SOCIO-ECONOMIC ANALYSIS OF PITSAWING IN TRADITIONAL AGROFORESTRY SYSTEMS: A CASE STUDY OF MOSHI RURAL DISTRICT

BY

KWAY SANFORD ELIMSU

A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT FOR THE DEGREE OF MASTERS OF SCIENCE IN FORESTRY, SOKOINE UNIVERSITY OF AGRICULTURE

1999

ABSTRACT

A socio-economic analysis of pitsawing in the traditional agroforestry systems was conducted in Moshi Rural District of Kilimanjaro Region in Tanzania. The specific objectives were: to estimate the productivity of local pitsawyers; to estimate the cost and benefits involved in pitsawing; to assess reservation prices of trees in the farm lands; to assess contribution of pitsawing to local economies and to identify the constraints facing pitsawyers in the area.

Data were collected from six randomly selected villages by administering both structured and semi-structured questionnaires and by physical measurements. Statistical Package for the Social Sciences (SPSS) was the computer programme used to analyze the data.

Results showed that majority of the pitsawyers originated within Kilimanjaro Region. Most of these pitsawyers had less than ten years of experience and they have an additional income from agriculture, livestock and petty businesses. The average income for a pitsawyer amounted to 173 500 Tsh/month with 77 500 Tsh orginating from pitsawing (about 44.7%). The study revealed the total inputs of 70 609 Tsh/m^3 and output of 109 750 Tsh/m^3 with a profit of 39 141 Tsh/m^3, an economic productivity (sales price/total costs) of 1.6 and sawnwood productivity of 0.1 m^3/manday. However pitsawing was found to be profitable to both the pitsawyer and pitsawyers employers.

On the basis of the synthesis of these findings it is recommended that: there is an urgent need to review pitsawing practices to make them compatible with sustainable management, the sawnwood from pitsawyers should be evaluated consistently to determine their long-term sustainability in supply to meet the ever increasing demands, encouragement of utilization of general utility sawntimber and lesser-utilized tree species such as *Rauvolfia caffra* and *Persea americana,* the Chagga agroforestry systems should be introduced to other suitable areas of the country and to other people. Also the following were recommended for further research: more research on the general properties and uses of various indigenous hardwood tree species to provide more information to the users, more research on traditional agroforetry systems which will include the ecological and silvicultural aspects such as planting techniques, regeneration and tree breeding of various indigenous tree species.

DECLARATION

I Sanford Elimsu Kway, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is a result of my own original work and it has never been submitted for a higher degree award in any University.

Signature .....

Date 19/10/1999

COPYRIGHT

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude and appreciation to all those who, directly or indirectly contributed to the successful completion of this study. In particular, I am greatly indebted to the following:-

Sokoine University of Agriculture (SUA) for providing me admission for M.Sc. studies and the Norwegian Agency for Development Cooperation (NORAD), for sponsoring the whole of my M.Sc. (For.) course.

Prof. Aku O'Kting'ati my supervisor for his invaluable guidance, detailed comments, suggestions criticisms and constant encouragement which made possible the development of research proposal and subsequently the production of the dissertation.

All members of staff in the Department of Forest Economics Faculty of Forestry and Nature Conservation, Sokoine University of Agriculture with whom I shared ideas and logistical support. All village leaders, pitsawyers, timber traders and farmers in the study villages who made data collection possible. Lastly but not least, sincere gratitude and appreciation is profoundly registered to my parents, brothers and sisters for their constant support and encouragement during the course of my study.

DEDICATION

This work is dedicated to my parents: My father Elimsu and mother Flora who brought me up and showed me the value of education.

Thank you very much.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Figure page

LIST OF PLATES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

AF	=	Agroforestry
DBH	=	Diameter at Breast Height
IAF	=	Indigenous Agroforestry
ICRAF	=	International Centre for Research in Agroforestry
Ltd	=	Limited
m^3	=	Cubic Metre
MTNRE	=	Ministry of Tourism, Natural Resources and Environment
NORAD	=	Norwegian Agency for International Aid
SIDA	=	Swedish International Development Agency
SPSS	=	Statistical Package for Social Sciences
SUA	=	Sokoine University of Agriculture
TFAP	=	Tanzania Forest Action Plan
Tshs	=	Tanzanian Shillings
TWICO	=	Tanzania Wood Industry Corporation
URT	=	United Republic of Tanzania
USD	=	United States Dollar

CHAPTER 1

1.0 INTRODUCTION

1.1 Background information

In many developing countries, forest and woodland resources are fast disappearing especially in arid and semi-arid areas where forest regeneration is low. More than 100 million people in these areas are short of fuelwood and other forest products (FAO, 1990).

Tanzania is endowed with vast forest resources which have great potential for economic development. Nearly half of the country's total area is covered by forests and woodlands which represent about 44 million hectares (MTNRE, 1994). Forest resources play a very important role in environmental functions, it offers a habitat for wildlife, unique natural ecosystems and genetic resources. Forests contribute significantly to the economic development and environmental protection of the country.

According to FAO (1992) estimates, Tanzania is loosing about 2% of her forest cover annually despite the afforestation efforts of about 20 000 ha per annum. This is said to be caused by clearing for agricultural lands, settlements, overgrazing, bush fires, harvesting for industrial use and woodfuel (Iddi and Nagoda, 1992; Ishengoma, 1994).

The population pressure in Tanzania is increasing at an annual growth rate of 3.4% (United Nations, 1990) and so is the demand for forest resources and land. Due to this rapid population growth, tropical forests have been and are continuing to be mined and wasted, some of which is converted into farmlands and ranges/ranches. The community living in and around forests continue to rely directly upon these wide forests for products and services for their daily subsistence (Tewari, 1994). To alleviate the problem of tree depletion, tree growing in rural areas of many developing countries has emerged as one of the forestry measures. Many programmes and projects designed to encourage tree growing in rural areas are now in existence.

Tanzania government started the village afforestation programme in 1967/68 with the objectives of providing in perpetuity enough fuelwood and building material to the rapidly growing population as well as maintaining a sound environmental condition for sustained agricultural production (Kaale, 1983). Kilimanjaro, Kagera, Mbeya, Tanga and Singida are among the regions that implemented this programme. The programme has been carried out in several ways through governmental organizations, communal, institutional and individual efforts and trees were planted in deforestated lands as well as in farmlands. However there were no definite establishment procedure followed in farmlands during the 1968-80 era.

1.2 Forest based industries in Tanzania

Forest industries play an important role in the national economy of the country. Forest products are source of foreign exchange earnings. In Tanzania forest industries absorb about 2.8% of paid labour and contributes about 3% of the total Gross Domestic Product (Mgeni and Malimbwi, 1990).

The forest industry sub-sector provides many and varied benefits such as sawntimber, wood based panel products, pulp and paper products, generate income and employment both to the local communities and to the nation as a whole. Forest based industries in Tanzania range from individual and village cooperative small scale forest industries to large industrial complexes. These industries produce wood and non-wood products. The wood products constitute the most important forest produce in the worldwide sense, but others may be of extreme importance nationally (Kowero, 1988).

The growth of forest industries in Tanzania was influenced by many factors which includes the type and distribution of indigenous forest resources, small domestic demand of some forest products which was concentrated in few large population centres, transportation system and scarcity of investments. These factors have led to the presence of many small industrial units. Nevertheless, forest based industries form an important part of the industry sector in Tanzania (Kowero, 1988).

1.3 Timber processing

Sawing of timber covers a wide range of technologies from hand hewed to pitsawing up to some most sophisticated electronically controlled automatic sawmills. Sawnwood in Tanzania is produced by both pitsawyers and sawmillers. Pitsawing is a method of sawing logs using two man crew by a double handled saw, the log is either rolled onto a platform or placed horizontally above a pit, where it is manually sawn into boards and planks. The two pitsawyers are placed one on top of the log and one in a pit underneath the log hence word "pitsawing". The process is arduous, time consuming and requires specialized craftsmen. However, earlier studies show that it yields reasonable quality boards (Kijoti and White, 1981; Skage and Naess, 1994; Monela, 1995). Logging is described by Skaar (1990) as the "cutting and the terrain transport operations which take place in connection with tree harvesting". The logging method describes in what form the harvested material is transported to the roadside. When logging equipment is used to implement a logging method, it is called a logging system, as when pitsawing equipment is used in order to convert roundwood into sawntimber. Pitsawyers produce hand sawn timber and is mostly unrecorded in trade. Pitsawing was introduced in Tanzania by the colonial powers. Harvesting of hardwood in the Eastern arc mountains started by the Germans in order to produce timber suitable for shipbuilding (Hamilton, 1989).

In 1981, pitsawing amounted to 29% of total timber production in Tanzania (Dykstra, 1983). Currently pitsawing is wide spread throughout Africa (Ole-Meiludie *et al.*, 1988). Timber industry was not developed before 1960's, and submontane forests

were regarded as marketable for timber, and hardly no any pitsawing were recorded in the Eastern arc mountains before 1960 (Skage and Naess, 1994). Major expansion of pitsawing activities did not occur until the early 1960's when also harvesting of timber from the Nguru Mountains and Ulugurus reached a large scale. The activity then expanded and increased until the late 1980's (Skage and Naess, 1994). The Indigenous Agroforestry systems of the West Usambaras provide different types of lumber for furniture and house construction from both indigenous and exotic tree species. Among the indigenous tree species *Cordia abyssinica* was found to produce quality timber while the exotic/naturalized counter part, *Grevillea robusta* is predominant and traditionally used for local beer brewing drums and other wooden containers which form an important component in livelihood in Northern Tanzania (Moshi, 1997).

1.4 Problem statement

Agricultural productivity in most Eastern African Highlands has often been associated with an ever expanding demographic pressure. This situation has consequently made people of these areas to adopt intensive indigenous land-use systems involving the mixing of trees and agricultural crops in an intimate combination with each other (Nair, 1989, 1993). These land-use systems are now collectively referred to as agroforestry (Gold and Hanover, 1987). The practice has resulted from traditional innovations and land scarcity on a predominantly a tropical rainforested land (O'kting'ati, 1985).

Agroforestry can provide many benefits to farmers and society with a good combination of tree species and food crops. Such a combination will provide direct benefits such as food, fodder fuelwood and shelter to the farmer. Additionally, indirect benefits to the farmer and society include reduction of soil erosion, improved utilization of scarce rainfall, improved fertility of the soil, and reduction in demand associated with subsistence agriculture.

Agroforestry systems has been introduced in rural areas including Kilimanjaro Region with the expectation that wood from these agroforestry tree species would substitute for or relieve pressure on the hardwood from natural forest which are now faced with degradation and deforestation. It is estimated that, agroforestry systems contribute only 13.5% of the present requirement of wood (Ishengoma *et al.*, 1992). In Kilimanjaro Region, over 100 plant species within about 40 families could be identified, which include 53 tree species and 21 non-woody plants (O'Kting'ati, 1985). Although the agroforestry systems in Kilimanjaro are endowed with a large number of tree species, it has been a common practice to harvest only those with desirable wood properties such as *Grevillea robusta, Cordia abyssinica, Olea carpensis, Millicia exelsa,* and *Albizia schimperiana.* The felling, crosscutting and sawing operations, as well as mode of transport to nearest road side is a common logging system used which is described as "pitsawing" in this study. Unfortunately little is known about the economy, productivity, costs and benefits of pitsawing under these traditional agroforestry systems.

When properly done the method causes minimal disturbances to the equilibrium of the forest since only selected mature trees are felled and sawn on spot thus avoiding log dragging or skidding (Abel, 1990). However the main disadvantages of pitsawing are:

- low surface quality of sawnwood produced,
- recovery rate is low compared to industrial sawmilling,
- heavy workload put on man,
- low output per work,
- difficult to monitor by law enforcement agents etc. With more than 80% of Tanzanians are unemployed, this system of wood processing can be considered as an employment opportunity (Johnson, 1989).

Against this background, more intensive studies need to be conducted in the areas where pitsawing is practised especially in the traditional agroforestry systems which ICRAF and other international bodies strongly advocate as an appropriate land management technique.

1.6 Objectives of the study

The overall objective of this study was to analyze the socio-economic of pitsawing in selected agroforestry systems in Northern Tanzania. The specific objectives were:

(a) To estimate the productivity of local pitsawyers.

(b) To estimate the costs and revenues involved in pitsawing.

(c) To assess reservation price of trees on farm lands.

(d) To assess contribution of pitsawing to local economies.

(e) Basing on the synthesis in (a)-(d) to prescribe remedial measures and policy interventions to improve the pitsawing sector and forest industry as a whole.

CHAPTER 2

2.0 LITERATURE REVIEW

2.1 Concepts of indigenous agroforestry systems

2.1.1 The origin of agroforestry

Traditional agroforestry systems may have originated in prehistoric times when hunters and gatherers deliberately or accidentally dispersed seeds of highly valued fruit trees in the vicinity of their camp sites (Hutterer, 1984). Historically, hunters and gatherers were firstly found in Africa since it is thought that the first human being lived there. Thus by implication, traditional agroforestry systems could have originated in tropical Africa. However, Wiersum (1987) reported that traditional AF practices have originated in Tropical Asia.

According to Soemarwoto (1987), historical sketch shows that, there is evidence that agroforestry practice is a very old tradition which may have evolved over a long time from the practices of the hunters or gatherers and continued in the ancient civilizations up to a modern times.

2.1.2 Indigenous agroforestry systems in general

Throughout the world, at one period or another in its history, it has been the practice to cultivate tree species and agricultural crops in intimate combination (Nair, 1989, 1993). The historical development of these AF systems in different parts of the world

is traced differently. Also the practices are widespread and extremely varied. They have been a traditional way of life for many upland farmers in the world and are still practised in many hilly areas of tropical Africa, Asia and Latin America (Swaminathan, 1987).

There are many examples which indicate the wide geographical coverage of the AF Systems and their early origin eg. Latin America (Altieri, 1991; Barton, 1994), Indonesia (Michon and Mary, 1994), Thailand (Takeda, 1990), Sir Lanka (Nakanish *et al.,* 1994) Kenya (Scherr, 1993; Waajenberg, 1994), Tanzania (Fernandes *et al.*, 1984; O'Kting'ati 1985; O'Kting'ati and Mgoo, 1992; Rugalema *et al.*, 1992), Uganda (Oduol and Aluma, 1990) and Zimbabwe (Campbell *et al.,* 1991).

Cases of indigenous AF practices have been reported where population pressure had reached a high peak as peasants resort to intensive use of land to sustain the needs of the growing populations on limited land. According to O'Kting'ati (1985), farmers in Kilimanjaro Region deliberately retain and manage numerous species of trees, shrubs and herbs in their farms. On average each farm maintains about 47 trees at different age classes most of which are local species About 30 percent of trees are timber trees while 17 percent and 36 percent are fodder and fruit trees respectively. Another 17 percent of the trees are for medicinal, antipest, climber crop supports, or trees for hanging beehives. Measurement of bole volume of commercially mature trees indicated an average volume of 19.1 m^3 per farm of about 0.5 ha in size.

Numerous indigenous AF systems and practices exist in the tropical highlands of the

world. Miehe (1988) reported about the traditional AF systems based on the acacia (*Faidherbia albida*) and other multipurpose tree as practised by sedentary people on the lower slopes and highlands of the Jebel Marra Miassif, Sudan. This system has sustained a densely settled population over centuries. Similarly, Jambulingan and Fernandes (1986) described numerous indeginous agroforestry systems and practices existing in the state of Tamil Nada of India which involve the use of multipurpose tree species on farmlands or rangelands. The hill farming systems in Western Nepal (Fonzen and Oberholzer, 1984), the Chagga multistoreyed cropping systems on Mount Kilimanjaro slopes (Fernandes *et al.*, 1984) and the North and South highland regions of Tanzania (Mnkeni, 1992) are all IAF systems. Growing *Faidherbia albida* as a permanent tree crop on farmlands with cereals, vegetables and coffee underneath or in between, as an IAF system in the Hararghe highlands of eastern Ethiopia (Poschm, 1986), while the shamba system a form of taungya where agricultural crops are grown together with forest tree species in plantations has been quite wide spread in the "high-potential" agricultural areas of Kenya (Odul, 1986) and Tanzania (Hofstad, 1978) since the early 1900s.

2.1.3 Indigenous knowledge and AF

The term "indigenous knowledge" as used by most researchers, refers to the myriad of small and large decisions taken on a daily basis by the local people in regeneration, protection and use of tree and crop resources (Indigenous Knowledge and Development Monitor, 1993). Local people have accumulated indigenous knowledge of manipulating tree through practices such as pollarding, lopping, pruning etc. and by

respecting (or not) both formal social controls and common sense rules on harvesting of herbs, shrubs and trees and other forest and agricultural resources. In this way the local man is showing his knowledge of agroforestry (Kajembe, 1994). Traditional farming systems have merged over centuries of cultural, economic and biological evolution and represent accumulated experiences of interacting with the environment by farmers without access to external inputs, capital or scientific knowledge (Nair, 1989). However this is not always true.

There are instances where formal and informal rules exist to enhance the productivity or protection of trees and shrubs against rampant cutting as for example among the Poket and Turkana of Kenya (Barrow, 1991). In other areas the importance of trees is strongly stressed culturally and some people have been named after trees (Kajembe, 1994).

Experience has shown that many agricultural groups have a clear knowledge of regeneration requirements of different tree species and know how to regenerate them if need arises (FAO, 1990). Among the local populations in the tropics, the protection of trees and shrubs has been seen to take two forms; prohibition and restriction on the use of some highly valued individual species, and the protection of all trees and shrubs in sacred groves (Gerden and Matallow, 1990).

The concept of IAF management refers to series of practices based on consensus use-rights and agreed rules carried out by local people aiming at the sustained availability of products and services from the trees and crops for today and for future generations.

These practices are generated by internal initiatives within the local community itself (Fisher, 1989).

2.1.4 Definition of an AF system

Lundgren (1982) and Nair (1989, 1993) summarized several definitions given by different authors and came up with a new definition. Accordingly AF should stress two characteristics common to all forms of AF and separate them from the other forms of land use, namely:

- the deliberate growing of woody perennials on the same unit of land as agricultural crops and/or animals, either in some form of spatial mixture or temporal sequence;
- there must be a significant interaction (positive and/or negative) between the woody and nonwoody components of the system, either ecological and or economical.

When promoting agroforestry one should then stress its potential to achieve certain aims, not only by making theoretical and qualitative remarks about the benefits of trees but also more importantly by providing quantitative information (Lundgren, 1982). However, these ideas were later refined through "in-house" discussions at the International Centre for Research in Agroforestry (Nair, 1993), and the following definition of agroforestry was suggested: "Agrofestry is a collective name of land-use systems and technologies where woody perennial (trees, shrubs, palms, bamboo, etc) are deliberately combined with agricultural crops and or/animals in some form of spatial arrangement or temporal sequence. In AF systems there are both ecological

and economical interactions between the different components (Lundgren, 1982)". According to Nair (1993), the implication of this definition is that:

- an agroforestry system always has two or more species of plants (or plants and animals), at least one of which is a wood perennial;
- an agroforestry system always has two or more outputs;
- the cycle of an agroforestry system is always more than one year; and
- even the simplest agroforestry system is more complex ecologically (structurally and functionally) and economically than monocropping system.

However, the definition of agroforestry has been revisited. Leakey (1996), suggests that AF should be reconsidered as a dynamic, ecologically based, natural resource management system that, through the integration of trees in farm and rangelands, diversifies and sustains small holder production for increased social, economic and environmental benefits.

2.2 Criteria used in classifying AF systems

In order to understand and evaluate the existing AF systems and to develop action plans for their improvement, it is necessary to classify them according to some common criteria (Nair, 1993). The main purpose of classification should be to provide a practical framework for the synthesis and analysis of information about the existing systems and the development of new and promising ones. Nair (1993) suggested that the most obvious and easy-to-use criteria for classifying AF systems are the spatial and temporal arrangements of components, the importance and role of components, the production aims or outputs from the system, and the social and

economic nature or ecological (environmental) spread. Thus AF systems can be categorized according to structural, functional, socio-economic and ecological sets of criteria.

2.2.1 Structural aspects of AF systems

This refers to the composition of the components including spatial admixture of the woody components, vertical stratification of the component mix and the temporal arrangement of the different components. (Nair, 1993).

2.2.2 Functional aspects of AF systems

This refers to the major function or role of the system, mainly of the woody components. They can be productive such as food, fodder, fuelwood, timber and among others or protective such as windbreaks, shelterbelts, soil conservation, soil improvement, and so on.

2.2.3 Socio-economic aspects of AF systems

Refers to the level of inputs of management or intensity or scale of management as well as commercial goals whether subsistence, commercial or intermediate. (Nair, 1985).

2.2.4 Socio-ecological aspects of AF systems

Refers to the environmental conditions and ecological suitability of systems on the assumption that certain types of systems can be more a set of AF systems for certain

soils in arid and semi-arid lands, tropical highlands, lowlands, humid tropics, the subhumid savannas and so on. (Nair, 1985).

The multistorey structure of AF systems such as homegardens play an important protective role against soil erosion by providing vegetative cover. Most of the agroforestry systems are found in specific ecological situations from different geographical regions (Nair, 1985).

2.3 Arrangement of components in AF

Plant and/or animal arrangements in multipurpose AF combinations in the field can involve the dimensions of space (spatial) and time (temporal). Spatial arrangements in AF mixtures can result in dense mixed stands as observed in homegardens or in sparse mixed stands as in most silvopastoral systems. The species mixed can sometimes be in zones or strips of varying width as in hedgerow intercropping (or alley cropping). On the other extreme of zonal planting is the boundary planting of trees on farm plots or fields for a variety of purposes and outputs such as fruits, fodder, fuelwood, fencing, protection, farm boundary, demarcation, soil conservation and among others. Temporal arrangements of plants in AF can take various forms such as shifting cultivation on the one extreme where cultivation lasts for a period of 2 – 4 years after which 15 or more years elapse leaving the land to regenerate to bush or forests to the other extreme of relay cropping.

2.4 The sawmilling industry in Tanzania

The sawmilling industry is usually the first of the forest industries to be established. The required initial investment in sawmilling can be kept moderate and the industry's labour requirements are very flexible (Kowero, 1988).

Most of the wood processing capacity in Tanzania is based in the sawmilling industry and utilizes hardwoods. The industry ranged from pitsawing to processing in large, technically advanced sawmills. Tanzania has approximately 100 sawmills which satisfy about 60% of the domestic demand for sawn wood. The remaining 40% is supplied by pitsawyers (Kowero, 1988). These sawmills operate in different environments which includes plantations such as Sokoine University of Agriculture training forest mobile sawmill in Arusha, Kilimanjaro mobile sawmills in Kilimanjaro, Mtibwa teak forest mobile sawmill in Morogoro. Some such as Mkata sawmills ltd and Tabora msitu products ltd are operating in miombo woodlands processing some of commercially valuable tree species namely *Pterocarpus angolensis* and *Brachystegia spiciformis*. The main products from these sawmills are sawntimber, railway sleepers and flooring strips (Kaoneka, 1987).

The sawmilling industry is currently faced with a number of problems, ranging from an inability to rationally match forest resources with utilization facilities to factory operational problems. Earlier studies (Moyo, 1985; Kaoneka, 1987 and Kowero, 1988) showed that one of the major problems affecting the performance of most sawmills is that of financing. In particular, Moyo (1985) observed that the financial

performance of most sawmills between 1979 through 1983 was negative measured in profit terms which was attributed to low production, declining real prices and escalating real costs. Further study on some sawmills showed that there was an increasing disparity between spending and acquisition of funds which resulted into a financial deficit (Kaoneka, 1987).

A number of the industry's operational problems are associated with the lack of both local and foreign funding. Funds have not been available to train enough workers. Past funding constraints impaired proper tending of many of the plantations. The consequence has been inadequately thinned plantations which has resulted in small dimension logs. When processed in stationary sawmills, the recovery rate for small dimension logs is low and uneconomical. In addition, the lack of foreign funding has made it difficult to obtain spare parts and logging gears, as reported by (Kowero, 1988). By not having sufficient wood processing facilities at present, many employment opportunities are lost and the government is loosing considerable revenues from the forestry sector that could be used for economic development.

2.4.1 Pitsawing and the forest industry in Tanzania

In developing countries such as Tanzania, where indigenous tropical hardwood species are widely used for timber, one main harvesting technique is pitsawing. This technique is widely used in Tanzania to produce timber used domestically for building, furniture, handcraft and many other uses (TFAP, 1989). Pitsawing plays an important role in the forest industry of Tanzania. Of the industrial roundwood

consumption (pulp and paper included), pitsawing timber make up as much as 21.6% (TFAP, 1989) as shown on Table 1. According to these data only hardwood species are pitsawn. This means that pitsawyers make up 74% of the total sawn hardwood production, estimated at 74 100 m^3 (TFAP, 1989). However, it is unclear how the gap between consumption and production for pitsawn wood is covered, as the imports of sawnwood has been restricted (TFAP, 1989).

Table 1: Sawnwood in forest industries in Tanzania

Forest industry	Production (m^3/Year)	Roundwood consumption (m^3/Year)	Government ownership (%)
Sawmills	160 000	380 000	90
Pitsawing	55 000	153 000	0
Wood based panels	14 100	31 000	100
Pulp and paper	28 700	144 000	90
Total	257 800	708 000	-

Source: TFAP (1989)

2.4.2 Cost-benefit analysis of pitsawing

Monela (1995) analyzed the financial benefits and costs of pitsawing in the Nguru Mountains. The analysis covers costs and benefits involved from licensing, tree felling, sawing and manual sawn timber delivery at the nearest roadside. This was done from the viewpoint of a pitsawing contractor who aims at making profit for his enterprise. Economic viability in this context implies to ensure that pitsawing contractor has the right incentive by getting profit from pitsawing activity. Experience in Tanzania has shown that this is often pursued without regard to

sustainability or other social benefits. The social profit aspect, though very important, was not included due to difficulty of quantifying the externalities of pitsawing into monetary units. It is important to indicate that at this stage pitsawing in Tanzania operates on an informal market structure hence complicating the estimation of costs and benefits so that you can carry economic analysis using cost benefit criteria. This point has also been underlined by Skage and Naess (1994) and by Jaako (1992) respectively who revealed that, pitsawing in Tanzania has no simple price trend, because the said costs, prices and other pricing elements are spontaneous, thus forming a complex pricing structure even from the same timber site. According to Solberg (1988), pitsawing profit depends on factors such as physical strain, sawnwood quality, terrain transport and ecological effects.

Fergues *et al.* (1977) present probably the first published and realistic estimates in Tanzania of productivity, costs and benefits of pitsawing. The study was based on very limited sample from sawing plantation softwood mainly *Pinus patula* logs at Sao Hill and Mbeya. Based on the performed time studies for 2-men crew, assuming 8 working hours per day, 250 working days per year and 40% sawnwood recovery percentage,he reported the average productivity of 0.2 m^3/manday or 45 m^3/year. Kijoti and White (1981) reported a pitsawing study of *Grevillea robusta* in Pare mountains of Tanzania. The time study-based average productivity for a normal 8 hour working day was 42% and the average cost of pitsawing hardwood was 897 Tsh per m^3. The pitsawyer earned approximately 40 Tsh per day compared to 14 Tsh per day for casual labour by assuming an exchange rate in 1981 of 1 USD = 8 Tsh.

Other studies not based on time study have also been conducted in Tanzania. Klem (1978) estimated 0.1 m^3/manday, whereas Jaakko (1992) estimated 0.3 m^3/manday. Some factors which influence this productivity include species sawn, type of tools, climate, topography, operational set up, pitsawyers experience and motivation. These vary from place to place. Economic viability of pitsawing enterprise relies partly on productivity levels and quality of timber produced (Monela, 1995).

2.4.3. Social aspects of pitsawing

The existing socio-economic literature is scarce and emphasizes mainly technical and economic aspects of pitsawing. It invariably covers pitsawing in three environments: plantation forests, woodlands and mountain forests. Skage and Naess (1994) studied pitsawing in 5 villages in Morogoro District. The study accommodated ecological and social components and estimated gross total cost of pitsawing to be 61 980 Tsh/m^3. As for pitsawing benefits, the average market timber price in Morogoro Town was 106 000 Tsh/m^3 (Monela, 1995). Survey resulted in Nguru mountains showed that timber price at the nearest roadside was 75 000 Tsh/m^3 (Monela, 1995).

CHAPTER 3

3.0 MATERIALS AND METHODS

3.1 Description of the study area

Moshi Rural District is among the six districts of Kilimanjaro Region; others include Moshi Urban, Mwanga, Same, Rombo and Hai. Kilimanjaro Region is located on the north eastern part of Tanzania mainland just South of Equator. It boarders Kenya to the North, Tanga Region to the East and Arusha Region to the West.

3.1.1 Geographical location and size

Moshi District is located in the Southern central part of Kilimanjaro Region. It encompasses an area of 1 529 km^2. It lies between latitude 3°S and 3° 30'S of Equator and Longitude 37° 30'E and 37° 45'E of the Greenwich meridian. Most of the area is highlands, 1 000 m to more than 2 000 m above sea level on the slopes of Mountain Kilimanjaro to 5 895 m a.s.l. at the highest peak of Mountain Kilimanjaro. Figure 1 shows the sketch map of Moshi District and the approximate location of Mawanjeni, Kondeni, Kiruweni, Mrimbo Uuwo, Maring'a and Lole Marera study villages.

3.1 2 The physical environment

3.1.2.1 Climate

Moshi District is characterized by a cool and wet climate. Mean temperature is close to 20°C throughout the year. The area receives a bimodal rainfall pattern with short

rains occurring from November to December. Long rains start mid March through late May or early June. The wettest areas are at the elevations from 1 500 m to 2 000 m a.s.l. where mean annual precipitation reaches 2 000 mm. Below 1 500 m rainfall decreases to about 700 mm on the low lying plain. Based on this variation, the agricultural, ecological zones and climate around Mount Kilimanjaro has been divided into three altitude belts viz.; lowlands, midlands and uplands. The uplands have an altitude of 1 100 - 1 800 m a.s.l., rainfall of between 1 250 - 2 000 mm, and temperature range of 15 - 25°C. The midlands reflect an altitude of 900 - 1 100 m a.s.l., rainfall of between 800 - 1 500 mm, and temperatures of 25 - 30°C respectively. The lowlands have an altitude of up to 900 m a.s.l., rainfall of up to 800 mm and temperatures of over 30°C respectively (URT, 1994).

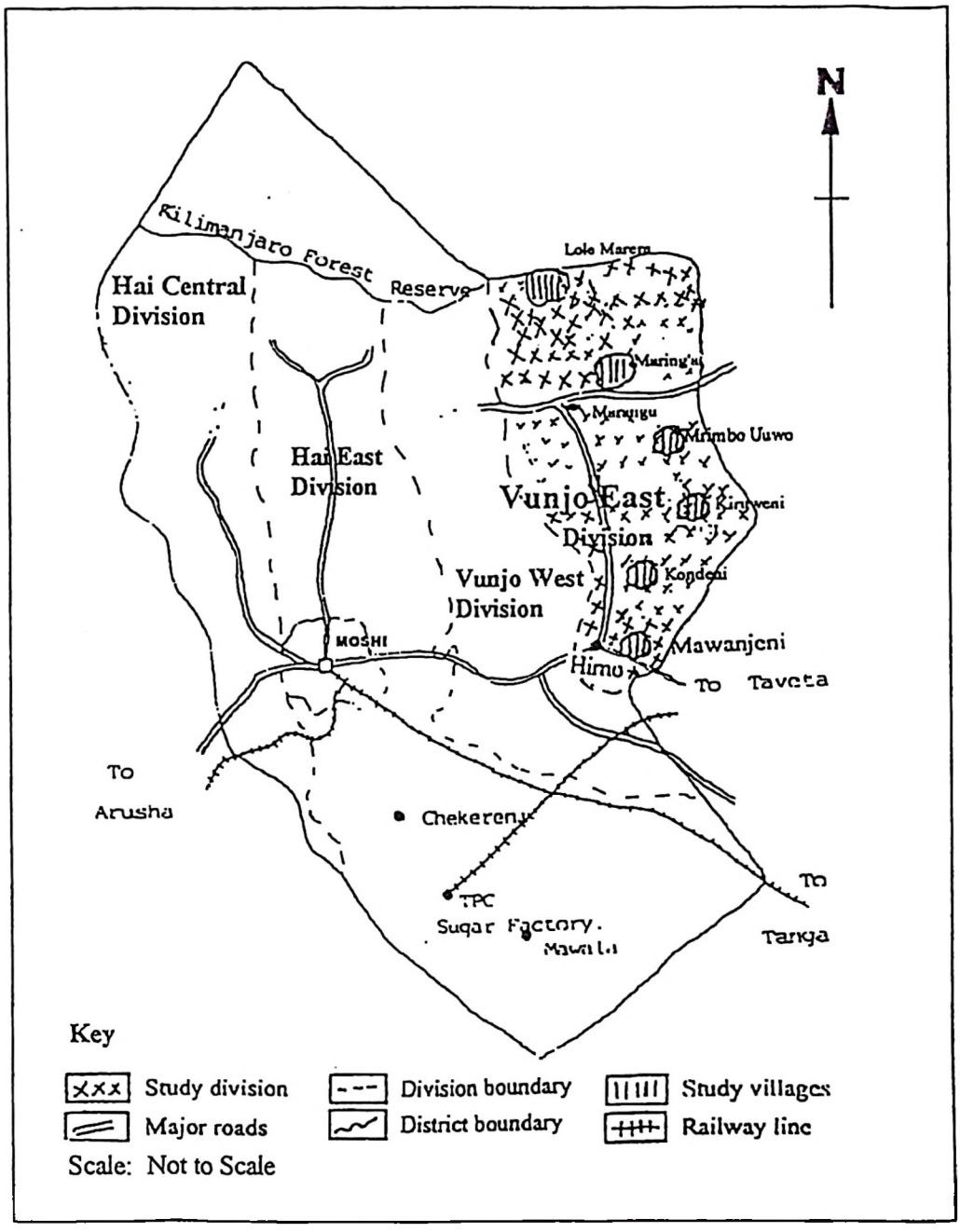

Figure 1: **Sketch map of Moshi District and approximate location of study villages**

3.1.2.2 Soils

Soils on the slopes of Mount Kilimanjaro have been formed by volcanic activities of Mountain Kilimanjaro. These soils show great variations because they have developed from volcanic materials of different ages (Deckers *et al.*, 1990). There are four major groups of soils which can be identified from Moshi District.

(a) Humic nitosols and associated humic andosols;

(b) Chromic cambisols and associated eutic cambisols;

(c) Orchric andosols and associated chromic cambisols and vitric andosols;

(d) Mollic andosols and associated eutic nitosols.

In general, these volcanic soils are fertile with a high base saturation and cation-exchange capacity (Fernandes *et.al.*, 1985) but they have been continuously used so they are nutrient depleted. Steep slopes in many areas of the mountain prevent farm mechanization and necessitate substantial erosion control in order to maintain high agricultural production. In other areas arability is limited by stoniness or by shallow petrocalcic horizon (O'Kting'ati and Kessy, 1991).

3.1.2.3 Vegetation belts

The vegetation changes with altitude and five types of vegetation cover can be identified in Kilimanjaro Region (Mwasaga, 1991). The vegetation of the plains at the lower elevations of Mount Kilimajaro is a woodland and bush land belt. On the wetter southern slopes of Mount Kilimanjaro, the upper limit of this belt is 900 m while on the drier northern slopes this belt reaches up to 1 500 - 1 650 m a.s.l. This belt is susceptible to fire and can be characterized as a mossaic of *Acacia sp*, thorn

bushland and *Combretum/Terminalia* woodland.

The cultivated belt constitute the replacement of the lower part of the montane forest belt. The cultivated belt completely encircles the mountain with exception of a narrow (8 km) corridor of native vegetation on the northwestern slope. Other vegetation belts identified from Kilimanjaro region on an altitude above 2 000 m a.s.l. are montane forest, ericaceous and alpine belts.

3.1.3 Socio-economic and environmental factors

3.1.3.1 Population

According to 1988 census total population was 342 553 people but according to population projections the population has increased. The population density is 224 persons per square km. Actual densities are as high as 700 people per square km in the zone between 1 100 - 1 800 m (where the majority of the population is settled) and as high as 3 339 people per square km in Moshi Urban (Makundi, 1996).

3.1.3.2 Land use systems

The land use system involves mainly combining coffee *(Coffea arabica)*, banana (*Musa paradisiaca*), livestock, trees and variety of other food crops on the same land hence the land is under intensive cultivation and fragmentation is severe (O'kting'ati, 1985). Land use is based on kinship structures which are patrilineal in terms of ownership and inheritance. As the human populations have increased so have the demands for food, fuelwood, timber and fodder. This has lead to deforestation and

highly accelerated soil erosion and a general decline in land productivity (O'kting'ati, 1985).

The agricultural land is differentiated into two types in Moshi District, that is, "Kihamba" and "Shamba". The kihamba is the principle clan land to which the occupant has permanent freehold and is located in the uplands. The kihamba or the Chagga homegarden is where an individual established his residence and plants permanent crops such as coffee and bananas. Shamba is land located on the lowland and is mainly used for growing maize (*Zea mays*), sorghum *(Sorghum vulgare*), sunflower (*Helionthis annus*), and finger-millet (*Eleusine coracana*). Most of the farmers from the uplands have more than one farm on lowlands.

3.1.3.3 Farming systems

Three distinct farming systems, which vary by altitude, can be recognized on Mount Kilimanjaro (O'kting'ati and Kessy, 1991). These are the lowland zone, middle zone and the highland zone.

3.1.3.3.1 The lowland zone (500 - 700 m a.s.l.)

The farming system in the lowland zone is one of the most intensive and mechanized of the three farming systems particularly in the open and flat regions.

Farmers residing in this zone do not own coffee/banana fields. A number of them may have more than one field in different areas of the zone but they do not own land

in the uplands. The major crops grown are maize and beans in combination, sorghum, sunflower and finger-millet. They graze their animals in the grazing land or in the farms after harvesting as the farms contain no permanent crops. No study village was chosen in this zone because it is mostly maize/beans farming system area.

3.1.3.3.2The middle zone (700 - 1 400 m a.s.l.)

The farming system in the middle altitudinal zone is one of the oldest and most intensive in the country. The farming system in this altitudinal zone is an agroforestry system that has evolved over the last 200 years and has changed muchless in the last thirty years than the farming systems in the lower and upper altitudinal zones.

The main components of this agroforestry system are coffee and bananas under various tree crops. The trees are grown for fruit, timber production, animal fodder and shade. The farms in this zone have a variety of shade tolerant food crops of which the main one is taro (*Colocasia spp*). Farmers plant fodder grasses such as *Setaria splendida, Seteria sphacelata,* Guatamala grass, Elephant grass and Guinea grass for stall feeding livestock along the road sides, farm boundaries, the entries to homes and footpath, as well as along the contours of the sloping terrain. Unlike the lowland zone there is virtually no open grazing area for livestock. Three villages of study were chosen from this middle zone.

3.1.3.3.3The high zone (1 400 - 2 000 m a.s.l.)

The farming systems in the high altitudinal zone are very similar to the farming

systems in the middle altitudinal zone only that the growing conditions for most crops are less favourable because of lower temperatures. As a result maize takes more than six months to mature whereas it takes only three months in the middle zone. Due to land scarcity and climatic condition in the high zone, maize and beans are mostly grown in the middle and lowland zones. This entails travel of as much as 20 km between the highlands and the lowlands for several times during the crop's life cycle.

The crop residues are sometimes transported to the homestead for feeding livestock. Trees and shrubs are deliberately retained in the homegardens to provide shade for coffee, fodder, timber, live fence, fuelwood, fruits and local medicine. There is also a higher prevalence of bee-keeping among farmers in this zone.

Historically, the grazing of livestock and the collection of fodder was more extensively practised in this zone. As human population in the middle altitudinal zone expanded, people moved into this zone to cultivate. Three villages of study were also chosen from this high altitudinal zone.

3.2 Villages selected for the study

The study villages were chosen from two different agro-ecological zones. Three villages; Lole Marera, Maring'a and Mrimbo Uuwo were chosen from the uplands (high altitudinal zone). They are typically Chagga villages. They are situated in the Mwika North ward in the slopes of Mount Kilimanjaro. These villages lie between an altitude of about 1 400 m to 1 600 m a.s.l.

Three other villages; Mawenjeni, Kondeni and Kiruweni were chosen from the midlands (middle altitudinal zone). They are situated in Mwika South ward in the midlands. They lie between an altitude of about 700 m to 1 400 m a.s.l. These villages are inhabited by a mixture of tribes; the Chagga, Taita, Kamba, Pare and few Mbulu.

3.3 Pitsawing operation

3.3.1 Equipment used in pitsawing

The equipment required per pair of pitsawyers vary according to the pitsawyer's economic condition and availability of equipment/tools. The condition of the tools influences the productivity of the work and the workers' satisfaction (Ole-Meiludie *et al.*, 1988). The most common tools are: pitsaw, cross-cutsaw, axes, wedges of wood, hammers, flat and round files, whetstones, sawtooth-setter, plumbline, ball of thread, charcoal or battery powder from dry-cell batteries, levellers of sprit or water, brush-cutters (machetes, pangas), shovels or hoes, pegs and levers, measuring tape or ruler and among others.

3.3.2 Description of the saws

The shape and design of the saws varies according to their specific use. The common saws used in the pitsawing operation are the cross-cut saw and the pitsaw.

The most widely used crosscut saws have four cutter teeth and one raker tooth. In the series of sawteeth the cutter teeth are bevelled alternately. The raker teeth peel off

cutfibres, collect them in the sawdust qullet and carry the sawdust out of the cut. The amount of sawdust carried out increases with the increasing diameter of the log. Thus the size of the qullets depend on log diameter. If this dust-chamber is not sufficiently larger or properly formed, the sawdust will not be carried out of the cut, and the saw will choke.

The pitsaw is a double-handed rip saw which differs in several ways from the ordinary cross-cut saw. As the pitsaw is designed to cut along the wooden fibres instead of across them, it has no raker teeth, and the cutter teeth are very coarse. The straight front of the teeth becomes curved as a result of filling. The saw narrows in towards the end, where also the sawteeth decrease. The handles of the saw are made of metal or wood and placed at right angles to the saw blade.

3.4 Procedures for pitsawing

3.4.1 Site preparation, felling and sawing

Felling is carried out by two men using a cross-cut saw or felling axes. The direction of felling depends on where it is easier to dig a pit or construct a platform, as well as considering the direction the tree is inclined to fall and where there is a minimal damage to the crops in case of the trees inside the farms. In most cases the felling rope is used to assist the tree to fall in the required direction. After the felling direction is agreed upon the pitsawyers the tree is felled by first notching with an axe and then back cutting with the pitsaw or cross-cut saw. Another cut is then made from the back of the trunk, towards the opening cut. The branches are trimmed close

to the trunk so they do not impede rolling or interfere with the marking out. A platform is often constructed when felling larger trees. In the case of *Grevillea robusta* and *Olea carpensis* only the branch-free part of the trunk is sawn. Some of the large branches of *Cordia abyssinica* and *Albizia schimperiana* are sawn and the straighter of the small branches used for the platform. The log is marked into lengths according to the wishes of the owner and then cross cut using the cross-cut saw.

The platform is constructed as shown in Plate 1. Uprights with a forked top are first placed in holes in the ground and firmed with wooden wedges. The horizontals are poles of about 12 cm diameter and 4 m long. The longer the poles the easier is the gradient for rolling the logs. Once on the platform the log is rotated until the diameter read horizontally most nearly corresponds with the combined thicknesses of the timbers required. The log is then firmly fixed on the platform with pointed struts. All the platform members can be removed easily for use elsewhere.

Plate 1: Platform construction (*Photo by Kway, 1997*)

If the owner requires boards of small thickness the log is sawn through repeatedly. For large thickness, slabs are first removed and the log is turned and wedged so that the slab sides are horizontal. A scale is used to mark out the ends of the log and the horizontal lines are marked along the upper surface by a means of a piece of string, coated with a black paste derived from old dry cell batteries or a paste prepared from charcoal (Ole-Meiludie *et al.*, 1988). The string is fastened in each end of the log and lifted in the middle part. It will then snap back along the log, making a linear mark accurately along the log for the sawyers to follow .

All the cuts are first made from one end to the middle of the log. They are then all made from the other end until they nearly meet at the half-way point (Plate 2). When sawing, wooden wedges are placed in the cut, to prevent the saw from binding and

make sawing easier. About 10 cm is left unsawn in the middle, and when all the cuts have been made the remaining piece is carefully sawn and each plank removed individually. During sawing the position of the log is constantly checked against the plumbline suspended at the further end of the log by the pitman to ensure that vibration has not caused it to rotate. (Kijoti and White, 1981).

Plate 2: Sawing to mid point (*Photo by Kway, 1997*)

3.4.2 Transportation of sawntimber and storage

Once the tree is felled the logs are rapidly converted, allowing no time for attack by ambrosia beetles or the introduction of blue stain fungi.

The transportation of sawtimber from the logging site to the owner is carried out either by the pitsawyers themselves or other workers employed casually in the villages. The sawntimber are carried as head loads to the owner where they are piled using sticks as spacers. Except during the rains, most planks are air-dried in two months. For longer periods of storage they may be placed across the tops of kitchen walls, for the smoke to prevent wood boring insects from establishing in the wood.

3.5 Sampling and data collection

3.5.1 Sampling design

Of the three agro-ecological zones found in Kilimanjaro region, high and middle zones have been purposively selected for this study and they form the primary sampling unit. From these two altitudinal zones, one division namely Vunjo East was purposively selected, from this division two wards namely Mwika North and Mwika South were randomly selected. From the two wards selected for the study, three villages from each ward were randomly selected. In Mwika North ward, Mrimbo Uuwo, Maring'a and Lole Marera villages were selected whereas Mawanjeni, Kondeni and Kiruweni villages were selected from Mwika South ward. A list of households for each sampled village was obtained from the respective village government offices as shown in Table 2.

Table 2: Villages and sampled households in Moshi Rural District

Sample villages	Sampled households	Percent
Mrimbo Uuwo	40	21.0
Lole Marera	40	21.0
Maring'a	30	15.8
Kondeni	30	15.8
Kiruweni	30	15.8
Mawanjeni	20	10.6
Total	190	100.0

Source: Own field data (1997)

About 5% of households were picked randomly from the roster of each sample village for administering questionnaires to heads of households, pitsawyers, and timber traders. Information needed from the heads of households was the reservation prices for the commercially matured tree species growing at their farms. A total of 190 households picked for the survey and sampled villages is as shown in Table 3. All pitsawywers and timber traders available in these villages were interviewed. Table 3 shows the sample of each category selected from each village. About 6% of households were interviewed. According to Boyd *et al.* (1981) a random sample should at least constitute 5% of the total population to be representative of that population.

Table 3: Sampled households by villages in Moshi Rural District

Categories	Name of Villages							
	Mrimbo Uuwo	Lole	Marera	Maring'a	Kondeni	Kiruweni	Mawanjeni	Total
Heads of households	21	25		14	16	15	8	99
Pitsawyers	12	10		10	10	10	9	61
Timber traders	7	5		6	4	5	3	30
Total	40	40		30	30	30	20	190

Source: Field survey data (1997)

3.5.1 Primary data

An approach encompassing both social survey and physical measurement methods was employed. This approach facilitated collection of both qualitative and quantitative data.

3.5.2.1 Social survey

Both structured and semi-structured questionnaires were administered to heads of households, pitsawyers, timber traders and village leaders (Appendices 1, 2 and 3). The questionnaires were pre-tested and revised accordingly prior to the interview process. The main purpose of interviewing the village leaders was to obtain aggregate data for the entire village, to cross-check household data and elucidate the political arrangement issues and some policy issues related to the village administration.

3.5.2.2 Physical measurements

The researcher made a reconnaissance survey in the selected household farms and made a physical observation on trees. Commercial trees with diameter at breast height (DBH) of more than 30 cm dbh were measured using a diameter tape rather than a calliper since many of these trees are quite big. Merchantable heights were also taken for the commercially matured trees; together with their stem form and their reservation prices in the respective location at the farms which includes: road side, inside farms and in open areas (Appendix 1). Calculation of volumes (m^3) of the trees were carried out using Huber's formula (Philip, 1994).

$$V = \frac{\pi D^2 H}{4}$$

Where V = Tree volume in (m^3)

H = Tree merchantable height

D = Tree diameter

π & 4 are constants

3.5.3 Secondary data

These data were obtained by consulting relevant documents, both published and unpublished to form an overview and identify gaps in information.

3.6 Data analysis and presentation

Data from the completed questionnaires were coded by using a coding key and compiled using a dbase computer programme. Later it was analyzed by using programmes from the Statistical Package for the Social Sciences (SPSS) at the Department of Forest Economics, SUA. Descriptive statistics was employed to analyze the qualitative data. These are measures of central tendency namely mean, measures of dispersion, mainly standard deviations, frequencies, percentages and proportions. The quantitative data covering prices, costs, revenues production input and output, was also computed and presented in the form of tables.

CHAPTER 4

4.0 RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter presents results and discussions on the socio-economic values of pitsawing based on traditional agroforestry systems in Moshi Rural District. It centres on analysis of households demographic and social characteristics, embracing place of origin for pitsawyers, their employment structure, organizing of pitsawing, years of experience, and other sources of income. This chapter also analyses and delineates the parameters on production input/outputs. The results are presented in the following subchapters.

4.2 Demographic and social characteristics

4.2.1 Place of origin

If pitsawyers are local or outsiders to the area,their work may have an important effect on the attitude towards long term planning and motivation for conservation. Furthermore, it influences the actual knowledge about the physical environment and the requirements for sustainable forest use (Skage and Naess, 1994). The data obtained through the questionnaires on this subject were treated in one unit, that is the answers were not separated by villages because all villages were situated within Moshi Rural District and the purpose was to find the extent of people from other parts of Tanzania conducting pitsawing in this area. This study revealed that all pitsawyers are originating within Kilimanjaro Region and all of them return to their

home after working hours (normally 8 hours per day) and they are engaging in other activities beside pitsawing. Almost all pitsawyers are Chagga by tribe from Moshi Rural and Rombo Disticts. Only few are Pare from Same District which are staying at Mawanjeni village which is situated in the midlands. This is different if comparison with other studies is made. BjØndalen (1992) reports that most pitsawyers operating in Tanzania's rainforests are imported from other regions. Many other authors share the view that pitsawyers mainly are strangers to the place they operate in. According to Hamilton (1989), pitsawyers in the East Usambaras for the most part come from Iringa Region and move around in response to job opportunities. In a study from Nguru mountains, Norris (1990) states that pitsawyers in that area are most commonly members of the Hehe tribe from Iringa. In the same area, Skage and Naess (1994) found that place of origin of pitsawyers is nearly equally distributed between Morogoro Region and other regions which includes Coast, Kagera, Kigoma, Mbeya, Tabora and Tanga.

According to SIDA/TWICO (undated) in Tabora Region pitsawing communities were migratory and individual members which were characteristically very mobile. Pitsawyers lived away from their families during working seasons (150 days per year), but generally go home during the rain season. The report points out that most of the pitsawyers, especially those who prefer living away from villages originate outside Tabora Region. The most common regions of origin were: Mbeya, Iringa, Kigoma, Singida, Kilimanjaro and Tanga. The tribes of Makete District and Hehe (both Iringa Region) and Sambaa from Lushoto were reported to be the most

reputed of the pitsawyers operating independently while on the other hand pitsawing organized as cooperative groupwork were normally formed by persons of local origin.

4.2.2 Organizing of pitsawing

The pitsawyer and pitsawyer employer will under normal conditions seek to maximize the financial benefits from pitsawing. Organizing of pitsawing is thus a trade-off between the various factors which they have to consider. The socio-economic and financial sustainability of pitsawing will to a considerable degree depend on an equitable distribution of benefits between the pitsawyer employer and pitsawyers, and that there will be local benefits from pitsawing. The results show that 49.2% of all the pitsawyers answered that their employers are individuals. About 41% of the pitsawyers answered that they are employed by timber traders and 6.6% are employed by contractors. Only 3.2% are self employed. The findings are summarized in Table 4 below.

Table 4: Employment structure for the sampled pitsawyers in Moshi Rural Distict

Employer	Percentage
Individuals	49.2
Timber traders	41.0
Self-employed	3.2
Contractors	6.6
Total	100.0

Source: Field survey data (1997)

Pitsawyers in the area are mainly employed by individual farmers who hire them to fell and saw mature commercial trees for their own purposes. A considerable number of individuals earn their living from lumber sales. Some run very good enterprises at village levels mainly timber traders. These timber traders purchase trees from individual farmers and pitsawyers are locally hired to saw the logs. Often the lumber is air dried prior to sale. Most of the customers come from the villages as well as from Moshi town and other regions which includes Arusha, Dar es Salaam and Singida. Few timber traders export their timber to the neighbouring country Kenya but illegally.

Few pitsawyers are self employed. These pitsawyers buy trees from individual farmers and saw logs and sale the lumber to the timber traders and other individuals in the villages. Another group of pitsawyers are those who are hired by contractors, village governments and religious bodies. These groups hire pitsawyers and supplementary labourers who undertake pitsawing and related works, to produce timber products according to stipulated and agreed terms. These centres on volumes of production and payment procedures. Timber products include timber logs, sawn timber planks, timber sleepers and timber squares. Advance payment in cash is necessary before the hired sawyers start to work.

Research done in the Usambara mountains indicates that the licence holders are businessmen from the local area or surrounding towns (Hamilton, 1989; Kaoneka, 1993) or business syndicates from other areas of Tanzania (Iversen, 1990). TFAP

(1989), reports that pitsawing largely is carried out by private individuals, who are organized into groups and provided with the necessary working capital. Dykstra (1983) claims that pitsawyers in Tanzania are either employed directly under the Forest Division, or by independent operators. Ferques *et al.*, (1977), reports that the pitsawyers in softwood plantation forests in Mbeya and Iringa Regions were working on piece-work contract, hired by the person who had got felling licence from Forest Department. Similarly Kijoti and White (1981) found that a team of sawyers were hired by the timber purchasers after payment of stumpage/licence fees. Butera and Klem (1983) observed three different arrangements for pitsawing in Rwanda.

a) Registered sawyers operating in Nyungwe Natural Forest and selling their products to forestry centres in Gisovu and Rangiro;

b) Contract sawyers working in communal or state forests as casual employees;

c) Private pitsawyers, working independently or being organized by a local contractor, purchasing trees from individuals, communes or the state and selling their products on the open market.

SIDA/TWICO (undated) from Tabora Region found that pitsawing was organized under three main set-ups:-

a) Independent individual groups usually consist of two to not more than six pitsawyers, one of them being the leader or elder with a final authority. They work together as a loosely bound unit, in which members of the group can separate and or join together at anytime they want. The work results are shared according to how much each has performed.

b) Groupwork-Cooperative. This set-up involves registered pitsawyers organisations. The set-up showed well preparedness and some good plans of production, but their performance did not attain the planned targets. In most cases the discrepancy was said to be caused by inadequacies in their management and too much bureaucracy.

c) Contractor-based pitsawing operations were the most predominant and successful in the Tabora study. the contractor-setups include Well-off or rich individuals popularly known as "digaras", registered individual businesses, private or public companies/corporations, villages and village governments and religious bodies.

The results in this study coincide to a great extent with the different arrangement for pitsawing in Rwanda (Butera and Klem, 1983) and close to what was found in the Usambara mountains (Hamilton, 1989; Kaoneka, 1993) and also with (Kijoti and White, 1981) in Pare mountains.

4.2.3 Years of experience among pitsawyers

It is obvious that for a manual logging method as pitsawing, the years of experience will have an influence on the sawnwood productivity and quality. In turn, this is one of the factors which contributes towards assessing the ability for pitsawing to compete with other mechanical techniques. Apart from individual differences and equipment quality, experience is one of the main factors determining recovery percentage, sawing accuracy and sawnwood productivity. Table 5 shows the years of experience for pitsawyers in each village and average for all villages. For all

villages an average of 39.3% of the pitsawyers were found to have between 1 to 5 years of experience, 31.2% have been pitsawyers for 6 to 10 years, while 19.7% have been pitsawyers for 11 to 15 years. Only 9.8% were found to have more than 16 years of experience (Figure 2).

The reason for the high percentage of pitsawyers having between one to five years of experience and low percentage having more than sixteen years of experience may be due to the fact that pitsawing is physically exhaustive work, and together with the commonly occurring lack of properly balanced diet therefore the time period in which pitsawing can be performed is limited and hence many pitsawyers are newcomer of one to five years of experience. This point was also observed by Skage and Naess (1994) who found that, 73.1% of the pitsawyers studied had less than ten years of experience.

Table 5: Years of experience among pitsawyers

	Villages						
Interval (Years)	Mrimbo Uuwo	Marera Lole	Maring'a	Kondeni	Kiruweni	Mawanjeni	All respondents
1 – 5	33.3%	40%	30%	60%	40%	33.3%	39.3%
6 – 10	25.0%	30%	50%	30%	10%	44.5%	31.2%
11 – 15	25.0%	20%	20%	10%	20%	22.2%	19.7%
More than 16	16.7%	10%	-	-	30%	-	9.8%
Total	100.0%	100%	100%	100%	100%	100.0%	100.0%

Source: Field survey data (1997)

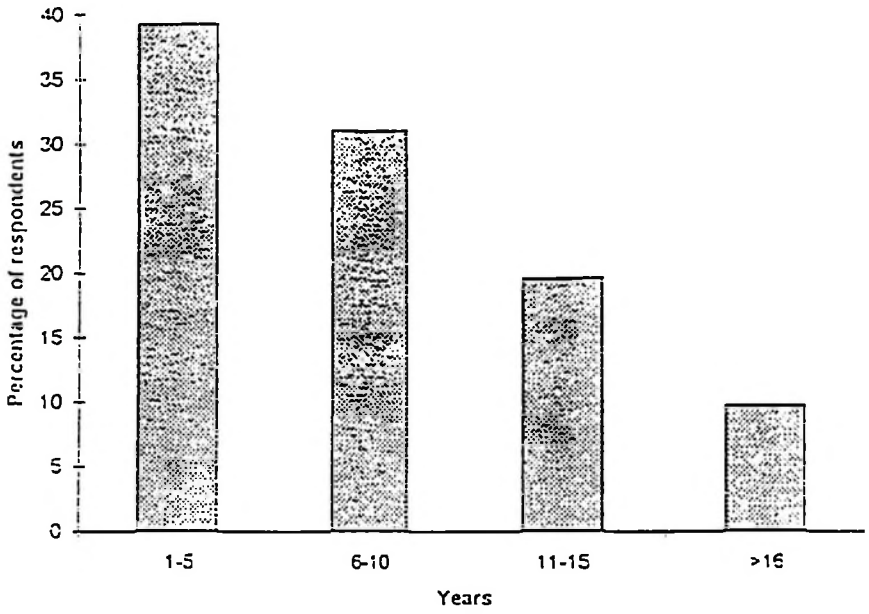

Figure 2: Years of experience among pitsawyers, average all respondents

4.3 Income sources for pitsawyers

Table 6 shows the relation between income per month from pitsawing and other income sources. Average total income was 173 500 Tsh for all respondents with 77 500 Tsh (44.6%) originating from pitsawing activities.

Table 6: Income sources for pitsawyers

Income source	Amount (Tsh/month)
Pitsawing	77 500
Agriculture	40 000
Livestock	22 000
Petty businesses	34 000
Total	173 500

Source: Field survey data (1997)

Butera and Klem (1983) reports that pitsawing is very much a part time occupation, the activity influenced by rains, the difficulties in obtaining tree for sawing, the workers' farming activities and the worker's general lack of interest in and ability for steady, hard, manual work. They found that the sawyers produced hardly more than 10-20% of what reported based on full time work. Kijoti and White (1981) also concludes that pitsawyers showed little inclination towards steady, regular work. SIDA/TWICO (undated) reports that there is no sawing activity during the rainy season. Almost 50% of the noted income was coming from pitsawing. Skage and Naess (1994) found that 71.2% of income was originating from pitsawing.

Agriculture was the most common additional income source. It has been revealed from the survey that, pitsawing in Moshi Rural District is also influenced by many factors such as rainfall, farming activities, difficulty in obtaining trees and so on. Due to the above mentioned factors, the period when pitsawing is of maximum production in Moshi Rural District is between months of July to December. Other months being of rainy season and other activities.

4.3.1 Other sources of income to pitsawyers

Job opportunities in pitsawing are restricted by factors like rainfall, and timber demand. Other income from cash crops, small businesses and livestock therefore help to generating income to the pitsawyers and may in that way secure stability for the pitsawyers and their family. Investigating the income structure of pitsawyers is necessary because it will reveal the distribution of benefits from the activity, for example: if pitsawyers are provided with enough money for pitsawing alone to support their families and if pitsawing is the main income source or if it is only additional to other sources.

In this study agriculture was the most common sources of income besides pitsawing. A total of 67% of the pitsawyers were found to have agriculture as an additional income source. Livestock and petty businesses were the two other sources mentioned with an average of 18% and 15% respectively. None of the pitsawyers said pitsawing was the only income source as indicated in Figure 3. However no differences have been observed between studied villages, suggesting that answers were not separated by villages.

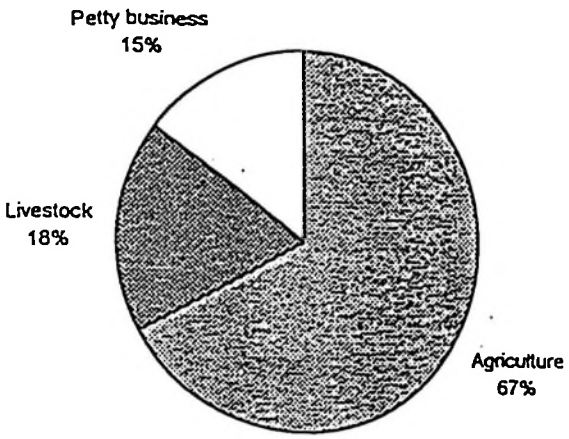

Figure 3: Additional income sources for pitsawyers, average all respondents

4.4 Production input/output: Costs and benefits in the pitsawing operation

4.4.1 Production input

These are the cost factors involved in the pitsawing operation. Based on Fergus *et al.* (1977) they may be categorized as follows:-

4.4.1.1 Log costs

This is the timber stumpage price, which includes, royalties paid to government, district or village authorities for a licence to utilize timber. In this study pitsawing was conducted in different environment whereby the trees were belonging to the individuals and hence the term reservation price which is the price paid to the owner of the tree instead of royalties was used.

4.4.1.2 Labour costs

Wages paid to the workers involved in pitsawing operations including; felling and crosscutting, logging to sawpit/platform construction sawing and transportation of the sawtimber to the owner.

4.4.1.3 Equipment

Investment in pitsawing was depreciated over a number of years ranging from 2 to 5 years depending on type and durability of the equipment (Table 10).

4.4.1.4 Other costs

Other cost factors which were considered and their authors in the brackets are: Fringe benefits and inter-district transfer levy charges (SIDA/TWICO, undated), interest (Butera and Klem, 1983) and import costs (Fergus *et al.*, 1977). No other costs have been considered in this study.

4.5 log costs

In this study pitsawing was conducted in an environment whereby trees were belonging to individual farmers in their farms. No royalties which are paid to any authority in order to get a licence for pitsawing. Most of the farmers sale the standing trees and the purchaser pay the reservation price to the farmers. The reservation price of an individual tree is influenced by several factors including tree volume, species stem form and location on the farm. Species such as *Cordia abyssinica* and *Olea carpensis* which are mostly preferred are sold at 20 000 Tsh/m^3

to 21 000 Tsh/m^3 for those growing inside farms, followed by *Albizia schimperiana* which is sold at 10 000 Tsh/m^3 and 8 000 Tsh/m^3 for those growing inside farms and in open areas respectively. *Grevillea robusta* which is poorly demanded and more frequently found along roadside and farm boundaries has a much lower reservation price ranging from 8 000 Tsh/m^3 to a maximum of 10 000 Tsh/m^3.

Table 7 shows the total reservation prices per cubic metre for the four tree species in three locations at the farm and average reservation prices per cubic metre for each tree species in three locations at the farm. It is the duty of the purchaser to fell such tree without causing too much damage to understorey crops. The value of the projected damage may explain the high reservation price for the trees inside farms.

Table 7: Reservation prices Tsh/m^3 in three locations at the farms in Moshi Rural District

Tree species	Location and reservation prices (Tsh/m^3)				
	Raodside	Inside farms	Open areas	Total	Average
Grevillea robusta	8 000	10 000	7 000	25 000	8 333
Olea carpensis	21 000	20 000	10 000	44 000	14 667
Cordia abyssiynica	16 000	21 000	15 000	52 000	17 333
Albizia schimperiana	9 000	10 000	8 000	27 000	9 000
Total	47 000	61 000	40 000	148 000	12 333

Source: Field survey data (1997)

4.6 Labour costs

4.6.1 Felling, sawing and cross-cutting

Pitsawyers enter into a contract for felling, crosscutting, logging to sawpit/platform construction and sawing operation. The average payment was found to be 48 500 Tsh/m^3 (Table 8). No differences were observed between villages studied.

Table 8: Sawing costs (Tsh/m^3) in Moshi Rural District

Tree species	Sawing cost (Tsh/m^3)
Grevillea robusta	29 000
Albizia schimperiana	56 000
Cordia abyssinica	53 000
Olea carpensis	56 000
Total	195 000
Average	48 500

Source: Field survey data (1997)

Economical use of wood can only be achieved through a thorough understanding of its anatomical structure and chemical composition. The sawing costs depend on the above mentioned factors and others such as tree species, size of the tree, sawntimber sizes, stem form and so on. The sawing costs for the studied tree species vary despite all being hardwood species. *Grevillea robusta* has the lowest sawing costs. The higher sawing costs for the other species such as *Olea carpensis, Cordia abyssinica and Albizia schimperiana* can be due to the anatomical structure of the wood, tree size, and sawntimber sizes. The sawntimber sizes required by most customers for these tree species are of small dimension compared to the tree sizes hence require the pitsawyers to saw them through and through as a result

higher sawing costs.

4.6.2 Transportation of sawntimber from logging site to the owner

The people transporting the sawntimber from the logging site to the owner might be the pitsawyers or other workers hired locally by the pitsawyers or by the timber owners. The workers are paid per piece of timber. In this study the current transport costs amounts to 7 000 Tsh/m^3.

4.6.3 Total labour costs

Table 9 presents the total labour costs which are calculated by adding up transport costs and the average sawing costs for the four tree species. It has been revealed from this study that the labour cost makes up the largest share of the total costs of pitsawing which is about 78.6% of the total costs. Other studies with their percentage of total costs are: Kijoti and White (1981) 92.1% Butera and Klem (1983) 82.1% and Skage and Naess (1994) 55.6%.

Table 9: Total labour costs of pitsawing in Moshi Rural District

Type of cost	Amount (Tsh/m^3)
Average sawing costs	48 500
Transportation costs	7 000
Total labour costs	55 500

Source: Field survey data (1997)

This study indicate that there is a costs rangig from 55.6% to 92.1%. This may be explained by the differences in general wage levels between 1981 to 1997 and the environment in which the pitsawing operation is conducted. However this underlines that labour cost is the dominating factor in pitsawing operation.

4.7 Depreciation of equipment

The current, approximate costs of buying equipment and tools in Moshi District together with useful time were obtained from the questionnaires on village level. This forms the basis for the calculation of write-off time and depreciation per year or cubic metre.

Assumptions which were made in calculating depreciation

- Hand tool has no scrap value,
- An approximate productivity of 10 m^3 per year was assumed after Skage and Naess (1994), Kijoti and White (1981) and Monela (1995).

In this study the total depreciation costs of equipment is 2 776 Tsh/m^3 or 3.9% of total costs (Table 10).

Table 10: Cost of equipment used for pitsawing in Moshi Rural District

Equipment	Buying price (Tsh)[1]	Life span (Years)	Deprec. costs (Tsh/year)[2]	Deprec. costs (Tsh/m^3)
Pitsaw	40 000	5	8 000	800
Crosscut saw	16 000	5	3 200	320
Axe	3 000	3	1 000	100
Hoe	2 500	2	1 250	125
Bush knife	1 500	2	750	75
Flat file	1 500	0	1 500	150
Round file	2 000	0	2 000	200
Measuring tape	2 000	0	2 000	200
Ruler	150	0	150	15
Thread	600	0	600	60
Plumbline	3 000	3	1 000	100
Saw set	3 000	2	1 500	150
Felling rope	3 500	0	3 500	350
Sped	2 500	2	1 250	125
Pencil	60	0	60	6
Total	81 310		27 760	2 776

Footnote: [1] At the end of 1997 prices (exchange rate: 1USD = 660 Tsh)
0 implies written-off when bought
[2] Depreciation is based on straight line method of depreciation

Source: Field survey data (1997)

Skage and Naess (1994) found a total depreciation costs of 1 480 Tsh/m^3 or 2.4% of total costs, Monela (1995) found a total depreciation cost of 1 192 Tsh/m^3, or 2% of total costs.

There might be limitations due to different capital factors included and different methods for calculating depreciation costs, which were used by other authors. A general observation is therefore that the capital costs contain a small part of the total costs in pitsawing operation.

4.8 Total costs of pitsawing

Table 11 shows the total costs of pitsawing operation which were calculated by adding up the average reservation prices, total labour costs and depreciation costs of equipment/tools per cubic metres respectively.

Table 11: Total production costs of pitsawing (Tsh/m^3)

Type of cost	Amount (Tsh/m^3)
Log costs	12 333
Labour costs	55 000
Depreciation costs	2 776
Total	70 609

Source: Field survey data (1997)

4.9 Sawnwood productivity

Sawnwood productivity is measured in cubic metre sawnwood per man per workday (m^3/manday). This is one of several important factors when comparing pitsawing with alternative logging techniques. Ferqus *et al.* (1977) obtained sawnwood productivity of 0.2 m^3/manday, Kijoti and White (1981) obtained 0.1 m^3/manday, Monela (1995) obtained 0.1 m^3/manday. Only Ferqus *et al.* (1977) and Kijoti and White (1981) have used time studies to calculate sawnwood productivity. Results in this study were based on field interview. Other reports were based partly on field interviews and annual reports on sawnwood output on the number of sawyers. Sawnwood productivity is also determined by a number of factors such as years of experience, tree species sawn, quality and type of equipment used, climatic

and topographic conditions, expertise, operational set-up motivation and among others. These vary from place to place. Economic viability of pitsawing enterprises relies partly on productivity levels and quality of timber produced (Solberg, 1988; Skage and Naess, 1994).

4.10 Production output

4.10.1 Market prices for pitsawn timber in Moshi Rural District

The price mechanism should be an indicator to consumers about all costs of timber production. The market price for pitsawn timber were obtained from pitsawyers and timber traders who run small enterprises in the villages visited, hence these prices should be seen as approximations. Table 12 shows the market prices per cubic metre of pitsawn timber for the four tree species.

Table 12: Market prices (Tsh/m^3) for pitsawn timber in Moshi Rural District

Tree species	Market prices (Tsh/m^3)
Grevillea robusta	60 000
Albizia schimperiana	117 000
Olea carpensis	132 000
Cordia abyssinica	130 000
Total	439 000
Average	109 000

Source: Field survey data (1997)

4.11 Summary of economic data for pitsawing in Moshi Rural District

This section aims to analyze the financial benefits and costs of pitsawing as

performed in Moshi Rural District. In this analysis, the cost factors included were: log costs, labour and equipment costs. Benefits were derived from timber sales hence were based on timber prices. Table 13 sums up the production input and output data, profit, economic and average sawnwood productivities.

Skage and Naess (1994) reported that pitsawyer's income in Morogoro District was about 14 000 Tsh/month contributing 71% of their total income. However this income is realized only periodically because pitsawing has often been a seasonal activity.

Table 13: Results of costs, benefits and productivities of pitsawing in Moshi Rural District

Item	Value
Pitsawn timber price at timber traders (Tsh/m^3)	109 750
Production costs (Tsh/m^3)	70 609
Profit (sales price - total costs) (Tsh/m^3)	39 141
Economic productivity (sales price/costs)	1.6
Average sawnwood productivity (m^3/manday)	0.1

Source: Field survey data (1997)

Economic productivity will give the pitsawyer and pitsawyer employer the right incentives to make sure that they get profit from pitsawing on the short and long term. Still in the long run there are also other requirements for economic productivity than profitability; namely institutional, social and political factors. Ferqus *et al.* (1977) obtained an economic productivity of 1.4, Butera and Klem (1983) obtained 1.5, SIDA/TWICO (undated) obtained 1.6, Skage and Naess (1994) obtained 1.2, and Monela (1995) obtained 1.2. The differences in economic

productivity might be caused by differences in the environment where pitsawing activity is conducted, timber prices, organisational set-ups, tree species and sizes and other factors. However based on 1997 prices, pitsawing is a profitable enterprise for the both pitsawyer and pitsawyer employer.

CHAPTER 5

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The main objective of this study was to analyze the socio- economic of pitsawing in the traditional agroforestry systems in Northern Tanzania. It was conducted in Moshi Rural District.

The study attempted to investigate the socio-economic features of pitsawing, to find if it is profitable and under which conditions. The results showed that the majority of the pitsawyers originated within Kilimanjaro Region and they are mainly employed by individual farmers and timber traders who purchase trees and hire them locally to saw the logs. Most of these pitsawyers (70.5%) have less than ten years of experience and an additional income from agriculture, livestock and petty businesses. The total income for a pitsawyers amounted to 173 500 Tsh/month with 77 500 Tsh originating from pitsawing. Basing on results, the total inputs for a pair of pitsawyers amounted to 70 609 Tshs/m^3 which includes the average reservation price of 12 333 Tsh/m^3, labour costs of 55 000 Tsh/m^3 and equipment cost of 2 776 Tsh/m^3. Market prices for four tree species was 109 750 Tsh/m^3. Benefits were derived from timber sales hence were based on timber prices. A pitsawyer can have a benefit of 39 141 Tsh/m^3, an economic productivity (sales price/total costs) of 1.6 and sawnwood productivity of 0.1 m^3/manday.

The profitability to the contractor, is however a function of factors such as wage

levels, timber inputs and prices of timber in the market. Although the profit may be influenced by these factors, the economic productivity should be reasonably reliable and give a good overview of the overall profitability of pitsawing. No account was taken of any returns to the society or to the world as a whole. The social profit aspect, though very important was not included due to difficult of converting positive and negative effects of pitsawing into monetary units. Moreover, pitsawing in Tanzania operates on an informal market structure thus making it hard to estimate the costs and benefits.

The reservation price of an individual tree is bargained between the buyer and owner and it is influenced by several factors including tree volume, species stem form and location on the farms. Labour costs make up the largest share of the total production costs. Maintenance costs are negligible.

Pitsawing was found to be a part time occupation in Moshi Rural District, the activity being influenced by the workers' farming activities and the general lack of interest in and ability for steady hard manual work hence little inclination towards steady regular work, however the activity was found to be profitable for the pitsawyer and pitsawyer employer. The Chagga agroforestry systems offer opportunity for increased foreign exchange earnings through sales of coffee and timber.

5.2 Recommendations

5.2.1 Recommendations for improvement of the sector

Basing on the results synthesis the following prescriptive remedial measures are recommended.

- There is an urgent need to review pitsawing practices to make it compatible with sustainable management while at the same time ensuring that benefits flow to pitsawyers and the community.
- The domestic prices of sawn - hardwoods are higher than the prices of sawn-softwoods. These prices have been changing several times per year, due to increases in transport costs and limited availability of sawn-hardwoods, in addition to increase in production costs. This situation indicates that future supply of sawnwood from pitsawyers need to be evaluated consistently to determine their long-term sustainability in supply to meet the ever increasing demands.
- The general consumption pattern of sawn-hardwoods indicates the need to encourage utilization of general utility sawntimber and lesser-utilized tree species such as *Rauvolfia caffra* and *Persea americana*. This observation emanates basically from the fact that much of the fine hardwood is being used as utility wood while the raw material base is declining at a fast rate.
- The Chagga agroforestry system should be introduced to other suitable areas of the country and to other people. This may prove a difficult task but certainly an important requirement in fragile ecosystems.

5.2.2 Recommendations for further research

The following are recommended for further studies:-

- More research is needed to establish the general properties and uses of various indigenous hardwood tree species to provide more information to the users.
- Research on traditional agroforestry systems which will include the ecological and silvicultural aspects such as planting techniques, regeneration and tree breeding of various indigenous tree species is needed.

REFERENCES

Abel, W.S. (1990) Harvesting timber in the natural forests. In: *proceedings of a joint seminar/workshop on Management of Natural Forests of Tanzania Under Sokoine University of Agriculture and Agricultural University of Norway Cooperation, Olmotonyi, Arusha Tanzania.* 5-10 December (1998) (Edited by Mgeni, A.S.M., Abeli, W.S., Chamshama, S.A.O. and Kowero, G.S.) Record No. 43 Faculty of Forestry, SUA, Morogoro 85-92 pp.

Altieri, M.A. (1991). How best can we use biodiversity in agroecosystems: *Outlook on agriculture* **20**:15-23 pp.

Barrow, E.G.C. (1991). Building on local knowledge: the challenge of agroforestry for pastoral areas. Agroforestry Today 3:4-7 pp.

Barton, D. (1994). Indigenous agroforestry in Latin America: a blue print for sustainable agriculture? NRI-Socio economic-series. Chattam, U.K.

BjØndalen, J.E. (1992). Tanzania's vanishing rain forests - assessment of nature conservation values, biodiversity and importance of water catchment. *Journal of Agriculture, Ecosystems and Environment* **40**:313-334 pp.

Boyd, H.K., Westfall, R. and Stasch, S.F. (1981). *Marketing Research, Texts and Cases.* Illinois, Richard D. Publisher 813 pp.

Butera, J. and Klem, G.S.(1983). *Pitsawing and Small Scale sawmilling in Rwanda.* University of Dar es Salaam, Division of Forestry Record No. 27, Morogoro, 19 pp.

Campbell, B.M. and Clarke, J.M. (1991). Traditional Agroforestry practices in Zimbabwe. *Agroforestry Systems* **14**:99-111 pp.

Deckers, J., Lyimo, E. and Harroo, J. (1990). *Towards fertilizer recommendation based on Geographical Soil information in Kilimanjaro and Arusha regions Tanzania.* Paper presented to the International Symposium on Agro-ecology and Conservation Issues in Temperate and Tropical Regions, Fardouc, Italy. 26-29 September, 1990. 120 pp.

Dykstra, D.P.(1983). Forestry in Tanzania. *Journal of Forestry,* 81 (11):742-746.

FAO (1992). Forests, trees and people. Forestry topics No. 2. FAO Forestry Department.

FAO (1990). Community forestry: Herders' decision-making in natural resources management in arid and semi-arid Africa. community forestry note No. 4, FAO, ROME, Italy 132 pp.

Ferdnandes, E.C.M., O'Kting'ati, A and Maghembe J.A.(1984). The Chagga homegardens: A multistoried agroforestry cropping system on Mount Kilimanjaro Northern Tanzania. *Agroforestry Systems* 2: 73-86.

Fergus, M., Kitambi, G. Seim, A. Skaar, R. Solberg. B. (1977). *Report on an atevaluion of the Sao Hill Sawmill project, Tanzania.* NORAD, Ministry of Finance and Planning, Oslo, 180 pp.

Fisher, R.J. (1989). Indigenous of common property management in Nepal. Working paper No. 18. Environmental and Policy Institute. East-West Centre, Honolulu, Hawaii, U.S.A.

Fonzen, P.F. and Oberholzer, E. (1984). Use of multipurpose trees in hill farming systems in Western Nepal. In: Steppler, H.A. and Nair, P.K.R. (ed.), *Agroforestry a decade of development* ICRAF, Nairobi, Kenya.

Gerden, C.A. and Matallow, S. (1990). Traditional forest reserves in Babati District, Tanzania. A study in human ecology. Swedish University of Agricultural Sciences. Uppsala.

Gold, M.A. and Hanover, J.W., (1987). Agroforestry Systems for the temperate zone. *Agroforestry Systems*. 5:109-121.

Hamilton, A.C. (1989). History of resource utilization and management. In: Bensted. Smith, R. and Hamilton, A.C. (ed): *The East Usambaras. Resources and their exploitation*. Part 1.

Hofstad, O. (1978). Preliminary evaluation of the Taungya System for combined wood and food production in north-eastern Tanzania. Faculty of Agriculture, Forestry and Veterinary Science Division of Forestry, Record No. 2.

Hutterer, K.L. (1984). Ecology and evolution of Agriculture in Southeast Asia In: Rambo, T.a. and Sajise, P.E. (ed.), An introduction to human ecology research on agricultural systems in Southeast Asia. Los Banos, Phillipens: University of Phillipines.

Iddi, S. and Nagoda, L. (1992). *Properties and Utilization of Solidwood:* Major and uses, machining, Seasoning, biodeterioration, natural durability preservation and other forest produce. A compendium Norway, 156 pp.

Indigenous Knowledge and Development Monitor (1993). Background to the International Symposium on Indigenous Knowledge and Sustainable development Special Issue 1:2-6 pp.

Ishengoma, R.C. (1994). The first international conference on development of wood science/Technology and Forestry. Conference proceedings 6-8 July, Missenden Abbey U.K. 10 pp.

Ishengoma, R.C, Sumari S.V and Gillah, P.R. (1992). Woodfuel consumption survey in rural areas of Hai District Kilimanjaro region. *In: Proceedings of a joint seminar/workshop on forestry Research in Tanzania under Sokoine University of Agriculture and Agricultural University of Norway cooperation Morogoro Tanzania,* 26-30 November, 1990. (edited by Abel, W.S. Mgeni, A.S.M. Chamshama, S.A.O, Iddi S and O'Kting'ati, A). Record No. 53 Faculty of Forestry, SUA, Morogoro 156-168 pp.

Iversen, S.T. (1990). Conservation of the Usambara mountains: Botanical values at the species and phytogeographical level. Acta Universitatis Upsaliensis Symbolae Botanicae Upsalienses. Uppsala 28(3):218-243 pp.

Jaako Poyry, (1992). *Industrial restructuring study on wood and paper industry - Tanzania.* Fact Book. The Swedish International Development Authority (SIDA). Summary, 8 pp.

Jambulingan, R. and Fernandes, E.C.M. (1986). Multipurpose trees and shrubs on farmlands in Tamil Nadu State (India) In: Steppler, H.A. and Nair, P.K.R. (ed.), *Agroforestry a decade of development.* ICRAF, Nairobi, Kenya.

Johnson, F.B. (1989). The political economy of Agricultural Development in Tanzania and Kenya. *Journal of Food Research Institute Studies.* vol. 21 No 3 Stanford University, UK. 349 pp.

Kaale, B.K. (1983). Tanzania five years National Village Afforestation Plan. Ministry of Natural Resources and Tourism. Dar es Salaam, Tanzania. 125 pp.

Kajembe, G.C. (1994). Indigenous management systems as a basis for community forestry in Tanzania: a case study of Dodoma urban and Lushoto districts. Wageningen Agricultural University, Wageningen, the Netherlands.

Kaoneka, A.R.S. (1987). *A Comparative financial analysis study of Tabora Msitu Products Ltd and Mkata Sawmills Ltd.* Sokoine University of Agriculture Morogoro Tanzania. Faculty Record No.57, 20 pp.

Kijoti, W.E. and White, M.G (1981). *Pitsawing in the Pare mountains of Tanzania.* Division of Forestry University of Dar es Salaam, Morogoro Record No. 21 11 pp.

Klem, G.S. (1978). *Planning of sawmilling industry in Africa. Possible source of energy.* University of Dar es Salaam, Division of Forestry Record No. 1 Morogoro, 17 pp.

Kowero, G.S. (1988). *An economic evaluation of the mobile sawmilling industry in Tanzania.* Winrock International Institute for Agricultural Development, Arkansas, U.S.A 56 pp.

Leakey, R. (1996). Definition of agroforestry revisited. *Agroforestry Today.* 8(1): 5-6.

Lundgren, B. (1982). What is agroforestry? *Agroforestry Systems* 1:3-12.

Makundi, F.L.K. (1996). *Household food security in rural Tanzania: A case study of Moshi rural district Kilimanajro Region* An unpublished M.Sc.

Dissertation. Management of Natural Resources and Sustainable Agriculture, Agricultural University of Norway. 138 pp.

Mgeni, A.S.M. and Malimbwi, R.E. (1990). Natural forest resources of Tanzania and their Management needs. In: *proceedings of a joint seminar/workshop on Management of Natural Forests of Tanzania Under Sokoine University of Agriculture and Agricultural University of Norway Cooperation, Olmotonyi, Arusha Tanzania.* 5-10th December (1998) (Edited by Mgeni, A.S.M., Abeli, W.S., Chamshama, S.A.O. and Kowero, G.S.) Record No. 43 Faculty of Forestry, SUA, Morogoro 67-76 pp.

Michon, G. and Mary, F. (1994). Conversion of traditional village gardens and economic strategies of rural households in the area of Bogor, Indonesia. *Agroforestry Systems* 25:31-58.

Mintze, S. (1996). Acacia albida and other multipurpose trees on the Fur farmlands in the Jebel Marra highlands, Western Darfur, Sudan. In: Steppler, H.A. and Nair (ed.), *Agroforestry a decade of development.* ICRAF, Nairobi, Kenya.

Mnkeni, P.N.S. (1992). *Role of Soil management in enhancing suitability of smallholder cropping systems in some agro-ecosystems of Tanzania. a review, ecology and Development paper.* Centre for Sustainable Development, Agricultural University of Norway.

Monela, G.C. (1995). *Analysis of the use of tropical rainforest species and Evaluation of buffer zones and other control mechanisms in preserving the tropical rainforest adjacent to Mhonda village in the Nguru mountains, Tanzania. An* Unpublished Doctor Scientarium Thesis Submitted to the department of Forest Sciences, Agricultural University of Norway, 76 pp.

Moshi, E.R.F. (1997). *Inventory of indigenous Agroforestry Systems in practice in the West Usambaras (WUS).* Unpublished M.Sc. (For.) Dissertation, Sokoine University of Agriculture, Faculty of Forest, Department of Forest Biology, Morogoro, Tanzania, 172 pp.

Moyo, C.L. (1985). *Some economic aspects of sawn-hardwood exports from Tanzania.*Unpublished Msc (For) Dissertation, Sokoine University of Agriculture Morogoro Tanzania, 195 pp.

MTNRE, Ministry of Tourism, Natural Resources and Environment (1994). Tanzania Forestry Action Plan (Draft) 1994/95 - 2007/08 Dar es Salaam. 104 pp.

Mwasaga, B.C. (1991). The natural forest of Mount Kilimanjaro. In: *The conservation of Mount Kilimanjaro.* (Edited by Newmark, W.D.) IUCHN-The world Conservation Union Switzerland and Cambridge, UK. 17-20 pp.

Nair, P.K.R. (1993). *An introduction to Agroforestry.* Klumer Academic Publishers. Dordecht. 500 pp.

Nair, P.K.R. (1989). Agroforestry defined. In: Nair P.K.R. (ed) *Agroforestry Systems in the Tropics.* Kluwer academic publishers. Dordecht.

Nair, P.K.R.Nair, P.K.R (1985). Classification of Agroforestry Systems *Agroforestry Systems* 3:97-128.

Nakanish, Y; Toyohara, H. and Amano, M. (1994). Traditional cultivation and cropping patterns in Papua New guinea, Rational diversity of shifting cultivation systems in sparsely populated areas. *Japanese Journal of Tropical Agriculture* 38:328-334

Norris, S.R.V. (1990). Using aerial photographs and GIS in quantifying deforestation of tropical rainforest. A case study from Nguru mountains, Tanzania. Unpublished M.Sc. Dissertation in Management of Natural Resources and Sustainable Agriculture. Agricultural University of Norway, 120 pp.

Ngaga, Y.M. (1991). *Present and future reqirerments of sawnwood in two urban centres of Tanzania.* Unpublished Msc (For.) Dissertation, Sokoine University of Agriculture, Faculty of Forest, Department of Forest Economics, Morogoro Tanzania, 205 pp.

O'Kting'ati, A. (1985). *An analysis of the economics of agroforestry in Kilimanjaro.* Unpublished PhD Thesis. Department of forest Economics, Sokoine University of Agriculture, Morogoro, 160 pp.

O'Kting'ati, A. and Mgoo, J.S. (1992). Comparative economics of agroforestry and traditional farming in Morogoro. Record No. 54. Faculty of Forestry, Sokoine University of Agriculture, Morogoro, Tanzania.

O'Kting'ati, A. and Kessy, J.F. (1991). The farming systems on Mount Kilimanjaro. In: *The Conservation of Mount Kilimanjaro* (Edited by Newmark, W.D.): IUCN-The World Conservation Union Switzerland and Cambridge UK. 71-80 pp.

Oduol, P.A. (1986). The Shamba System, an indigenous system of food production from forest areas in Kenya. *Agroforestry systems* 4:365-373.

Oduol, P.A. and Aluma, J.R.W. (1990). The banana (Musa spp) - Coffee robusta. Traditional agroforestry system of Uganda. *Agroforestry Systems* 11:213-226.

Ole-Meiludie, R.E.L, Mariki, S.W.L, and Abeli, W.S. (1988). Productivity and workload in pitsawing Plantation grown timber in Tanzania, *International Journal of Industrial Ergonomic,* 3:13-17.

Philip, M.S. (1994). *Measuring Trees and Forests.* 2nd Ed. CAB International Wallinford, UK. 310 pp.

Pocs, T. (1988). *Management of Natural Forests in Tanzania.* Professorial Inaugural Lecture. Faculty of Forest, Sokoine University of Agriculture Morogoro Tanzania, 19 pp.

Poschen, P.A. (186). An evaluation of the *Acacia albida* based agroforestry practices in the Hararghe highlands of eastern Ethiopia. *Agroforestry Systems* 4:129-143.

Rugalema, G.H.R. (1992). The traditional homegarden agroforestry system of Bukoba, Tanzania. Description, critical constraints and farm economic analysis of possible solutions to falling productivity. M.Sc. Dissertation. Agricultural University of Norway.

SIDA/TWICO (undated). *Pitsawing industry in Tanzania, Tabora region.* Draft, study and survey report. Hauba Enterprises, Dar es salaam, Tanzania, 89 pp.

Scherr, S. (1993). Evaluation of Agroforestry practices over time in the crop-livestock system of Kenya. Social Science research for agricultural technology development: Spatial and temporal dimensions. Proceedings of an International Institute of Tropical Agriculture (IITA). Ibadan, Nigeria.

Skage, T. and Naess L.O. (1994). *Pitsawing and Sustainable forest management. A case study of ecological and social considerations from Morogoro District, Tanzania.* M.Sc. Forestry Dissertation, Department of Forestry AUN, 147 pp.

Soemarwoto, O. (1987). Homegardens: a traditional agroforestry system with a promising future, In: Steppler, H.A. and Nair, P.K.R. (ed) *Agroforestry a decade of development.* ICRAF, Nairobi, Kenya.

Solberg, B. (1988). *Choice of technology in less industrialized countries with particular reference to forestry and sawmilling.* Agricultural University of Norway, Department of Forest Economics Report No. 3/1988 41-43 pp.

Swaminathan, M.S. (1987). The promise of agroforestry for ecological and nutritional security In: Steppler, H.A. and Nair, P.K.R. (ed.), *Agroforestry a decade of development.* ICRAF, Nairobi, Kenya.

Takeda, S. (1990). (Lac cultivation and host tree plantation in Northern Thailand). *Southeast Asian Studies* 28:182-205, Faculty of Agriculture, Kyoto University, Kitashirakawa, Sakyo-ku, Kyoto 606 Japan. 182-205 pp.

Tewari D.D. (1994). Developing and sustaining non-timber forest products: Policy issues and concerns with special reference to India. *Journal of World Forest Resource Management.* 7:151-178.

TFAP (1989). Tanzania Forestry Action Plan. 1990/91-2007/08 and Technical Annexes, Vol. I, II, VII and IX. Ministry of lands, Natural resources and Tourism, Dar es Salaam, Tanzania. 31 pp.

United Nations. (1990). *Population, Environment and development in Tanzania.* University of Dar es Salaam 198 pp

URT (1994). *Kilimanjaro Regional Statistical Abstract.* President's office, Planning Commission, Bureau of Statistics, Dar es Salaam. 1-30 pp.

Waajenberg, H. Mijikenda agriculture in Cost Province of Kenya: *Peasants in between tradition, ecology and policy.* Thesis, Wageningen Agricultural University, Wageningen, Netherlands, Amsterdam Netherlands, KIT press.

Wiersum, K.F. (1987). Development and application of agroforestry practices in tropical Asia.

APPENDIX 1

Questionnaire to pitsawyers and heads of household

A: General information

(Commonly used measurement units are employed to be converted later to SI units in the analysis).

1. Name.....
2. Village.....
3. Ward.....
4. Age..... Years.....
5. Tribe.....Place of origin.....
6. Marital Status:
    1) Married.....
    2) Unmarried.....
    3) Divorced.....
    4) Single.....
7. Sources of income
    1) Petty/commercial business.....
    2) Livestock.....
    3) Agriculture.....
    4) Pitsawing.....
    5) Others, Specify.....

8. Revenues from the income services

Activity	Tsh/month	Tsh/day
1) Pitsawing		
2) Petty business.....		
3) Agricultire		
4) Livestock..		
5) Others.....		

9. How many years of experience with pitsawing do you have
   (1) 1-5
   (2) 6-10
   (3) 11-15
   (4) more than 16

10. Which species of trees do you pitsaw?
   (1) Grevillea robusta.
   (2) Cordia abyssinica
   (3) Olea carpensis
   (4) Albizia schimperiana
   (5) Others, specify.....

11. Which are more preferred species
   (1) Grevillea robusta.
   (2) Cordia abyssinica
   (3) Olea carpensis
   (4) Albizia schimperiana
   (5) Others, specify.....

12. What is the minimum dimension that is being pitsawn?
   .....cm (DBH)

13. Which is the preferred dimension
   ..... cm (DBH)

14. Which parts of the tree are being utilized?

   (1) Lower trunk.....
   (2) Upper trunk.....
   (3) Branches.....

15. Where is sawnwood used?
   (1) Locally.....
   (2) Other regions.....

(3) Export.....

16. How is transportation of sawnwood arranged (from the logging site to the owner)

(1) By foot.....
(2) Animal.....
(3) Vehicle.....
(4) Combination, specify.....

17. Average transportation distance from the logging site to road
..... (km)

18. Do you employ any labor
Yes.....
No.....
If yes how many labour do you have
.....

19. Terms of payment to labour
1) per day
2) per timber piece
3) per week
4) per month
5) 0ther specify.....

20. How much do you pay them with respect to terms ofpayment

(1)..... Tsh/month
(2)..... Tsh/day

21. When is the period of maximum production?

22. How do you get the trees for pitsawn?

(1) Buying.....

(2) From your farm.....

(3) Other sources specify.....

23. Terms of payment for pitsawing

1) per day

2) per timber piece

3) per week

4) per log

5) per month

6) 0ther specify.....

B Transport

Payment for carrying the timber from the sawing site to the owner.

Payment per timber piece	Tsh.
1" 12" 7'	
2" 6" 7'	
2" 4" 12'	
Other	

C: Sawing costs and productivity

Species sawn	Size of sawnwood	Sawing cost (Tsh)	Production per day (pieces).
Grevillea robusta	1" 12" 7' 2" 6" 7' 2" 4" 12' Other		
Cordia abyssinica	1" 12" 7' 2" 6" 7' Other		
Albizia schimperiana	1" 12" 7' 2" 6" 7' Other		
Olea carpensis	1" 12" 7' 2" 6" 7' Other		

D. Costs of equipment

Type of equipment	No per crew	Buying price (Tsh)	Depreciation (Years)
Saw			
Axe			
Hoe			
Panga			
Files			
Measuring tape			
Thread			
Crosscut saw			
Felling rope			
Plumbline			
Saw set			
Pencils			
Others			

24. Are there any cost factors than the above mentioned you would consider as important regarding pitsawing operations?

25. Do you pay royalties?
Yes.....
No.....

26 If yes where do you pay them?
.....
.....

27 What are the procedures?
.....
.....
.....

28. Which offices issues the licence?

.....

.....

29. What are the procedures?

30. Do you compesate for the damages when cutting the trees for pitsawing

Yes.....

No.....

31. If yes specify.....

Reservation prices for the tree species pitsaw grown at road side

Tree species.....

Diameter Classes (cm)	Merchantable height (m)	Price (Tsh)
31 – 40		
41 – 50		
51 – 60		
61 – 70		
71 and above		

Reservation prices for the tree species pitsaw grown inside farms

Tree species.....

Diameter Classes (cm)	Merchantable Height (m)	Price (Tsh)
31 - 40		
41 - 50		
51 - 60		
61 - 70		
71 and above		

Reservation prices for the tree species pitsaw grown in open areas.

Tree species.....

Diameter Classes (cm)	Merchantable height (m)	Price (Tsh)
31 - 40		
41 - 50		
51 - 60		
61 - 70		
71 and above		

APPENDIX 2

Questionnaire to village leaders

a) Name of Village.....

b) Ward.....

c) Number of household/families.....

d) Average size of household/family.....

e) Village main activities

1) Farming.....

2) Livestock husbandry.....

3) Pitsawing.....

4) Agriculture

5) Petty/commercial business.....

6) Others (specify).....

f) How many pitsawyers are in the village.....

g) Where do they come from?

(1) Region.....

(2) Area.....

(3) Village.....

h) How many years of experience with pitsawing do they have.....

i) Revenue from income services

		Tsh/month	Tsh/day
(1)	Pitsawing	.....	.....
(2)	Agriculture	.....	.....

(3) Petty/Commercial business ....

(4) Livestock ....

(5) Other specify ....

j) Do you issue licences to the pitsawyers?

Yes

No.....

k) If yes what are the procedures?

l) Who is employing the pitsawyers?.....

m) Which tree species do pitsawyers saw?

(1) *Grevillea robusta*

(2) *Cordia abyssinica*

(3) *Olea carpensis*

(4) *Albizia schimperiana*

(5) Others specify.....

n) Which are the more preffered tree species?

(1) Grevillea robusta.

(2) Cordia abyssinica

(3) Olea carpensis

(4) Albizia schimperiana

(5) Others specify.....

o) What is the minimum dimension that is being pitsawn?

.....cm (DBH)

p) Which is the preferred dimension (DBH)

.....cm (DBH)

q) Where is sawnwood used?

(1) Locally.....

(2) Other regions.....

(3) Export.....

r) Do pitsawyers pay royalty?

s) If yes what are the procedures?

APPENDIX 3

Questionnaire to timber traders

A.General information

1. Name of trader/organization.....
2. Number of persons working at the depot.....
3. Class of business
   - (1) Small.....
   - (2) Medium.....
   - (3) Big.....
4. Sources of sawnwood
   - (1) Sawmill.....
   - (2) Pitsawyers.....
   - (3) Others specify.....
5. Availability of sawnwood
   - (1) Abundant.....
   - (2) Scarce.....
   - (3) Very scarce.....
6. What quantities of sawnwood do you sell per day?
   - (1) .....m^3
   - (2) .....cubic foot

3) Others specify.....

7. Where do you sell your timber

(1) in the district

(2) other regions.....

(3) Export.....

(4) Others specify.....

8. Who are the major customers

1) individuals.....

2) institutions.....

3) contractors.....

4) others sprcify...

. Do you export sawnwood?

yes.....

no.....

If yes specify.....

10. Export price

1) ..... Tsh/m^3

2) ..... Tsh/cubic foot

11. Amount of sawnwood available in stock

1) ..... m^3

2) ..... Cubic foot

3) Other specify.....

12. Do you trade in other commodities as well.

Yes.....

No.....

13. If yes what are they.....

1).....

2).....

3).....

14 What is your priority to sawnwood?.....

.....

15. What factors do you think influence your business.

.....

16. What are your future plans.....

.....

17. Which species are preferred?

(1) Grevillea robusta...

(2) Cordia abyssinica...

(3) Olea carpensis....

(4) Albizia schimperiana.

(5) Others....

18. What are the main uses of the following tree species

(1) Grevillea robusta...

(2) Cordia abyssinica...

(3) Olea carpensis....

(4) Albizia shimperiana...

(5) Others....

19. Are the prices of sawnwood flactuating?

Yes.....

No.....

20. If yes how and when.....

21. What is the distance to the sources?

..... (km)

22. Market prices

Current market prices for pitsawn timber at timber traders near the sawing site:

Tree species	Price per 1" 12" 7'	Price per 2" 6" 7'	Price per 2" 4"12'
Grevillea robusta			
Cordia abyssinica			
Olea carpensis			
Albizia schimperiana			

23. Are there any regulations in the timber trade?

Yes.....

No.....

24. If yes specify.....