesting would also need to be assessed to determine how many rotations the ecosystem would sustain in coupes before coppice starts losing vigour, since this would affect the supply over time.

# CHAPTER 5

## THE SOCIAL FEASIBILITY OF COMMUNITY-BASED COPPICE MANAGEMENT


### ABSTRACT

Effective management of natural resources in communal lands is dependent on the support and co-operation of resource users. Current fuelwood harvesting rules that prohibit the cutting of livewood do little to secure the natural resource in a context of fuelwood shortages which necessitate illegal harvesting of livewood. One proposed alternative is the legalized but controlled rotational harvesting of coppice. However, the feasibility of community-based coppice management (CBCM) is critically dependant on favourable local social conditions. The social feasibility of such a coppice management has not been tested in the African context. This study thus aimed at assessing the social feasibility of the community-based coppice management, in terms of compliance with harvesting rules and cooperation among local resources users and the local institutions. Data on these aspects were collected using questionnaires, focus group discussions, and key informant interviews before and during the trial. During the harvesting trial, there was a significant increase in the number of respondents who complied with harvesting rules and cooperated with the local institutions, compared to before the intervention. Community members also engaged with the project after the feasibility study period had expired. The results demonstrated that through CBCM the social sustainability can be achieved in communal woodlands while not neglecting the social needs of the poor to harvest fuelwood which is their affordable energy. As a result, this implies that in certain communal woodland areas, in South Africa, social conditions are conducive to community-based coppice management.

## 5.1 INTRODUCTION

Common property tenure systems are still prevalent in communal woodlands and involve management of diverse natural resources such as woodlands, water, artisanal fishery, rangelands, and forests (Heltberg, 2002; Kirkland *et al.,* 2007). Common property refers to resources under communal ownership where access rules are defined with respect to community membership (Heltberg, 2002). However, not all common property resources (CPRs) are managed in any meaningful sense of the term 'common property' (Arnold, 1990). For instance, in India, unreserved forests have turned into an open access type resource within a structure of rules and regulations imposed externally by the state (Arnold, 1990), similar to the woodlands in communal areas of southern Africa (Ainslie, 1999) including South Africa (Kirkland *et al.,* 2007). The breakdown of CPRs management is generally due to decline or collapse of traditional authorities (TAs) (Arnold, 1990), since they are at the core of managing them (Bradley and McNamara, 1993; Nemarundwe and Kozanayi, 2003) applying access rules. However, CPR theory places emphasis, not on power, political conflict or legitimacy as shaping forces of institutions, but on voluntary exchange that is mutually agreed and beneficial, and that supports collective action (McCay 2002).

Collective action is influenced by group size and heterogeneity, which both affect the ability to cooperate and the incentive to agree to a particular action (Lingani *et al,* 2013). For instance, large, heterogeneous groups will be unlikely to act in their group's interest (Lingani *et al.,* 2013), while, small, ethnically homogenous groups may be better at working together in the study area (Cunningham, 2002). This is because in a small group, there is a greater sense of collective identity, making it simple to enforce rules (Murphree, 1998; Cunningham, 2002). Additionally, although conflicts are expected in community based natural resource management (CBNRM) (Fabricius *et al.,* 2004), small group have greater capability to solve them as well as problems related to collective action (Agrawal, 2002). Nevertheless, communities are rarely homogenous groups but are differentiated according to gender, age, income, level of education, distance of household from the forest among others (Cunningham, 2002). These socio-economic factors also influence the perceptions and the attitudes of local people (Racevskis and Frank, 2006) which affect their collaboration in CBNRM (Lingani *et al.,* 2013). On the other hand, the direct benefits resulting from CBNRM projects, influence the development of positive attitudes and perceptions of the local resource users (Mbaiwa, 2004). Although understanding of these is required for designing targeted policy measures to address people's aspirations in sustainable forest such an understanding exists around protected areas communities globally, including southern Africa (Clarke and Gillespie, 2008). This is due to much policy focus to wildlife in such areas which is a concern in South Africa for communal woodland management (Shackleton and Shackleton, 2004a).

Collective action is also eased by the presence of social capital e.g. trust, norms, strong networks (Ostrom, 1994) and the institution that has strong penalties for cheaters in a community (Ostrom, 1999). However, traditional harvesting rules regarding fuelwood in southern Africa over-concentrate on the biological and ecological aspects neglecting social aspects. This is not practicable with the current energy consumption patterns in many areas in communal areas (Fabricius *et al.,* 2004) because it has become difficult for harvesting fuelwood without breaking harvesting rules that prohibits harvesting of livewood in southern Africa (Fabricius, 2004). For instance, in South Africa, resource users harvest livewood out of necessity (Gandar, 1997) and this has become a norm, despite it constituting an illegal activity, due to factors including lack of deadwood (Kirkland *et al.,* 2007; Makhado *et al.,* 2009).

Rotational harvesting of coppice regrowth has been suggested as a promising sustainable source of fuelwood harvesting (Neke *et al.,* 2006), since most of the savanna species readily coppice (Shackleton, 2000) providing an opportunity for rotational harvesting strategies at relatively short intervals (Shackleton, 2001). However, as an approach, a rotational harvesting strategy should be embedded in CBNRM e.g. CBCM, to ensure that all relevant stakeholders, particularly local resource users, participate in project activities such as designing rules. Related projects have proved successfully in Nepal with local people changing attitudes, complying with agreed harvesting rules resulting in the recovery of the resource base (Phokarel, 2008). A few available studies in South Africa have focused on the biological feasibility of the rotational harvesting strategies (e.g. Shackleton, 2001; Kaschula *et al.,* 2005; Twine, 2008), but while these studies provide much needed information on the ecological basis for sustainability, the social sustainability of the harvesting strategies is equally critical (Ribot, 2003). The absence of such knowledge occurs even with the readiness of local resource users in certain communities such those in Thorndale indicating that they can engage in a locally managed coppice system (see Neke, 2004). In the context of the above, this chapter seeks to assess the social feasibility of CBCM in terms of compliance, perception, attitudes and cooperation, guided by the following questions:

- How do attitudes and perceptions affect the cooperation of/among local resource users throughout the trial period?
- To what extent did local resource users participate in the implementation of the project throughout the trial period?
- How does compliance differ across local demographics?

## 5.2 METHODS

Mixed methods (both qualitative and quantitative methodologies) were employed before the harvesting trial and again towards the end of the project to collect relevant data. Key informant interviews were conducted with the senior ranger in charge of each of the study village on two occasions, i.e. before and during the trial. Aspect of compliance with harvesting rules, perceptions and attitudes about the project were covered. Separate focus group discussions facilitated by the researcher were conducted with men, women, youth, and the headmen with council members on two occasions, i.e. before and during the trial. A purposive sampling method was used. In terms of identifying and accessing the required participants in each village, the researcher specified the required number and age (minimum and maximum) of women, men and youth he required to the local headman who arranged them for him (Table 5.1). The same group of participants who took part in the first focus discussion before the trial were considered in the second focus group discussions during the trial and this enabled the research to compare the experiences or the findings of those before and during the trial. The, age, gender and the level of education of the respondents were captured (Appendix 14). During the group discussions aspects of compliance with harvesting rules, perceptions and attitudes about the project were covered similar to the interviews conducted with the government rangers.

Table 5.1: Composition of respondents for focus group discussion before and during the implementation of the trial.

| Village | Group | Sample size | | Age: | | Education: | |
|---|---|---|---|---|---|---|---|
| | | Before trial | During trial | Minimum | Maximum | Level attained | |
| **Thorndale** | Headman and council | N=8 | N=7 | 39 | 85 | Primary | Secondary |
| | Women | N=10 | N=10 | 35 | 43 | Primary | Secondary |
| | Men | N=4 | N=4 | 36 | 49 | | |
| | Youth | N=9 | N=7 | 21 | 32 | Primary | Tertiary |
| **Peninghotsa** | Headman and council (men and women) | N=10 (9 female and 4 male) | N=10 (9 female and 6 male) | 34 | 64 | No schooling | Secondary |
| | Women | N=11 | N=11 | 35 | 53 | No schooling | Secondary |
| | Men | N=6 | N=6 | 36 | 54 | No schooling | Tertiary |
| | Youth | Not done | Not done | | | | |
| **Homu 14B** | Headman and council | N=6 | N=6 | 56 | 92 | Primary | Secondary |
| | Women | N=9 | N=9 | 29 | 57 | Primary | Secondary |
| | Men | N=4 | N=3 | 47 | 64 | Primary | Primary |
| | Youth | N=6 | Not done | | | | |
| **Makhuva** | Headman and council | N=4 | N/A | 59 | 76 | No schooling | Primary |
| | Women | N=10 | N/A | 32 | 46 | Primary | Tertiary |
| | Men | Not done | N/A | | | | |
| | Youth | N=11 | N/A | 21 | 28 | Matric | Tertiary |

Likert scale questionnaires were administered to the sampled households to gather data on the compliance of the local resource to harvesting rules under traditional management and CBCM. The interviews were done in the sampled households which were 30 (30 respondents) in Thorndale and Peninghotsa, 70 (70 respondents) in Homu 14B and 120 (120 respondents) in Makhuva and these constituted a sample size of between 11% and 24% before and during the harvesting trial. Any likert item has two parts: the 'stem' statement and the 'response scale (Johns, 2010). A likert scale is an ordered scale from which respondents choose one option that best aligns with their views, and it is often used to measure respondents' attitudes by asking the extent to which they agree or disagree with a particular question or statement. In this study a likert question was used when assessing compliance based on the respondent in each household which was used as a unit of observation. The participants had to choose either of the following answers: "Agree, Strongly agree, Do not know, Disagree, and Strongly disagree". To compare and contrast the compliance status with harvesting rules under the traditional management rules and those of CBCM, two likert items were used to collect data before and during the trial. Local demographics and socio-economic variables were taken into consideration to capture perception differences accordingly (e.g. age, education, employment and household size (Table 2.1 and Appenidx 14).

In order to measure the effectiveness level of participation by community members in the management system through the different phases of the trial, the participation typology of participation by Pretty *et al.* (1993) was used (Table 5.2). Aspects that demonstrated that local resource users participated in the project were assessed against the typology, and these included decision making and creation of harvesting rules by local resource users in community meetings. The population statistics acquired from the local municipality of each study village was also used to determine the attendance of the local people in relation to the total population size. Direct observations were also used especially to collect data in community meetings.

Chi-square tests were used to determine the difference in the raw frequency data of local resource users accessing fuelwood through buying and/or harvesting, preferring certain species and harvesting frequencies between the two survey rounds. They were also used to determine the difference between the frequencies of individual and community compliance status with harvesting rules, based on the number of respondents indicating either of the likert scale response answer (Agree, Strongly agree, Do not know, Disagree, and Strongly disagree) before and during the project. Statistical Package for the Social Sciences (SPSS) version 23 was used for all statistical analyses. Qualitative data from focus group discussions and interviews were processed and analysed through identifying relevant common themes and quotations from the community members, chieftaincy and government officials. These themes were perceptions and attitudes of local resource users, traditional and relevant government institutions to CBCM and compliance with harvesting rules among local resource users.

Table 5.2: A typology of participation (Pretty *et al.*, 1994).

| Type of participation | Description |
|---|---|
| ***1 Passive participation*** | People being told what is going to happen or has already happened. Unilateral announcement without any listening to people's responses. The information being shared belongs only to external professionals. |
| ***2 Participation in information giving*** | People answering questions: questionnaire surveys or similar approaches. People do not have the opportunity to influence proceedings; findings are neither shared nor checked for accuracy. |
| ***3 Participation by consultation*** | People are being consulted and external agents listen to views. External agents define both problems and solutions; may modify these in light of people's responses. Does not concede any share in decision making; professionals are under no obligation. |
| ***4 Participation for material incentives*** | People provide resources- for example, labour- in return for food, cash or other material incentives. Much in-situ research and bio prospecting falls in this category. |
| ***5 Functional participation*** | People for groups to meet predetermined objectives; can involve the development of externally initiated committees etc. Does not tend to be at early stages of project cycles or planning; rather, it occurs after major decisions have been made. Initially dependent upon external initiators and facilitators; may become self-dependent. |
| ***6 Interactive participation*** | Joint analysis, leading to action plans and the formation of new local groups or the strengthening of existing one. Involves interdisciplinary methodologies, multiple perspectives and learning processes. Groups take control over local decisions; people have a stake in maintaining structures |
| ***7 Self-mobilization*** | Initiatives taken independently of external institutions. May challenge existing inequitable distributions. |

## 5.3 RESULTS

### 5.3.1 Perceptions and attitudes of traditional leadership on the effectiveness community based coppice management.

The chiefs in Thorndale, Peninghotsa, Homu 14B and Makhuva exhibited positive perceptions about CBCM from the first meetings in which the researcher presented the concept. However, in Peninghotsa the headman accepted the project without referring the researcher to the chief as other headmen did in other villages. There was thus no need to approach the chief as it was the responsibility of his headman to inform him. However, the chief was reported to be positive about the project as the headman reported during the conversation with the headman of Peninghotsa:

> "*The chief is excited about the project. He asked me where I found you. He wants it to be implemented in all his villages*. *We were happy when you came here that time but worried that you do not come back so that we start the project, we thought you disappeared*," said the headman.

Furthermore, he also trusted that his people would cooperate with him since he knew them in a community meeting:

> "*We are a small community and these households have lived together for so many years before they were forcefully removed with my grandfathers from a place in Kruger National Park which is under land claim now. There is no one from outside like Mozambicans among us so we know each other very well. When you see that school it was not built by the government but by the community. We have a history of working together. So I trust that we will work together also in this project.*"

In Homu 14B, as in Makhuva, the headmen and some council members were divided between those who had negative and positive perceptions on the project. One of the reasons in Homu 14B was because the project did not have monetary benefits and this was noted in a community meeting. "*Once you speak of a project there should be jobs. People have to participate because this project will help them, not the researcher. That is when we can work in a project," said one headman council member*."

In all the study villages it was found that positive perceptions showed by the chiefs and the headmen in certain villages were mainly based on problems such as lack of compliance with harvesting rules, commercial harvesting by outsiders and budget cut which resulted in inadequate number of rangers to enforce rules. Therefore, they expected the project to help address these problems: "*Since 1994 we have been witnessing escalating problems of cutting of livewood but this is mainly done by outsiders*," said the Peninghotsa headman in a community meeting. "*I feel blessed that the project will help us in solving fuelwood vendors*," said one of the headmen in Makhuva in a community meeting. However, although the chief in Makhuva also expected the CBCM to help address harvesting problems, he blamed the problems on Mozambicans who resided in the village during one of the CBCM meetings:

> "*You are destroying the trees because you know you do not have your umbilical cord here* (do not belong here) *and you may return to Mozambique when things go back to normal in the country*," said the chief.

Like in Makhuva, Mozambicans were integrated in Homu 14B and were also blamed for overharvesting of trees during one of the conversations with the headman council member: "*Mozambicans are the ones causing huge problems here because they hardly get jobs. So they heavily rely on cutting trees for poles to make roofs for hunts*." In Thorndale, although Mozambicans were also integrated, there were few households as reported by one of the headman council member.

Over the study period in Thorndale and Peninghotsa, perceptions affected the headmen and the chiefs' attitudes towards CBCM positively. This was because of improved compliance, reduced intrusion by outsiders and more arresting of offenders during CBCM period. "*This project should not stop; it has really helped us in reducing the problems that we had before*, said the Thorndale headman in one of the community meetings while that of Peninghotsa indicated this in the similar platform: "*We understand that your research period has come to an end and the licence has expired, but we want to continue with the project*." On comparing the two natural resource management (NRM) systems, the headmen in Thorndale and Peninghotsa indicated that NRM under CBCM proved more effective than NRM under traditional management regime administered by TA. Described below are the words by the headman in Thorndale in one of the conversation with the headman towards the end of the project:

> "*Our people have really complied with harvesting rules. When we told them to harvest from one coupe they did exactly that. As we are standing here, you would see vehicles coming in and going out of our woodlands but now it is rare because of that team* (patrol committee) *that patrols*."

The Peninghotsa headman praised the project for instilling sense of responsibility, ownership of the resource base in the community members which improved compliance among local resource users while preventing intrusion by outsiders. He indicated that due to the controlled nature of harvesting access, other stakeholders relevant to NRM around the village assisted with compliance monitoring. For instance, those from the Department of Agriculture, Forestry and Fisheries in charge of monitoring and repairing the redline fence used to alert him and the patrol committee when encountering intruders or hearing cutting occurring during the weekdays.

### 5.3.2 Perceptions and attitudes of the local government institutions on the effectiveness of community based coppice management.

The perceptions of the senior rangers/enforcement officers concerning the project were positive in the beginning of the project in Thorndale, Homu 14B and Makhuva, but not in Peninghotsa. "*The project is good because people are not complying with rules and we are not able to cover all the area, since we are a small number of officers*," said the officer in Thorndale during the first interview. Positive perceptions in Homu 14B and Makhuva were observed based on similar reasons (under the same local department). However, in Peninghotsa, the senior enforcement officer had a negative perception on the project as the quote shows emanating from the first interview: "*Your project Mr Mathebula* (researcher) *will lead to people destroying trees*." A year later positive perception from the enforcement officers in Thorndale had developed into positive attitudes although they did not work closely with the patrol team members in Peningotsa as indicated in the second and last interview. "*Mr Mathebula, your project is good but the problem is that it is in one village. I think you should include all the villages falling under the Mnisi TA*," said the enforcement officer. Similarly, the senior enforcement officer in Peninghotsa had his negative perception changed to positive attitude towards the project as he acknowledged during his presentation in the meeting to discuss the way forward (chapter 6, Figure 1D):

> "*Initially, I asked Mr Mathebula what will happen if local people take advantage of the access given by the research and harvest destructively. To my surprise this has not happened. Instead, it has helped us in arresting fuelwood vendors through cooperation of the village and the patrol team members. We are also learning as we did not have this type of project before,*" elaborated the officer.

Below are the contributions of the project as perceived by the senior ranger:

> "*My colleagues who are with me today were not worried about this village when doing their patrols. They ended their patrol at Phugwani* (neighbouring village) *knowing that in this village people were helping to patrol through the project. We would be happy if Mr Mathebula could initiate this type of project in other villages. Unfortunately, in other villages such as Shigalo, as Mr Mathebula has indicated, trees have been destroyed*."

### 5.3.3 Perceptions and attitudes of the local resource users

From personal observation in Thorndale and Peninghotsa, it was found that all the resource users who were in the first community meeting expressed positive perceptions of the project. For instance, one woman in Thorndale had this to say: "*We are happy and support the project since it promotes conservation of trees. I am in a Marula project and I like it because it will help conserve Marula trees which are creating jobs for us*." Words of support and appreciation for CBCM were expressed by resource users, and volunteered to undertake patrols in these villages. However, there were those who inquired about the possible monetary benefits in the project: *How are those going to work e.g. conducting patrol and compliance monitoring going to benefits*? one man asked.

Over the project period positive perceptions of local resource positively affected the attitudes of the local resource users towards the project. This was evidenced by the collective desire to continue with the project after the feasibility study period had expired by local resource users in Thorndale and Peninghotsa. Conversely, in Homu 141B, local people were divided among those who had developed negative and positive attitudes. Those who had negative attitudes were observed leaving the CBCM meetings whose attendance became poorer over the period. "*We thought it was a meeting for jobs, we need jobs. Who can participate in project without getting remunerated? We are using electricity these days*" said a woman in a group of four women while leaving the meeting. Among youth and men the perception had also developed into negative attitudes as demonstrated by their unwillingness to be interviewed in the second phase. "*They said they cannot attend a project that does not benefit them as it is a waste of time for them. They said they better go to Giyani and look for job than to come here*," a woman narrated. Traditional healers who were part of the selected patrol committee were among the few women who developed positive attitudes on the CBCM: "*As traditional healers, we use trees to heal people, so we are happy because the project will help conserve our trees*."

Like in Homu 14B, local people were divided among those who had negative and positive attitudes in Makhuva. "*We do not want the project because we have deadwood,*" said one woman to the surprise of the headman in a community meeting: "*I am surprised people say there are deadwood where are they because you burn trees and let them dry, is that deadwood*? asked the headman. However, unlike in Homu 14B where the polarized attitudes appeared almost equal 50–50, in Makhuva in relative terms, the majority of the local people showed positive attitudes to the project. "*We want the project, those who say that there is deadwood they will have to go and show us after the meeting*," said one woman. *It is a good project and you should come implement it here*," said another. However, it was found that the woman who spoke of the availability of deadwood had a tendency of opposing the agreement reached in community meetings and that she was mentally challenged. This was revealed during the conversation with one of the woman after the meeting. "*Do not take her seriously. She does that in most meetings. Most people want the project*."

### 5.3.4 Participation of local resource users in the project

The community meetings participation statistics reported are only for the first and the last community meetings for the academic period in Thorndale and Peninghotsa (Table 5.2). However, in Peninghotsa youth younger than 21 years were not allowed in community meetings and also for the project, therefore, the statistics would be an underestimate since the total attendance also includes them. "*We do not allow people of less than 21 years of age to* *attend community meetings, but do so when we have issues that relate to them,*” said the headman during the first focus group discussions. In Homu 14B and Makhuva, only the statistics of the meetings that were highly attended are presented (Table 5.2). This was because many meetings were held especially in Homu 14B some of which were poorly attended with only the researcher, the headman and his council members present. Moreover, in Homu 14B, no specific information on the total population in the project area existed since the available population number on census was 3 012 which included all Homu village sections (A and B). Hence, unlike in other village there was no breakdown of attendance based on gender.

Table 5.3: Participation statistics in the first and the last project meeting in Thorndale, Peninghotsa, Homu 14B and Makhuva (source: Statistics South Africa, 2011).

| **Village** | **Total village attendance** | **Total female attendance** | **Total male Attendance** | **Female population** | **Male population** | **Village Population** |
|---|---|---|---|---|---|---|
| **Thorndale** | | | | | | |
| First meeting | 9.53% (49) | 10.80% (31) | 7.92% (18) | 287 | 227 | 514 |
| Last meeting | 10.31% (53) | 13.58% (39) | 6.16% (14) | 287 | 227 | 514 |
| **Peninghotsa** | | | | | | |
| First meeting | 8.00% (64) | 7.47% (34) | 8.64% (30) | 455 | 347 | 802 |
| Last meeting | 8.22% (66) | 9.23% (42) | 7.20% (25) | 455 | 347 | 802 |
| **Homu 14B** | | | | | | |
| Highest attended meeting | 1.69% (51) | 38 | 13 | - | - | 3 012 |
| **Makhuva** | | | | | | |
| Highest attended meeting | 2.24% (81) | 1.59% (26) | 2.79% (55) | 1970 | 1633 | 3 606 |

Regarding the attendance statistics of local resource users in the patrol committee, women had higher proportion than men constituting 66.7% (10 in 15 members) in Thorndale and 60% (12 in 20) in Peninghotsa. However, in Thorndale, the number of local resource users decreased from 15 to 12 members because of three youth who got employed in the nursery in Kruger National Park. Ironically, this came as result of the project because of the botanical knowledge acquired from the project. Such knowledge came through an empowerment by the researcher who undertook ecological surveys with the patrol committee members every quarter as revealed during the focus group discussion with youth:

> “*Three of us* (patrol committee members) *have been employed in the nursery in Kruger National Park. It was through the knowledge we got from the project that we got the job. For instance, during the interviews they asked us the name of the trees that we learnt during the project while doing the ecological survey every three months with you* (researcher), said one member.

In Peninghotsa, ecological monitoring with the patrol committee was not easy because some of the members belonged to other local institutions such as civic and NGO, and their schedules were, therefore, unpredictable. However, no decrease in the number of patrol committee was reported in Peninghotsa. Unlike in Thorndale, there were no youth of less than 21 years of age because of the age restriction of such people in the project.

The participation in Thorndale and Peninghotsa was judged to be at level 6 of the participation typology (interactive participation). As observed during community meetings, not only did local people designed the rules of the project but the implementation of the project but its implementation was contingent upon their involvement after the project was conditionally accepted by the headmen. In order for the participation of local people to be considered effective they should be involved in the planning and the implementation of the local initiatives (Fabricius, 2004), which was the case during the trial in Thorndale and Peninghotsa. However, although local resource users were given an opportunity to design harvesting rules, they restricted their discussions to matters pertaining to access. They did not discuss about the rules regarding penalties despite the headmen not prohibiting them to talk about it since he gave prescription such as harvesting of *Dichrostachys cinerea*. Instead they wanted the headmen to continue using the money received from fining rules violators and this was indicated by one of the women during conversation with the researcher after a community meeting. “*We are happy because when the patrol committee find offenders they will bring them to our headman, meaning the fine money will be used by our own son and not go to the chief in traditional authorities in Madonsi*, said one women” On the other hand, the headmen in Peninghotsa demonstrated a democratic approach during the discussion of such rules. For instance, a count of vote to make a ruling was done between the two preferences which saw those who preferred access on Saturdays and Sundays winning and endorsed by the headman towards the end of the meeting. “*Those who preferred to harvest on Fridays and Saturday should accept that they have been defeated by those who preferred to harvest on*

*Saturdays and Sundays. This means harvesting will be done on Saturdays and Sundays*," the headman said.

Local people participated throughout the project period on aspects pertaining to the project. For instances, in Thorndale patrol committee members requested the headman to summon a meeting to find replacements of those members left for job opportunities. In Peninghotsa, proposed policing changes by the patrol committee were done in a meeting which was summoned by the headmen after a request was made by the committee members that women members patrol within the nearby places only, with men going deep into the communal woodlands. In Homu 14B, it was not easy to assess the participation level because the local resource users were not interested in the project.

### 5.3.5 Individual and community compliance with harvesting rules

There was a significant difference in the proportion of the respondents who agreed (agree and strongly agree) with the statement that they had complied with the harvesting rules during the two survey periods, and was high during the trial, e.g. more than 80% in Thorndale and Peningotsa $\chi$ (4)=31.192, $p$<0.001) and $\chi$ (4)=30.545, $p$<0.001) respectively (Table 5.6). Similarly, significantly more respondents agreed with the statement that more community members have complied with harvesting rules during the second survey of CBCM than in the first survey in Thorndale and Peninghotsa $\chi$ (4)=25.362, $p$<0.001) and $\chi$ (4)=30.984, $p$<0.001)) respectively (Table 5.7). In Homu 14B, more than 80% of the respondents acknowledged to have failed to adhere to harvesting rules while in the second survey the number was insignificantly reduced $\chi$ (4)=7.724, $p$=0.102) (Table 5.6). More than 90% of the community members were reported to have failed to comply with harvesting rules in the first survey and the second survey $\chi$ (4)=9.724, $p$=0.432) (Table 5.7). However, one of the reasons could be the death of two enforcement officers who resided in the village as it was found out during the second survey. "*People now are no longer afraid because of the death of the enforcement officers who resided in the village, that is why the situation is even worse now*," said one woman. In Makhuva, more than 80% of the respondents acknowledged to have failed to comply with harvesting rules with more than 90% of the community members also reported to have failed to do so.

"*You do not harvest livewood and protected species as it is illegal to do so*" (individual compliance statement before the trial) and, 2 (during the trial): *You harvest only from coupes on Fridays and Saturdays (Thorndale) or Saturdays and Sundays (Peninghotsa) based on agreed rules during the workshop meeting*".

Table 5.6 Individual compliance reported from the household energy surveys in, A) Thorndale, B) Peninghotsa, C) Homu 14B) and, D) Makhuva.

| | **Agree** | | **Strongly agree** | | **Do not know** | | **Disagree** | | **Strongly disagree** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **1st survey** | **2nd survey** | **1st survey** | **2nd survey** | **1st survey** | **2nd survey** | **1st survey** | **2nd survey** | **1st survey** | **2nd survey** |
| **Thorndale** | 17.30% | 67.90% | 3.40% | 25.00% | 6.90% | 3.60% | 65.50% | 3.60% | 6.90% | 0% |
| **Peninghotsa** | 13.80% | 82.10% | 6.90% | 7.10% | 6.90% | 3.60% | 48.30% | 7.20% | 24.10% | 0% |
| **Homu 14B** | 3.20% | 6.50% | 0% | 4.80 % | 9.50% | 6.50% | 68.30% | 50.00% | 19.00% | 32.30% |
| **Makhuva** | 9.30% | | 0.80% | | 4.20% | | 7.46% | | 11.00% | |

"C*ommunity members do not harvest livewood as it is prohibited to do so*" (community compliance statement before the trial), and 2 (during the trial): *Community members harvest only from coupes on Fridays and Saturdays* (in Thorndale) *or Saturdays and Sundays* (in Peninghotsa) *based on agreed rules*".

Table 5.7 Community compliance reported from the household energy surveys in Thorndale, Peninghotsa, Homu 14B and Makhuva.

| | **Agree** | | **Strongly agree** | | **Do not know** | | **Disagree** | | **Strongly disagree** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **1st survey** | **2nd survey** | **1st survey** | **2nd survey** | **1st survey** | **2nd survey** | **1st survey** | **2nd survey** | **1st survey** | **2nd survey** |
| **Thorndale** | 10.30% | 53.60% | 13.80% | 35.70% | 7.40% | 3.60% | 62.10% | 7.10% | 6.40% | 0% |
| **Peninghotsa** | 6.70% | 74.10% | 13.80% | 10.70% | 3.70% | 8.10% | 17.20% | 7.10% | 58.60% | 0% |
| **Homu 14B** | 1.60% | 3.20% | 0% | 0% | 4.80% | 0% | 72.20% | 52.40% | 21.4 | 44.40% |
| **Makhuva** | 3.40% | | 0% | | 5.10% | | 67.80% | | 23.70% | |

### 5.3.6 Socio-economic influence on compliance

Compliance based on age, education, household size and employment status of the household were assessed (Appendix 10, 11, 12, 13). High frequencies of those who acknowledged incompliance with rules in the first survey were in the middle-aged class (35–60) across the study villages, and also turned to be significantly higher during the trial in Thorndale $\chi$ (6) =12.450, $p<0.05$) and Peninghotsa $\chi$ (8)=22.154, $p<0.05$). This indicates the existence of relationship between the age of resource users and fuelwood harvesting. For instance, those in the middle class are women who are responsible for cooking in the households, therefore, they are the ones who suffer most in the scarcity of fuelwood and vice versa. Regarding education, the majority of those who reported to have not complied with harvesting rules before had primary education whose number turned to be significantly high during the trial in Thorndale $\chi$ (9) = 31.221, $p<0.001$). This also indicates the availability of relationship between education and resource users because those with tertiary education are likely to be employed as professional, therefore, can afford electrical appliances. No significant difference was recorded regarding compliance and education in Peninghotsa $\chi$ (8)=9.801, $p=0.633$), similar to Homu 14B $\chi$ (12) = 15.209, $p$ 0.230), contrary to Makhuva where many of those who reported to have not complied with harvesting rules had secondary education $\chi$ (16)=28.733, $p<0.05$). Across the villages, there was no significant difference associated with employment status, Thorndale $\chi$ (3)=0.258, $p=0.968$), Peninghotsa $\chi$ (4)=2.097, $p=0.718$), Homu 14B $\chi$ (4)=4.990, $p=0.297$) and Makhuva $\chi$ (4)=5.653, $p=0.227$).

## 5.4 DISCUSSION

### 5.4.1 The impact of perceptions and attitudes on community-based coppice management and cooperation

Across the study villages, all the chiefs showed positive perceptions of CBCM with all their headmen except one of the headmen in Makhuva. The fact that positive perception of CBCM was prompted by the hope that it would help address NRM problems, points to convergent thinking that participatory approaches such as CBCM can be well received in certain villages where such problems exist. This is because perceptions are an indispensable form of evidence that is useful in conservation (Bennet, 2016). Perceptions affect people's attitudes towards management practices either positively or negatively (Ormsby and Kaplin, 2005), at the same time, attitudes change with experience (Heberlein, 2012). This has been case in Peninghotsa where the change from unfavourable to favourable attitudes by the senior enforcement officers in the department of environmental affairs was based on the observed CBCM benefits such as improved compliance, reduced harvesting by outsiders among others. Favourable attitudes towards CBCM indicate that CBCM was more effective than the traditional top down NRM system. Therefore, stakeholders are willing to work in partnership with the community in NRM and this is in agreement with Buchenrieder and Balgah (2013) that community based forest management is often advanced as a remedy for failing top-down approaches to nature conservation. Similar observations were made by Mary (2011) in Chumkiri in Cambodia South-Eastern Asia where the forest got heavily degraded due to forest exploitation by both outsiders and insiders. Being aware of these issues, in 2001, the Community forestry research project (CFRP) and relevant institutions initiated community forestry named Domnak Neak Ta Thmor Puan with an area of 992 ha forestland which was effective. In the central Yucatan Peninsula and Mexico, Ellis and Bolland (2008) found that community-managed forests were more effective than state-protected areas. However, in Malawi, Zulu, (2008) found that the forests deteriorated under community management and blamed this to competition between the local community forest committees and traditional institutions as well as a lack of accountability of leaders at the community level. This highlights the importance of relationships and cooperation among stakeholders in participatory approaches, which in this study was observed in Thorndale and Peninghotsa contrary to Homu 14B. For instance, the relationships in these villages between the local structures, e.g. civic organization and that TA existed even before the trial and were strengthened by the project during the trial (chapter 6).

Perceptions, in turn affect people's attitudes towards management practices either positively or negatively (Ormsby and Kaplin, 2005). Different perceptions and attitudes towards CBCM in the study villages could be associated with different levels of dependence on fuelwood by local people, since perception is first determined by the dependency on the forest resources and then by the reception of the project or not (Ratsimbazafy *et al.*, 2012). For instance, if an individual is highly dependent on a resource, one can assume that he or she places greater value on that resource's long–term sustainability than someone who is not dependent on that resource (Cunningham, 2002). The positive attitudes of the traditional healers in Homu 14B demonstrate their high dependence on woodland for resources where they harvest medicinal plants, similar to Thorndale where one resource user was employed in a marula project.

Therefore, this suggests that local resource users may be aware that they are the ones who stand to lose or gain from their unsustainable or sustainable use of natural resources. Thus, given an opportunity to contribute to the natural resource sustainability they are willing to do so as demonstrated by the desire to continue with CBCM after the expiry of the feasibility period in Thorndale and Peninghotsa where higher dependence was observed. Most communities that are fully or partially dependent on the forest for their livelihoods play an important role in the participatory natural-resource-management approach (Manandhar and Shin 2013). This suggests that in Thorndale and Peninghotsa, CBCM could be socially sustainable because participatory initiatives have proved to be most successful in situations where stakeholders have positive attitudes to such initiatives (Bauer 2003).

Previous studies show that monetary incentives and rewards can be beneficial in incentivizing community participation and adopting conservation behaviours and more positive attitudes (Stem *et al.*, 2003). This implies that had the CBCM involved monetary benefits, participation of people would have been higher in the study villages especially those who were unemployed. Nonetheless, the findings from Thorndale and Peninghotsa demonstrate the opposite. Without monetary benefits local people participated freely although funding possibilities occurred, this was at the later stage of the project and had little impact on the participation of the local people. Therefore, monetary incentives are not always successful in changing conservation behaviour agreeing with Winkler (2011). Furthermore, material incentive distorts perceptions, as it creates dependencies and misleading impressions that local people are supportive and when such incentives stops local people cannot continue. However, this only occurs when local people lack capacity and skills (Winkler, 2011), suggesting that capacity building would be required when such funding possibilities materialize for CBCM in Thorndale and Peninghotsa. Similar observations have been made by Nott *et al.* (2004) in Namibia in Torra conservancies where the committee members did not know how to utilize funds because the executive was employed elsewhere.

Socio-economic context prior to implementation of the CBNRM should be considered (Yeatman *et al.,* 2003; Fabricius and Collins, 2007; Twine *et al.,* 2003b). Findings from this study are in agreement with those of the aforementioned authors since it played a role in preventing support for CBCM in Homu 14B. Local socio-economic context determines the level of social cohesion (Yeatman *et al.,* 2003). However, social cohesion improves when social capital conditions are met (Pretty and Ward, 2001)-relations of trust, reciprocity and exchanges, common rules, norms and sanctions and connectedness in networks and groups because it facilitates cooperation. For instance, people have confidence investing in collective activities knowing that others will do so (Yeatman *et al.*, 2003; Pretty and Ward, 2001) alluding to CBCM harvesting rules. Therefore, social capital is one powerful determinant in the success of CBNRM (Ostrom, 1999) and a requirement before CBNRM implementation (Pretty, 2003). This suggests that social capital can have existed before the CBCM in Thorndale and Peninghotsa hence the resource users worked together and managed to attain the desirable outcome in these villages. This is because almost all people in Thorndale had the same origin which is linked to shared values, which is a reflection of social capital reflection (Gauntlett, 2011). Similar findings have been found by Silva and Mosimane (2014) in Mayuni conservancy, where ethnic homogeneity in communities played a lesser role to shared norms since resource users were made up of individuals that have lived together in the same area for generations and have developed shared norms and culture. Conversely, although in Homu14B and Makhuva local people were of the same ethnicity like those in Thorndale and Peninghotsa, the large number of people from Mozambique could explain the lack of shared values in these villages.

Trust is an important element of social capital (Winter, 2000) and lubricates cooperation (Pretty and Ward, 2003). In Thorndale, during her doctoral research, Neke (2004) found that local people had lost confidence in the local TA and the department of environmental affairs because they did not have enough resources to police their communal woodland, as this led to more and more outsiders invading the village common. As a result, local people were eager to engage in a locally managed coppice system as they trusted in their collective to address the overharvesting problems for which the TA and the relevant government had proved ineffective or failed to address. Thus, the willingness by local resource users to engage in CBCM indicates the continuation of the eager noted relevant scholar (see Neke, 2004). Similarly, in Peninghotsa, loss of trust was demonstrated by the headman's council member after dismissing the need for cooperation between themselves and the government enforcement officers. Like his people, the headman also believed that local people would work together and be effective in carrying out the CBCM given the history of cooperation such as having built school on their own without government assistance. However, this was mainly based on the basis that they were a small community and knew each other very well which agrees with Shyamsundar and Ghate (2011) findings that group sizes matters. For instance, in a small user groups there is identity since people can easily come face to face, enabling members to interact with each other and prevent people from defaulting on cooperative agreements (Olson, 1965). Moreover, people cooperate while free-riding is easily overcome (Olson, 1965) which was observed in Thorndale and Peninghotsa. However, recent research suggests that middle level groups do particularly well with forest management (Nagendra, 2007) because they have the resources to participate in rule formation, monitoring and enforcement. Nonetheless, from the findings of this study, the desirable outcomes were achieved only in Thorndale and Peninghotsa which were all small communities. In carrying out monitoring and enforcement duties local resource users did not need any resources as they patrolled on foot. Enforcement challenges such as defiant intruders as seen in Peninghotsa were overcome through partnership with government enforcement officers. Therefore, this suggests that although small group may lack adequate resource as Nagendra (2007) argues, through partnership with relevant stakeholders such challenges can be overcome. On the other, no harvesting problems were encountered in Thorndale that was beyond the capacity of the village. This further suggests that small group can be effective even in the absence of partnership or support to address problems but this will depend on the magnitude of such problems.

### 5.4.2 Participation of local resource users

The increase in the overall attendance of the local resource users in the last community meeting during the trial increased in Thorndale and Peninghotsa indicates that the interest that local resource users had on the project increased not only over the trial period, but beyond it. This is demonstrated by the local resource users continuing to be involved in the project after the expiry of the harvesting trial period. However, the increase in the female attendance indicates that the project continued to benefit them by providing the required access since they are the ones who are mainly involved in domestic fuelwood harvesting, for which the project was all about. For the local resource users to participate in ecological surveys indicate that the CBNRM project managers and facilitators can share their knowledge and experiences to the local people. This would ensure that local people acquire knowledge required for the sustainability of the project which would be important because it means that the project can continue with minimum or without outside facilitation which is the ultimate aim of the CBNRM (Fabricius, 2004). The appointment of three youth patrol committee members in the nursery in Kruger National Park indicates that such knowledge can also help local resource users especially youth to get employment. Their employment means that the project has in addition to promoting access to fuelwood contributed towards reducing unemployment since this means that the number of household without employed members were reduced. Lack of youth participation of younger than 21 years of age in Peninghotsa indicates that opportunities to empower them would be forfeited and this would not be good for the long-term sustainability of the project. This is because if there is no interest from the young ones it means that there would be less and less number of people who would voluntarily participate in the project activities such as taking part in the patrol committee in the future.

The participation of local resource users in community meetings and designing rules was mediated by the traditional institutions, indicating traditional institutions' appreciation of the importance of local people's participation in CBNRM. For instance, community meetings were used as forums by local institutions for local people to participate and have their views on CBNRM (Logan, 2008). This was evidenced by all local headmen across the study villages accepting the project tentatively and implemented it when local people approved it in a public meeting. Similar findings have been found by Logan (2008) that through community gatherings local people are given an opportunity to give their opinions and participate in consensus-based decision making. Such gatherings are known variously e.g. as *pitso* (Lesotho), *kgotla* (Botswana), *shir* (Somalia), *baraza* (Kenya) (Logan, 2008), while in this study they were called *ahubyeni* (Tsonga/Shangaan language, South Africa). Although traditional system sometimes exhibit characteristics that are profoundly un- democratic, especially, in terms of leadership selection since it is hereditary (Logan, 2008), it is evident from the results that they are effective in terms of enabling participation of local people.

Defining local participation and monitoring the level of participation of all stakeholders across all stages of project management is crucial if conservation is to achieve effective community participation (Rodríguez-izquierdo *et al.*, 2010). In this study, on their prescription for participation, the headmen did not prohibit discussion regarding who should benefit from the money accrued from fining rules violators during the trial. Surprisingly, instead of discussing about it local people especially women indicated their satisfaction for the headmen to continue using the money accrued from fining rules violators. This indicates that local people are happy with the way traditional structures operate (chapter 6), and that they also want to see their leaders benefit in CBNRM or see them being better off in their communities. Similar findings have been in CBNRM in Makuleke where local people were happy that their chief be bought a nice car (Fabricius *et al.,* 2004). For the patrol committee members to propose to their headmen in Thorndale that a community meeting be held to replace those committee members who left for employment demonstrates that traditional leadership is more accessible. The findings agree with Logan (2008) who further indicates that traditional leadership is closer to people than any other system of government. Under such a system people have more direct access to their leaders because they live in the same village and because any individual can approach the leader and ask him or her to call a meeting. That in Peninghotsa the patrol committee members also requested the headman to summon a meeting to discuss their recommendations of changes in the patrolling approaches substantiates this. Therefore, this indicates that local leaders recognize where to draw the balance regarding their powers and the need to promote participation of their own people. The fact that in all the study villages it was the community members whose decisions were key to determining whether or not the project progressed illustrate this. On the other, the failure of CBNRM under democratic institutions such as local civic institution in Fish River in the Eastern Cape Province (Cocks *et al.,* 2001), indicates that democratic institutions may as not as effective as traditional institutions in promoting the sustainability of CBNRM in communal areas. However, democracy has succeeded in north-western Europe and in a few countries outside Europe because it has become entwined in the traditions of the people. In its developed form, the western model assumes levels of mass literacy, communication, economic development, individualism, a sense of national identification that simply does not yet exist in most sub-Saharan African countries (Logan, 2008) as seen from the socio-economic information in this study.

### 5.4.3 Compliance with harvesting rules and the socio-economic influence

A high proportion of stems in the intermediate size class provides evidence of compliance because the local leadership only allowed harvesting of stems in this class. This can be attributed to the freedom given to local resources users by the TAs, government departments to design and agree on harvesting rules that suited their harvesting patterns since it is key in fostering compliance (Ostrom, 1990). For instance, women who are the main resource users were given the responsibility to agree on harvesting rules such as days and time that most suited them by the headmen. This also shows an appreciation of gender relationship in NRM by the local leadership. The fact that compliance with harvesting rules in Thorndale and Peninghotsa improved during the trial demonstrates that rules restricting harvesting of livewood are a burden to the local resource users. This is true particularly because deadwood is scarce or no more in certain villages. Therefore, rules that restrict harvesting of livewood in such areas are bound to be broken because subsistence harvesting of fuelwood is important in many communities (Scoones *et al.,* 1992). The results in Homu 14B was a case in point, because poor compliance was based on traditional rules that inhibited harvesting of livewood since harvesting trial did not occur in this village.

When local people agree to the rules, enforcement is easier (Ribot *et al.,* 2010), and this has been the observed during trial in Thorndale and Peninghotsa. Consequently, the probability of violators for being caught during the CBCM period was higher than before and can be the reasons for compliance in Thorndale and Peninghotsa which agrees with work elsewhere. In Malawi, Abbot and Mace (1999) found that women harvested fuelwood illegally in Lake Malawi National Park because of low patrolling efforts. Of the 42 wood collection groups tracked, enforcement officers/rangers were encountered on only five occasions, suggesting that women had an approximately 12% chance of being caught by patrollers. In Massachusetts, Sutinen and Gauvin (1989) show that the rate of violation of lobster fishermen varied with perceived probability of detection and conviction. Twine and Moshe (2003) and Twine (2005) in South Africa, found that local people and fuelwood vendors harvest live trees with impunity, knowing that the chance of getting caught is slim. Therefore, the probability of detection is a highly significant factor in the poacher's decision to hunt (Williams and Gulland, 1992). This suggest that in Homu 14B poor compliance could be linked to low probability of offenders for being caught because there was no policing by local people as in Thorndale and Peninghotsa: since enforcement was the responsibility of the TA and the department of environmental which prior to CBCM were cited as the major reasons for problems in the village as already been demonstrated. Furthermore, two enforcement officers who resided in village passed on over the CBCM whose death was cited as the reasons for an increase in non-adherence to harvesting rules by community members. This substantiates the importance of visible policing since it increases the probability of offender for being caught.

A number of scholars have called for the implementation of CBNRM in communal woodland to help address overharvesting and compliance problems (see Shackleton and Shackleton, 2004a; Makhado *et al.,* 2009). With no published or known CBCM study in South Africa, the findings respond to such calls demonstrating that compliance problems can be reduced through CBNRM projects such as CBCM in such areas. However, the socio-economic conditions indicate that this can only occur in areas with high dependence on the resource and where the group is small. The findings support those of Twine *et al.,* (2003b) who found that local people in certain villages such as those in Limpopo and Mpumalanga were willing to engage in CBNRM to help address such problems. Similar approaches have been promoted successfully in west Africa termed “Farmer Managed Natural Regeneration (FMNR).” For instance, although they are not necessarily representative of the broader population, farmers identify, protect and stimulate the growth of naturally regenerating shrubs and trees in their fields (Haglund *et al.,* 2011).

That many people who reported to have not complied in Thorndale and Homu 14 had primary and secondary level education across the study villages indicate that the majority of resource users are less educated, which is not surprising because those with tertiary can afford electricity because of good income. Similar findings have been found in Nigeria where those with less education used fuelwood because they could not afford modern energy (Baiyegunhi and Hassan, 2014). On the other hand, lack of significant difference on compliance based employment status indicates that fuelwood is used by those employed and those not alike. This is true particularly because the majority of those employed worked as labourer (unskilled workers) (Appendix 14). Hence, similar to those not employed, they find it hard to afford electric stoves.

## 5.5 CONCLUSION

This study has demonstrated that implementing CBCM would potentially be socially feasible only in communal woodland areas with small population size as illustrated by local resource users in Thorndale and Peninghotsa reporting compliance. This corresponded with harvesting of stems in the intermediate size class which demonstrates the interconnectedness of social and ecological concepts in an attempt to achieve the sustainability of communal woodland resources. The fact that the majority of the resource users did not comply with harvesting rules before the trial indicates that with negative perceptions and attitudes to traditional harvesting rules, local resource users will continue to defy them because they do not have other options but to harvest livewood. This is because they are too poor to afford electricity, meaning that if sustainable harvesting of fuelwood is to be achieved in communal woodlands, controlled access would be recommended because this can enable local resource users to participate in designing harvesting rules that they can adhere to thereby leading to social sustainability central to achieving ecological sustainability.

# CHAPTER 6

## CAPACITY OF LOCAL GOVERNANCE SYSTEMS TO SUCCESSFULLY IMPLEMENT COMMUNITY-BASED COPPICE MANAGEMENT

### ABSTRACT

The problem of overharvesting of fuelwood is widespread in communal woodlands and this is blamed partly on the lack of capacity of the relevant local institutions to enforce harvesting rules, and their perceived legitimacy among others. In order to address this problem, the participation of the local resource users has been recommended as carrying potential to address the incapacity problems among the local institutions. One such recommendation is community-based coppice management (CBCM). However, as to whether or not the local governance can be conducive towards enabling the implementation of such a management system is yet to be established, especially given its novelty. For instance, good leadership and cooperation among the local institutions are necessary for the successful implementation of community-based natural resource management (CBNRM), but since much focus of CBNRM has been in protected areas in Africa, there is no basis for estimating the institutional feasibility of CBCM. This study thus sought to assess capacity of local natural resource governance systems to successfully implement CBCM. Questionnaires, focus group discussions and interviews and design principles were used to gather data before and during the trial on the level of cooperation, perceived legitimacy, capacity of relevant institutions and effectiveness of the governance management system. The local traditional institutions were considered by all groups to be the relevant and legitimate institutions for managing the CBCM system. The incapacity problems were resolved though monitoring by local resource users. The adaptive capacity and the flexibility of the leadership in Thorndale and Peninghotsa contributed to the successful implementation of CBCM which completed one full adaptive management cycle of the trial. However, problems associated with boundaries would need to be addressed for long-term sustainability of CBCM. The lack of transparency and the use of absolute power contributed to the failure of the trial in Homu 14B and Makhuva. This implies that through CBCM, the incapacity problems could be resolved in communal woodlands. This is likely to result in a cost saving for the local institutions because enforcing rules would be undertaken by local people voluntarily. This is important in

a context where none of the relevant institutions have adequate resources to address harvesting problems.

## 6.1 INTRODUCTION

CBNRM is a term to describe the management of local natural resources by collective, local institutions for local benefit. CBNRM can be based primarily on subsistence uses of resources such as Non-Timber Forest Products (NTFP) (Roe *et al.,* 2009) which include fuelwood (Ninan, 2006). CBNRM has been implemented throughout the world (Fabricius, 2004), and become an important strategy for the conservation and sustainable use of biodiversity and wildlife in Africa (Newman and Webster, 1993). In southern Africa, the implementation of CBNRM started during the mid-1980s when natural resource management (NRM) institutions began to realize that they lacked financial and human resources to effectively prevent resource degradation (Koch, 2004). Therefore, CBNRM is a response to the limitations of a resource management paradigm based on bureaucratic centralization (Pinkerton, 1989). Notable benefits have been seen under CBNRM in communal areas, for example, communal woodlands with the Community Areas Management Programme for Indigenous Resources (CAMPFIRE) CBNRM project in Zimbabwe, such as Mahenye, have a greater variety of wildlife than communal areas without it (see Average and Ephraim, 2010). However, effective local governance is central to CBNRM (Turner, 2004).

Traditional authorities (TAs), which are a type of institution in which the authority of a ruling regime is largely tied to tradition or custom (Lumen, 2005), have weakened in many areas in southern Africa (Campbell *et al.,* 2001; Twine *et al.,* 2003; Shackleton and Shackleton, 2004b; Turner, 2004; Twine, 2005). This has serious implication for CBNRM projects (Twine *et al.,* 2003b; Shackleton and Shackleton, 2004a; Tuner, 2004). For instance, in certain parts of South Africa, such as Fish River in the Eastern Cape, TAs are completely eroded and replaced by modern structures such as civic organizations (Cocks *et al.,* 2001). This has hindered successful implementation of CBNRM (Cocks *et al.,* 2001). However, TAs carry the potential to either positively or negatively influence NRM (Grundy and Michell, 2004). For instance, in Namibia, the exclusion of the traditional leadership from new CBNRM structures resulted in conflict and delays, and their subsequent co-option onto the conservancy committees (Campbell and Shackleton, 2001). Nonetheless, other studies have shown that traditional leaders too are not immune from using their position of office to serve their own interests (Ribot, 1999; Shackleton *et al.*, 2001), but this mainly happens when their legitimacy is questionable (Mwalukomo, 2008). In most savanna woodlands in the former homelands areas of South Africa, TAs still exist (DWAF, 1997), and currently share management responsibilities with structures such as community development forums (CDF), district municipalities, and provincial authorities (Kirkland *et al.,* 2007). However, there is a lack of clarity with respect to the roles of each authority system because of overlapping responsibilities (Turner, 2004; Kirkland *et al.*, 2007).

Consequently, ambiguities and power struggles characterize resource management regimes in many parts of post-apartheid South Africa (Mamimine and Mandivengerei, 2001; Yeatman *et al.,* 2003; Shackleton and Shackleton, 2004a; Twine, 2005; Kirkland *et al.,* 2007). Therefore, there is pessimism about implementing future CBNRM projects in South Africa, and in the region as a whole (see Campbell *et al.,* 2001; Mamimine and Mandivengerei, 2001; Turner, 2004) because of the similar problems having compromised CBNRM initiatives (see Mamimine and Mandivengerei, 2001; Campbell *et al.,* 2001; Koch, 2004). However, compared to woodland management, too much attention has been given to CBNRM in the wildlife sector (Shackleton and Shackleton, 2004a; Roe *et al.,* 2009) which is the most lucrative CBNRM subsector in southern Africa (Turner, 2004). On the other hand, in South Africa, CBNRM has focused on the tourism sector within the protected areas, e.g. Makuleke, and Richterveld (Fabricius and Collins, 2007) and state forests (Shackleton and Shackleton, 2004a; Von Maltitz and Shackleton, 2004), but capacity remains a problem.

Capacity encompases, on the one hand, the functions or tasks that the relevant institutions should have the competence (ability) to perform, and, on the other, the required resources (e.g. human, and financial) and structures they need in order to perform them (functions). Furthermore, the “ability,” which refers to the knowledge and skills embodied in individuals, is considered under “resources” as “human resources (Bhagavan and Virgin, 2004). The South African Department of Agriculture, Forestry and Fisheries (DAFF), the custodian of forests in the country, does not have sufficient resources to monitor communally owned forests let alone its own state forests (Von Maltitz and Shackleton, 2004). Similarly, the Department of Environmental Affairs (DEA) is hindered by a shortage of human and financial capacity for its monitoring and compliance enforcement mandate, to ensure sustainable utilization of woodland and forest resources (Shackleton *et al.,* 2004a). This has resulted in harvesting of livewood in communal woodland areas (see Gandar 1997; Kirkland *et al.,* 2007; Makhado *et al.,* 2009).

In order to address the incapacity problems such as the shortage of human and physical resources in the relevant institutions - political authorities (Crook, 2005), strategies such as locally managed coppice systems have been recommended (Gandar, 1997; Makhado *et al.,* 2009). This is because there was a belief that the involvement of local resource users in policing might contribute to addressing such problems. However, CBNRM is a costly exercise (Fabricius, 2004; Fabricius *et al.,* 2004), and the incapacity problems have affected CBNRM implementations in southern Africa (Turner, 2004; Roe *et al.,* 2009) and remains a widespread problem in many governments in the region (Jones, 2004). For instance, most CBNRM programmes are initiated in areas where there is high poverty (Harrison *et al.,* 2014), and officials do not have vehicles to get into the field, also they are not trained in working with people (Jones, 2004; Fabricius and Collins, 2007). Nevertheless, more attention has been given to formal CBNRM (Shackleton and Shackleton, 2004a; Turner, 2004) which is state-supported, structured, and funded programme contrary to informal CBNRM (Roe *et al.,* 2009). Where CBNRM takes place on an informal, 'traditional' basis, the costs involved in administering management regimes are likely to be relatively minimal, and to be met entirely by local people (Roe *et al.,* 2009). Contrary to informal CBNRM, formal type of CBNRM requires a high quality capacity building component and initial start-up costs such as paying for technical expertise, equipment etc., and ongoing management costs such as staff salaries and vehicles (Roe *et al.,* 2009).

Lack of informal or "every-day" CBNRM is especially worrying because it involves resources like fuelwood which is important to so many people (Shackleton and Shackleton, 2004a; Turner, 2004). Its absence occurs despite it being recommended in rural South Africa (Shackleton and Shackleton, 2004a; Turner, 2004), meaning that if CBNRM aims to target the rural poor, greater attention should be paid to such resources (Shackleton and Shackleton, 2004a). This can be done through the implementation of locally managed coppice system, e.g. community-based coppice management (CBCM) which has been recommended in communal woodlands (Shackleton, 2001; Kaschula *et al.,* 2005; Makhado *et al.,* 2009). However, in case such a management system is implemented, it should be guided by CBNRM principles since it involves fuelwood which is a common property resource in communal woodlands (Kirkland *et al.,* 2007). Moreover, its implementation should be guided by the common property design principles recommended by Ostrom (1990) to improve its chance of success although they are not blue print (Agrawal, 2003). This is because the eight design principles provide vital conditions that help sustain the management of common property resources (Ostrom, 1990) (Refer to chapter 2 and Table 6.1). In the context of the above, this chapter seeks to assess the capacity of existing local governance systems to implement CBCM in rural South Africa, and addresses the following questions:

- Which institutions are relevant to CBCM and how effective is their cooperation in promoting resource sustainability before and during the CBCM implementation?
- To what extent do relevant institutions have capacity to implement CBCM, and how might this affect the implementation of CBCM, and vice versa
- How do the governance systems measure against the design principles as the aspects recommended for successful implementation of common pool resource management during the harvesting trial?

## 6.2 METHODS

Both qualitative and quantitative methodologies were used across the study villages, Thorndale, Peninghotsa, Homu 14B and Makhuva. Focus group discussion with the headman and his council were undertaken on two separate occasions to explore and compare the levels of effectiveness of the traditional NRM and CBCM systems. Central to the discussions was the capacity to deal with harvesting problems such as the ability to not only ensure that only local resource users harvest, but that they adhere to agreed rules while doing so while cooperating with other relevant institutions. Focus group discussions were also held with women, men, youth, before and during the harvesting trial, to identify institutions relevant to NRM, their perceived legitimacy, levels of power and cooperation among them. The same participants who took part in the first focus group discussion, before the trial, took part in the second focus group discussion, towards the end of the trial (refer to Chapter 5). This enabled the participants and the researcher to compare and contrast the experiences acquired from the two separate occasions. Participatory methods, such as Venn diagrams, were used to illustrate perceived power of relevant institutions and the extent of cooperation among them. For instance, the bigger the circles drawn for a particular institution, the bigger the power/influence of such institution in NRM, while those that cooperated were demonstrated by overlapping circles by the resource users.

Two separate interviews with the senior rangers of the local DEAs were also conducted, because the local department has a monitoring mandate (see Von Maltitz and Shackleton, 2004). The first interviews were undertaken face to face and with the senior ranger from the local government department in Thorndale. This was done at Wits Rural Facility, in Bushbuckridge area, Mpumalanga province. With the senior ranger in the local DEA office for in Peninghotsa the interview was conducted in the local office, Thohoyandou similar to those of Homu 14B and Makhuva in Giyani. Similar to the focus group discussion with headmen, the purpose of the interviews was to understand the effectiveness of traditional NRM in the first interview and that of CBCM in the second one. The design principles from Ostrom (1990) were reviewed and used as yardstick against which aspects related to performance of the CBCM governance system was assessed (Table 6.1). They were chosen over other principles because they are regarded as key in measuring the effectiveness of common property resource management in participatory approaches such as CBNRM (Ostrom, 1990). Other qualitative data gathering techniques used, were unstructured interviews with local resource users and personal observation. Leadership styles, such as the taking a democratic approach, as observed from the beginning of the project when the researcher approached the chieftaincy throughout the project, was assessed, as was the perceived legitimacy of the local institutions and the project (Refer to chapter 2 and 5 and 6).

Questionnaires were administered to all randomly selected households which constituted between 11 and 24 % of the total households in the study villages, to gather information of institutions considered relevant, most powerful to NRM, legitimate and those that worked together. Frequencies of respondents who perceived particular institutions to work together were recorded, and those institutions with more respondents met that they were the most perceived cooperative institutions by the community. Chi-square tests using SPSS version 23 were done to determine if there was a significant difference between the proportions of the respondents indicating cooperating institutions over the two periods.

Table 6.1: Eight design principles for managing common property resources (Ostrom, 1990).

| | |
|---|---|
| ***6.1.1 Clearly defined boundaries*** | Individuals or households who have the rights to use resources must be clearly defined, as must the boundaries of the of the resource itself |
| ***6.1.2 Congruence between appropriation and provision rules for resource exploitation*** | Rules for the resource or providing it to resource users, such as restricting time, place, technology and how much can be used, must be appropriate to the resource itself, including availability |
| ***6.1.3 Collective choice arrangements*** | Most individuals affected by the operational rules can participate in changing the rules |
| ***6.1.4 Effective monitoring procedures*** | Those monitoring the rules and the use of the resources are either resource users themselves or accountable to the users |
| ***6.1.5 Graduated sanctions*** | Resource users who break the rules are likely to face various degrees of punishment, depending upon the seriousness and context of the offence. Punishment are decided by other resource users, by officials accountable to them, or both |
| ***6.1.6 Conflict resolution mechanisms*** | Resource users and their officials have rapid access to low-cost mechanisms to resolve conflicts among users or between users and officials |
| ***6.1.7 Recognition of right of resource users to devise their own institutions by external (government) authorities*** | Government supports, or at least does not challenge, the rights of resource users to devise their own institutions. |
| ***6.1.8 Nested enterprises*** | Resource use or provision, monitoring, enforcement, conflict resolution and governance activities are organized in multiple layers of nested institutions, where rights and responsibilities are clearly defined |

## 6.3 RESULTS

### 6.3.1 Relevant institutions and cooperation

Most notably, the TA (represented by the chief at the chieftaincy level and the headman at the village level) was indicated as the legitimate, most powerful and relevant institution for NRM during the focus group discussions with all groups before and during the harvesting trial in all four study villages (Table 6.2). However, whether or not the same results would have been observed from youth in Peninghotsa and men in Makhuva could not be established since no focus group discussions were done with them in these villages. Youth cited school examination preparation as the reason for failing to respect the focus group discussion appointment in Peninghotsa, while men in Makhuva considered the CBCM project and its activities as relevant to women only: "*My husband said he cannot come because the project is about fuelwood and feels it is a project for women*," said one woman after the required number of men did not arrive for focus group discussion. Moreover, two men who had arrived, left after the researcher had briefed them of the focus group discussion whispering to each other: "*The aspects of fuelwood are for women, not us*."

Reasons were sought as to why particular institutions were considered relevant, powerful and legitimate. The TAs were considered the most relevant, powerful and legitimate institution because they designed harvesting rules and enforced them through their own rangers (tribal rangers) across the study villages. Although other institutions such as the local civic organization and the local municipality (represented by the councillor) were also indicated to be relevant, they were reported to be primarily involved on aspects of development such as bringing clinics in the villages. However, while the headmen represented TAs at the village level, they were also said to assist in carrying out patrols to ensure compliance with harvesting rules, although these were primarily the duties of the rangers in their respective villages. The local DEA was also reported to conduct patrols to ensure compliance with harvesting rules using its own rangers (government rangers). In Thorndale, Peninghotsa and Homu 14B, local civic organizations were also indicated as a relevant institution to NRM, but it was in Thorndale and Peninghotsa where it was effective in its contribution to NRM and cooperated with the TAs through the headmen at the village level. The reason for this was said to be that members of the local civic organization also helped with patrols: "*When civic members see you harvesting livewood they notify the headman*," said one woman, to the agreement of others during the focus discussion with women in Thorndale. "*They sometimes patrol the woodland with the headman*," said a woman in Peninghotsa during the focus group discussion." The magistrate institution was also indicted to be relevant in the NRM because it was used as the last resort for settling disputes in Peninghotsa on aspects such as fines between the TAs and the offenders especially when the latter disagreed to pay.

Notable changes were recorded during the focus group discussion with all groups during the harvesting trial in Thorndale and Peninghotsa. For instance, the community development forum (CDF) was reported to be relevant to NRM during the harvesting trial in Thorndale. "*We worked together with the headman, the local civic organization and the patrol committee members. We also erected fence around the harvesting camps together*," one participant, a member of the CDF said during the focus group discussion with men. However, an interesting finding was recorded during the focus group discussion with youth in Thorndale. They suggested that the "community" should be regarded as one of the institutions forming the resource governance system because its people carried out patrols to ensure compliance with harvesting rules. In Peninghotsa, a local NGO dealing with home-based care was a new institution regarded as relevant to NRM during the discussion with women, because some of its members were in the patrol committee that enforced harvesting rules during the project. An improved level of cooperation between the local civic organizations and the TA was reported in Thorndale and Peninghotsa, ascribed to the participation of the members of civic organization in project activities like being in the patrol committee, which was accountable to the headman.

Table 6.2: Relevant institutions in natural resource management, ranked from most to least powerful (relevant), as identified by women, men and youth.

| Women | | Men | | Youth | |
|---|---|---|---|---|---|
| **1st survey** | **2nd survey** | **1st survey** | **2nd survey** | **1st survey** | **2nd survey** |
| **Thorndale** | | | | | |
| 1 TA<br>2 Civic organization<br>3 Department of environmental affairs<br>4 Magistrate court | 1 TA<br>2 Civic organization<br>3 Department of environmental affairs<br>4 Magistrate court<br>5 Community development forum (CDF) | 1 TA<br>2 Department of of environmental affairs | 1 TA<br>2 Department of environmental affairs | 1 TA<br>2 Civic organization<br>3 Department of environmental affairs<br>4 Magistrate court | 1 TA<br>2 Civic organization<br>3 Department of environmental affairs<br>4 Magistrate court<br>5 Local municipality<br>6 Community policing forum |
| **Peninghotsa** | | | | | |
| 1 TA<br>2 Civic organization<br>3 Department of environmental affairs | 1 TA<br>2 Civic organization<br>3 Department of environmental affairs<br>4 Non-profit organizations | 1 TA<br>2 Civic organization<br>3 Department of environmental affairs | 1 TA<br>2 Civic organization<br>3 Department of environmental affairs | Not done | Not done |
| **Homu 14B** | | | | | |
| 1 TA<br>2 Civic organization<br>3 Department of environmental affairs | 1 TA<br>2 Civic organization<br>3 Department of of environmental affairs | 1 TA<br>2 Civic organization<br>3 Department of environmental affairs | 1 TA<br>2 Civic organization<br>3 Department of environmental affairs | 1 TA<br>2 Civic organization<br>3 Department of environmental affairs<br>4 Local municipality | Not done |
| **Makhuva** | | | | | |
| 1 TA<br>2 Department of environmental affairs | Not done | Not done | Not done | 1 TA<br>2 Department of environmental affairs | Not done |

Institutional cooperation among those relevant to NRM was also assessed from information gathered using questionnaires (Table 6.3). The proportion of respondents indicating cooperating institutions over the two study periods was significantly different from each other in Thorndale $\chi$ (5)=38.299, $p$<0.001) and Peninghotsa $\chi$ (5)=23.826, $p$<0.001). For instance, 76.70% of the respondents indicated the TA and the civic organization as the most cooperative institutions during the harvesting trial, but this was an increase from 20% respondents before the harvesting trial in Thorndale. 13.30% of the respondents indicated the local municipality (which was a new relevant institution represented by the ward councillor residing in the village) and the TA as the second most cooperative institutions during the trial in Thorndale. Similar to Thorndale, TA and the civic organization were indicated by many respondents as the most cooperative institutions, 53.30% which was an increase, from 36.70% before the trial. The second most cooperative institutions included TA, civic organization and the DEA indicated by 30% of the respondents, which was cooperation not observed before the harvesting trial. In Homu 14B, there was no significant difference on the proportion of the respondents indicating any cooperative institutions between the two survey periods. The TA and the DEA were indicated as the most cooperating institutions in both occasions $\chi$ (5)=2.345, $p$=0.503). Similar results to those of the first survey in Homu 14B was recorded in Makhuva. However, since the project was terminated before the feasibility period came to an end meant that no data were available for the second survey to compare with those of the first one in this village.

Table 6.3: Relevant institutions in natural resource management, ranked from most to least cooperative, as perceived by the respondents during the questionnaire survey in villages (%=percentage of respondents, f=frequencies, in brackets).

| Village 1st survey | % and F | 2nd survey | % and F |
|---|---|---|---|
| **Thorndale** | | | |
| 1 TA | 66.70 (20) | 1 TA and civic association | 76.70 (23) |
| 2 TA and civic association | 20 (6) | 2 Municipal and TA | 13.30 (4) |
| 3 TA and environmental department | 6.70 (2) | 3 TA, environmental department and civic association | 6.70 (2) |
| 4 Do not know | 6.70 (2) | 4 Do not know | 3.30 (1) |
| **Total** | **100 (30)** | **Total** | **100 (30** |
| **Peninghotsa** | | | |
| 1 TA and civic association | 36.70 (11) | 1 TA and civic association | 53.30 (16) |
| 2 Do not know | 30 (9) | 2 TA, civic association and environmental department | 30 (9) |
| 3 Tribal | 23.30 (7) | 3 TA, civic association, environmental department and Non-profit organizations | 6.70 (2) |
| 4 TA and environmental department | 10 (3) | 4 Tribal and environmental department | 3.30 (1) |
| **Total** | **100 (30)** | 5 Tribal | 3.30 (1) |
| | | 6 Do not know | 3.30 (1) |
| | | **Total** | **100 (30)** |
| **Homu 14B** | | | |
| 1 TA and environmental department | 74.30 (52) | 1 TA and environmental department | 67.10 (47) |
| 2 TA | 15.70 (11) | 2 TA | 22.90 (16) |
| 3 Civic association and TA | 5.70 (4) | 3 Do not know | 7.10 (5) |
| 4 Do not know | 4.30 (3) | 4 Civic association and TA | 2.90 (2) |
| **Total** | **100 (70)** | **Total** | **100 (70)** |
| **Makhuva** | | | |
| 1 TA and environmental department | 67.50 (81) | Not done | |
| 2 TA | 26.70 (32) | | |
| 3 Do not know | 4.20 (5) | | |
| 4 TA, environmental department and civic association | 1.70 (2) | | |
| **Total** | **100 (120)** | | |

From personal observation, similar findings to those reported during focus group discussion and questionnaires were observed, such as some level of cooperation before the harvesting trial between the TA and the civic organization in Thorndale and Peninghotsa. This was observed in meetings with members of the local civic organization chairing meetings and discussing the agenda of such meetings before the commencement of the meeting. However, no cooperation between the TA and the DEA pre-existed in Peninghotsa, which was observed in one of the meetings revealed by the headman's council member when emphasis on cooperation with rangers was made by the researcher, as one council member cut in:

> "*Those* (referring to government rangers) *are the ones causing problems because they do not do their job. People come from as far as Venda to steal our trees while they are there doing nothing.*"

However, during the harvesting trial, there was an improvement in the relationship between the TA and the DEA, as demonstrated by the findings from the focus group discussions with men and women and also from personal observation. This was illustrated through cooperation between rangers and the patrol committee, which was also acknowledged by the senior ranger in the meeting held to discuss the way forward after an end of the harvesting trial. "*We did not know each other* (referring to the headman) *before. I am coming here for the first time*," said the senior ranger. The headman commended the cooperation between the patrol committee team and the government rangers during the meeting. For instance, it was reported that there was defiance by some of the fuelwood vendors from the neighbouring villages whose names were known to the patrol committee members. After the patrol committee gave the government rangers the names of the intruders and villages, they approached them and threatened to open a court case if they continued defying the patrol committee when enforcing rules. After the threat, the fuelwood vendors were never reported to have invaded the village commons again.

In Homu 14B, the lack of cooperation between the TA and the local democratically elected civic organization, also contributed to the lack of harvesting trial. For instance, on two occasions, the members of the local civic organization held unknown meetings at the school premises parallel to that of the project held at the headman's premises which was said to have a high local attendance. "*Our visitors from government are here and the researcher. Where are our people so we can start our meeting? These people do not want development*," said the headman. After the news broke that the members of the civic association had a parallel meeting, one of the government rangers said: "*Your people do not respect you. How can they do have meeting in your land without your knowledge? You must cut them ears*" (meaning the headman should discipline them). Furthermore, lack of motivation by the influential royal member to encourage community members to participate freely also contributed negatively to the CBCM: "*People cannot participate and get nothing out of it. People can only participate if they benefit something. The government should do something to help compensate our people*," said one royal council member in one of the meetings to the applause of local people.

### 6.3.2 Material capacity of the relevant institutions

From the initial interviews with the headmen, it emerged that there were common problems across the study villages, with all of the TAs primarily worried about the shortage of tribal and government rangers required to conduct patrols especially against intruders harvesting for commercial purposes (Table 6.4). The shortage of rangers in Homu 14B contributed immensely to deterring the intervention as substantiated by the statement below:

> "*If we had our own rangers we would use them to monitor local people during the project because we do not trust local people since they have failed to comply because of lack of rangers. Will they comply in the name of the project without being monitored by rangers? I refuse. I think we are putting our woodland at risk of being destroyed in the name of a project*," said one headman council member.

Table 6.4: Number of rangers in charge of each of the study village and those falling in the same traditional authority.

| Village | Number of rangers | Name of the TA | Total number of villages under TA |
|---|---|---|---|
| **Thorndale** | 3 | Mnisi | 11 |
| **Peningotsa** | 4 | Madonsi | 16 |
| **Homu 14B** | 4 | Home | 8 |
| **Mathura** | 4 | Mathura | 1 |

During the harvesting trial in Thorndale and Peninghotsa, problems of capacity regarding the shortage of both tribal and government rangers were addressed through the involvement of local people as acknowledged by the headmen of these villages. For instance, below is the quote from the headman in Thorndale which provides evidence:

> "*As we are standing here, you would see vehicles coming in and going out of our woodland but now it is rare because of that committee* (patrol committee) *that patrols*."

In Peninghotsa, the headman said:

> "*It was easy to track down intruders and local resource users who did not comply by hearing cutting tools sounds during the days when local people were not supposed to harvest. We did not know that we could be enforcement officers ourselves before the project but now we know we are. We volunteer on our own good and we thank you for making us aware that we can do this*."

By way of supporting the effectiveness of the CBCM system, the headman in Peninghotsa reported that through CBCM, more offenders were brought to him than before the CBCM project:

> "*I remember to have only been brought one offender by the government rangers before the project intervention, although I cannot remember, the patrol committee brought more than ten offenders, but many of them were not from here.*"

The headman further indicated that the patrol committee confiscated fuelwood loads which were kept in his possession and later sold, with the money shared among the patrol committee, R150 to each member: "*We wanted to motivate them*" he said. One patrol committee member confirmed receiving R150 after been asked by the researcher during conversation: "*Yes the confiscated loads and timbers were sold and the money was shared among us and this helped us a lot since we are not working.*" As evidence of the effectiveness of the CBCM, the headman presented confiscated cutting tools before the researcher and the DEA rangers during the meeting aimed at discussing a way forward after the researcher's period had come to an end. "*Ever since I started working as the headman, we have never confiscated this amount of cutting tools,*" the headman told the government rangers and the researcher (Figure 6.1A). Members of the local civic organization who were also members of the patrol committee were present in the meeting and had this to say:

> “*There were tracks created by donkey carts and bakkies coming in and out of the communal woodland but now grasses are growing and closing those tracks. Unlike you* (DEA rangers) *we do not knock off at 16:00 but work until late*,” he told the rangers from the DEA (Figure 6.1B).

The patrol committee kept a record of minutes for every patrol they undertook which supported the headman on the effectiveness of the CBCM since local people complied after it was seen by the researcher. In Peninghotsa, the patrol committee did not keep record of patrols. However, this is what the headman described regarding the effectiveness of the project in the village:

> “*It was easy to track down intruders and local resource users who did not comply by hearing cutting sounds during the days when local people were not supposed to harvest. We did not know that we could be enforcement officers ourselves before the project but now we know we are. We volunteer on our own good and we thank you for making us aware that we can do this*.”

The rangers from DEA commended the performance of the project and took photos of the confiscated cutting tools (Figure 6.1C and D). They wanted the project to continue after the feasibility study period had come to an end also recommending that it be upscaled to other villages to address similar problems.

A

B


C

D


Figure 6.1: A) The headman in Peninghotsa presenting the confiscated tools before the researcher and the government rangers as left by the fuelwood vendors during patrols by the patrol committee. B) One of the civic members commenting on the success of the project towards addressing commercial harvesting. C) A government ranger taking a photo of the confiscated tools. D) Senior government ranger commending the contribution of the CBCM project during the meeting held in the headman premises.

However, CBCM was not without challenges. In Peninghotsa, challenges were related to women patrol team members as described by the headman:

> "*Although women are still part of the patrol team, we felt it was not safe for them to travel deep into the woodland, so we restricted their patrol within nearby places. Only men are allowed to monitor deep into the communal woodland.*"

In Homu 14B, the council members wanted to turn the project into a cooperative so that people can benefit. "*I am working in a government department, and I know government has money. We can get funding if we apply. That way we will see people will come they are hungry,*" said the influential council member to the applause of the community members."

Regarding the capacity of the local government institutions, the Department of Land Reform and Rural Development (DLRRD) was the only department which appeared better capacitated in terms of resources. This was witnessed through a range of factors including the availability of officers to process harvesting permit application and visiting the study village driving from the provincial office located about 200 kilometres away from the Peninghotsa. However, their relevance was limited to communal woodland ownership. In contrast, the two key departments, DAFF, the custodian of the resource base, and the DEA, which had a monitoring mandate as already demonstrated, lacked material resource capacity to support the implementation of the project let alone to conduct patrols to ensure compliance with rules. For instance, no ranger has attended a community meeting in Thorndale. They cited their number and lack of vehicles as their limitation. During an interview with the senior ranger in the local DEA in Thorndale he said:

> "*Government does not want to appoint new rangers. Look we were 20 before 1994 and now we are three. I am going to retire now and I can tell you I am not going to be replaced. This current government is unlike the old one. For instance in the old one we cooperated very well with rangers from the TAs. People did not know which rangers were appointed by TAs and those by the government but now things have changed.*"

In terms of the number of local government rangers, from the local DEA responsible for resource management in Bushbuckridge local municipality, they were only three rangers (as already been indicated above) with one vehicle in charge of 10 TAs and 141 villages including Thorndale (Statistics South Africa, 2011). Similarly, the number of rangers responsible for resource management in Thulamela local municipality which had 14 TAs and

228 villages including Peninghotsa study village (Statistics South Africa, 2011), were also three sharing one vehicle. Those responsible under Greater Giyani Municipality in which Homu 14B and Makhuva study villages were located, were fifteen patrolling 10 TAs and 91 villages (Statistics South Africa, 2011).

Similar to Thorndale, rangers failed to attend all project meetings in Peninghotsa but gave apologies. They cited a shortage of vehicles and adequate personnel as the reason for their absence.

> "*Pass my apology to the community members in a meeting. Although I really wanted to attend the project launch meeting, something just came up. I have to attend a court case involving a crocodile. We only have one vehicle otherwise I would delegate my colleague to come*. *Give me an update of how did the meeting go*," said the senior DEA ranger.

Notably, the senior ranger in Peninghotsa almost repeated the same words to that of the local DEA in Thorndale: "*When someone dies it is a bonus to our government since it is minus one from the payment roll*," said the senior officer. During the conversations, stressing how incapacitated they were in terms of personnel and vehicles, vis-à-vis the size of the area they patrolled, a junior ranger said: "*We patrol a radius of 600 kilometres from Malamulele to as far as Masisi towards Zimbabwe border*." Furthermore, the number was expected to decrease as the junior ranger elaborated:

> "*We are three but one is going on retirement next month so only two of us will be left. We do not cover all villages and sometimes the year ends without covering certain villages. We have one vehicle that we exchange. I will also be going on leave and when on leave the work will just stop*."

However, the rangers supported the project, which was evidenced by their cooperation with the patrol committee, after the researcher facilitated the communication between them and the patrol committee. Like the rangers from the local DEA, no officers from the DAFF attended the project meetings in Peninghotsa, despite their knowledge of such meetings as they were informed upfront by the researcher. Two officers indicated travel limits as the primary reason for their absence after attending a project meeting in one study village (Homu

14B): "*I cannot come to Peninghotsa because we have specific mileage that we are allowed to reach so I have reached that limit*," said DAFF officer.

In Homu 14B and Makhuva, although the rangers' number was greater than those of other local DEAs for Thorndale and Peninghotsa, shortage of vehicles was still a major problem and they had to borrow from other section. Officers from the DAFF attended two meetings with apologies in Homu 14B out of eight and none in Makhuva out of three.

### 6.3.3 Non-material capacity of the relevant institutions

The ability of the local leaders to understand the CBCM concept, its implementation processes and making appropriate decisions was noted (also refer to chapter 2). In Thorndale, the chief understood that the project had to be managed at the village level, and this was seen by him delegating the power to the headmen who accepted the project to manage it with his own people. "*Go and present your work to the headmen, those who want it will take you to their villages*," said the chief. The headman in Thorndale showed better insight into the project. This was partly accounted for by rotational grazing of the cattle that once occurred in cattle camps that were later used during the rotational fuelwood harvesting trial, since the project was based on the same concept.

Unlike in other villages, the ability of the local chief in Peninghotsa chief Madonsi for understanding the CBCM concept and its implementation processes in Peninghotsa study village was not assessed. This is was because the headman in this village accepted and informed the chief of the project after its implementation: "*The chief will not have a problem with me accepting the project because I will inform him through reports that we give in the TA every week on Tuesdays*," said the headman. However, although the concept was new to the headman in Peninghotsa, he showed a strong willingness to learn and adhere to its required implementation processes: "*It is a good idea but you will let us know how to implement it and whether we are doing it the way we should do it*," said the headman.

Towards the end of the project, the researcher approached the chief Madonsi in the local TA office to meet him and find out what his understanding and the reaction to the CBCM was after getting the report from the headman about the CBCM intervention in Peninghotsa.

> "*He told me about the project and I am so happy about it. I have asked him that where he found you because it is a good project and I want it in all my villages. I have a lot of ideas that I have to develop my villages, since I am not happy seeing my people not employed. I am thinking of establishing a foundation that can help support people such as those volunteering to do patrols in the project. I have applied for a mining licence to reopen the Madonsi Gold Mine, while I have more than 100 ha that I want to use for agriculture and employ people from all my villages*," said the chief.

The chief in Homu14B had difficulty in understanding the CBCM concept and its processes. As a result, he requested that I write down the project roll-out processes for him. "*As you talk I do understand but if you leave I may forget. I will ask you to write down all that you have explained on a letterhead paper*." After that he ordered that the project be implemented under the supervision of one of his four headmen. Accountable to the chief, the headman to whom the project was delegated for piloting and most council members felt obliged to implement it:

> "*Our visitor* (the researcher) *has been accepted by the chief himself to do his work here after I took him to present it before him. So we do not have any choice since the chief accepted him. However, he indicated that the project initially be piloted here and other headmen will learn from us after its implementation*," said one of the royal council member who was the younger brother of the headmen in a community meeting.

In Makhuva village, (unlike chief Homu (of Homu 14B)), the chief showed good understanding of the CBCM concept and its processes, but this was explained by his previous experience in leadership as demonstrated below:

> "*I have worked in a number of community projects while serving in portfolio committees in Gazankulu administration during the apartheid era led by the then Prime Minister, Professor Hudson Tsanwisi. So I know the community processes. You are welcome to do it here. This is your village, you are at home* (the researcher shared the same surname with the chief)."

Although, the chief in Makhuva requested the researcher to present the project before his headmen (four of them in charge of different of the village), he appeared to have exercised absolute power over his decision to accept the project. This was observed by the fear from one of his four headmen, who was very influential and articulate, to express opposing views in his presence but did so in his absence. "*If we allow sending people to harvest we will be killing ourselves, what we want here is water and electricity other things are supplementary,*" said the headman in the meeting. This fuelled the polarity that existed among the chieftaincy and the community members. At the same time, the chief also failed to delegate power and responsibilities to his headmen in his absence. Therefore, the majority of the headmen who supported the project were disempowered to allow the harvesting trial to commence in his absence: "*We know the chief has accepted the project but we cannot allow people start harvesting in his absence, we will give him report that you were here,*" indicating one headman to the agreement of others.

In the local DEA of Peninghotsa, the senior ranger had difficulty understanding the CBCM concept which left him undecided whether to accept or reject the project: "*Mr Mathebula, I think we should meet with the provincial director in Polokwane about the project. I am not sure what to do,*" he said. However, unlike other senior rangers, he seemed to have good understanding of the relevant legal provisions like the Limpopo Environmental Management Act No. 7 of 2003 section 64 (3) which provided for CBCM implementation. For instance, this provision, extracted below, demonstrated that projects such as CBCM were legally supported and this was vitally important for motivating community participation. For instance, it led to the issuance of formal harvesting rights through harvesting permit copies from the Department of Land Reform and Rural Development (DLRRD) which serves to define local people as the legal resource users during the CBCM period.

> *"No person on land of which that person is not the owner, can pick any indigenous plant without the owner's written permission"*

Furthermore, the senior rangers communicated with his junior rangers whom he delegated to work with the patrol committee in Peninghotsa unlike those in Homu 14B and Makhuva. Aspects of capacity in a community gathering setting could not be observed in Peninghotsa and Thorndale since the rangers did not attend community meetings. However, it became clear that the rangers across the study were ill-equipped with the social skills required for community based projects such as CBCM, as the senior ranger in Peninghotsa acknowledged, towards the of the CBCM period: "*It was hard for me to accept the project because I have* *not engaged in a community project before. This was a learning curve for me*." The same applied to the officers from DAFF as indicated by one of the senior officer during conversation:

> "*We do not have expertise in community project for communal woodland. Our department focuses mainly on commercial forestry, which benefits few*."

As the officer elaborated on the magnitude of problems, he said: "*We do not have adequate extension services, skills, and a proper regulatory framework for participatory forest management in communal woodland area.*"

Among the government institutions, non-material capacity aspects observed were on the ability of relevant officers to organize, coordinate, manage and communicate in the relevant departments. In the local DEA for Homu 14B and Makhuva, there was a lack of proper coordination and communication between the senior and junior rangers and across the two relevant units: permit and enforcement. For instance, while senior officers understood and approved the CBCM concept, they failed to communicate this between their units. This emerged when junior ranger accountable to them did not know that the project was about controlled rotational harvesting of livewood in harvesting coupes: "*We do not have the problem with the project as long as it abides by the rules of not harvesting livewood*," said a junior ranger in a project meeting in Makhuva. Since people in this village were divided between those who supported the project and those not, this created confusion and the impression that the researcher was implementing an unknown and illegal project. "*Is it from the government that we can harvest livewood in camps rotationally or is it from you*?" a community member asked the researcher in a meeting.

### 6.3.4 Institutional performance against design principles (key aspects for successful implementation of community governed commons)

***Clearly defined boundaries*:** Across the study villages, none were found to have clear boundaries. For instance, in Peninghotsa, clear boundaries only existed between the study village and three neighbouring villages, Nkovani, Gijamhandeni and Mtititi, located on the northern, southern and western sides. On the eastern side towards the neighbouring village of Govhu, there were boundary conflicts, as the quote below indicates. Consequently, the project activities such as demarcation of harvesting camps and coppice growth monitoring, were restricted to the communal woodland on three cardinal points (north, south and west).

> "*We cannot allow the harvesting of fuelwood in the eastern side because people of Govhu can harvest since we have issues over the boundary line with them. So you do not have to put your experiments that side. The fight has been going on for years now*," said the headman during *transect-walks*."

However, boundaries in terms of the rights of resource users to harvest fuelwood during the intervention were clear. The DLRRD, which as mentioned earlier had the title deed of the communal woodland, issued a harvesting permit to each household. This provided property rights to all local resource users who had to carry the genuine copy permit (with headman's original stamp) with them while harvesting, as evidence that they were the legal resource users. In Thorndale, no harvesting permit was required by the rangers. This would have similar also in Homu 14B, which indicates that rangers interprete laws differently. However, the issue of boundaries was the same. For instance, it was clear on the northern side towards the neighbouring villages of Hlalakahle and Gottenburg, on the eastern boundary with Manyeleti Game Reserve, and on the western side towards the village of Seville A. However, on the southern side towards the neighbouring village, Makirepeni, the boundary was unclearly delineated by a dam: "*The dam on a map belongs to Thorndale but people in Makirepeni claim it belongs in their village*," said one council member during the conversation while undertaking transect-walks. As in Peninghotsa, harvesting was not allowed in the harvesting camp in this side for fear that it would be prone to harvesting by intruders. However, through the CBCM process, a meeting involving all the headmen of all the neighbouring villages was held to discuss the need for people to respect village boundaries. This appeared to have lessened the problems: "*I have heard you and will invite a meeting to tell my people to respect the boundaries between our villages*," respond the headmen of Hlalakahle to the request made by the Thorndale headman.

In Homu 14B, although the full intervention did not occur, much progress was made including focus group discussions and the demarcation of harvesting camps. However, in this village, the issue of unclear boundaries was more severe. For the purpose of CBCM, the road was used as a boundary to demarcate households that fell within the area from which households had to be considered for the project while they belonged to the same village.

Furthermore, there were no harvesting permits to distinguish legal from non-legal resource users as there were in Peninghotsa.

***Congruence between appropriation and provision rules for resource exploitation*:** Only harvesting for domestic purposes was allowed during the harvesting trial in Thorndale and Peninghotsa. The harvesting rules designed and agreed upon in a community meeting and were ensured that they were based on the National Forest Act No. 18 of 1998 and the Limpopo Environmental Management Act No. 7 of 2003 as was recommended by the rangers. Resource users were given a list of all protected species with local names, such as *Combretum imberbe* and *Sclerocarya birrea*. In addition, harvesters also agreed that trees such as *Diospyros mespiliformes* and *Colophospermun mopane* were not supposed to be harvested because they gave food in Thorndale and Peninghotsa. Certain harvesting tools such as chainsaws were prohibited, leaving only machetes allowed for harvesting equipment. In order to promote vegetative regeneration and sustainability, local resource users had to harvest unprotected woody plants based on agreed prescriptions (e.g. harvesting tree stems of between 4 and 8 cm diameter). Using local metrics, this was roughly equivalent to the diameter of a beer bottle. The recommended cut height was 50 cm from the ground with only amount that could be carried by either a wheelbarrow or headload allowed. Rules agreed upon in Thorndale and Peninghotsa were documented by the researcher, using the local language, into leaflets which were stamped by the headman to prevent counterfeit copies. After collecting the copy each household was recorded (Appendix 2 and 3).

***Collective choice arrangements*:** Women are the ones who suffer from fuelwood scarcity (Agarwal, 2002). There was an understanding by the local leadership and men that the project related to women than it did to men during the trail in Thorndale and Peninghotsa. "*Women should participate otherwise, we will participate when we know little about fuelwood,*" one man facilitating the project meeting said encouraging women to participate in meetings in Thorndale." During the focus group discussion with the headman and his council in Peninghotsa, the headman emphasized that women were the ones who had to be involved in fuelwood harvesting for domestic purposes, although men participated in policing. Therefore, this is what he pointed of the interviews before the intervention: "*Issues of fuelwood relate more to women than us, so we should allow them (women) to take the lead on these issues,*" he said. Through personal observation in the community meeting, this was also seen happening. Since similar to Thorndale, it was women who were the only ones involved in designing harvesting rules before the trial in a community meeting in the presence of men and the headmen. Such rules included aspects of access including when to harvest, number of hours, and mode of transportation (headload or wheelbarrow). However, community members of less than 21 years of age did not attend community meetings because they were not allowed to do so as per local rules but did so only when there were issues considered relevant to them by the headman and the community.

Although the trial did not happen in Homu 14B, similar to the local leadership in Thorndale and Peninghotsa, there was an understanding that the project related more to women than it did to men. This was observed in a community meeting where harvesting rules were supposed to have been designed, but were not because of poor women attendance. For instance, the number of the women who attended that meeting was less than 10 members. "*As you can see, people are not here who cook* (referred to women are not here). *As for us* (leadership) *we do not cook. We only eat when we arrive at home, so we cannot decide for them*," indicating one council member.

***Effective monitoring procedures*:** Compliance monitoring in all the villages was primarily the responsibility of everyone in the village and the reports from the headmen indicated that they cooperated with them during the project. However, for accountability purposes, a patrol committee comprising 15 resource users in Thorndale and 20 in Peninghotsa, was put in place during the launch meeting and was accountable to the headman. This came after the researcher suggested that a team that would have a primary responsibility be selected. For instance, they had the obligation to report patrol and compliance monitoring results after every round and to bring offenders to the headman. Women, who were the main resource users, contributed high number in the patrol committee than men in the two study villages. They constituted 66.7% (10 in 15 members) in Thorndale and 60% in Peninghotsa (12 in 20 members). Similarly, their involvement was a recommendation by both the headmen in the two villages, who acknowledged that fuelwood was more relevant to women than men. The monitoring procedure involving the local resource users proved effective, it was through their policing that harvesting problems experienced under the traditional management rules, were addressed. Evidence for this is also demonstrated by the confiscated in Peninghotsa where the headman indicated that he has never had never seen such tools confiscated before, while in Thorndale, reports of a decrease in commercial harvesting was also made.

***Graduated sanctions*:** Sanctions were only graduated by the headman during the trial in Thorndale and Peninghotsa. For instance, the community members allowed him to decide on the severity of the sanctions as was the case before. Therefore, the patrol committee had a mandate to confiscate fuelwood loads and cutting tools, for which the offender had to pay a fine to redeem them. However, in Peninghotsa, the headman reported to give heavy penalties for intruders when they had to rescue the confiscated tools by the patrol committee. This is demonstrated by the explanation he made during the meetings in where he presented them: "*They can only get their tools after paying particular amount deemed necessary for the damage they caused*," said the headman. While the reports of intruders were also reported in Thorndale, such intruders were visited in their homes where they apologized and indicated pledged that they would intrude the village commons again.

> "*We have visited those who gave us problem while patrolling in the homes. They were not fined after they seriously apologized and indicated they will never come to our village again*. *Since then they never gave us problems*," said the headman council member in a meeting involving headmen from the surrounding villages.

***Conflict resolution mechanisms*:** In Thorndale and Peninghotsa, there were no conflicts related to CBCM across the villages. However, in Thorndale, a conflict that was not related to the project occurred temporarily halted occurred. This conflict emanated from council members who competed for the position of the headman after he received promotion to be in the chief council in the local TA. As one patrol committee member explained during the conversation about the CBCM progress:

> "*The project had stopped for a while because people we did not know where to report patrol and monitoring results before. However, we finally went with the majority after a new headman was elected by the community*."

This problem was resolved by the community through nominating the preferred candidates to replace the promoted headman. The one who received more votes when voting in a public meeting, which was done by show of hands, became a headman. "*Those who preferred particular candidates raised their hands and were counted*. *The one with more hand won who is the current headman*," indicated a council member. No fuelwood related conflict was reported during the CBCB period in Peninghotsa. However, I witnessed conflicts being resolved by the headman and his council before the start of the project discussion, since community members had public meetings every fortnight. The conflict was resolved in a community meeting by community members engaging the problem in an interactive manner then giving possible solutions to it. The similar situation was also observed in Homu 14B with those involved in conflicts given an opportunity to indicate if they were satisfied with the proposed solution by community members. In cases where penalties were given by the headman, an option to appeal s to the chief or magistrate's court was given.

In Homu a conflict related to the project which also contributed to the lack of support occurred, because of the lack of transparency. For instance, after the tribal chief accepted the project, he delegated the project to one of the four headmen without discussing with the other headmen why a particular headman was chosen. Therefore, his failure to justify why a particular headman was chosen over others led to other village headmen feeling hard done by, which resulted in the lack of their support and cooperation during the project implementation in the village (Homu 14B).. "*One of the headmen that I cannot give his name here, was invited to attend the project meeting said that he will not attend a project that he knows nothing about,*" said a council member in a community meeting. Other headmen were also reported to have stated that they cannot attend meetings arranged in the premises of one headman during the conversation with a headman's council member. Furthermore, over a one year period of the project, this conflict continued and not resolved.

***Recognition of the right of resource users to devise their own institutions by external (government) authorities*:** The government officers from DEA and DAFF respected the local resource users' rights to devise their own institutions. This was evidenced by allowing resource users to devise rules to be used during the harvesting trial in public meetings without any interference. For instance, they accepted rules devised in their absence since as indicated they failed to attend community meeting. However, they required that such rules had to be within the required legal framework. This is was illustrated by officers from DAFF in the meeting in Homu 14B gave the researcher a list of protected species printed in local local language and advised him to get a permit from other department for harvesting of woody plants. Senior rangers gave a researcher a copy of the Limpopo Environmental Management Act No.7 of 2003 to read in order to ensure the project complied with all the rules as required by the Act. Moreover, the headman and the patrol committee did not report any interference from any department during the intervention except words of appreciation and the need to see the project continue after the feasibility study period had expired. However, the challenge was the need to repeatedly renew harvesting permit especially in Peninghotsa where the senior demanded that permit be applied unlike in Thorndale where such a permit was not required.

***Nested enterprises:*** The nested enterprise design principle describes the multiple levels of institutional arrangements that should be present in more complex CPR regimes (Ostrom, 1990). In this study, aspects related to this criterion were not observed, since no such levels were observed. For instance, it was only the patrol committee team that reported to the local headman. However, there are far more variables that can affect resource management than is possible to analyse carefully, in addition to the eight design principles (Agrawal, 2003). In this study, as described below, it was also the leadership style that contributed to having the harvesting trial implemented and reaching the desirable outcomes contrary to Makhuva. In Homu 14B, lack of transparency was one aspect which also contributed to hindering the implementation of the trial in this village.

## 6.4 DISCUSSION

### 6.4.1 Relevant institutions and their cooperation

Although the power of the TAs has been eroded (see Shackleton *et al.,* 2001; Yeatman *et al.,* 2003; Shackleton and Shackleton, 2004a; Twine *et al.,* 2003b), the focus group discussions showed that they remain the most relevant, legitimate and powerful institution. Similar findings have been shown by Twine *et al.,* (2003b) who found that although the TAs did not exercise the same level of control over resource harvesting as in the past in villages in Mpumalanga, Limpopo and Kwazulu Natal Provinces of South Africa, they were still considered by local communities to be the most relevant institutions for NRM. This suggests that TAs should be considered for CBNRM projects such as CBCM in communal South Africa since they are likely to remain an important institution in such areas (Shackleton and Campbell, 2001). The fact that the erosion of TAs has hindered the effective implementation of CBNRM in Fish River, Eastern Cape province, as found by Cocks *et al.* (2001), emphasizes their importance for CBNRM. Therefore, the findings support a number of studies that have argued against the creation of new institution for CBNRM where local traditional institutions exist, which affirms their importance as key stakeholder in CBNRM (see Shackleton *et al.,* 2001; Fabricius *et al.,* 2004; Kirkland *et al.,* 2007). As a result, any emerging institutions for the management of common property resources on the rural landscape that exclude traditional institutions will likely worsen rather than ameliorate resource management, agreeing with Mamimine and Mandivengerei (2001).

The local governmental departments responsible for environmental management in the study villages were also identified as relevant to NRM by all groups (women, men and youth) during the focus group discussions. This means that it is a well-known relevant institution to resource users despite their differences in gender and age, but this was not surprising given that the DEAs has a monitoring mandate in communal woodland. For the magistrate to be identified as relevant only by women and youth indicates that women and children are the ones with thorough knowledge of relevant institutions. This is true especially because it acts as a court of appeals for tribal court findings in settling disputes between the TAs and resource users especially when they do not want to pay fines after being found guilty. Similar findings have also been found by Du Toit (2002). At the same time, this may also indicates that women and girls are usually the ones who get involved in such disputes. For institutions such as CDF and NGO to be considered as relevant to NRM during indicates that there are other institutions that are interested in contributing to the sustainability of NRM in communal areas, and they can only do this through participatory approaches such as CBCM. Moreover, they can be afforded an opportunity to contribute to NRM sustainability by improving its capacity through its members dedicating time to take part in enforcing rules through new ideas and information dissemination among others. For the municipality to be regarded as relevant only by youth in Thorndale and Homu 14B indicates that it is not one of the key institutions relevant to NRM, which is not surprising because the municipality deals mainly with development projects such the building of clinics and roads.

Although the TA and the local civic organization were reported to be the most cooperating institutions before the harvesting trial in Thorndale and Peninghotsa, their level of cooperation improved during the trial, manifested by high number of respondents during the trial showing that they were cooperative. However, that the DEA was also included in the second most cooperating institution along with local civic organization and the TA, indicates CBCM has been able to fulfil part of its mandate of promoting cooperation between the villages and the government in NRM. This is because CBCM is an example of CBNRM – designed to promote such relations (Alcorn *et al.,* 2002). Evidence for this is demonstrated by an acknowledgement by the senior ranger of the local DEA in Peninghotsa who had not met the headman before until but did so through the CBCM. However, it is important to note that while cooperation among the relevant institutions included the TAs and the local civic organization, the headmen in Thorndale and Peninghotsa were singled out as the primary leaders cooperating with members of the local civic organization. Therefore, this means that the CBCM was managed at the village level rather than the tribal level because the headmen represent the TAs at the village level similar to local civic organization South African National Civic Organization (SANCO). Managing CBNRM projects at the tribal level or district level has been a major critic of CAMPFIRE projects in Zimbabwe (Murphree, 2005; Average and Desmond, 2007). For instance, Sibanda (2004) found that communities did not fully support CAMPFIRE because the administration was decentralized to the district councils rather than the communities themselves.

For the TA and the local DEA to be indicated as the most cooperating institutions in Homu 14B and Makhuva means that in certain areas the traditional and government institutions do work together. However, the reason for the similarities in these villages can also be attributed to the fact that both villages were under the same local DEA office and municipality. Nonetheless, despite the local DEA and TA reported to be working together, there were harvesting problems similar to those in Peninghotsa, where cooperation between such institutions was not reported. This indicates that the cooperation between community-based and state institutions, without involvement of community members themselves, is an obstacle to effective management of rotational wood harvesting, and CBNRM in general, i.e. community-based institution are not enough to make it community-based natural resource management. On the other, this study shows that it is the cooperation that includes the TA and other locally represented institutions like civic organization that would be critical in the future CBCM implementation. Accordingly, it is in such contexts that CBCM will be more feasible, because each institution cannot do without the other in achieving sustainable CBNRM (Mamimine and Mandivengerei, 2001). The findings concur with those of Shackleton *et al.* (2002) that where traditional and modern structures can work together in land and resource management, much is possible. Yet, they also demonstrate that the existence of effective institutions is one factor vital to the success of community woodland management (Yeatman *et al.*, 2003), and that the management system to be effective institutional structures should be at the lowest possible level, e.g. single villages agreeing with Ostrom (1992) and Shackleton *et al.* (2002). This also support the findings by Waylen *et* *al.* (2010) who indicate that local institutional context influences intervention outcomes and determines the likelihood of success in conservation interventions as illustrated by the findings in Homu 14B where the harvesting trial did not take place because of aspects including power conflicts between traditional and modern structures. On the other hand, the findings also indicate that power conflicts can also occur within a single institution, since in the TA in Homu 14B one headman did not attend CBCM because it was held in another' headman premises and not in the neutral venue. The reason for this is that all the institutions have constituencies, and therefore, if they do not cooperate, local people might be divided along socio-economic status as seen in Homu 14B, with some community members attending a meeting arranged by the local civic organization held in parallel with that of the CBCM.

### 6.4.2 Capacity

None of the key relevant institutions (neither traditional nor government) had sufficient capacity in terms of the number of rangers and vehicles required to effectively conduct patrols, highlighting the fact that capacity is a major constraint in NRM in communal South Africa. This indicates that the role and the importance of communities and their local institutions in management of their local resources, such as fuelwood, is likely to increase with the observed attrition in capacity of the state institutions responsible for resource management in the communal lands. Its severity was illustrated by the headmen and the members of the local civic organization doing patrols themselves to enforce rules, which also indicates that its impact is felt heavily at the village level by the headmen rather than by the chief at the chieftaincy level. This suggests that without interventions such as CBCM, unsustainable harvesting will continue in areas like Makhuva and might lead to other environmental problems. For instance, local resource users were reported to burn down trees, revisiting them when dried out to collect fuelwood, so that they appear complying with traditional rules. Related findings have been found in Zimbabwe where in areas without Communal Areas Management Programme for Indigenous Resources (CAMPFIRE) project, some areas are at risk of quickly becoming a desert if the current level of degradation continues (Average and Ephraim, 2010).

The variation in numbers of rangers across the various TAs and government departments across the study villages means that some traditional and government institutions are worse off than others, since the size of the areas for which they patrolled was not the same. The number of rangers in the local government department in Thorndale has not changed since the early 2000, because the same number (three) was recorded by Du Toit, (2002). This substantiates the findings from the interview with the senior rangers in charge of Thorndale and Peninghotsa that new rangers were not appointed to add to the existing number nor to replace those going on retirement. Shortage of vehicles proved to be important because without them rangers were not able to reach the villages under their jurisdiction to patrol as seen in the local government department for Homu 14B and Makhuva, which shows that the conventional natural resource management system is costly. That the senior ranger could not attend CBCM meeting in Peninghotsa because of attending a court case involving crocodile indicates that rangers in communal woodlands have other responsibilities involving wildlife in addition to that of compliance monitoring. Although this may also indicate that rangers may have given wildlife duties a priority over fuelwood, it is also evident that generally, incapacity remained a problem as reflected by their number and vehicles in relation to the number of villages they patrolled.

Although lack of capacity was common across all the study villages, villages responded differently to its impact on the CBCM, which provides several lessons regarding the contribution of lack of capacity in CBNRM projects. On one hand, this demonstrates the importance of capacity in CBNRM as seen in Homu 14B, since the local leadership in this village indicated that they would allow harvesting trial if they had enough rangers to monitor compliance with CBCM rules. This is because although eventually it appeared like they wanted to implement the project they did not motivate local people to participate because of this problem and that of lack of monetary benefits. However, this also indicates a lack of trust in the resource users by the local leaders, which can be explained by high incompliance recorded in this village, but also implies a more authoritarian leadership, contrary to that observed in Thorndale and Peninghotsa, which was flexible. This means that lack of capacity in certain villages, such as those of Homu 14B, will hinder the implementation of CBCM, which is ironic since CBCM is aimed at addressing the incapacity problems through involving local resource users. This is in agreement with Fabricius *et al.* (2004) findings that capacity is important in the beginning of CBNRM and that it is essential in order for local institutions to be effective (Shackleton *et al.*, 2001). Similar findings have been found by Grundy and Mitchell (2004) when all pilot participatory forest projects initiated by DAFF in certain villages from three different provinces of South Africa were unsuccessful partly due lack of capacity building at all levels (i.e. national, provincial and local). On the other hand, in Thorndale and Peninghotsa, despite an inadequate number of rangers, local headmen and resource users were not discouraged, as they engaged in CBCM until they reached the desirable outcomes, continuing even beyond the feasibility study period on their own. This demonstrates that although material capacity might be seen as fundamental to enforcing rules, it is not a panacea in CBNRM, since local people can engage in a CBNRM without them. Lack in physical capital can be compensated for, to some degree with higher levels of social capital, such as flexible and trusted local institutions, legitimacy of local institutions and cooperation, and community mobilization. History of cooperation in Thorndale (rotational grazing in coupe used during the trial) and Peninghotsa (community building schools) can also account for engaging in the trial in these villages since past experiences of cooperation is critical to achieve cooperation to manage resources (Baland and Platteau, 1996).

The implementation of the harvesting in Thorndale and Peninghotsa also indicates that the headmen in these villages had adaptive capacity. In the context of NRM, adaptive capacity implies learning-by-doing where complexity, uncertainty, and incomplete knowledge are acknowledged and management actions are treated as experiments (Simon *et al.*, 2016). Therefore, that the headman in Homu 14B did not allow harvesting tria because of incapacity (shortage of rangers), demonstrates that he did not have the adaptive capacity, contrary to the chief reflected by his understanding that CBCM can be piloted as an experiment from which other villages had to learn. Therefore, it is true that in a socio-institutional context, adaptive capacity depends on the attributes of individuals, organizations, and institutions that might foster learning in the context of change and uncertainty, such as a willingness to learn from mistakes, engage in collaborative decision-making arrangements, and encourage institutional diversity (Folke *et al.*, 2003). As a result, the findings indicate that leaders who have adaptive capacity, such as those in Thorndale and Peninghotsa, will be willing to attempt CBCM as a new approach to managing fuelwood resources given the ineffectiveness of traditional NRM approach to fuelwood. This means that in certain villages lack of capacity cannot hinder the implementation of CBCM nor require specialised skills which are scarce in South Africa (Fabricius, 2004). In Homu 14B, the findings indicate that while the tribal chief can have adaptive capacity, their headmen might not and this can lead to CBCM not being implemented if the chief does not get involved. Since the headmen might not share the same vision. This is because the institution and its management structure should be adaptive, flexible and evolve for CBNRM to stand a chance to succeed (Fabricius, 2004) implying that the institutions as a whole, and not just individuals, need to be adaptive for CBCM to be implemented in communal woodlands.

The fact that local resource users volunteered to conduct patrols and enforce rules indicates that local resource users can take responsibility to manage resources such as fuelwood in communal woodlands, as recommended by Shackleton and Shackleton (2004a), and this will in return strengthened the capacity of relevant institutions. This is important because in the light of incapacity problems, it is not clear how the communal woodlands are going to be managed given the scarcity of personnel and financial resources (Von Maltitz and Shackleton, 2004). In Peninghotsa, that the headman informed his chief after accepting the CBCM could mean that good understanding might have existed between the headman and the chief, which is one of the seven key principles necessary for a successful CBNRM programme (DEAT, 2003). For instance, after knowing this, the chief thought of establishing a foundation to support those volunteering to do policing work, which also indicates a sense of sympathy to his people. For the delegated junior rangers to oppose the project in a community meeting because they were not aware that the project involved harvesting of livewood, despite it being approved by the senior manager, demonstrates lack of communication and coordination which are required for successful CBNRM. The findings are consistent with those of Fabricius *et al.* (2003), who found that lack of coordination is one of the stumbling blocks of CBNRM in South Africa.

### 6.4.4 Institutional performance on design principles

The boundary conflicts which led to one of the coupes being excluded in Thorndale highlight the importance of clear bounraries, and mechanisms for resolving confict over these, for the successful implementation of CBCM (**design principle 1, 6.1.1**, refer to Table 6.1). This is true especially because even in Peninghotsa, there was also one portion of the woodland that was excluded because of the conflicts with the neighbouring village, Govhu. This is problematic because in common property management systems, boundaries should be agreed upon between neighbours, both community-community and community-state neighbours (Whande *et al.*, 2003). For instance, when resource boundaries are unclear, no one knows what they are managing or for whom (McGinnis and Ostrom, 1992). In such instances, even resource users not residing in the village can use the resources, thereby threatening the ecological sustainability of the resource. Hence clear resource boundaries are crucial in ensuring sustainability of the resources (Jensen and Jensen, 2010). This suggests that unclear boundaries in the study villages can be a threat in the long term sustainability of the CBCM in Thorndale and Peninghotsa as observed elsewhere. In Namibia, Shackleton and Campbell (2004) found that *Torra* conservancy decided to leave out the disputed areas from their conservancy applications after being involved in a boundary dispute with another emerging conservancy that needed mediation to resolve the conflict.

Harvesting during the CBCM was done in a manner that promoted sustainability through initiating a coppice stools for trees that were not protected by law and all those that borne fruits (**design principle 2, 6.1.2** refer to Table 6.1). Unless the number of individuals authorized to use a common property resource is so small that their use patterns do not adversely affect one another, at least some rules related to how much, when, and how different products can be harvested are usually designed by those using the resource (Cox *et al.*, 2010). In Thorndale and Peninghotsa, the size of the communal woodland was relatively big which enabled the demarcation of harvesting blocks that allowed for sustainable ecological rotation of four years. The fact that there was an appreciation seen by giving women the responsibility to devise harvesting rules demonstrates an understanding by the local leadership that fuelwood relates more to women as the aforementioned author point out. This proved to be one of the key aspects that enhanced sense of ownership during the CBCM (**design principle 3, 6.1.3** refer to Table 6.1). During the trial, policing involving the local resource users proved more effective than when the local institutions policed alone, and was demonstrated by the reduction in the number of non-adherence and higher compliance with harvesting rules (**design principle 4, 6.1.4** refer to Table 6.1). For instance, the patrol committee member indicated that grass was growing on the paths that were created by donkey carts and *bakkies* which illustrates that the vegetation was recovering under CBCM. This occurred despite policing being done voluntarily. This differs from the findings by Cox *et al.* (2010) that monitors may not perform satisfactorily if they do not directly benefit from improved resource conditions. However, in Peninghotsa, the headman gave each patrol committee member an amount of R150 after selling the confiscated fuelwood, as an incentive. This shows that the headman appreciated the efforts of the local patrol committee team because, like before the harvesting trial, resource users did not expect any monetary benefits, since it is usually the local headman entitled to use such monies.

Punishing rule violators was the responsibility of the leadership across the study villages. In the absence of local resource users discussing how violators rules indicate that although graduated sanctions help to maintain community cohesion while genuinely punishing severe cases (Cox *et al.,* 2010), local people are happy with some of the traditional management rules. Therefore, some of the design principles might not be applicable in villages such as those in Thorndale and Peninghotsa (**design principle 5, 6.1.5** refer to Table 6.1).

During the harvesting trial, no fuelwood related conflict was observed (**design principle 6, 6.1.6** refer to Table 6.1). Conflict over an exhaustible resource is inevitable in common property resource management, necessitating the presence of established mechanisms for conflict resolution to maintain collective action (Ostrom, 1990; Fabricius *et al.,* 2004). However, although no conflict related to fuelwood was observed, conflict resolution is at the centre of the headman's responsibilities in the village. The fact that local resource users can appeal before the magistrate court if they are not satisfied by the decision taken by the headman regarding aspects of fine etc, shows that there are conflict resolution mechanisms in the NRM in communal woodland. This is because the tribal court deals with cases like tree cutting deals and put a fine up to a specific limit (Du Toit, 2002), while the magistrate acts as an appeal court to tribal findings. This indicates that the government too is involved in conflict resolution mechanism in NRM in communal South Africa. Therefore, the fact that the headmen were left to decide on the fines means that similar conflict resolution mechanisms would have applied had conflicts arose during the harvesting trial. Lack of transparency contributed to the conflict between the headmen which contributed to the lack of buy-in CBCM in Homu 14B. For instance, transparency plays an important role in improving local attitudes towards conservation, while generating trust and buy-in for CBNRM processes (Chevallier and Harvey, 2016), which was not the case in Homu 14B. Similar findings have been found in Botswana, where lack of transparency is one of major hindrances to CBNRM success, causing limited participation by local villagers (Chevallier and Harvey, 2016). Nonetheless, whether transparency exists depends on how traditional leaders exercise power, and on the habits of a particular society. Furthermore, in theory, traditional leaders are less transparent than modern ones because the justification of their decisions is not institutionalised (Linder, 2004).

Through CBCM, all villages were to be given rights to actively exclude outsiders, but this did not have similar impacts across villages (**design principles 7, 6.1.7** refer to Table 6.1). On one hand the findings from Homu 14B and Makhuva suggest that the right to exclude non-locals do not always provide enough incentive to engage in a CBNRM project. This is because in these villages local resource users were aware that through CBCM they could exclude outsiders who were reported to be the main problems. Nonetheless, the right to exclude outsides is key to successful CBNRM (Yeatman *et al.,* 2003), and evidence for this is given by the headmen and local resource users in Thorndale and Peninghotsa, who after being made aware of their communal rights to harvest resource while excluding others, engaged in CBCM. However, that the headman in Peninghotsa indicated that they were not aware that they could be police officers themselves policing their village commons against outsiders, demonstrates that some local leadership may need to be made aware of the communal rights. This suggests the need to educate leaders about communal rights, which is in line with Twine (2004), where he found that education was needed in communal South Africa about rights and responsibilities, since local people interpreted democracy as meaning unbounded freedom in which people are entitled to do as they wish.

## 6.5 CONCLUSION

Although this study has demonstrated that both traditional and government institutions had inadequate material resources to be effective in preventing unsustainable harvesting problems, it is evident that the TAs would be the appropriate institutions to lead CBCM at the village with support from other institutions because it is regarded it the most relevant and legitimate institution in communal woodland areas. In certain villages such as Homu 14B, incapacity problems contributed to hindering the implementation of the trial, while not in others such as Thorndale and Peninghotsa. However, it was the adaptive capacity of the local leaders that was fundamental to achieving the desirable outcomes, because this enabled the local resource users to be involved in project activities such as designing rules and policing thereby resolving the incapacity problems that existed before. Nonetheless, it would be recommended that chiefs must not only rely on reports from their headmen, but also attend CBCM meetings to assess how the headmen manage CBCM projects. This would provide checks and balances thereby ensuring that the headmen use their powers effectively while the chief can give support where necessary such as delegating tribal rangers. The study also demonstrated that the effectiveness implementation of CBCM can be enhanced by applying Ostrom design principles since in most of such criteria were met.

# CHAPTER 7

## SYTHESIS AND GENERAL DISCUSSION

This concluding chapter is a synthesis of findings within the conceptual framework developed in chapter 1. It also discusses the study contributions to an understanding of the factors affecting the implementation of community-based coppice management (CBCM) in communal areas and the opportunities and constraints for future CBCM implementation.

### 7.1 The conceptual framework

Centred on sustainable implementation of the CBCM intervention, the framework developed for this study considered internal and external drivers as positively or negatively affecting the project implementation (Fig. 7.1). Resource users (compliance and perception and attitudes and time spent harvesting), village consumption patterns (access to electricity), resource supply (size of the communal woodland area, density of stems in the harvestable diameter size class and coppice shoots), local traditional institutions and management system (harvesting period and rotation time) were internal drivers that directly affected the project. External drivers were government institutions and their influence to the project was indirect. Although the market is also one of external drivers for fuelwood harvesting, the focus of this study was on subsistence use of fuelwood, hence market is not include in the conceptual model.

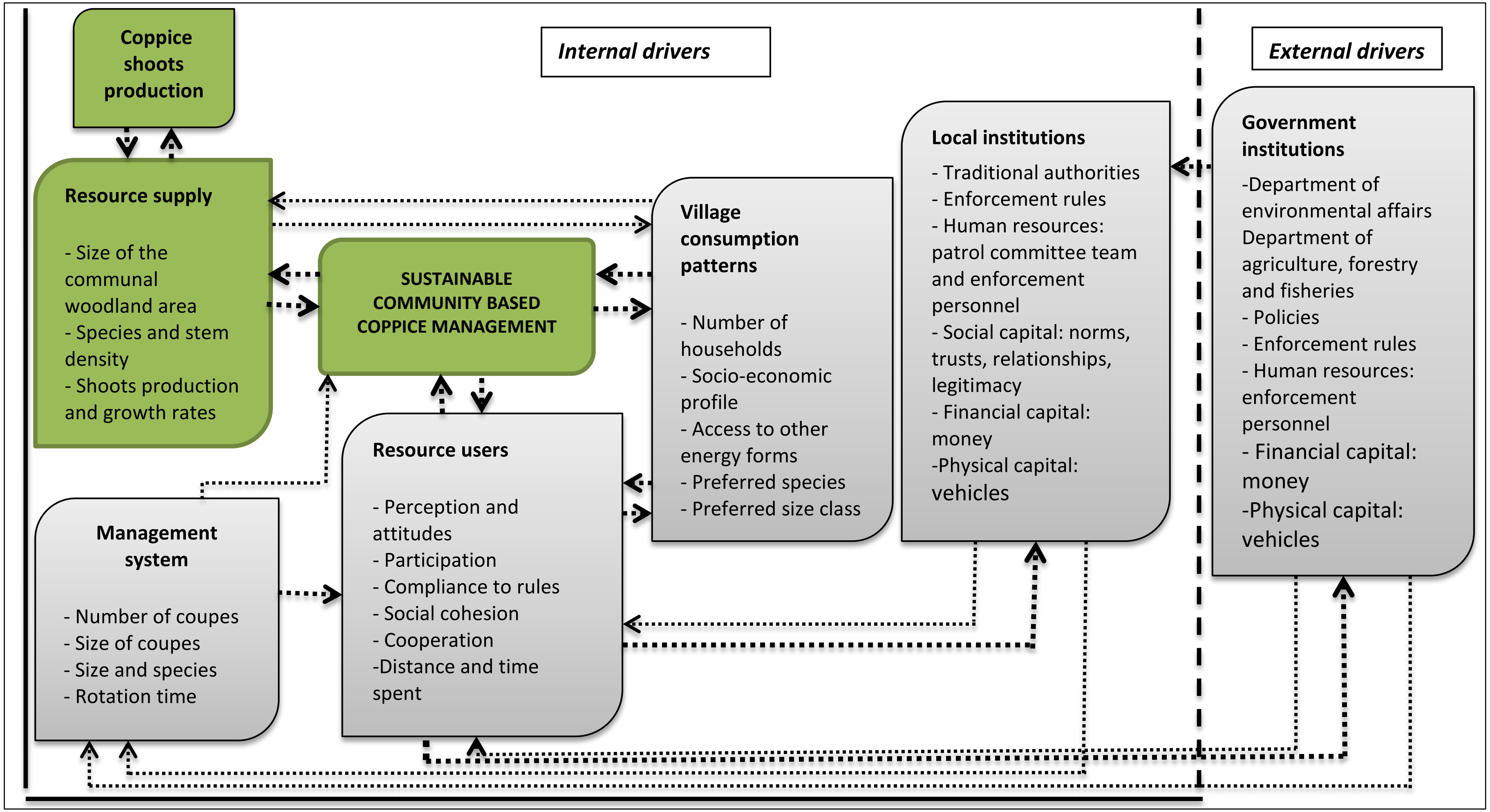



Figure 7.1: The expanded conceptual framework of the elements brought together in the discussion in the study villages, Thorndale and Peninghotsa. The thickness of the arrows indicates the factor's significance and impact on the project.

When considering the influence of both the internal and external drivers of the sustainability of CBCM in Thorndale and Peninghotsa, the internal drivers had a greater influence than the external drivers during the harvesting trial. This is demonstrated by the thick arrows in Figure 7.1. For instance, as observed during the community meetings, all people in these villages accepted the project since it responded to their energy needs. This was because of the village consumption patterns, where the majority of the resource users depended heavily on fuelwood for cooking due to high unemployment rates, and, electricity was mainly used for lighting. In contrast, Homu 14B and Makhuva, especially in the former, which had relatively high proportions of households using electricity for cooking, 20%? Therefore, resource users in Thorndale and Peninghotsa had more positive perceptions and attitudes towards the project which resulted in them supporting the implementation of the project and worked closely with the local leadership with minimal and/or no support from local government. This indicates that traditional institutions would be key in the implantation of the CBCM interventions in communal woodlands.

The density of stems in the harvestable size class, coppice shoots that emanated after harvesting in the intermediate size class and the size of the harvesting coupes contributed substantially to determining the ecological feasibility of the project in Thorndale and Peninghotsa. For instance, although, the third coupe was small, 210 ha, in Thorndale, there would be adequate biomass to allow for rotational harvesting in this village, because of high density of stems in the harvestable size class. On the other hand, while the density of stems was relatively lower in Peninghotsa, there would be adequate biomass in coupes to permit rotational harvesting of coppice because of the large area of coupes. The direct impact of the management system on the project, as demonstrated by the framework, was visible through shorter harvesting periods of six months, after which local resource users shifted into the second coupe. Harvesting in the last six months especially towards the end of the feasibility study period meant that it was too early to record coppice shoots. Therefore, most of the coppice shoots were recorded in the first coupe.

The implementation of the project influenced resource drivers, in a feedback loop, as illustrated in the conceptual framework diagram. This has been demonstrated by the change in the perception and attitudes during the harvesting trial, which led to the increase in the number of local resource users complying with harvesting rules. For the village consumption patterns, this was reflected by local resource users incurring less opportunity costs when harvesting fuelwood during the harvesting trial than in traditional NRM. Species preference changed mainly in Peninghotsa, where harvesting of *Colophospermun mopane* was prohibited because it is a host of mopane caterpillars, which resulted in *Combretum apiculatum* being the most preferred species during the harvesting trial. Although its harvesting continued during the harvesting trial, which indicated incompliance, this occurred at a much lower rate than before the trial. This means that their sustainability can be enhanced through a management system such as CBCM in communal lands of South Africa. Similarly, through the project, the harvesting pressure on *C. apiculatum*, which was the predominant and most preferred species before the trial, was reduced, with more pressure being put on *Dichrostachys cinerea* in Thorndale and Peninghotsa. This is because emphasis was made for it to be harvested indiscriminately because of it is an encroacher species in communal South Africa. The project's influence on the resource supply has been seen through the emergence of new coppice shoots. This emanated from stumps/coppice stools created by fuelwood harvesting based on agreed rules to harvest stems sizes from 4 cm to 8 cm. Through the project, the number of saplings increased during the trial which also indicated compliance because harvesting occurred in on the stems in the intermediate size class.

The local institutions impacted the project differently across the study villages. In Thorndale, the local institutions (chieftaincy and the local civic organization) worked together worked together, and a pattern was observed also in Penighotsa. However, it was in Homu 14B and Makhuva where there was a lack of cooperation at the village level which negatively affected the project. None of the relevant institutions had sufficient capacity in terms of the required resources to help support the project. Nonetheless, the inadequate levels of human and physical resources, which were reported to be the main reasons for overexploitation during the traditional NRM, were compensated for by the social capital among local resource users. The existence of social capital, in the form of trust enabled local resource users to cooperate and voluntarily undertook patrols while complying with agreed CBCM rules. Furthermore, the project fostered relationships among local institutions and allowed for the new ones such as a Non-Profit Organization in Peninghotsa, and the Community Development Forum and the local municipality in Thorndale, to take part in NRM. These results conformed to the conceptual framework. Whether or not the same results would have been observed in Homu 14B and Makhuva could not be established, because no harvesting trial took place in these villages.

### 7.1.1 Effect of fuelwood consumption patterns

In the study, the fuelwood consumption patterns were similar across the study villages. However, the problem of commercial harvesting, especially by outsiders, decreased in Thorndale and Peninghotsa during the trial contrary to under traditional management rules in Homu 14B. This indicates that incapacity problems to enforce traditional harvesting rules can negatively affect the energy livelihood of the local resource users, because the local resources are shared with intruders. However, the decrease in the number of outsiders intruding the commons during trial indicates that such problems can be resolved through CBCM, while reducing the opportunity costs. This would be critical considering that commercial problems are widespread in communal woodlands (Gandar, 1997; Twine *et al.,* 2003b; Shackleton and Shackleton, 2004a; Shackleton *et al.,* 2004b). Further, this also suggests that the implementation of the rotational harvesting strategies of coppice elsewhere in the continent where it has been recommended (White, 1979; Kennedy, 1998; Shackleton and Clarke, 2007) can help address similar problems.

The unsuccessful implementation of the harvesting trial in Homu 14B supports a number of studies that show that CBNRM is more feasible in communities with small population size, since smaller, more homogenous groups are more likely to engage in successful collective action (Olson, 1965; Wade, 1987; Agrawal, 2002; Bond *et al.,* 2006). This suggests that although rotational harvesting strategies have been recommended in communal woodlands, its implementation would be limited to villages with small population size mainly in those with population size of less than 1 000. Therefore, this implies that other interventions would need to be considered in certain villages where the local socio-economic conditions would not be conducive for CBCM to address the unsustainable harvesting in other villages as a matter of agency. This is because the problems for which CBCM have been recommended to address will continue in such villages thereby leading to more unsustainable harvesting patterns in communal woodlands. This indicates that although CBNRM is advocated as key to addressing natural resource management problems in communal woodland areas, it is not panacea.

Less harvesting pressure on the predominant species such as *Combretum apiculatum* and *Colophospermun mopane*, and the increase in the number of saplings demonstrates that sustainable harvesting or conservation of trees in communal woodland areas cannot be enhanced simply by the local leadership's prohibition of harvesting, but through controlled harvesting. However, this would happen provided that the supply of biomass is higher than the fuelwood demand in the village. This indicates the importance of stewardships among the local resource users in communal woodland areas, without which the local institutions cannot be successful in their need to protect and conserve resources central to the local people. Therefore, although the importance of stewardship or involving local resource users has been observed in CBNRM in the wildlife sector, the results indicate that it is important for any natural resources upon which local people depend upon in communal areas, if the relevant institutions seek to conserve them. Most importantly, in South Africa local people harvest livewood out of necessity (Gandar, 1997) which means that local people need to have their primary needs recognized by the relevant institutions seeking to protect natural resources upon which they depend because they do not afford electricity. Reduced opportunity costs provides evidence that deadwood are scarce while by giving controlled access to local resource users, local institutions will in turn, be contributing to resolving communal rights which have been blamed for overharvesting since 1994 (Twine, 2004), which they battle to resolve. This indicates the reciprocal relationship that local people can show when their needs are recognized.

The fact that women harvested fuelwood throughout the season during the trial in Thorndale and Peninghotsa contrary to only winter in Homu 14B indicates that winter is not the most preferred harvesting season, but a reflection of imposed rules. This is because when they were presented with an opportunity by the local headmen to indicate the time and period by which they would prefer to access fuelwood resources they did not specify the season. Yet the differences in the access rules in the two villages also indicates that across communal woodlands rules may not be the same, therefore, it would be the responsibility of the project facilitator to ensure that such rules do not undermine the sustainability of the resource base. This is true especially because in villages around Bushbuckridge, Neke (2004) found that the majority of resource users (more than 80%) harvested stems in the large classes than those in the intermediate size classes which were harvested in CBCM. The prohibition of *C. mopane* demonstrates the impasse between the TA's obligation and intention to protect resource and the local need for fuelwood, while less harvesting of such species demonstrates at the expense of those causing environmental problems, *Dichrostachys cinerea*, indicate that CBCM offers a new approach to overcome this impasse. However, it is also ironic for the chieftaincy to recommend that such a species be harvested because doing so would be against the harvesting rules despite its environmental problems. Yet this might also indicates that local leaders are flexible and can relax rules when they affect them.

The continued existence of commercial harvesting means the ecological sustainability can be threatened over time especially if increasing numbers of resource users harvest for commercial purposes or engage in self-employment activities using fuelwood such as baking. This demonstrates that CBCM cannot address unemployment concurring with Fabricius *et al.* (2003) that CBNRM will not solve all community problems in the project area. Instead, it will reduce jobs created by commercial harvesting in the woodland as seen in Thorndale and Peningotsa. Hence, concurring with Von Maltitz and Shackleton (2004) it would be recommended that CBCM should not be implemented in isolation with other programmes aimed at addressing poverty problems in the communal woodland areas. On the other, through greater security of the resource base of the mopane woodlands, the project would contribute to local economic improvement since harvesting of mopane catepillars would be restricted to local resource users only. Thus, this suggests that in such areas CBCM can contribute to poverty alleviation because of the strict boundary control undertaken by local resource users. This is because poorly regulated communal tenure systems highly expose resource base for overuse and degradation (Wantrup and Bishop, 1975), which was the observed before. In a CBNRM people have to be encouraged to continue with their different activities and not rely completely upon the benefits from CBNRM (Fabricius, 2004), which suggests that those who usually harvest mopane for selling can have more profit.

### 7.1.2 Resource supply from coupes and the effect of management system

The study provided evidence that rotational harvesting of coppice can be ecologically sustainable in communal woodland areas. This justifies a number of studies that have called for a feasibility study (see Shackleton, 2001; Twine, 2008). The emergence of coppice shoots under the second scenario, where the standing stock in the intermediate size class was exhausted, indicates that the savanna ecosystem is resilient even under heavy harvesting pressure. This is also the reason why the savannas have not collapsed as predicted by Banks *et al.* (1996) in communal woodlands in Bushbuckridge, Welverdiend (Matsika *et al.,* 2013). Nonetheless, while this indicates that the ecosystem could be replaced by coppice stems in the loss of all primary stems due to harvesting such may vary in contexts because coppicing abilities are affected by local conditions such as edaphic factors (Kaschula *et al.,* 2005), browsing and fire which is the most important driver of savanna structure after climatic constraints (Bucini and Hanan, 2007; Staver *et al.*, 2011). Furthermore, this also suggests that the supply of fuelwood through CBCM would not be the same across the woodlands even where the species composition is the same therefore, an understanding of disturbances specific to local context would be necessary.

The fact that large trees would not be harvested in the CBCM means that there would be less harvesting pressure under CBCM because harvesting would be restricted to stems in the intermediate size class, 4-9 cm. Thus, although authors caution that high harvesting may potentially reduce the future reproductive potential of such species and thereby impacting the future ecological sustainability (Shackleton *et al.*, 2005), under CBCM, the reproductive potential can be enhanced. This is because saplings can recruit into large classes. Therefore, large trees can continue to perform other ecological functions, although this would depend on compliance of harvesting rules restricting its harvesting and whether they escape harvesting and other disturbances for which they are vulnerable

Ecologically, the project had an impact on the communal woodlands, in a feedback loop, which indicates that human actions would need to be managed effectively in the CBCM areas. The two results from the prediction scenarios can also be used to indicate the human-environment relationships, and that the woodlands are affected by the types of harvesting rules designed by the local institutions. Most importantly, more saplings and more coppice stools in the intermediate size class during the trial suggests that CBCM rules should be sensitive to such relationships, because with benefits local resource users would comply to rules while protecting the resource base against the outsiders, and this would enhance the ecological integrity. Therefore, while achieving the right balance between fuelwood access and sustaining the environment is a challenge (Basiago, 1999), the result indicate that such a balance can be achieved through CBCM. However, since edaphic factors influence coppice response, this means that the predicted growth of coppice observed in this study cannot be generalized in communal woodlands. This means that in some villages the rotation time can be shorter while longer in others, therefore, this will affect the ecological sustainability of the project differently.

Harvesting in the trial was a hybrid of the size-based and area-based systems, because resource users rotated between coupes but there were size restrictions. The fact that this worked well suggests that CBCM can use different approaches, but also indicates that project facilitators need to be creative and flexible while implementing project since some of the systems may not be easy to implement, such as size based system which is difficult to enforce (Gandar, 1997). The fact that borrowing aspects of the two systems was easy was illustrated by the headmen in Thorndale and Peninghotsa who successfully managed the system without seeking any technical advice either from the researcher or government officers after the researcher had supported them by printing agreed harvesting rules that had to be distributed to each household. As evidenced by the patrol committee which patrolled voluntarily on a daily basis, it is given that ecological sustainability under CBCM can be achieved with limited resources from relevant government and this can be a cost saving to the government because such resources could be spent to other services. However, this will also depend on how long could people volunteer to patrol voluntarily which is something that could be not observed due to time limitation. Nonetheless, if improved access to fuelwood is in itself an adequate incentive to patrol voluntarily means that they can patrol for a very long time. This can create long term conditions in which the local chieftaincy and local resource users can cooperate, thereby leading to mutual benefits.

For the headmen to work closely with other community members constituting the management system, also reveals that certain traditional leaders in communal woodlands are willing to work with community members and other local institutions in participatory projects. This will be critical in the implementation of CBCM and other projects informed by CBNRM principles because the absence of local institutions is one of the most limiting factors in CBNRM (Agrawal and Gibson, 1999; Leach *et al.,* 1999). Similar findings have been found in Malawi and Lesotho where the participation of the chiefs and headmen has been cited as one of the strengths of CBNRM (Campbell and Shackleton, 2001).

The absence of the harvesting trial in Homu 14B and Makhuva, contrary to Thorndale and Peninghotsa, indicates that high socio-economic differences among local resource users would limit the implementation of CBCM, but this is highly likely to be the case in large villages. However, based on the findings, it is probably not ecologically feasible in many if not in most villages which are more representative of typical villages and woodland across the two provinces; Thorndale and Peninghotsa or Homu and Makhuva. This is because the sustainability in Thorndale and Peninghotsa indicates that CBCM would be ecological sustainable in villages that have relatively large woodland areas with high density of the stems in the preferred size class, while many villages had scarcity of fuelwood resource.

### 7.1.3 Effect of perceptions and attitudes

Positive perceptions and attitudes towards CBCM in Thorndale and Peninghotsa were influenced by the fact that there were relatively more people depending on fuelwood in these villages that it was the case in Homu 14B and Makhuva. Based on the findings, this shows that positive perceptions and attitudes are likely to exist in villages with small population groups of less than 1 000 inhabitants with high dependence on the fuelwood resource. Nonetheless, that it was the perceptions of the women that determined the outcomes across the villages suggests that for any CBNRM projects to be successfully implemented in communal woodlands, it is the perceptions of those that are directly affected by the project whose perceptions would be key for the support of such a project. Hence, although attitudes and perceptions of communities towards conservation initiatives are important for sustainable management of natural resources, agreeing with Sesabo *et al.* (2006), it will be of those who are likely to benefits directly from the CBNRM project in question that will determine the likelihood of communities reaching their desired outcome.

Credit should also be given to the leadership who created an enabling environment for the women to participate in the project in Thorndale, in contrast to Homu 14B. Appreciation for this has been demonstrated by all the headmen in study villages including those in which the trial did not happen which demonstrates an understanding that women participation would be instrumental for the successful implementation of CBCM across the communal woodlands across the continent. This is because they remain the primary users of fuelwood and use it for domestic purposes for which CBCM is about. For instance, in the absence of women in a community meeting where CBCM rules were supposed to have been designed, the available men and the local leadership cancelled the meeting indicating that such rules would only be designed by women because the formulation of such rules required them as occurred in Thorndale and Peninghotsa. Based on the results, similarity in perceptions is likely to occur in villages with small groups where the user group is relatively homogenous with strong social capital and the woodland is less degraded. Similar findings have been found by Cunningham (2002) that people residing in less degraded woodlands are likely to cooperate and defend their resource base. This indicates that participation of local resource users in area where CBCM projects are implemented may occur also because of the value attached local resource users attach to fuelwood resource which has been the case in this study. On the hand, low homogeneity in Homu 14B and Makhuva suggests that in villages with large population CBCM may not be implemented because local people may be highly differentiated along socio-economic factors thereby affecting the need to work together, meaning in such places the project would not be socially sustainable and other interventions may be required to address fuelwood problems. Furthermore, homogeneity breaks down with the influx of outsiders into the area (Cunningham, 2002); the relatively high number of people from Mozambique in Homu 14B and Makhuva may have also contributed substantially in the heterogeneity of the village. This is because although they were available in Thorndale, the number of their households was reported to be less than five. Moreover, it was in Homu 14B and Makhuva where problems associated with Mozambicans were reported. This indicates that the sense of ownership or feeling attached to the resource base would be important for the compliance of harvesting rules and that it is those who have permanent resident who are likely to comply with harvesting rules as opposed to outsiders and those originally from other countries such as Mozambicans.

### 7.1.4 Effect of governance system on success of project implementation

One of the key principles for local governance institutions is that the institutions and their management structures must be adaptive, flexible and evolve (Fabricius, 2004), which is the reason why the trial was successfully implemented in Thorndale and Peningotsa. This is because it was in these villages where the local leadership demonstrated such characteristics ,contrary to Homu 14B and Makhuva, implying that these would be critical and required for local leadership to successfully implement CBCM in communal woodlands. This is true because unlike under the traditional management styles where rules are imposed by the local institutions upon the resource users, local resource users should be able to participate in designing rules since this is key for them to comply with such rules as seen.

The implementation of the trial with minimal or without government support in terms of resources in Thorndale indicates that capacity is mainly central under traditional management systems contrary to CBCM. This is because although the incapacity problems affected the implementation of the project in Homu 14B, it is evident that in the lack of support by the local resource users even if the required capacity support was given, the trial would not have been implemented because harvesting required local people. Concurring with Fabricius *et al.* (2004) this shows that CBNRM projects are about local people because they designed rules and undertook policing every day which was effective not in only addressing problems of the shortage of physical resources and human resources (Koch, 2004), but also reducing commercial harvesting problems by outsiders.

The effectiveness of CBCM resource governance system in addressing harvesting problems for which the traditional governance system have failed to address since 1994 demonstrates that the latter system is no longer a viable option. This is not only on the basis of the budget cuts by the national department which impedes enforcement of rules agreeing with Kirkland *et al.* (2007), but because deadwood which is legal as per traditional management rules are scarce or no more. Thus, this also means that capacitating local institutions in terms of rangers would only increase the ineffectiveness of the traditional management system, because this would without access to fuelwood there would be an increase negative attitudes which undermines the effectiveness of local resource governance system in addressing resource sustainability in natural resource management (Boggs, 2000), as this study has also found. Moreover, without providing any alternative energy source, prohibiting harvesting of livewood by the local governance would be morally questionable. This is true especially when research such as this shows that controlled access would not only be ecologically sound but also that there would be reduced transaction costs on the part of the responsible institutions, because enforcing rules would come at the cost of the local resource users through carrying out patrols in coupes which would represent a cost saving since the state has limited funds and resources (De Villiers and De Villiers, 2004). The findings support those of the work by Cunningham (2002) that resource users need to live near the resource since this will simplify the monitoring of thereby restricting access by outsiders. Similar findings have also been found from joint forest management in Tanzania (see Baldus and Siege, 2002) and in community forestry in Nepal (see Schereir *et al.*, 1994; Virgo and Subba 1994 and Jackson *et al.,* 1998) where the involvement of local people played a significant role to enhancing resource recovery exists. Yet this also indicates that although the benefits of involving local resource users by the local resource governance has been observed in the wildlife sector given the focus of many CBNRM projects, the findings of this study also demonstrate that such benefits can also be realised in other sectors especially in the woodlands where which has received less attention (Shackleton and Shackleton, 2004a; Turner, 2004).

Institutional cooperation was instrumental in the successful implementation in Thorndale and Peninghotsa. However, the project was successfully implemented in Thorndale although such cooperation did not include the local DEA contrary to Peninghotsa which demonstrates that primarily, it would be the institutional cooperation involving local institutions at the village level that would be critical if successful implementation of CBCM is to be achieved in communal woodlands. However, in certain communal woodlands reports of fuelwood vendors armed intruding the commons with guns have been made (Yeatman *et al.,* 2003), suggesting that in such areas support from the local governmental department would be necessary if CBCM is to be effective because local resource users would powerless.

Although the issuance of the written consent for the harvesting trial was critical in enabling the harvesting trial, its expiry demonstrates that without policy changes that can allow for livewood harvesting, the long-term implementation of CBCM would not be realised despite the findings indicating that it would be feasible. Moreover, since harvesting of livewood requires permit also in the miombo woodlands (Gandar, 1997; Shackleton and Clarke, 2007) that such policy changes would be necessary similar to South Africa since rotational harvesting has been recommended (Kennedy, 1998). Having said that, while Shackleton and Shackleton (2004a) point out that that there is need to have state change policies and strategies to address management of everyday resources one such changes should be to allow for controlled harvesting of fuelwood based on livewood because it was a major hindrance for both the local traditional and governmental institutional to continue with CBCM. On the other hand, that it was not required in Thorndale, Homu 14B and Makhuva although they were in the same province for which the Act on which the required of the written was based indicates that Acts are prone to different interpretations and that clarity might be needed in the future. Therefore, such policies should also address this problem.

For the senior local ranger in the local Department of Environmental Affairs (DEA) indicating that the project would only commence one the written consent was issued out means that the local DEA is not only an important stakeholder in the resource governance but can also play a role of a facilitator. On the other hand, this also demonstrates that although the TAs were considered to be the most powerful institutions in the resource governance system, this is not the case in certain aspects, because the local chieftaincy could not start implementing the trial before receiving the written consent required by the local rangers. The involvement of the Department of Land Reform and Rural Development (DLRRD) in issuing the written consent demonstrates that there are a number of stakeholders relevant to the resource governance which may be unknown to key stakeholders but would be key to unlocking the implementation of opportunities of CBCM through changing policies since this is the major hindrance.

Despite the local institutions having successfully implemented the trial, the lack of clear boundaries in Thorndale and Peninghotsa demonstrate that of all the eight design principles unclear boundaries would highly likely affect the implementation of CBCM. This is because aspects related to other principles such conflict resolving mechanism could be addressed through the existing resource governance system such as local chiefs and the magistrate courts since they are used for appeals in conflicts related to fuelwood resources.

## 7.2 KEY OPPORTUNITIES AND CONSTRAINTS FOR FUTURE IMPLEMENTATION OF COMMUNITY-BASED COPPICE MANAGEMENT

### 7.2.1 Key opportunities

- ***Coppicing ability of savanna woody plants*:** CBCM is applicable in large part of the country, meaning that its absence represents a lost opportunity. This is because rotational strategies could go a long way towards promoting the sustainability particularly because the resource base is currently under pressure from over-exploitation.
- ***Continued dependence of fuelwood despite access to electricity*:** High dependence of fuelwood despite access to electricity indicates that CBCM will remain relevant in communal areas for a long time. This is especially true because there will still be significant biomass use in developing countries in 2030 as incomes are not expected to increase enough for people to be able to switch away from traditional biomass to any significant degree (IEA, 2006).
- ***Desire for capacity*:** The likelihood of natural resource management occurring in any society increases when people value a resource and that it is becoming scarce while they can do something to halt the decline in that area (Cunningham, 2002). The implementation of the harvesting trial in Thorndale and Peninghotsa indicate this, since the local resource users volunteered to undertake policing activities which were primarily the duties of the relevant institutions. A genuine concern against

degradation and misuse of common property resource can induce local (Arnold, 1990), indicating that in less degraded villages where people heavily depend on fuelwood energy there would be an opportunity to engage in CBCM.

- ***Acknowledged failure of traditional harvesting rules*:** The local leaders acknowledged the local resource users did not comply with the traditional rules prohibiting harvesting of livewood because such fuelwood were no more or scarce. Since deadwood are scarce or no more in communal woodlands (Shackleton, 1993; Gandar, 1997; Kirkland *et al.*, 2007), this indicates that CBCM could be well received in many areas such as those in Thorndale and Peninghotsa.
- ***Villages with small population size*:** CBNRM is linked to the scale of the user group (Koch, 2004), and a communal resource management regime is enhanced if it is small enough (membership size) for all members to be in occasional face-to-face contact, enforce conformity to rules through peer pressure and has a long standing collective identity (Murphree, 1998). Based on the findings it is evident that CBCM would be implemented in villages with less than 1 000 since in Thorndale and Peninghotsa, the population size was less than this number.
- ***Villages with woodlands in reasonable condition:*** Based on the findings it is evident that there are still some villages which still have woodlands in reasonable condition. However, these are typically small and isolated, and may thus not represent the majority of villages in these rural areas.
- ***Continued respect and support for the local leadership:*** CBNRM is mainly implemented in areas where the land is communal (Heltberg, 2002). It is evident from the study that, despite issues and short comings, traditional leaders are still regarded and respected as the most appropriate custodians of the fuelwood resource base.

### 7.2.2 Key constraints

- ***Lack of supporting policies*:** Harvesting of live trees constitute an illegal activity in South Africa, although harvesting of such trees has become a norm as across the villages. For instance, although the local institutions and the local resource had the desire to manage the communal woodlands under CBCM rules, they could only continue provided they had permit, because this was a requirement by the relevant Act (Limpopo Environmental Management Act). However, the permit extended harvesting for six months, but from the report of the local headman, the project continued beyond this expiry date. This means that for the project to be legal another permit requesting extension was required, which would be a challenge because the previous permit was granted for academic purposes. Concurring with Cocks *et al.* (2001) the results show that government policies offer very little support concerning CBNRM in South Africa. This suggests that although the rangers wanted the project to continue indefinitely, a long term permit would be required which unfortunately, would have to be approved by a different department provided they were satisfied. The findings support the findings by Fabricius (2004) that the natural legislation has generally failed to take into account the intricate relationships between people and nature that were typical of the culture of most African societies.

- ***Lack of institutional cooperation*:** Local-level power relations should be favourable for CBNRM to stand a chance to succeed (Fabricius, 2004). This was not the case in Homu 14B as evidenced by the local people attended two parallel meetings, the one hosted by the local civic organization and the one by the headman. The existence of institutional cooperation between the local traditional institutions and the civic organization illustrate this, because the CBCM intervention only strengthened the relationship at the village level in Thorndale and Peninghotsa.
- ***Incapacity problems of the governance institutions*:** The lack of rangers in Homu 14B was one of the aspects that contributed to the lack trial in this village. This was because there was during the discussion about the project that local people would not comply with harvesting rules if they failed to do so under the limited number of rangers they had at the time, meaning in such villages this might pose a challenge for CBCM.
- ***Diverse socio-economic differentiation*:** Although no community is completely homogeneous in outlook, many are far more divided in terms of socio-economic status and diverse interests (Cunningham, 2002). Diverse socioeconomic differentiation and interest in Homu 14B were also one of the aspects that accounted for lack of participation in the CBCM. From his analysis of 176 specific common property resources which exhibited at least one instance of local concern, which was to protect them, Arnold, 1990 found that less socio-economic differentiation was found to be important in this regard. This means that in villages where there is diverse socio-economic differentiation and interests it would be difficult to have people speaking in one voice. This is because instead of wanted to have more access the priority of those using fuelwood would be to move up the ladder, since fuelwood

would be associated with low status in such villages. This is also more likely to occur in large population, e.g. in Homu 14B and Makhuva.

- ***Unclear boundaries and/or boundary conflicts***: During the harvesting trial in Thorndale and Peninghotsa aspects of unclear boundaries were reported which in the former accounted for harvesting occurring only in three of the four coupes. Although the project would be sustainable from a four-year rotation the existence of this problem indicates that this could be serious problems that could affect the sustainability of CBCM.
- The scarcity of fuelwood varies from one village to another (Williams and Shackleton, 2002). Degraded resources and insufficient communal land in many cases such as those like in Homu, with small woodland area and but high fuelwood demand cannot allow feasible for CBCM.

## 7.4 KNOWLEDGE CONTRIBUTION

### 7.4.1 Ecological sustainability

This study offered an opportunity to test if rotational such strategies could be solution in offering the sustainable provision of fuelwood, with the results indicating that such strategies can offer a sustainable supply of fuelwood. This is an important contribution since much of what is known about resprouting trees comes from the forestry research on plantation tree species. Moreover, while environmentally sound methods for sustainable fuelwood production that minimise damage to indigenous vegetation need to be developed (Kennedy 1998), rotational harvesting strategy is one such method. Therefore, it is evident that overharvesting will not occur in the supply of fuelwood in the CBCM area since it occurs due to uncontrolled utilization.

### 7.4.2 Social feasibility

In the absence of a harvesting trial, whether or not, socially, rotational harvesting of coppice shoots would sustainable was not known, since few available studies have focused on the ecological sustainability in the continent (White, 1979; Shackleton, 2001; Kennedy, 1998; Twine, 2008). As pilot project, this study had an opportunity to indicate that rotational harvesting strategies can be socially sustainable in communal woodland areas. This has been illustrated by positive perceptions and attitudes towards CBCM among local resource users and the local leadership, and their cooperation in Thorndale and Peninghotsa.

### 7.4.3 Institutional sustainability

Although incapacity problem in the relevant institutions has been diagnosed, capacitating these institutions (tribal institution) to carry their expected duties such as compliance monitoring is yet to be seen (Shackleton *et al.*, 2004a). On the other hand, the scale of support and capacity-building needed is high; consequently, resources are required (Shackleton and Shackleton, 2004a). Having said that, Twine *et al.* (2003b) recommended that local government should work with communities to manage and police fuelwood resources effectively, and reduces competition for the resource between local domestic users and commercial interests. The results of this study indicate that such a recommendation could be through CBCM, since local resource can take part in policing in partnership with local institutions ensuring that the only the legal resource users harvest as per agreed rules.

### 7.4.4 Local leadership' perceptions

Although the conceptual framework does not demonstrate the role of perceptions and attitudes from the local governance institutions, the results showed that their perceptions and the attitudes, also affected the project. For instance, it was through the local institutions' leaders' positive perceptions that the project was piloted in the study villages, such as chiefs, headmen and government rangers. Efforts to analyse perceptions rarely happen and included in decision-making processes (Chase *et al.*, 2004), suggesting that understanding different perceptions also from the local leaders will help ensure that negative perceptions and attitudes do not necessarily hinder project such as CBCM.

## 7.6 SUGGESTIONS FOR FUTURE RESEARCH ARISING FROM THE STUDY

- Follow-up research aimed at longer-term monitoring of wood harvesting and consumption patterns would be recommended, and it can be done through revisiting the vegetation plots that were sited for this study after four years. Through such a study, growth rates of coppice shoots of all the species harvested during the trial could be established because the time of cutting time was recorded.

- The study would help provide more accurate knowledge of the growth rates of coppice shoots of all the species that were harvested. This is because the predicted growth rates of coppice shoots was an average growth of all the observed species. Thus, it is possible that some coppice shoots will grow slower while some will grow quicker because coppice growth is species-specific, yet coppice growth patterns are poorly understood in African savannas (Kachula *et al.*, 2005). The interplay of site factors such as soil fertility with individual species' coppice regimes has important implications for understanding the long-term productivity and sustainability of a repeat harvest system (Kaschula *et al.*, 2005). Therefore, since the prediction indicates that there will be re-harvesting of coppice shoots, such a study would contribute towards revealing the number of felling cycles that different species can endure before losing coppicing vigour, since this can affect the ecological sustainability, while also testing my projected yield which might not be accurate. Yet monitoring the vegetation plots would also reveal if the local resource users continued to comply with harvesting rules long after the expiry of the feasibility study, through the frequencies of stems in different size classes.
- More broadly, monitoring of woody vegetation to better understand tree demographics, including coppice shoots in human impacted savannas, in communal woodland would also be proposed. This is because harvesting alters supply in ways that are more complex than simply subtracting biomass (Twine and Holdo, 2016), meaning it can be conducted in areas with and without CBCM alike.
- There are few examples of long-term success of community based initiatives. For instance, there is high incidence of degeneration through time (Fabricius, 2004). Thus, since it is also possible that social processes, institution adaptation, resource harvester behaviour can change over time, such a study would assess all these aspects, including if the members of the patrol committee team were still available and carrying out patrols. This is true especially, because those who participated in this did so because they were not working, and also if the funding opportunities eventually materialized and the possible impact on the participation and the sustainability of the project as a whole.
- Research that can investigate trade-offs between conservation and CBCM sustainability would also be proposed. Such a study would be recommended mainly in communal woodlands where predominant species have socio-economic value such as *C. mopane* in the mopane woodland areas, to assess the viability of CBCM while such

species are also harvested. This is because if predominant species such as *C. mopane* in such areas are not harvested as it was recommended by the local leadership, CBCM may not be ecological feasible, while the mopane caterpillars were also available before the project despite even large trees being harvested. Thus, such a study would also help give knowledge of whether or not mopane caterpillars prefer coppiced plants or large trees.

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# 9 APPENDICES

**APPENDIX 1:** Written consent permitting harvesting of livewood required by rangers in Peninghotsa

rural development
& land reform
Department:
Rural Development & Land Reform
**REPUBLIC OF SOUTH AFRICA**
Limpopo Shared Service Centre: Private Bag X9312, POLOKWANE, 0700 - Tel (015) 297 3539
Fax (015) 297 4988

**Enq: Molele T.S**
**Date: 09/12/2013**

Box 798
Sambo
0986

Attention: Mr Norman Mathebula

**RE: APPLICATION FOR WRITTEN CONSENT TO HARVEST FIREWOOD ON ROTATIONAL BASIS**

The Department of Rural Development and Land Reform acknowledges receipt of your letter

Kindly note that the farm Schute 217 LT is under the custodianship of the Department of Rural Development and Land Reform State Land allocated to Madonsi Tribe in terms of GN23/1974.

Kindly note that Mr Norman Mathebula ID No.790215427081 is given a consent to do research on sustainable harvest firewood without deforestation at a village called Peninghotsa. The research will take place for a period of twelve months starting from January to December 2014.

Mr Mathebula is a third year PhD student at the University of the Witwatersrand, he will be focusing on helping sustain natural environment through educating local people on how they can harvest firewood without causing deforestation. The research will look into the practices of harvesting firewood from coppice growth and determine if this is sustainable and attempt to institute sustainable harvesting practices.

It is written in the report from Limpopo Department of Environmental Affairs that the trees listed as being monitored in this research are not protected by any legislation .They are being harvested anyway for subsistence purposes and it is unnecessary to obtain a permit for this research.

Hope you will find this to be in order.

Kind regards

..........................

**ACTING CHIEF DIRECTOR: LPSSC**

**DATE:** 11. 12. 2013

**APPENDIX 2: Harvesting rules designed for harvesting trial in Thorndale, written in local language, Xitsonga or Shangaan and translated into english.**

**MILAWU LEYI NGA VEKIWA YA MATSEMELE YA TIHUNYI EKA PROJEKE YA TIKO RA THORNDALE/FUELWOOD HARVESTING RULES THAT WERE AGREED IN THORNDALE VILLAGE DURING THE COMMUNITY BASED COPPICE MANAGEMENENT PROJECT IN THORNDALE**

Hi kwalaho ka ndzavisiso lowu wu nga rhangeliwa hi Norman Mathebula lowu a wu endlaka na Univhesita ya Witwatersrand, vaaka tiko vaka Peninghotsa tsena vanyikiwile pfumelelo kusuka eka ndzawulo ya hluvukiso wa le makaya ku tshova tihunyi a tikambeni. Leswi swiendleka e hasi ka vulawuri na vurhangeri bya tiko Nduna and hosi Madosi na hi kuya hi milawu leyi/Based on the research led by Norman Mathebula who is a student at the University of the Witwatersrand, the community members of Peninghotsa have been given permission by the Department of Land Reform and Rural Development to harvest livewood in coupes under the local leadership. This happens under the control of the local leadership, headman and the chief Madosi.

Milawu ya matshovele leyi ku nga twananiwa yona hi leyi landzelaka,Harvesting rules that were agreed upon are as follow:

1. Vaaka tiko va ta tshova tihunyi e ka kamba leyi va nga ta kombiwa yona hi Nduna ku fika karhi lowu va nga ta byeriwa leswaku va tlulela e ka yinwayana/Community members will harvest livewood in coupes as directed by the local headman.
2. Vaaka tiko va ta pfumeleriwa ku tshova ti hunyi hi Wavutlhanu na Mugivela (Saturday) tsena ku suka hi 05:00 ya na pundzu ku fika hi 18h:00 . Lava nga ta kumeka va tshova tihunyi hi masiku lawa va nga pfumeleriwangiki va ta xupuriwa hi Nduna. Community members will be permitted to harvest on Fridays and Saturdays only from 06:00 in the morning till 18h00. Those who will be found harvesting on days other than those agreed upon will be fined.
3. Komiti leyi yi nga hlawuriwa yi ta patirola ku kambela leswaku vanhu hikwavo vaka Peni va landzelela leswi milawu leyi yi nga bohiwa hi ku landza projeke. Loko komiti yikuma vanhu vatshova hi masiku lawa va nga fanelangiki kutshova hi wona yi ta yisa yisa mavito ya vanhu lava eka Nduna leyi yinga ta vona kuri yi va xupurisa ku yini. Patrol committee will be established that will undertake patrols to ensure that

harvesters adhere to the agreed rules. If patrol committee members find harvesters or people not adhering to the agreed rules, they will present such people before the local headman who will decide on the severity of punishment.

4. Misinya leyi vaaka tiko va faneleke ku yi papalata loko vatshova tihunyi ekambeni i misinya leyi yi tswalaka mihandzu na ku hinyika swakudya. Xikombiso, toma and hlangula na hikwayo leyi vayitivaka ku ri yina swakudya. Na hi kwayo leyi yi yirisiwaka hi milawu ya tiku, xikombiso yi fanele ku papalatiwa, ku fana na sinya wa mondzo a wufanelanga ku tshoviwa hikuwa wu hlayisiwile hi nawu National Forest Act No. 18 of 1998. Trees that community members must avoid are all trees that bear fruits. For example, *Diospyros mespiliformes, Sclerocarya birrea and Euclea divinorum*. All trees protected by local by the Acts such as *combretum imberbe* which are protected by National Forest Act No. 18 of 1998 must be avoided.
5. Matshovelo ya tihunyi lawa ya lavekaka hi lawa: vaaka tiko vafanela vatshova ti hunyi to ringana bodlhela ra biya kumbe ra kholidiringi. Loko ku kuri rihunyi ra kona risuka e hasi va fanele vatsema e ka pfhuka wa letsolweni (50 cm from the ground) kusukela e hasi. Leswi swi ta endla leswaku sinya walowo wu hluka hikuhatlisa la ha vanhu va nga ta kuma tihunyi endzhaka karhi nyana. Misinya leyikulu a yi fanelangi ku tsemiwa leswaku yiendla mbewu. The recommended harvesting practices are that: community members should harvest stems of the diameter equivalent to that of a cold drink size. If the stem is harvested from the ground it must be harvested at height of about 50 cm because this will enhance the regenerative ability of the harvested trees leading to the quick growth of the emerging coppice shoots which can be harvested in a short rotation.

**APPENDIX 3: Harvesting rules designed for harvesting trial in Peninghotsa, written in local language, Xitsonga or Shangaan and translated into english.**

**MILAWU LEYI NGA VEKIWA YA MATSEMELE YA TIHUNYI EKA PROJEKE YA TIKO RA THORNDALE/FUELWOOD HARVESTING RULES THAT WERE AGREED IN THORNDALE VILLAGE DURING THE COMMUNITY BASED COPPICE MANAGEMENENT PROJECT IN PENINGHOTSA**

Hi kwalaho ka ndzavisiso lowu wu nga rhangeliwa hi Norman Mathebula lowu a wu endlaka na Univhesita ya Witwatersrand, vaaka tiko vaka Peninghotsa tsena vanyikiwile pfumelelo kusuka eka ndzawulo ya hluvukiso wa le makaya ku tshova tihunyi a tikambeni. Leswi swiendleka e hasi ka vulawuri na vurhangeri bya tiko Nduna and hosi Madosi na hi kuya hi milawu leyi/Based on the research led by Norman Mathebula who is a student at the University of the Witwatersrand, the community members of Peninghotsa have been given permission by the Department of Land Reform and Rural Development to harvest livewood in coupes under the local leadership. This happens under the control of the local leadership, headman and the chief Madosi.

Milawu ya matshovele leyi ku nga twananiwa yona hi leyi landzelaka,Harvesting rules that were agreed upon are as follow:

1. Vaaka tiko va ta tshova tihunyi e ka kamba leyi va nga ta kombiwa yona hi Nduna ku fika karhi lowu va nga ta byeriwa leswaku va tlulela e ka yinwayana/Community members will harvest livewood in coupes as directed by the local headman.
2. Vaaka tiko va ta pfumeleriwa ku tshova ti hunyi hi Mugivela na Sota tsena ku suka hi 06:00 ya na pundzu ku fika hi 18h:00. Lava na nga ta kumeka va tshova tihunyi hi masiku lawa va nga pfumeleriwangiki va ta xupuriwa hi Nduna. Community members will be permitted to harvest on Fridays and Saturdays only from 06:00 in the morning till 18h00. Those who will be found harvesting on days other than those agreed upon will be fined.
3. Komiti leyi yi nga hlawuriwa yi ta patirola ku kambela leswaku vanhu hikwavo vaka Peni va landzelela leswi milawu leyi yi nga bohiwa hi ku landza projeke. Loko komiti

yikuma vanhu vatshova hi masiku lawa va nga fanelangiki kutshova hi wona yi ta yisa yisa mavito ya vanhu lava eka Nduna leyi yinga ta vona kuri yi va xupurisa ku yini. Patrol committee will be established that will undertake patrols to ensure that harvesters adhere to the agreed rules. If patrol committee members find harvesters or people not adhering to the agreed rules, they will present such people before the local headman who will decide on the severity of punishment.

4. Misinya leyi vaaka tiko va faneleke ku yi papalata loko vatshova tihunyi ekambeni i misinya leyi yi tswalaka mihandzu na ku hinyika swakudya. Xikombiso, toma and hlangula na hikwayo leyi vayitivaka ku ri yina swakudya. Na hi kwayo leyi yi yirisiwaka hi milawu ya tiku, xikombiso yi fanele ku papalatiwa, ku fana na sinya wa mondzo a wufanelanga ku tshoviwa hikuwa wu hlayisiwile hi nawu National Forest Act No. 18 of 1998. Trees that community members must avoid are all trees that bear fruits. For example, *Diospyros mespiliformes, Sclerocarya birrea* and *Euclea divinorum*. All trees protected by local by the Acts such as combretum imberbe which are protected by National Forest Act No. 18 of 1998 must be avoided.
5. Matshovelo ya tihunyi lawa ya lavekaka hi lawa: vaaka tiko vafanela vatshova ti hunyi to ringana bodlhela ra biya kumbe ra kholidiringi. Loko ku kuri rihunyi ra kona risuka e hasi va fanele vatsema e ka pfhuka wa letsolweni (50 cm from the ground) kusukela e hasi. Leswi swi ta endla leswaku sinya walowo wu hluka hikuhatlisa la ha vanhu va nga ta kuma tihunyi endzhaka karhi nyana. Misinya leyikulu a yi fanelangi ku tsemiwa leswaku yiendla mbewu. The recommended harvesting practices are that: community members should harvest stems of the diameter equivalent to that of a cold drink size. If the stem is harvested from the ground it must be harvested at height of about 50 cm because this will enhance the regenerative ability of the harvested trees leading to the quick growth of the emerging coppice shoots which can be harvested in a short rotation.

**APPENDIX 4: Percentage (%) and frequency (F) of stumps per size class observed before and during the trial in Thorndale (n=27)**

| **Species** | **Size class and frequencies of stumps** | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **0.1–0.9 cm** | | | | **1-3 cm** | | | | **4-9 cm** | | | | **10-19 cm** | | | | **>20 cm** | | | | **Total** | | | |
| | **1st survey** | | **2nd survey** | | **1st survey** | | **2nd survey** | | **1st survey** | | **2nd survey** | | **1st survey** | | **2nd survey** | | **1st survey** | | **2nd survey** | | **1st survey** | | **2nd survey** | |
| | **%** | **F** | **%** | **F** | **%** | **F** | **%** | **F** | **%** | **F** | **%** | **F** | **%** | **F** | **%** | **F** | **%** | **F** | **%** | **F** | **%** | **F** | **%** | **F** |
| *Combretum apiculatum* | | | | | 46.66 | 7 | | | 75.51 | 37 | 40.84 | 29 | 42.85 | 15 | | | 33.33 | 1 | | | 58.82 | 60 | 34.11 | 29 |
| *Dichrostachys cinerea* | | | | | 26.66 | 4 | 78.26 | 18 | 2.04 | 1 | 9.85 | 7 | | | | | | | | | 4.90 | 5 | 29.41 | 25 |
| *Acacia nigrescens* | | | | | 6.66 | 1 | | | 2.04 | 1 | 5.63 | 4 | 22.85 | 8 | 71.42 | 5 | 66.66 | 2 | 100 | 3 | 11.76 | 12 | 14.11 | 12 |
| *Terminalia sericea* | | | | | 6.66 | 1 | 17.39 | 4 | 8.16 | 4 | 4.22 | 3 | | | | | | | | | 4.90 | 5 | 8.23 | 7 |
| *Philenoptera violacea* | | | | | 6.66 | 1 | | | | | | | 8.57 | 3 | | | | | | | 3.92 | 4 | | |
| *Dalbergia melanoxylon* | | | | | 6.66 | 1 | | | 2.04 | 1 | 2.81 | 2 | 5.71 | 2 | | | | | | | 3.92 | 4 | 2.35 | 2 |
| *Pterocarpus rotundifolius* | | | | | | | | | 2.04 | 1 | 1.40 | 1 | 8.57 | 3 | | | | | | | 3.92 | 4 | 1.17 | 1 |
| *Gymnosporia senegalensis* | | | | | | | | | | | | | 5.71 | 2 | | | | | | | 1.96 | 2 | | |
| *Ziziphus mucronata* | | | | | | | | | | | | | | | 14.28 | 1 | | | | | | | 1.17 | 1 |
| *Acacia nilotica* | | | 100 | 1 | | | 4.34 | 1 | | | 1.40 | 1 | | | 14.28 | 1 | | | | | | | 4.70 | 4 |
| *Combretum hereroense* | | | | | | | | | 2.04 | 1 | 4.22 | 3 | | | | | | | | | 0.98 | 1 | 3.52 | 3 |
| *Euclea divinorum* | | | | | | | | | 2.04 | 1 | | | 2.85 | 1 | | | | | | | 1.96 | 2 | | |
| *Peltophorum africanum* | | | | | | | | | 2.04 | 1 | 1.40 | 1 | 2.85 | 1 | | | | | | | 1.96 | 2 | 1.17 | 1 |
| *Grewia monticola* | | | | | | | | | 2.04 | 1 | | | | | | | | | | | 0.98 | 1 | | |
| **Total** | | | **100** | **1** | **100** | **15** | **100** | **2** | **100** | **49** | **100** | **71** | **100** | **35** | **100** | **7** | **100** | **3** | **100** | **3** | **100** | **102** | **100** | **85** |

**APPENDIX 5: Percentage (%) and frequency (F) of stumps per size class observed before and after the project in Peninghotsa (n=36)**

| **Species** | **Size class and frequencies of stumps** | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **0.1–0.9 cm** | | | | **1-3 cm** | | | | **4-9 cm** | | | | **10-19 cm** | | | | **>20 cm** | | | | **Total** | | | |
| | **1st survey** | | **2nd survey** | | **1st survey** | | **2nd survey** | | **1st survey** | | **2nd survey** | | **1st survey** | | **2nd survey** | | **1st survey** | | **2nd survey** | | **1st survey** | | **2nd survey** | |
| | **%** | **F** | **%** | **F** | **%** | **F** | **%** | **F** | **%** | **F** | **%** | **F** | **%** | **F** | **%** | **F** | **%** | **F** | **%** | **F** | **%** | **F** | **%** | **F** |
| *Colophospermum mopane* | | - | | - | | - | | | 45.83 | 11 | 33.33 | 12 | 50.00 | 14 | | - | 45.83 | 11 | | - | 44.44 | 36 | 20.33 | 12 |
| *Combretum apiculatum* | | - | | - | 60.00 | 3 | 100 | 5 | 29.16 | 7 | 61.11 | 26 | 17.85 | 5 | 66.66 | 2 | 12.50 | 3 | 100 | 1 | 22.22 | 18 | 57.62 | 34 |
| *Peltophorum africanum* | | - | | - | - | - | | | 4.16 | 1 | | | 10.71 | 3 | | | 12.50 | 3 | | | 8.64 | 7 | | |
| *Ehretia amoena* | | - | | - | - | - | | | | | 2.77 | 1 | | | | | | | | | | | 1.69 | 1 |
| *Dichrostachys cinerea* | | - | | - | - | - | | | 4.16 | 1 | | 9 | 3.57 | 1 | | 1 | 4.16 | 1 | | | 3.70 | 3 | 16.94 | 10 |
| *Philenoptera violacea* | | - | | - | - | - | | | | | | | 7.14 | 2 | | | 8.33 | 2 | | | 3.70 | 3 | | |
| *Dalbergia melanoxylon* | | - | | - | 20.00 | 1 | | | 4.16 | 1 | | | | | | | 4.16 | 1 | | | 3.70 | 3 | | |
| *Pterocarpus rotundifolius* | | - | | - | - | - | | | | | | | 3.57 | 1 | | | 4.16 | 1 | | | 2.46 | 2 | | |
| *Sclerocarya birrea* | | - | | - | - | - | | | 4.16 | 1 | | | | | | | 4.16 | 1 | | | 2.46 | 2 | | |
| *Ziziphus mucronata* | | - | | - | - | - | | | | | | | 3.57 | 1 | | | 4.16 | 1 | | | 2.46 | 2 | | |
| *Gymnosporia senegalensis* | | - | | - | - | - | | | 4.16 | 1 | | | | | | | | | | | 1.23 | 1 | | |
| *Celtis africana* | | - | | - | 20.00 | 1 | | | | | | | | | | | | | | | 1.23 | 1 | | |
| *Acacia nigrescens* | | - | | - | - | - | | | 4.16 | 1 | 2.77 | 1 | | | 33.33 | 1 | | | | | 1.23 | 1 | 3.38 | 2 |
| *Securinega virosa* | | - | | - | - | - | | | | | | | 3.57 | 1 | | | | | | | 1.23 | 1 | | |
| **Total** | | **-** | | **-** | **100** | **5** | **100** | **5** | **100** | **24** | **100** | **49** | **100** | **28** | **100** | **3** | **100** | **24** | **100** | **1** | **100** | **81** | **100** | **59** |

## APPENDIX 6: Percentage (%) and frequency (F) of stumps per size class observed in Homu 14B (n=21)

| Species | Size class and frequencies of stumps | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.1–0.9 cm | | | | 1-3 cm | | | | 4-9 cm | | | | 10-19 cm | | | | >20 cm | | | | Total | | | |
| | 1st survey | | 2nd survey | | 1st survey | | 2nd survey | | 1st survey | | 2nd survey | | 1st survey | | 2nd survey | | 1st survey | | 2nd survey | | 1st survey | | 2nd survey | |
| | % | F | % | F | % | F | % | F | % | F | % | F | % | F | % | F | % | F | % | F | % | F | % | F |
| *Colophospermum mopane* | | | | | 100 | 3 | | | 80 | 16 | 100 | 1 | 85.29 | 29 | | | 84.37 | 27 | | | 84.26 | 75 | 50 | 1 |
| *Dichrostachys cinerea* | | | | | | | | | 5 | 1 | | | 2.94 | 1 | | | 3.12 | 1 | | | 3.37 | 3 | | |
| *Combretum apiculatum* | | | | | | | | | 5 | 1 | | | 2.94 | 1 | | | | | | | 2.24 | 2 | | |
| *Philenoptera violacea* | | | | | | | | | | | | | | | | | 6.25 | 2 | | | 2.24 | 2 | | |
| *Acacia nigrescens* | | | | | | | | | | | | | 5.88 | 2 | | | | | | | 2.24 | 2 | | |
| *Terminalia sericea* | | | | | | | | | | | | | | | | | 3.12 | 1 | | | 1.12 | 1 | | |
| *Ziziphus mucronata* | | | | | | | | | 5 | 1 | | | | | | | | - | | | 1.12 | 1 | | |
| *Combretum imberbe* | | | | | | | | | | | | | | | | | 3.12 | 1 | | | 1.12 | 1 | | |
| *Securinega virosa* | | | | | | | | | | | | | 2.94 | 1 | | | | | | | 1.12 | 1 | | |
| *Acacia nilotica* | | | | | | | 100 | 1 | 5 | 1 | | | | | | | | | | | 1.12 | 1 | 50 | 1 |
| **Total** | | | | | **100** | **3** | **100** | **1** | **100** | **20** | **100** | **1** | **100** | **34** | | | **100** | **32** | | | **100** | **89** | **100** | **2** |

**APPENDIX 7: Percentage (%) and frequency (F) of uncut stems per size class observed before and after the project in Thorndale**

| Species | Size class and frequencies of stems | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.1–0.9 cm | | | | 1-3.9 cm | | | | 4-9 cm | | | | 10-19 cm | | | | >20 cm | | | | Total | | | |
| | Before | | After | | Before | | After | | Before | | After | | Before | | After | | Before | | After | | Before | | After | |
| | % | F | % | F | % | F | % | F | % | F | % | F | % | F | % | F | % | F | % | F | % | F | % | F |
| *Combretum apiculatum* | 15.14 | 163 | 16.29 | 125 | 18.55 | 77 | 26.4 | 127 | 33.9 | 136 | 29.52 | 119 | 30.66 | 23 | 26.47 | 18 | 15.78 | 3 | 18.75 | 3 | 19.37 | 402 | 22.47 | 392 |
| *Acacia nigrescens* | 8.64 | 93 | 11.21 | 86 | 11.32 | 47 | 7.29 | 35 | 12.5 | 53 | 10.91 | 44 | 5.33 | 4 | 7.35 | 5 | 10.52 | 2 | 6.25 | 1 | 9.71 | 199 | 9.80 | 171 |
| *Terminalia sericea* | 6.97 | 75 | 8.08 | 62 | 5.06 | 21 | 1.66 | 8 | 9.28 | 33 | 8.93 | 36 | 2.66 | 2 | 1.47 | 1 | | | | | 6.65 | 132 | 6.13 | 107 |
| *Dichrostachys cinerea* | 7.80 | 84 | 8.60 | 66 | 6.50 | 27 | 8.33 | 40 | 2.85 | 29 | 2.97 | 12 | 4 | 3 | 5.88 | 4 | | | | | 6.54 | 143 | 6.99 | 122 |
| *Securinega virosa* | 8.64 | 93 | 7.17 | 55 | 5.54 | 23 | 5.62 | 27 | 0.35 | 10 | 2.97 | 12 | 4 | 3 | 4.41 | 3 | | | | | 6.44 | 129 | 6.13 | 107 |
| *Euclea divinorum* | 7.99 | 86 | 12.25 | 94 | 1.20 | 5 | 5 | 24 | 2.14 | 8 | 2.48 | 10 | 10.66 | 8 | 11.76 | 8 | | | | | 5.63 | 107 | 7.79 | 136 |
| *Acacia nilotica* | 4.18 | 45 | 11.08 | 85 | 12.77 | 53 | 7.29 | 35 | 3.57 | 20 | 6.45 | 24 | | | | | 5.26 | 1 | | | 5.85 | 119 | 8.37 | 144 |
| *Microberlinia brazzavillensis* | 5.29 | 57 | 1.56 | 12 | 5.06 | 21 | 7.5 | 36 | 1.07 | 13 | 4.46 | 18 | | | | | 0 | | | | 4.34 | 91 | 3.78 | 66 |
| *Ziziphus mucronata* | 3.43 | 37 | 1.17 | 9 | 2.65 | 11 | 2.29 | 11 | 1.78 | 5 | 1.24 | 5 | 10.66 | 8 | 10.29 | 7 | 21.05 | 4 | 18.75 | 3 | 3.48 | 65 | 2.00 | 35 |
| *Dalbergia melanoxylon* | 2.23 | 24 | 5.73 | 44 | 6.50 | 27 | 6.04 | 29 | 4.28 | 12 | 4.46 | 18 | 4 | 3 | 2.94 | 2 | | | | | 3.54 | 66 | 5.33 | 93 |
| *Ormocarpum trichocarpum* | 3.62 | 39 | 1.04 | 8 | 5.78 | 24 | 5.41 | 26 | 1.78 | 5 | 2.72 | 8 | | | | | | | | | 3.65 | 68 | 2.58 | 41 |
| *Grewia monticola* | 2.50 | 27 | 3.12 | 24 | 2.16 | 9 | 1.66 | 8 | 1.42 | 4 | 1.73 | 7 | | | | | | | | | 2.14 | 40 | 2.23 | 39 |
| *Combretum hereroense* | 2.13 | 23 | 1.43 | 11 | 0.96 | 4 | 2.70 | 13 | 1.42 | 14 | 1.48 | 6 | 2.66 | 2 | 1.47 | 1 | 5.26 | 1 | 6.25 | 1 | 1.82 | 44 | 1.83 | 32 |
| *Philenoptera violacea* | 4.27 | 46 | 0.39 | 3 | 1.20 | 5 | 0.83 | 4 | 6.42 | 18 | 4.21 | 17 | 4 | 3 | 5.88 | 4 | 10.52 | 2 | 18.75 | 3 | 3.97 | 74 | 1.77 | 31 |
| *Gymnosporia senegalensis* | 3.90 | 42 | 0.52 | 4 | 0.96 | 4 | 0.20 | 1 | 0.35 | 1 | 0.24 | 1 | | | | | | | | | 2.52 | 47 | 0.34 | 6 |
| *Gymnosporia* | 0 | 0 | 0.39 | 3 | 1.92 | 8 | 1.45 | 7 | 1.07 | 3 | 0.74 | 3 | 1.33 | 1 | 0 | | 0 | | 0 | | 0.64 | 12 | 0.74 | 13 |

| | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *buxifolia* | | | | | | | | | | | | | | | | | | | | | | | | |
| *Pterocarpus rotundifolius* | 1.30 | 14 | 2.60 | 20 | 1.20 | 5 | 1.04 | 5 | 1.78 | 12 | 1.24 | 5 | 2.66 | 2 | 2.94 | 2 | 15.78 | 3 | 18.75 | 3 | 1.55 | 36 | 2.00 | 35 |
| *Peltophorum africanum* | 1.20 | 13 | 1.95 | 15 | 3.13 | 13 | 4.375 | 21 | 2.85 | 8 | 2.72 | 10 | 10.66 | 8 | 11.76 | 8 | 5.2695 | 1 | 6.25 | 1 | 2.30 | 43 | 3.21 | 55 |
| *Cassine transvaalensis* | 1.11 | 12 | 2.08 | 16 | 0.48 | 2 | 1.66 | 8 | | | 0.49 | 2 | | | | | | | | | 0.75 | 14 | 1.49 | 26 |
| *Albizia harveyii* | 3.06 | 33 | 0.52 | 4 | 0.96 | 4 | 0.20 | 1 | 2.5 | 7 | 2.23 | 9 | | | | | | | | | 2.36 | 44 | 0.80 | 14 |
| *Acacia hereroensis* | 1.02 | 11 | | - | | | | | | | | | | | | | | | | | 0.59 | 11 | | |
| *Lannea schweinfurtii* | 0.83 | 9 | | - | 0.48 | 2 | | | | | | | | | | | 5.26 | 1 | 6.25 | 1 | 0.64 | 12 | 0.05 | 1 |
| *Acacia karoo* | | | 1.95 | 15 | 0.24 | 1 | 0.20 | 1 | 0.71 | 2 | 0.49 | 2 | | | | | | | | | 0.16 | 3 | 1.03 | 18 |
| *Acacia gerrardii* | 0.46 | 5 | 0.13 | 1 | 4.81 | 20 | 2.5 | 12 | 4.28 | 12 | 4.46 | 15 | 1.33 | 1 | 1.47 | 1 | | | | | 2.03 | 38 | 1.83 | 29 |
| *Combretum collinum* | 0.37 | 4 | | - | 0.48 | 2 | 0.20 | 1 | 3.57 | 10 | 2.72 | 11 | 2.66 | 2 | 2.94 | 2 | | | | | 0.96 | 18 | 0.80 | 14 |
| *Ehretia amoena* | 3.25 | 35 | 0.65 | 5 | | | | | | | | | | | | | | | | | 1.87 | 35 | 0.28 | 5 |
| *Ximenia caffra* | | | | | | | | | | | | | 1.33 | 1 | 1.47 | 1 | | | | | 0.05 | 1 | 0.05 | 1 |
| *Strychnos spinosa* | 0.55 | 6 | | - | | | | | | | | | | | | | | | | | 0.32 | 6 | | |
| *Sclerocarya birrea* | | | | | | | | | | | | | 1.33 | 1 | 1.47 | 1 | | | | | | | 0.05 | 1 |
| **Total** | **100** | **1076** | **100** | **767** | **100** | **415** | **100** | **480** | **100** | **415** | **100** | **394** | **100** | **75** | **100** | **68** | **100** | **19** | **100** | **16** | **100** | **1999** | **100** | **1738** |

## APPENDIX 8: Percentage (%) and frequency (F) of uncut stems per size class observed before and after the project in Peninghotsa

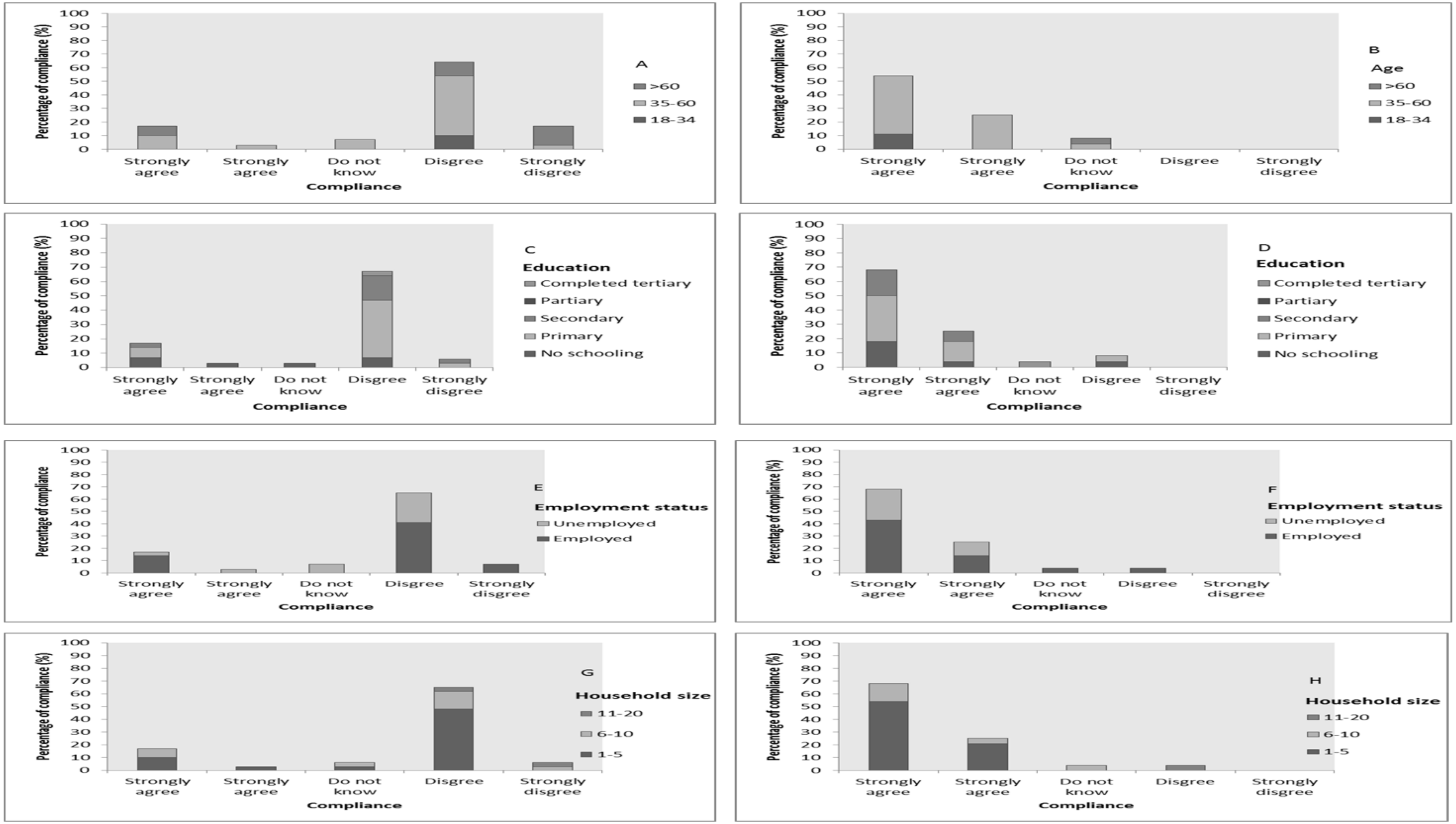
| Species | Size class and frequencies of stems | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.1–0.9 | | | | 1-3 cm | | | | 4-9 cm | | | | 10-19 cm | | | | >20 cm | | | | Total | | | |
| | Before | | After | | Before | | After | | Before | | After | | Before | | After | | Before | | After | | Before | | After | |
| | % | F | % | F | % | F | % | F | % | F | % | F | % | F | % | F | % | F | % | F | % | F | % | F |
| *Colophospermum mopane* | 68.36 | 899 | 58.88 | 560 | 47.28 | 209 | 56.58 | 365 | 52.77 | 131 | 61.87 | 123 | 13.63 | 12 | 29.72 | 10 | 18.75 | 3 | 26.66 | 4 | 62.17 | 1251 | 58.28 | 1064 |
| *Combretum apiculatum* | 4.63 | 61 | 6.20 | 59 | 20.81 | 92 | 20.31 | 131 | 15.97 | 43 | 15.81 | 32 | 22.37 | 5 | 18.91 | 4 | 12.50 | 2 | 6.66 | 1 | 9.56 10.23 | 203 | 12.60 | 227 |
| *Dichrostachys cinerea* | 5.24 | 69 | 7.99 | 76 | 2.94 | 13 | 1.70 | 11 | 4.86 | 7 | 4.18 | 9 | 4.54 | 1 | 2.70 | 1 | | | 6.66 | | 4.70 | 90 | 5.32 | 98 |
| *Euclea divinorum* | 4.33 | 57 | 7.15 | 68 | 2.94 | 13 | 3.41 | 22 | 1.38 | 2 | 1.39 | 3 | | | 2.70 | 1 | | | | | 3.76 | 72 | 5.10 | 94 |
| *Peltophorum africanum* | 2.73 | 36 | 0.31 | 3 | 1.58 | 7 | 0.77 | 5 | 6.25 | 9 | 1.86 | 4 | 13.63 | 3 | 8.10 | 3 | 6.25 | 1 | 13.33 | 2 | 2.92 | 56 | 0.92 | 17 |
| *Ehretia amoena* | 0.53 | 7 | 0.73 | 7 | | - | 1.08 | 7 | 1.38 | 2 | | | | | | | | | | | 0.47 | 9 | 0.76 | 14 |
| *Acacia nigrescens* | 1.53 | 21 | 1.89 | 18 | 9.50 | 42 | 3.41 | 22 | 2.77 | 4 | 3.72 | 7 | 4.54 | 1 | 2.70 | 1 | 12.50 | 2 | 13.33 | 2 | 3.65 | 70 | 2.77 | 50 |
| *Combretum hereroense* | 1.14 | 15 | 2.41 | 23 | 0.90 | 4 | 0.1.08 | 7 | | | | | | | | | | | | | 0.99 | 19 | 1.62 | 30 |
| *Combretum imberbe* | 1.14 | 15 | 1.26 | 12 | 0.22 | 1 | 1.24 | 8 | 0.69 | 1 | 1.39 | 3 | | | | | | | | | 0.88 | 17 | 1.08 | 20 |
| *Philenoptera violacea* | 1.29 | 17 | 0.84 | 8 | | - | 0.15 | 1 | 2.08 | 3 | 1.39 | 2 | 9.09 | 4 | 10.81 | 4 | 12.50 | 2 | 6.66 | 1 | 1.25 | 26 | 0.92 | 16 |
| *Dalbergia melanoxylon* | | | - | | 1.13 | 5 | 0.77 | 5. | 3.47 | 5 | 0.34 | 2 | | | 2.70 | 1 | | | | | 0.52 | 10 | 0.48 | 7 |
| *Pterocarpus rotundifolius* | 2.96 | 39 | 5.15 | 49 | 2.48 | 11 | 2.79 | 18 | 0.69 | 1 | 0.46 | 1 | | | | | | | | | 2.66 | 51 | 2.71 | 50 |
| *Microberlinia brazzavillensis* | 0.38 | 5 | 1.15 | 11 | - | | | | | | | | | | | | | | | | 0.26 | 5 | 0.59 | 11 |
| *Ximenia Americana* | 1.97 | 26 | 0.21 | 2 | 2.26 | 10 | 1.24 | 8 | 2.08 | 3 | 0.46 | 1 | | | | | | | | | 2.03 | 39 | 0.59 | 11 |
| *Sclerocarya birrea* | | | | | | | | | | | | | 9.09 | 2 | 5.40 | 2 | 31.25 | 5 | 13.33 | 2 | 0.36 | 7 | 0.21 | 4 |
| *Ziziphus* | 1.06 | 14 | 3.68 | 35 | 3.16 | 14 | 2.94 | 19 | 2.77 | 4 | 1.39 | 3 | 13.63 | 3 | 8.10 | 4 | 6.25 | 1 | 13.33 | 2 | 1.88 | 36 | 3.36 | 63 |

| | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *mucronata* | | | | | | | | | | | | | | | | | | | | | | | | |
| *Gymnosporia senegalensis* | 1.59 | 21 | 1.15 | 11 | 1.13 | 5 | 0.31 | 2 | | | 0.39 | 1 | | | | | | | | | 0.10 | 2 | 0.81 | 14 |
| *Acacia nilotica* | 0.60 | 8 | 0.42 | 4 | 0.22 | 1 | 0.77 | 5 | | | | | | | | | | | | | 0.47 | 9 | 0.48 | 9 |
| *Securinega virosa* | 0.38 | 5 | 0.52 | 5 | 3.16 | 14 | 1.39 | 9 | 2.77 | 5 | 3.25 | 7 | 4.54 | 1 | 2.70 | 1 | | | | | 1.25 | 25 | 1.19 | 22 |
| *Diospyros mespiliformes* | | | | | 0.22 | 1 | | | | | | | 4.54 | 2 | 5.40 | 2 | | | | | 0.05 | 2 | 0.10 | 2 |
| *Grewia monticola* | | | | | | | | | | | | | | | | | | | | | | | | |
| **Total** | **100** | **1315** | **100** | **951** | **100** | **442** | **100** | **645** | **100** | **220** | **100** | **198** | **100** | **31** | **100** | **34** | **100** | **16** | **100** | **15** | **100** | **1998** | **100** | **1823** |

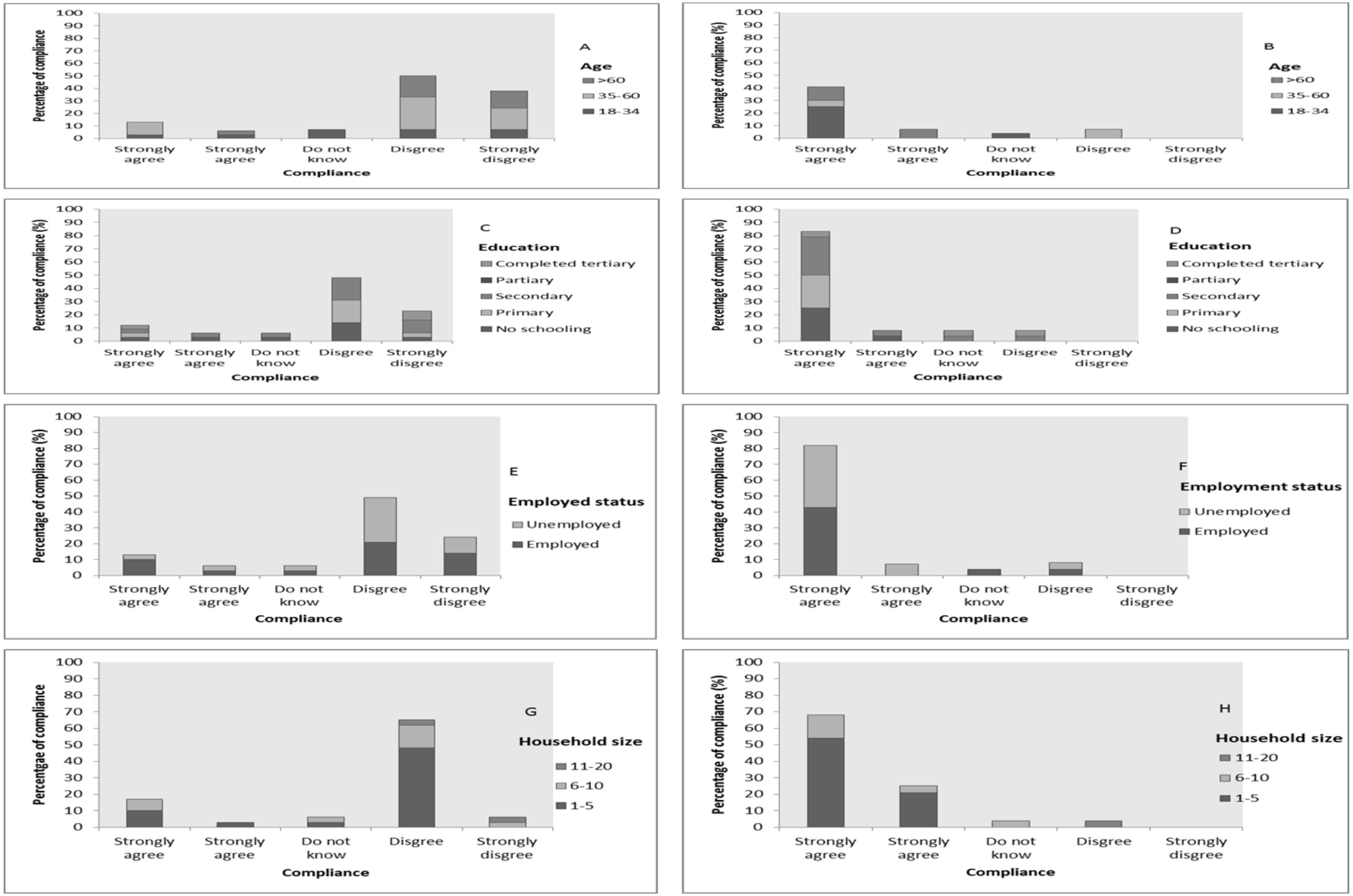
## APPENDIX 9: Percentage (%) and frequency (F) of uncut stems per size class observed before and after the project in Homu 14B

| Species | Size class and frequencies of stumps | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.1–0.9 cm | | | | 1-3 cm | | | | 4-9 cm | | | | 10-19 cm | | | | >20 cm | | | | Total | | | |
| | Before | | After | | Before | | After | | Before | | After | | Before | | After | | Before | | After | | Before | | After | |
| | % | F | % | F | % | F | % | F | % | F | % | F | % | F | % | F | % | F | % | F | % | F | % | F |
| *Colophospermum mopane* | 34.94 | 101 | 33.33 | 91 | 41.86 | 162 | 41.06 | 177 | 36.47 | 62 | 37.16 | 84 | 66.66 | 4 | 66.66 | 4 | | | | | 38.88 | 329 | 38.27 | 356 |
| *Combretum apiculatum* | 10.72 | 31 | 4.76 | 13 | 9.81 | 38 | 6.49 | 28 | 2.35 | 4 | 6.19 | 14 | | | | | | | | | 8.62 | 73 | 5.91 | 55 |
| *Peltophorum africanum* | | | | | | | | | | | | | 16.66 | 1 | 16.66 | 1 | | | | | 0.11 | 1 | 0.10 | 1 |
| *Dichrostachys cinerea* | 23.87 | 69 | 21.97 | 60 | 23.51 | 91 | 24.82 | 107 | 35.88 | 61 | 28.76 | 65 | | | | | | | | | 26.12 | 221 | 24.94 | 232 |
| *Philenoptera violacea* | | | | | | | | | | | | | | | | | | | | | | | | |
| *Acacia nilotica* | 5.53 | 16 | 10.62 | 29 | 3.61 | 14 | 5.56 | 24 | | | | | | | | | | | | | 3.54 | 30 | 5.69 | 53 |
| *Albizia harveyi* | 1.73 | 5 | 1.83 | 5 | 2.84 | 11 | 1.39 | 6 | 2.94 | 5 | 3.98 | 9 | | | | | | | | | 2.48 | 21 | 2.15 | 20 |
| *Dalbergia melanoxylon* | | | | | | | | | 1.76 | 3 | 1.32 | 3 | | | | | | | | | 0.35 | 3 | 0.32 | 3 |
| *Grewia monticola* | 3.11 | 9 | 5.49 | 15 | 5.42 | 21 | 6.72 | 29 | 2.94 | 5 | 3.53 | 8 | | | | | | | | | 4.13 | 35 | 5.59 | 52 |
| *Pterocarpus rotundifolius* | 3.46 | 10 | 2.19 | 6 | | | | | 1.76 | 3 | 2.21 | 5 | 16.66 | 1 | 16.66 | 1 | | | | | 1.65 | 14 | 1.29 | 12 |
| *Sclerocarya birrea* | | | | | | | | | 0.58 | 1 | 0.44 | 1 | | | | | 100 | 1 | 100 | 1 | 0.11 | 1 | 0.10 | 1 |
| *Ziziphus mucronata* | 4.49 | 13 | 2.93 | 8 | 4.90 | 19 | 4.87 | 21 | 6.47 | 11 | 6.63 | 15 | | | | | | | | | 5.08 | 43 | 4.73 | 44 |
| *Gymnosporia senegalensis* | | | | | | | | | | | | | | | | | | | | | | | | |
| *Combretum* | | | | | | | | | 5.29 | 9 | 3.98 | 9 | | | | | | | | | 1.06 | 9 | 0.96 | 9 |

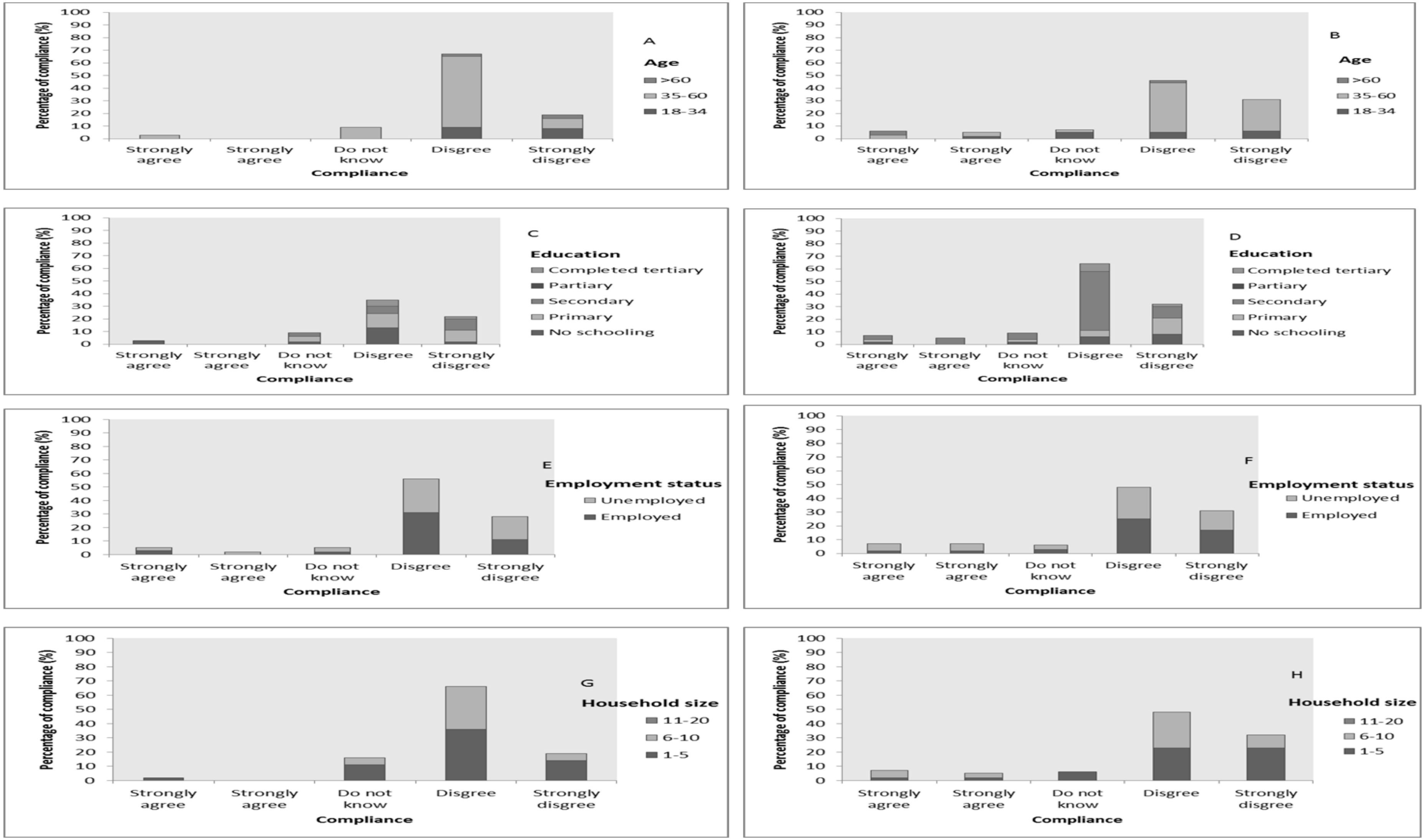
| | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *collinum* | | | | | | | | | | | | | | | | | | | | | | | | |
| *Combretum hereroense* | | | | | 1.29 | 5 | 0.46 | 2 | 1.76 | 3 | 2.65 | 6 | | | | | | | | | 0.94 | 8 | 0.86 | 8 |
| *Acacia nigrescens* | 8.99 | 26 | 12.08 | 33 | 2.06 | 8 | 3.48 | 15 | 0.58 | 1 | 0.44 | 1 | | | | | | | | | 4.13 | 35 | 5.26 | 49 |
| *Securinega virosa* | 3.11 | 9 | 4.76 | 13 | 3.10 | 12 | 2.78 | 12 | 0.58 | 1 | 0.44 | 1 | | | | | | | | | 3.19 | 27 | 2.79 | 26 |
| *Euclea divinorum* | | | | | 1.55 | 6 | 2.32 | 10 | 0.58 | 1 | 2.21 | 5 | | | | | | | | | 0.82 | 7 | 1.61 | 15 |
| **Total** | **100** | **289** | | **273** | **100** | **387** | | **431** | **100** | **170** | **100** | **226** | **100** | **6** | **100** | **6** | **100** | **1** | **100** | **1** | | **846** | | **930** |



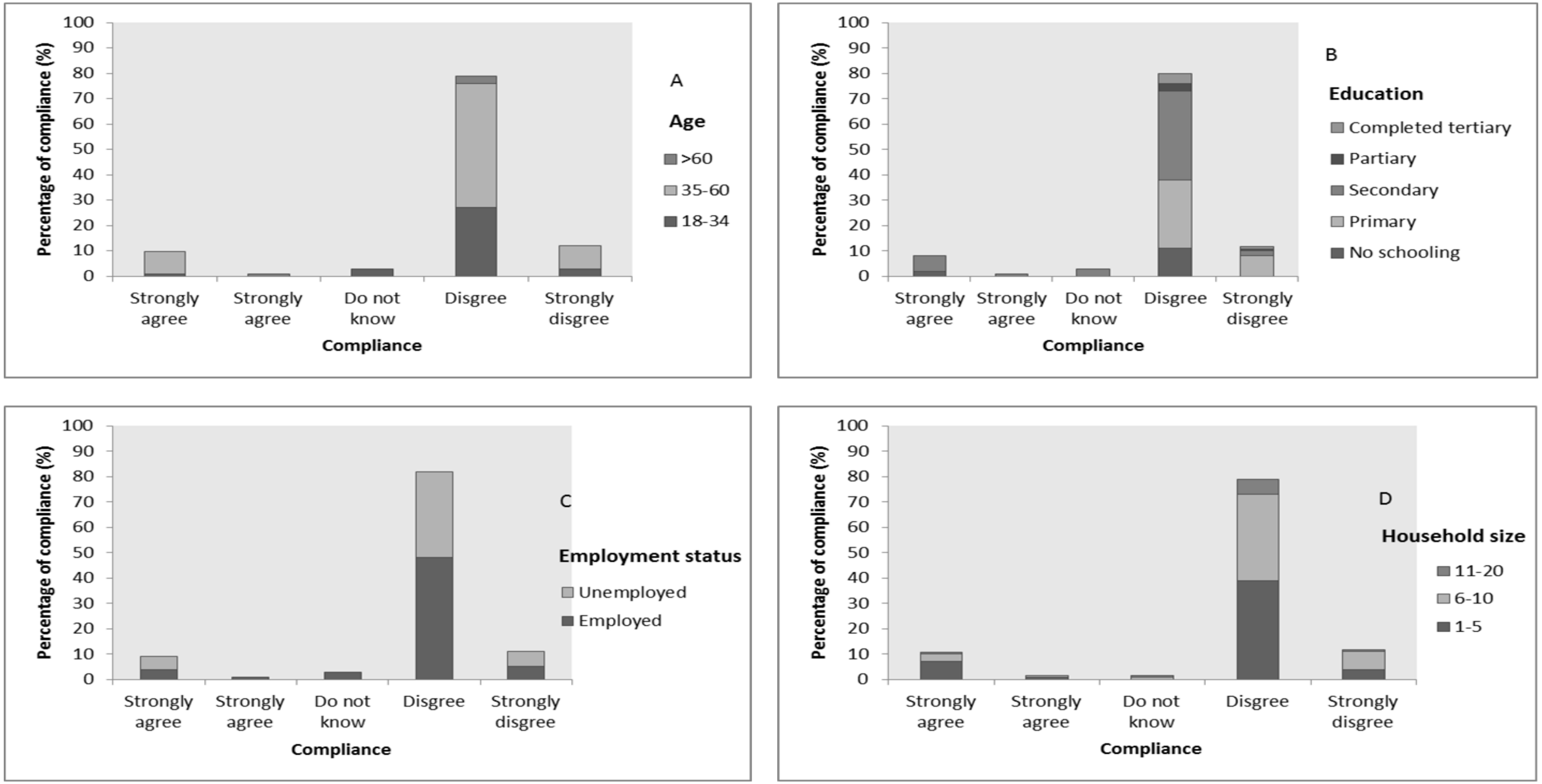

**APPENDIX 10**: Socio-economic influence on compliance, in Thorndale (A, age, 1st survey, B age 2nd survey; C, education 1st survey, D, education 2nd survey; E, employment status, 1st survey, F employment 2nd survey; G, household size 1st survey, H, 2nd survey).




**APPENDIX 11**: Socio-economic influence on compliance, in Peninghotsa (A, age, 1st survey, B age 2nd survey; C, education 1st survey, D, education 2nd survey; E, employment status, 1st survey, F employment 2nd survey; G, household size 1st survey, H, 2nd survey).




**APPENDIX 12**: Socio-economic influence on compliance, in Homu 14B (A, age, 1st survey, B age 2nd survey; C, education 1st survey, D, education 2nd survey; E, employment status, 1st survey, F employment 2nd survey; G,  household size 1st survey, H, 2nd survey).




**APPENDIX 13**: Socio-economic influence on compliance, in Makhuva (1st survey only) (A, age; B, education; C employment; D household size).

**APPENDIX 14**: Socio-economic information of the respondents in the study villages (Household surveys).

| Variable | Thorndale | Peninghotsa | Homu 14B | Makhuva |
|---|---|---|---|---|
| **Socio-economic variables** | | | | |
| **Age of the respondents (%)** | | | | |
| 18-35 | 10 | 30 | 18.60 | 31.70 |
| 35-60 | 70 | 53.30 | 77.10 | 65 |
| 60>above | 20 | 16.7 | 4.3 | 3.30 |
| **Gender of respondents (%)** | | | | |
| Female | 93.30 | 90 | 94.30 | 89.20 |
| Male | 6.70 | 10 | 5.70 | 10.80 |
| **Education of the respondent (%)** | | | | |
| No schooling | 20 | 26.70 | 17.10 | 11.70 |
| Primary | 53.30 | 23.30 | 38.60 | 35 |
| Secondary | 23.30 | 40 | 32.90 | 45.20 |
| Partial tertiary | 0 | 0 | 1.40 | 3.30 |
| Completed tertiary | 3.30 | 10 | 10 | 5.80 |
| **% of HH with members employed** | | | | |
| Employed | 43.30 | 50 | 52.9 | 56.7 |
| *Occupation type (%)* | | | | |
| Labourer | 47.10 | 53.3 | 40 | 56 |
| Professional | 11.80 | 20 | 37.10 | 26.20 |
| Business e.g. baking fat cook and fish | 41.20 | 26.70 | 22.90 | 18 |

# APPENDIX 15

**HOUSEHOLD QUESTIONNAIRE**

| HOUSEHOLD QUESTIONNAIRE |
|---|
| VILLAGE NAME: |

**INTRODUCTORY INFORMATION A**

I. I introduced myself to the interviewees and briefly explained that this questionnaire has been developed for a study being undertaken by PhD student. The study aims to understand how households use different fuels, how easy or difficult it is for households to access fuels under the traditional management rules and those under CBCM during the harvesting trial.

2. Before I started with an interview I highlighted to them how long the interview will take and ask them if they are willing and ready to be interviewed, and it was only if they were willing that I continued to interview

3. I also explained to each respondent that data collected will remain confidential and will not be communicated to anyone outside the research team

NB: I administered these questionnaires to all the sampled households before the harvesting trials and during the trial, January 2014 and Janury 2015, but in between these two major survey rounds; I revisited the households in July to collect data on daily winter consumption.

**INTRODUCTORY INFORMATION B**

Household GPS Coordinates: Latitude……………………........................ Longitude…………………………………………….
Date of visit……………………………………………………………
Household agreed to participate after filling the consent form?

| | | | |
|---|---|---|---|
| a)1=Yes | | b)0=No | |

Start time and End time

| | | |
|---|---|---|
| | To | |

Participation sheet read in local language and understood?

| | | | |
|---|---|---|---|
| a)1=Yes | | b)0=No | |

Completed successfully

| | | | |
|---|---|---|---|
| a)1=Yes | | b)0=No | |

**SECTION A: SOCIO-ECONOMIC INFORMATION**

**1 Gender of the interviewee and the age group**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| a)Male | a) <5 | b) 5-9 | c) 10-14 | c) 15-19 | d) 20-29 | e)30-39 | f)40-49 | g)50-59 | h)>60 |
| b) Female | a) <5 | b) 5-9 | c) 10-14 | c) 15-19 | d) 20-29 | e)30-39 | f)40-49 | g)50-59 | h)>60 |

**2 How many are permanent family members in this household?**

| |
|---|
| |

**3 How many are migrant members? (Being home for less than three nights and away at least six months of the year)**

| |
|---|
| |

**4 How many are female and male members in this household, also indicate how many are in each age group?**

| **a)Male** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Age** | a)<5 | b)5-9 | c)10-14 | c)15-19 | d)20-29 | e)30-39 | f)40-49 | g)50-59 | h)>60 |
| **b)Female** | | | | | | | | | |
| **Age** | a)<5 | b)5-9 | c)10-14 | c)15-19 | d)20-29 | e)30-39 | f)40-49 | g)50-59 | h)>60 |

**5 What is the level of education?**

| | |
|---|---|
| 1= No-schooling | |
| 2= Primary | |
| 3= Secondary | |
| 4= Tertiary | |
| 5= Completed tertiary | |

**6 Indicate type of government grant received**

N=None
C=Child support
F= Foster grant
D=Disability
P=Pensioner

**7 Employment and income information**

**7.1 Employment type, you can also specify the sector in which you are employed**

| | |
|---|---|
| 1= Employed full time | |
| 2=Employed part time | |
| 3=Self-employed | |
| 4=If other indicate | |

**7.2 What is your income, is it monthly/weekly/fortnight income (combined if more than one job including grant if received)**

| | |
|---|---|
| 1 =Less than R1000 pm | |
| 2= R1000-1999 pm | |
| 3=R2000-3,999pm | |
| 4=4000-5999pm | |
| 5=6000 and above pm | |
| X=Donot know | |
| If other specify | |

**SECTION B: FUELWOOD CONSUMPTON AND USE PATTERNS**

**1 Do your household use fuelwood?**

| | | | |
|---|---|---|---|
| a)1=Yes | | b)0=No | |

**2 If so what do you use it for?**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **a)Cooking** | | **b)Heating** | | **c)Lighting** | | **d)Rituals** | | **e)Other** | |

**3 How do you acquire, e.g. do you harvest or buy or both?**

**3.1 Collect:**

| | | | |
|---|---|---|---|
| a)1=Yes | | b)0=No | |

**3.2 Buy:**

| | | | |
|---|---|---|---|
| a)1=Yes | | b)0=No | |

**3.3 Both**

| | |
|---|---|
| a)1=Yes | |

**5 Who is mainly involved in fuelwood harvesting, and how often is it collected?**

| Fuelwood collector/s | Responses | | | | |
|---|---|---|---|---|---|
| | 1-2x/week) | 3-x/week) | <1/month) | 1-2x/month) | N/a |
| a)Women | | | | | |
| b)Girls | | | | | |
| c)Boys | | | | | |
| d)Men | | | | | |

If collected, where does it come from? (*several answers possible*)

| | | | | | |
|---|---|---|---|---|---|
| c)= Own fields | | d= Bush/woodland | | e)Others (specify) | |

**6 Indicate way/s you carry fuelwood to the household**

| FORMAT OF WOOD | | |
|---|---|---|
| a) | Head load | |
| b) | Wheelbarrow | |
| c) | Bundle of firewood | |
| d) | Pick truck/donkey cart | |
| e) | Other specify | |

**3 Rank any 3 species that are sought after fuelwood according to their order of preference**

| Rank | Local name | Reason for preference |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |

**9 If you buy only how much per headload, wheelbarrow, donkey cart or bakkie?**.......................................

**10 Do people harvest fuelwood and sell?**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| a) Yes, to locals only | | b) Yes, to outsiders only | | c) Yes, to locals and outsiders | | d)No | | e) Not sure | |

**11 Mention factors influence preference of certain species over others and can they be ranked according to order of their preference from the top to bottom?/ I yini le xi xi endlaka leswaku mirhandza sayizi yo karhi a hehla ka yinwana?**

1……………………………………………………………………………………………………………………………2……………………………………………
……………………………………………………………………………3………………………………………………………………………………………
……………………………………………………………………………4………………………………………………………………………………………
………5…………………………………………………………………………………………………………………………………………………

**12 Show the bundles or quantities of fuelwood that you used on a daily basis for summer and winter respectively? (Collected on three separate occasions, January 2014, July 2014, and January 2015)**

| Daily summer fuelwood bundles (Kg) (Before the harvesting trial) | Daily winter fuelwood bundles (Kg) (During the harvesting trial) | Daily summer fuelwood bundles (Kg) (During the harvesting trial) |
|---|---|---|
| a) | b) | c) |

**13 How many minutes do you take to get to the harvesting area, from the time you leave the house and reach the harvesting area?**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| a) 30 minutes or less | | b)1 -2 hours | | c)3-5hours | | d)5-7hours | | e)10 hours and above | |

**14 How many minutes do you take to harvest fuelwood, after arriving in the harvesting area?**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| a) 30 minutes or less | | b)1 -2 hours | | c)3-5hours | | d)5-7hours | | e)10 hours and above | |

**15 What are the other sources of energy?**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| a)Electricity | | b)Cow dung | | c)Crop residues | | d)Other | |

*(If you answered is a) (ELECTRICITY), proceed with questions below).*

**16 Do you access Free Basic Electricity?**

| | | | |
|---|---|---|---|
| a)Yes | | b)No | |
| Reason: | | Reason: | |

**17Please indicate how often do you use electricity for lighting?**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| a)1-7x/week | | b) <1x/week | | c) Do not use it | | d) Do not have access | |

**18Please indicate how often do you use the electricity stove for cooking?**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| a)1-7x/week | | b) <1x/week | | c) Do not use it | | d) Do not have access | |

**19 If you use fuelwood and electricity why you use fuelwood**……………………………………………………………………………..

**SECTION C: GOVERNANCE QUESTION**

**1 Mention local institutions/group/s that you know is/are relevant to natural resource management**

| | | | | |
|---|---|---|---|---|
| a) | b) | c) | d) | e) |

**2 Who (from the answers above) is responsible for the management of the woodland?**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| a) | | b) | | c) | | d) | | e) | |

**3 Explain why you think your chosen institution/s group/s is/are important?**

………………………………………………………………………………………………………………………………………………………………
………………………………………………………………………………………………………………………………………………………………
…………………………………………………………………………………………………………

**4 From all the institution/s group/s indicate those/ that work together to promote resource sustainability**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| a) | | b) | | c) | | d) | | e) | |

**5 Is there any conflicts that these institutions bring?**

| | |
|---|---|
| a)Yes | b)No |

If yes explain the type of conflict…………………………………………………………………………………………………………………

Also explains how is it resolved ……………………………………………………………………………………………………………………….

**5 Please list local rules about used to promote natural resource sustainability of fuelwood in particular**

| | | | | |
|---|---|---|---|---|
| a) | | b) | c) | d) |
| e) | | f) | g) | h) |

**6 “You do not harvest livewood and protected species as it is illegal to do so” (Before the harvesting trial)**

| | | | | |
|---|---|---|---|---|
| a) Agree | b)Strongly agree | c)Do not know | d)Disagree | e) Strongly disagree |

**7 “You harvest only from coupes on Fridays and Saturdays (Thorndale) or Saturdays and Sundays (Peninghotsa) based on agreed rules during the workshop meeting.”(During the harvesting trial)**

| | | | | |
|---|---|---|---|---|
| a) Agree | b)Strongly agree | c)Do not know | d)Disgree | e) Strongly disgree |

**“Community members do not harvest livewood and protected species as it is illegal to do so” (Before the harvesting trial)**

| | | | | |
|---|---|---|---|---|
| a) Agree | b)Strongly agree | c)Do not know | d)Disgree | e) Strongly disgree |

**“Community members harvest only from coupes on Fridays and Saturdays (Thorndale) or Saturdays and Sundays (Peninghotsa) based on agreed rules during the workshop meeting.”(During the harvesting trial)**

| | | | | |
|---|---|---|---|---|
| a) Agree | b)Strongly agree | c)Do not know | d)Disgree | e) Strongly disgree |

**8 How often do you get caught when not complying, e.g cutting live trees or harvesting not in the required coupe?**

| | | | | |
|---|---|---|---|---|
| a)Once a week | b)Twice a week | c)Once a month | d)Twice a month | e) Once a year |
| f) Do not get caught | g) Other (specify) | | | |

**9 Does the designated institution have enough tribal police to enforce rules?**

| | | | | | |
|---|---|---|---|---|---|
| a)Yes (give No if you know) | | b)No | | c) Do not know | |

**10 What are the penalties if caught not complying with harvesting rules?**

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| a)R100 | | R200 | | R300 | | )R400 | | )R500 | | e)>R500 | |
| f)Other specify | | | | | | | | | | | |

**11 Who do you approach when you have fuelwood related problem between the relevant stakeholders ( you can give those not given below  if they exist) and why?**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| a)Chief/hosi | | b) headman | | c)Councilor | d) CDF | | e) Other (Specify) | |

**12Have you approached the Municipality when you have fuelwood related problem?**

| | | | |
|---|---|---|---|
| a)1=Yes | | b)0=No | |

If yes give reason……………………………………………………………………………………………………………………………………

**13 Where do the fines go?**

……………………………………………………………………………………………………………………………………………………………
……………………………………………………………………………………………………………………………………………………………
…………………………………………………………………………………………………………….

**14 How are they used?**

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……………………………………………………………………………………………………………………………………………………………………
……………………………………………………………………………………………………

**15 When is collection of fuelwood forbidden?**

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……………………………………………………………………………………………………………………………………………………………………
……………………………………………………………………………………………………

**16 Are there restrictions on volume?**

| a)1=Yes | | b)0=)No | |
|---|---|---|---|

If yes give the required volume/amount
required………………………………………………………………………………………………………………………………….

**17 Are any technologies or methods of harvest or collection restricted?**

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…………………………………………………………………………………………………………………………………………………………………
……………………………………………………………………………………………………

**THANK YOU FOR TAKING YOUR TIME TO ANSWER MY QUESTIONS**