KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY
INSTITUTE OF RENEWABLE NATURAL RESOURCES

AGROFORESTRY FOR SUSTAINABLE FUELWOOD INDUSTRY IN ASHANTI AND BRONG AHAFO REGIONS

CASE STUDY: KUMASI, ATWIMA AND ATEBUBU DISTRICTS

A THESIS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES,
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AWARD OF A MASTER OF PHILOSOPHY DEGREE IN AGROFORESTRY

DAVID CASTEL
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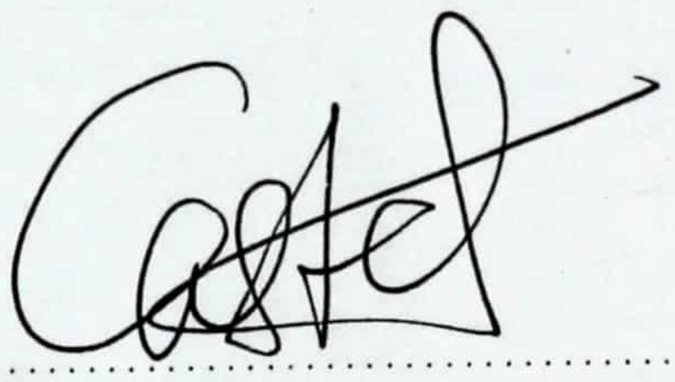
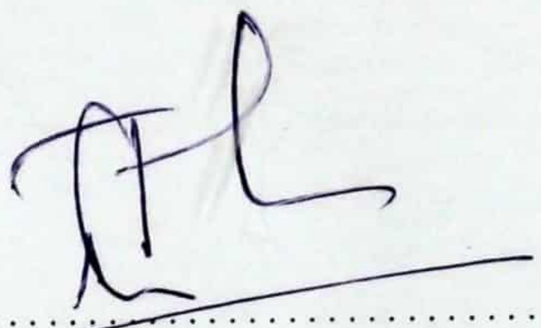
CERTIFICATION

CERTIFIED that, this thesis is the candidate's own account of his research.



DAVID CASTEL
STUDENT



DR S. J. QUASHIE-SAM
SUPERVISOR /HEAD OF
DEPARTMENT

DEDICATION

This research output is dedicated to my son David Kwame Castel Junior to inspire him for greater heights of achievement.

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ABSTRACT

Fuel wood is the source of energy for households and many industrial activities in Ghana. Fuel wood is widely used in urban areas but mostly in rural areas. Even though Fuel wood is a renewable energy if well managed, there are some signs of scarcity in the country.

During the thesis research the socio economic background of people involved in the fuel wood industry were investigated. Farmers' interest and responses to agroforestry interventions were evaluated.

Structured as well as unstructured interviews were conducted through questionnaire administration, focal group discussions and individual interviews. The study area can be viewed in two phases: the urban phase and the rural phase.

In the urban phase fuel wood production, markets and sources of fuel wood were identified. Mill residue was identified as a source of fuel wood. Some of the mills identified included Logs and Lumber Limited (LLL), AG Timbers, Paul Sagoe Sawmill and FABI Timbers. The identified areas of charcoal production in Kumasi included Kaase, Ahinsan, Akosombo and Asokwa. The markets identified included Ayigya, Adum, Sepebuokrom, Krofrom, and Tafo. The rural phase identified communities in Atebubu and Atwima districts. Due to the proximity the of Atwima district and the fact that a lot of firewood markets identified their sources from the Atwima district led to majority of the research communities being chosen from the

district. Some of the communities identified in Atwima district included Kobeng, Mpasatia, Apenkro, Mofranfadwene,Kyereyase, Amanchia and Toase.

Identified communities in Atebubu district were Amantin, Kyato-Zongo and Sulemana. The results obtained indicate that some species used for fuel wood are experiencing shortages and may become extinct in areas where they used to be in abundance. Roadside communities that actively participated in fuel wood production and sale such as Kobeng, Mpasatia and Amanchia lacked the preferred fuelwood species such as *Celtis* while communities in the interior like Mentukwa, Mmehame, Oforikrom Akentensu and Kramokrom still have most of the preferred species. The preferred species that were identified in these communities include *Celtis* Species, *Fiscus experata, Amphimas pterocarpiodes,Albilzia zygia, Phylanthus* and *Terminalia ivorensis*. The research also looked at farmers' knowledge of Agroforestry and their responses to its interventions. It was noted that farmers had indigenous knowledge of agroforestry, the use of shade trees and the practice of taungya using *tectona grandis* in their farming practices can be cited as examples.

In the final analysis it would sum up to the issue that the fuel wood problem is a multifaceted one, which can be, addressed nation wide at the policy level through the district assemblies to put in measures that would aim at sustainable management of our forest resource that would curb the ever increasing urban demand for fuel wood. The beneficiary stakeholders such as the fuel wood communities should be encouraged to practice sustainable farming practices such as agroforestry, which

apart from its numerous benefits can sustain their livelihood as fuel wood communities.

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CHAPTER ONE

INTRODUCTION

In developing countries wood is the chief domestic fuel. It is used to cook meals, to heat and light people's homes. It is also significantly used in small-scale industries such as fish smoking, beer brewing, soap making and a host of other commercial activities. Many income generating industries such as bakers, blacksmiths, potters and craftsmen use fuel wood, for it is convenient and because most of them have no other alternative means of energy supply. According to the FAO (1987), 73% of energy consumption in Sub-Saharan Africa is in the form of biomass. The rural and urban poor cannot afford high priced liquefied petroleum gas and thus they have to depend on fuel wood for their domestic and industrial activities. The dynamics of the fuel wood situation represents a growing crisis. In 1980, 55 million people in Sub-Saharan Africa lived in areas where there was acute fuel wood shortage. Another 146 million lived in areas with an increasing deficit. It was then estimated that by 2000 about 535 million people will experience a critical fuel wood deficit if exploitation continues at the then current rate.

Wood fuel exploitation is not solely responsible for environmental degradation. In forest areas deforestation is caused to a large extent by timber merchants and forest clearance for cultivation. Many secondary forest trees are also lost as fallow periods are shortened.

General areas with high rate of tree re-growth can meet the needs of a larger population than those with low growth potential. Areas with wood fuel deficits are those with low to moderate rainfall and high population densities. Even areas where there is very low population density, low rainfall can make the demand for wood fuels outstrip the growth of woody plants creating acute fuel wood shortages.

Deforestation is affecting many rural people who have been accused of being the cause of the deforestation. More often these people harvest fuel wood from their own food farms. Secondary forest or fallow lands where trees are cleared for agriculture are a ready source of fuel wood. Deforestation is caused primarily by the need for fuel wood for the curing of tobacco and tea. by excessive felling of timber for domestic and the export market. by agricultural production. by urbanization. by bushfires. etc., The wood security problem is in fact a manifestation of much broader deeper-rooted problems of poverty. such as unequal distribution of income and land. as well as structural inequalities.

The problem is worsened further by the demand for wood fuel by urban households. Patterns and levels of household use of fuel wood in urban areas are far more complex than those in rural areas.

As rural-urban migration opens up more avenues for the people. it also brings various problems with limited opportunities. Catering for the fuel needs of the people are just one of the essential services those poor migrants has to provide in the urban areas. These are services that would have been free if they were in rural areas. As most

towns and cities are growing rapidly, urban growth is paralleled by an increasing demand for energy to meet consumption needs, which are met by wood fuels.

The magnitude of the fuel wood crisis has reached such an alarming proportion that the statement made by O'Keefe (1990) that if the current population growth should continue, urban wood fuel consumption will surpass that of rural areas in the next 20 years or so, can be said to be an understatement.

The significance of fuel wood in the urban energy balance is the limited access to alternative fuels. Fuel wood competes with other household fuels such as kerosene, liquefied petroleum gas (LPG) and electricity. The choice of fuel wood depends on their availability, security and cost as compared to other alternatives such as LPG with its attendant supply bottlenecks and price fluctuations.

The prohibitive LPG cost and perennial shortages tend to increase the reliance of poor women on fuel wood even if it is expensive. Besides, there is also the high cost of modern cooking stoves, which is not affordable to many households that may want to switch fuels (e.g. the expensive gadget involved in the use of LPG such as the cylinder and stove).

In Ghana cooking in the home depends on fuel wood, which is responsible for more than 75% of all the energy consumed annually. Most small-scale industries and food processing enterprises that women undertake depend in large part on wood fuel. This dependence on wood fuels has contributed to the growing exploitation of the country's

forest. In all about 650,000 ha. of forest are destroyed every year through the carbonization of fuel wood to charcoal.

"Ghana's environment is suffering the effects of dramatic changes. its forest have been degraded into grasslands and the savannah areas are fast turning into deserts. The invasion of deserts through over-grazing has been worsened by extreme changes in climate of West Africa since the recent severe persistent droughts; vegetation has become so impoverished that it is difficult for the forest to recuperate even with the onset of rains. At the current rate of deforestation, about two-thirds of the country will soon experience severe wood shortages and serious environmental resource degradation. The most affected areas are the northern and coastal grasslands" (Dankelman and Davidson, 1980; 1988).

Trees, which are used for fuel wood, are also beneficial in many environmental services in the long-term. Trees collect and store carbon in their biomass in soils, thus keeping carbon dioxide out of the atmosphere where carbon dioxide and methane are components of greenhouse gases that contribute to global warming. Tree cover is crucial for maintaining healthy watershed and is of growing importance as we move towards the 21st century, when many people predict that water will become the world's primary natural resource concern.

The exploitation of Ghana's forest is drawn into limelight by known researchers such as Nketia *et al.* (1988), who reported that charcoal is predominantly the domestic fuel for 69% of urban households. Per capital consumption was 108.8 kg per annum and it

is estimated 476.8 thousand metric tones are consumed in Ghana. Between 1974 and 1990 wood fuel consumption increased by an alarming 50% in the country (Ardayfio-Scandorf, 1993).

Where problems pertaining to fuel wood exist a greater burden is put on women who have to make some trade offs. Women curtail cooking time and even cut down on economic enterprises to make time for fuel wood production, the distance covered is reflected in the cost of fuel wood production.

Agroforestry systems decrease the need for forest encroachment and thus help preserve the forest's biodiversity while providing niches for a range of organisms. In the tropics, the ever-increasing population pressure on land threatens natural woodlands and forest. So the more trees that can be integrated into the landscape in dynamic Agroforestry systems the better. It was therefore the aim of this thesis to research into the potential that Agroforestry has to conserve, protect and sustain the firewood and charcoal industry.

1.1 Objectives

1. To study the socio-economic background of the people involved in the firewood and charcoal industry in the study area.
2. Identify the structure, problems associated with firewood and charcoal, its production and trade.
3. To identify Agroforestry interventions that can be employed to sustain firewood and charcoal industry.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

If population growth occurs without development sub-Saharan Africa will be compelled to exploit its resources on a non-renewable basis thus accelerating environmental deterioration. The main commercial energy resources consumed in SSA are petroleum (41%). natural gas (14%) hydro electricity (10%) and coal (35%). In the total resources including traditional fuels. wood fuel is dominant (Ardayfio, 1986).

2.1 Fuel wood

In Agroforestry. trees may provide fruit. fuel and fodder. enhance soil fertility. and conserve soil. and also act as windbreaks. Accordingly a tree that serves more than one purpose is a multipurpose tree. Fuel wood is defined as wood and pulp material obtained from the trunks. branches and other parts of trees and used as fuel. This definition may cover a wide variety of materials used as fuel wood. comprising even roots. barks and leaves of woody plants or crop residues such as straw. husks and products from pruning of fruit trees. Corder (1973) reported that over 43% of wood cut worldwide was used for fuel.

2.2 Characteristics of a Good Fuel wood

A good fuel wood should:

- Light easily and burn well but not quickly. Wood that will burn when wet is especially preferred.
- Burn into coals that retain heat for a slow, even cooking.
- Have stems that are not too thick or can be easily split.
- Be easily converted to charcoal. Charcoal is easier to transport than wood and burns steadily and without smoke.
- Burns without producing irritating smoke, sparks or unpleasant odours and without giving food a bad taste (Lartey *et al,* 1994).

Examples of good fuelwood trees are: *Albizia zygia, Azadirachta indica, Butyrospermum parkii, Celtis spp., Diospyros mespilliformis, Ficus exasperata, Khaya senegalensis, Mangifera indica, Phyllantus discoides and Spathodea companulata* (Anane *et al,* 1988; Abbiw, 1990, and Irvine, 1961).

2.3 Wood Structure

Wood is a heterogeneous complex material formed during the growth of certain plants. It is made up of tissues of very different kinds of cells with tiny opening membranes and intricate by layered walls (Browning, 1975).

The cells have thinner walls than fully developed ones, but in some cells the walls are of complex structure and often permit the recognition of layers available in chemistry and structure (Esau, 1965).

Wood is composed principally of carbon, hydrogen and oxygen. In Table 2.3, details of the chemical composition of a typical North American wood show carbon to be the dominant element on a dry weight basis. In addition, wood contains inorganic compounds that remain after higher temperature combustion in the presence of abundant oxygen (Haygreen and Bowyer, 1996).

Table 2.1: Percentage elements in wood (by weight).

Element	Dry Weight
Carbon	49
Hydrogen	6
Oxygen	44
Nitrogen	Slight amounts
Ash	0.1

Source: Kollman and Coté (1981).

Wood has been aptly described as an inter-penetrating system of high polymers. The compounds that are present generally in woods can be classified chemically as carbohydrage-phenolic substances, terpenes aliphatic acids, alcohols, proteins and inorganic constituents (Browning, 1975).

2.3.1 Softwood

In the United States of America and most European countries, 35 percent of important commercial species of wood are soft. Softwood are produced by conifers. Softwood

because of their resin content to produce more tars, and there is less acetic acid and similar products in pyroligenous acid fraction (Haygreen and Bowyer, 1996).

2.3.2 Hardwoods

In tropical regions of the world the number of wood producing species of tree exceed 10,000; of these the number of softwood constituent vary between softwood and hardwoods (Kollman and Coté, 1984; Dinwoodie, 1989).

2.3.3 Carbonization

Carbonization is a particular process in chemical technology called pyrolysis that is the breakdown of complex substances into simpler ones by heating. Carbonization is the term used when complex substances such as wood or agricultural residues are broken down by heating into elemental carbon and chemical compounds which may also contain some carbon in their chemical structure (Fernandes, 1991). The carbonization stage in charcoal making process is the most important step of all since it has such power to influence the whole process from the growing tree to the final distribution of the product to the user (Fernandes, 1991).

2.4 Qualities of Charcoal

In many developing countries charcoal is an important household fuel and to a less extent industrial fuel. It is mainly used in the urban areas where its ease of storage, high energy content, lower levels of smoke emissions and resistance to insect attacks make it more attractive than wood-fuel (Nkonoki and Sorensen, 1984). It is estimated

that the net calorific value of charcoal is about 30 mj/kg which is about twice that of wood which ranges from 15 to 16 mj/kg (World Bank, 1988).

In Tanzania, charcoal accounts for an estimated 90% (round wood equivalent basis) of bio-fuels consumed in urban centers (World Bank, 1988). In 1970 it was estimated that 90% of the wood cut for use in urban areas of Thailand was for charcoal (Arnold, 1979).

The production of charcoal spans a wide range of technologies that includes simple and rudimentary earth kilns and complex large capacity methods. The various techniques of production results in charcoal of varying quality (Table 2.2).

Table 2.2: Typical characteristics of good quality charcoal.

Characteristics	Percentage (%)
Ash Content	5
Fixed Carbon Content	75
Volatiles Content	20
Bulk Density	250-300 kg/m^3
Physical Characteristics	Moderately friable

Source: Karekezi (1986).

2.5 Importance of Fuelwood

Wood fuel is the largest primary energy in both rural and urban households. Wood fuel constitutes an indispensable input for commercial and industrial activities as well as domestics (Asare and Opam, 1986). For example it is estimated that fish smoking

accounts for at least 12 tonnes of fuelwood consumption per year in Ghana (Anane and Twumasi-Ankrah, 1985).

According to Eckolm (1975), 90% of people in the tropics depend on wood as the chief source of fuel. Much of it is used in the homes for cooking, heating and lighting. It has been found by fuelwood surveyors that many families in the tropics spend more than 40% of their daily wages on firewood (NAS, 1980).

Some of the benefits derived from a well planned fuelwood industry is enumerated by Earl (1974) include:

a) Creation of employment

b) Provision of money in the rural sector

c) Saving in foreign exchange

d) Provision of a chemical fuel base for industry

e) Increasing the total profitability of the forest

f) Provision of smokeless fuel for cities (charcoal).

2.6 Selected Agroforestry Trees That Can Be Harvested for Energy in Ghana

2.6.1 *Acacia auriculiformis*

Acacia auriculiformis belongs to the family Leguminosae and originated from coastal Queensland, Island of Torres Straight and Papua New Guinea. It is a resilient, fast-growing, evergreen tree, heavily branched with crooked trunk; dense foliage and large

branches with leaves that are thick and feathery. *Acacia* has a fuelwood of calorific value ranging between 20110-20450 kj/kg.

Height: To 30cm, 60cm girth, site rainfall 1500-1800mm. Withstands seasonal water logging.

Propagation: Established by seeds.

Management: Maintained by pruning, coppices poorly but re-grows faster after pollarding.

Growth: Very fast. Annual wood yields of 17-20 m^3/ja at rotations of 10-12 years.

Uses: Nitrogen-fixing, charcoal, dune fixation, soil improvement and conservation; windbreaks, shade and shelter, ornamental, gum, tannins and dyes, fence post, industrial purpose, pulp (NAS, 1980; Derek *et al.* 1984; Von Carlowitz, 1986).

2.6.2 Albizia adantifolia

Albizia adantifolia belongs to the family Mimosaceae. It has a flattened crown and is a semi-deciduous plant, which grows up to a height between 3-4m (Taylor, 1960; Skerman *et al.* 1988; NAS, 1980).

Uses: Nitrogen fixing, fuelwood, poles.

***Albizia lebbek* (Woman's Tongue, Lebbek)**

Albizia lebbeck is of Burma and India origin and belongs to the family Leguminosae. It is a deciduous single-stemmed tree, height of 20-30m, 1m diameter, and large spreading crown of feathery.

Foliage Site: Rainfall, 600-2500mm, wide range of soils.

Propagation: By seeds, stem and root cuttings as well as suckers (Hartman *et al*, 1968).

Management: Coppicing, logging and pollarding.

Growth slow, moderately fast, firewood yields are 5 m^3/ha/yr in dry areas for rotations to 10-15 years. *Albizia lebbek* has a fuelwood of calorific value ranging between 21300-21350 kj/kg.

Uses: Nitrogen-fixing, fuelwood, charcoal, fodder, soil improvement and conservation, green manure, windbreaks, shelterbelts, shades, ornamental, dune stabilization, mulch, furniture, industrial purposes, veneer, plywood, timber, poles and medicine (NAS. 1980; Derek *et al*, 1984; Von Carlowitz, 1986).

***Albizia zygia* (Okoro)**

Albizia zygia is usually a small tree not much bigger than 30m and 24m girth at breast height. Bole is short not very straight nor cylindrical. The canopy forms low down and is spreading (Nogent, 1971).

Propagation: Propagated by seeds (Irvine, 1961).

Growth: Rapid heights up to 3m have been recorded for 2-year old plants.

Uses: Fodder, fuelwood, soil conservation, windbreaks, nitrogen-fixing, mulching, shade, medicine, food, fodder (Derek *et al*, 1984; Taylor, 1960 and Von Carlowitz, 1986).

***Ampyhimas pterocarpoides* (Yaya)**

Ampyhimas pterocarpoides is a tree about 40m high and 3m girth. The bole is long and slender with buttress reaching 3m high. The crown is fairly small, compact and rounded.

Growth: Rapid in the open, but can be irregular.

Height: Varies from 0.2 to 0.8m at 18 months.

Uses: Medicine, shade, fuelwood (Derek *et al*, 1984 and Von Carlowitz, 1986).

***Anogeissus leiocarpus* (Anogeissus)**

Anogeissus leiocarpus is a tall tree up to 30m high and 2.4m at breast height. Single-stemmed and does not coppice well.

Uses: Charcoal, fuelwood, wood for various products, food, human medicine, veterinary medicine, dead fencing, windbreaks (Rocheleau *et al*, 1988).

***Azadirachta indica* (Neem)**

Azadirachta indica is a medium size tree up to 24-30m high, single-stemmed, coppice growth faster than growth from seeds.

Propagation: Seeds and wildlings.

Uses: Fuelwood, shelterbelts, fodder (leaves, pods), alley cropping, soil conservation, fence post, insect repellent, charcoal, soil improvement, shade, medicine, windbreaks, wetland reclamation (Abbiw, 1990 and NAS, 1980).

***Baphia natal* (Odwon)**

Baphia natal is a shrub or small tree that grows to 9m high and 0.5m in diameter.

Propagation: Easily propagated from seeds or cuttings (Hartman *et al*, 1968).

Uses: Nitrogen fixing, fodder, fuelwood, hedgerow, live fences, human medicine, carvings, chewing sticks, windbreaks, shade, poles, soil improvement (Derek *et al*, 1984).

***Butyrospermum parkii* (Shea, Nkudua)**

Butyrospermum parkii is a small tree with spreading habit, grows to 12m high and 1.5-1.8m in diameter. Bark is thick and fissured both horizontally and longitudinally. Wood is red, heavy, difficult to work and termite proof.

Propagation: By seeds.

Uses: Fuelwood, shade, fodder (pods, seeds, leaves), soil conservation, windbreaks, charcoal, mulching, nitrogen-fixing, food and medicine (Abbiw, 1990 and Rocheleau, 1988).

***Cajanus cajan* (Pigeon pea, Congo pea, Redgram)**

Pigeon pea has a height up to 4m but usually 1-2m.

Site: Rainfall 250-375mm, temperature 18-35°C, wide range of soils.

Propagation: By seeds.

Management: Pollarding.

Growth: Fairly slow during the seedling stage but vigorous once established. Weed is essential in the first two months to improve performance. Wood yields range from 2-10 tons/ha/yr and grain yields from 900-1550 kg/ha/yr.

Uses: Nitrogen-fixing, fodder (pods, leaves), food (seed grain), soil conservation, fuelwood (Derek *et al*, 1984 and Von Carlowitz, 1986).

Cassia siamea

Cassia siamea is of South-Eastern Asia, India, Sri Lanka and Malaya origin and belongs to the family Leguminosae. It is a medium, single-stemmed, evergreen tree up to 15-18m high with dense crown of foliage.

Propagation: Seeds and stumps (Hartman *et al*, 1968).

Growth: Grows fast and coppices well; continues yielding well for 4 to 5 rotations.

Uses: Fuelwood, shade, soil conservation and stabilization, windbreaks, charcoal, hedgerow, live fencing, fodder, industrial timber.

Celtis

The flora of most tropical Africa (Hutchinson and Dalziel, 1954) class Celtis under the plant family Ulmaceae. Celtis species extend from West Africa through Central Africa to Uganda, Tanzania and parts of Kenya (Brown, 1979).

***Celtis milbraedii* (Esa Fufuo)**

Celtis milbraedii is a tall tree reaching about 55mm high and a girth of 3m above buttress. It has a long slender cylindrical straight bole and a small glabose crown.

Growth: Initially slow, but once established can grow rapidly.

Uses: Firewood, fufu pestles, framework of mud houses, plywood, veneer, shade, live stakes (Brown, 1978 and Nwoboshi *et al*, 1992).

***Celtis zenkeri* (Esa Kokoo)**

Celtis zenkeri is a tree up to 27m high, seldom exceeding 2.7m in girth above buttress, straight slender stem and round crown, but spreading than that of *C. milbraedii*.

Propagation: By seeds (Willan, 1985).

Uses: Firewood, fufu pestles, framework of mud houses, shade, live stakes (Brown, 1978).

Diospyros mespilliformis

A simple-stemmed unbuttressed tree up to 15-21m high and with a girth about 2-5m. Wood is a hard compact, durable, white or light red or often grayish when freshly cut, darkening to dark-brown. Black heartwood develops in trees from open Savanna after cutting and exposure, coppices well.

Propagation: Seeds (Willan, 1985).

Uses: Fodder, mulching, nitrogen fixing, fuelwood, charcoal, windbreaks, shade, food, wood for various products. (NAS, 1980 and IIAR, 1992).

***Ficus anomani* (Doma)**

Ficus anomani is an epiphytic shrub or tree up to 9m high.

Propagation: Seeds and readily from cutting.

Uses: Live fencing, firewood (Irvine, 1961).

***Ficus exasperata* (Nyankyerene)**

Ficus exasperata is a tree up to 21m high.

Propagation: Seeds and readily from cuttings.

Uses: Human medicine, leaves as sand paper for polishing wood and calabashes, shade and soil improvement, firewood and fodder (Derek *et al.* 1984, and Von Carlowitz, 1986).

***Gliricidia sepium* (Gliricidia, Quick Stick, Mother of Cocoa)**

Gliricidia sepium belongs to the family Leguminosae and originated from tropical America. It has a height of 5-20m, 30cm girth, many-stemmed with an open round crown and often-contorted trunk; medium spreading crown, wood is hard.

Site: Rainfall 900-2300mm; temperature 22-30°C; tolerates seasonal water logging but well drained soils are preferred.

Propagation: Easily established from seed branches and stem cutting (Hartman *et al*, 1968 and Willan, 1985).

Management: Coppicing, pruning, lopping pollarding.

Uses: Nitrogen-fixing, fodder leaves, shoots pods, seeds) fuelwood, charcoal, soil conservation and improvement, windbreaks, hedgerow, mulching, live fencing, shade (NAS, 1980; Skerman *et al*, 1988).

***Pterocarpus ennaceaus* (Pterocarpus)**

Pterocarpus is a single-stemmed tree up to 15m high and 2m in girth. Erect buttressed when old with a high crown.

Propagation: Seeds (Willan, 1985).

Uses: Live fences, shade, conservation, windbreaks, charcoal, fuelwood, bee forage leaves, carvings, medicine, wood for various products (Adjare, 1981 and Rocheleau *et al*, 1988).

***Rauwolfia vomitoria* (Kakapenpen)**

Rauwolfia vomitoria is a shrub or a small tree up to 6m high.

Propagation: Seeds (Willan, 1985).

Uses: Medicine, pesticides, shade, fuelwood, live stakes, soil improvement, fodder (Abbiw, 1990 and Irvine, 1961).

***Terminalia ivorensis* (Emire)**

Terminalia ivorensis is a tall tree about 40m high and with a girth of about 2-7m above buttress, but much shorter in open conditions. Bole is straight and clean, branching is whorled and crown flattens at the top at maximum height.

Growth: Slow at first but plants are obtainable 15 months after plantation work.

Uses: General carpentry, building lorry bodies, canoe, latex, shade, fuelwood, medicine (Abbiw, 1990 and Irvine 1961).

***Khaya senegalensis* (Mahogany)**

Khaya senegalensis is a glabrous single-stemmed tree up to 30m high and about 3m in girth, often dividing at about 6m into 2-3 large vertical limbs with wide-spread crown, coppices well.

Propagation: Seeds and suckers (Dupriez *et al*1988.)

Uses: Fuelwood, fodder (leaves), charcoal, shade, live fencing, medicine, carvings, soil improvement, windbreaks, timber, cosmetic, hygienic poles (NAS, 1980; Abbiw, 1990 and Irvine, 1961).

Leucaena leucocephala

Leucaena leucocephala belongs to the family Leguminosae and originated in the midlands of Southern Mexico. It is a tall, slender tree, usually up to 20m high or rounded; many-branched shrub, less than 5m high. Medium canopy wood is dense.

Site: Rainfall 750-1800mm; temperature 10-30°C. Tolerates a wide range of soils.

Propagation: By seeds, cutting and grafts (Hartman et al, 1968).

Management: Coppicing, pruning and pollarding. Had Mimosine toxicity and is attacked by Psyllid (Heteropsylla cubana).

Growth: Establishes slowly but has outstanding vegetative vigour. Yields of 35 tons/ha/yr of green leaves and twigs have been obtained from pruning every two months.

Uses: Nitrogen-fixing, soil conservation and improvement, fuelwood, charcoal, fodder, windbreaks, shade, green manure, hedgerows and alley cropping (Anane *et al*, 1988 and Kaho, 1998).

***Terminalia superba* (Ofram)**

Terminalia superba is a tall tree often 43m high and about 2.4m girth above buttress. Stem is very straight, long and cylindrical; whorled branches, dense foliage and small crown.

Propagation: Seeds and cutting (Hartman et al, 1968 and Willan 1985)

Uses: Mulching, soil conservation, firewood, poles, medicine, second-rate shingles, local joinery, shade (Abbiw, 1990 and Taylor, 1960).

2.7 Agroforestry Technologies that can be used for Fuel wood Production

2.7.1 Woodlots

The practice of establishing woodlots and small plantation for fuelwood is relatively of recent origin (Evans, 1986).

A woodlot is an Agroforestry technology managed over time, which can integrate other crops and or animal component during the initial establishment stage. A woodlot mainly contains woody perennial and serves as a principal source of fuelwood. Community woodlot which forms part of community forestry are establish to provide wood and other forest product to local people. (FAO, 1983). Because a woodlot keeps the soil surface covered, it is also a soil water conservator (Rocheleau *et al*, 1988). Some species may be chosen if their foliage can be used as fodder and their ability to coppice (Burley, 1978). Examples are *Cassia siamea* in Burkina Faso, Mali, Niger and *L. leucocephala* in the Philippines.

2.7.1.1 Woodlot Establishment and Maintenance

On cultivable lands the recommended spacing is 2m x 2m, 2m x 3m or 3m x 3m. This spacing enables intercropping to be practiced in the first year before the tree canopy closes on marginal lands and the recommended spacing is 1m x 1m. This ensures early tree canopy closure providing soil protection and suppression of weeds. The pruning, weed removal, thinning and replacement of dead seedlings are essential to maintain a good stand (Quashie-Sam *et al*. 1993).

2.7.1.2 Rotational Harvest

The woodlot can be established so that a rotational harvest system can be followed over time. The woodlot area is divided into several areas each of which can be harvested in a different year. Several factors are considered to determine the rotational

set including rate of growth, soil fertility and silvicultural factors (Quashie-Sam *et al.* 1993).

2.7.1.3 Benefits of Woodlots

According to Evans (1982) establishment of woodlots help to raise rural living standards.

- A woodlot supplies fuelwood for domestic and industrial use (tobacco curing, brick burning, etc.).
- Improves soil conditions of marginal or fallow lands and makes them more suitable for crop production, soil productivity and enhancing sustainability particularly if nitrogen-fixing trees are used and proper nutrient cycling is maintained.
- Can be used as windbreaks or shelter for adjoining areas and croplands.
- Provides stakes for supporting yams and other creeping plants.
- Provides poles for building and other construction purposes (like electric and telephone poles, etc).
- Provides improved habitat for wildlife.
- General improves the environmental and aesthetic conditions of an area (FAO, 1985 and NAS, 1980).

2.7.2 Alley Cropping

Alley cropping is an Agroforestry technology in which food crops or forages can be grown in the alleys formed by the establishment of tree and shrub hedgerows. The trees or shrubs are established in single or multiple hedgerows.

Alley cropping can be practiced by smallholders and can also be easily adapted for medium to large sized mechanized farms. Good alley cropping species include *Leucaena, Gliricidia* and *Acacia albida*. The trees or shrubs are established in single or multiple hedgerows usually spaced 2-8 meters apart. Trees within the hedgerows are usually spaced 0.5 to 1 meter apart (Quashie-Sam, *et al.* 1993).

Alley cropping as contrasted to contour farming focuses mainly on soil improvement and maintenance of soil fertility. However alley cropping can also be designed to reduce soil erosion and improve water infiltration as in contour farming (Young, 1989).

2.7.2.1 Tree Management in alley cropping

During the cropping season the trees are periodically pruned and managed to reduce or eliminate competition for light and to prevent shading of the crop or forage. Hedgerow pruning is done using a sharp cutlass at height varying from 50cm to 1m above soil level. The pruned material can be used as mulch or be incorporated as green manure (Quashie-Sam, *et al.* 1993).

2.7.2.2 Benefits of Alley Cropping

- Rapidly regenerates soil fertility.
- Allow farmers to manage their land resources more intensively.
- Controls soil erosion through the presence of hedgerows.
- Provides tree leaf mulch, which creates favourable soil conditions for microorganisms that are beneficial for soil improvement and nutrient cycling.
- Hedgerows provide high quality forage for livestock.
- Hedgerows provide fuelwood and stake material for climbing plants.
- Serves as windbreaks, providing protection to companion crops.
- Increases available moisture by improving soil infiltration and reducing runoff.
- Serves as firebreak.
- Serves as best barrier (Quashie-Sam,1993 and Rocheleau *et al,* 1988).

2.7.3 Buffer Zone Agroforestry

The establishment of forest and wildlife reserves and sacred groves conserve natural resources. These areas are managed for the conservation of floral and faunal biodiversity. With population increases, these areas are encroached upon for the benefits they offer, including fuelwood, poles, etc.

A buffer zone can be created around reserves. Tree products can then be harvested from buffer zone, rather than from the forest (Rohecleau *et al,* 1988).

2.7.4 Trees Dispersed on Cropland

Multipurpose trees can be grown dispersed with annual crops the benefits they may provide include (eg, fuelwood, shade fertilizer stakes, etc) and these benefits may be useful enough to farmers to be allowed on cropland (Baumer, 1990).

2.7.5 Live Fencing

Trees can be grown on a farm usually combined with other plants as a live fence to keep animals in or out. Live fences are less costly to install and are easier to maintain. Tree species that can be grown as live fences include *Acacia nilotica, Cassia siamea and Gliricidia sepium* (Rocheleau *et al,* 1998 and IIRR, 1992).

2.7.6 Improved Fallow

Improved fallow is the replacement or enhancement of natural fallow vegetation by introduction of selected trees or shrubs. When crop rotation is alternated with a fallow period, the soil can rest and recover its fertility during the fallow period. The purpose of improved fallow can be to shorten the fallow period. Trees preferably nitrogen-fixing species like *Leucaena spp., Acacia spp., Sesbania spp.* can fulfil economic and ecological functions. Introduced fallow system can help improve soil fertility. This improved fallow system may prove particularly relevant for farmers with secure land tenure and can provide farmers with an alternative source of timber, poles and fuelwood (Rocheleau *et al,* 1988).

2.8 Global Biomass Energy Distribution

Current estimates indicate that biomass energy is the fourth most important source of energy in the world (Scurlock and Hall, 1990). Biomass energy still accounts for a substantial proportion of world energy supply. Its contribution to global energy consumption is higher than that of nuclear energy and hydroelectricity. In the developing world the importance of biomass energy is even more pronounced.

In many sub-Saharan African countries, biomass energy accounts for over 93% of national energy supply (World Bank, 1984); while in the SADCC region the total contribution of biomass energy is estimated to be close to 80% of total energy supply (Kaale, 1997).

As shown in Table 2.3, significant dependence on biomass energy is an important characteristic of the south that can be used to distinguish developing countries from developed nations. Table 2.3 below shows biomass energy distribution with countries such as Germany and the USA consuming very little whilst most developing countries such as Zaire, Rwanda have a high percentage in biomass energy consumption.

Table 2. 3: The distribution of biomass energy in selected countries.

Country	Share of Biomass Energy (National Energy Consumption - %)
Zaire	74
Madagascar	83
Rwanda	87
Haiti	84
Indonesia	48
China	23
India	27
Bolivia	18
Cote d'Ivoire	53
Cameroon	46
Peru	18
Brazil	35
Germany (West)	< 1
United States	1

Source: Office of Technology Assessment (1991); and Peskin *et al.*(1992).

Biomass energy is produced, transported and consumed in a multitude of ways. Biomass energy systems include a wide range of technologies. There is also a wide variation in the sale of biomass energy systems – from the simple and rudimentary, three-stone fire (sometimes known as the open fire), common in many rural areas of the developing world to the multi-million dollar ethanol complexes.

2.9 Fuel wood Energy in Africa

In the sub-regions of Africa the fuel wood situation may be determined by the political economy, the ecology, the geography, the demography and culture. Thus the fuelwood

situation varies from the Sahel across Humid West Africa through Sudan, Kenya and the SADCC countries.

In 1981 the Food and Agriculture Organization (FAO) undertook a survey in order to determine fuel wood supplies and demand for developing countries in Africa (1980-2000 Period of Survey). This was supposed to be one of its contributions to the United Nations Conference on Renewable Sources of Energy. The data was based on projections from the early 1980s but the results present a reasonable picture of the status of fuel wood in Africa.

- Areas where they have been over-exploiting biomass to the extent that there is fuel wood shortage.
- Areas where fuel wood demand is in excess of sustainable supply referred to as Crisis regions.

Areas where population growth is likely to give rise to crisis in the foreseeable future categorized as satisfactory. In this regard the situation in the Sudano-Sahelian region is critical because acute shortages are expected, especially in rapidly growing peri-urban areas. This is occurring because of increased encroachment of agricultural land and industrial residential and commercial developments. Bushfires and fuel wood production compounded by population expansion has also resulted in gradual depletion of fuel wood resources on an annual basis.

Areas estimated to be generally free of fuel wood supply problems include the humid and semi-humid areas. Nevertheless, large urban centers such as Yaounde, Brazzaville and Kinshasa located with the forest ecosystem are already experiencing local

shortages. Fuelwood shortages are also occurring in semi-humid areas of East Africa where very high population densities threaten wood fuel resources. Communal land reserves are particularly in danger of fuel wood depletion.

If fuel wood is insufficient, farmers will burn agricultural waste, which, if just left on the fields, could have a beneficial effect on soil conservation and fertility. Fuel wood is usually collected by women and children, which means that men are not usually interested in planting trees for fuelwood purposes. Women may be discouraged by men from planting trees on farm fields, since this could be interpreted as making a claim on the land.

2.10 Fuel wood and Charcoal Consumption in Ghana

The total annual national charcoal and firewood consumption which rose from 8.2 million tonnes in 1985 to 9.976 million tones in 1990 is expected to reach 11.7 million tonnes by the end of 1994. Based on national population growth figures, it is now clear that charcoal consumption in the country is growing at the rate of 5% per annum and firewood consumption at the rate of 3% per annum. At the present, wood fuel consumption growth rates estimate by forestry experts in the country indicate that in less than 30 years from now most of the country's forest resources would be greatly depleted (Gbeogo Rural Energy Planning Committee, 1994). Table 2.2 indicates the growth in fuelwood consumption over the years.

Table 2.4: Growth in fuelwood consumption in Ghana.

Year	Total Wood Fuel Consumption (m tonnes)
1985	8.2
1986	8.528
1987	8.869
1988	9.224
1989	9.592
1990	9.976
1991	10.375
1992	10.790
1993	11.222
1994	11.671

Source: A paper presented at a workshop for Gbeogo Rural Energy Planning Committee on "Cultivation and efficient utilization of fuelwood resources In the Upper East Region. 28-30th June. 1994.

2.10.1 Household Consumption of Fuel wood in Ghana

In all 69.1 per cent of households use firewood as the main source of fuelwood for cooking. This is followed by charcoal with 26 per cent and to a lesser extent 3.2 per cent use electricity or gas (Ghana Statistical Service, 1999).

2.10.2 Urban Consumption of Fuel wood

Increased reliance on modern fossil fuels and electricity rather than wood fuels usually accompanies economic development. As national income rises more people are able to increased cleanliness, convenience and efficiency associated with modern fuels. For example, wood fuels typically make up 60-95% of total energy use in poor developing

countries, 25-60% in middle income countries and less than 5% in high income countries (Leach, 1988; Leach and Mearns, 1988).

The concept of energy transition is central to any understanding of urban fuel wood use. As urbanization proceeds there is a tendency for household energy use to increase diversity and switch fuel from wood and charcoal to modern fuels. ESMAP (1990a) has discovered this pattern in Indonesia and Soussan *et al* (1990) discuss a number of examples showing a hierarchy of fuel preference with wood at the bottom. Firewood as a sole fuel is used by only 14% of urban households in Ghana (Nketia *et al*, 1988).

It has been realized that unaffordability of expensive cooking gadgets by low income households compel them to depend solely on wood fuel which is economically feasible where locally available and burned in properly designed furnace and stoves, wood should be just as economical as or more or so than other types of fuel (Panshin *et al*, 1962).

According to the Ghana Statistical Services Quarterly Report (1999), the use of firewood decreases in urban households as people become richer. The use of charcoal thus increases with decreasing poverty. It is estimated that in urban Ghana charcoal is consumed by an estimated 61.8% (Ghana Statistical Service Quarterly Report, 1999).

2.10.3 Rural Consumption of Fuel wood in Ghana

Firewood remains the dominant source of fuel wood to most rural households in Ghana. It is estimated that majority of rural households, that is up to 91.8% use firewood as their main source of fuel (Ghana Statistical Service Quarterly Report, 1999).

Over the past decades there has not been any significant changes in the status of wood fuel in the rural economies. The following reasons account for this situation.

1. Wood has been found to be a renewable natural resource which does not require technical knowledge as individuals can produce for themselves.
2. Wood is accessible physically, economically and socially to most rural population in developing countries (Panshin *et al*, 1962).
3. Most rural homes in developing countries have no supply of gas or electricity for cooking and heating.
4. Kerosene provides a substitute only for wealthy minority. As a result wood fuel plays a major role in supplying energy to the rural masses and the poorest groups in the towns. Wood fuels occupies a special place in rural energy systems owing to the importance of domestic consumption for which it is mainly used and the fact that it is produced with the system itself (FAO, 1983).

2.11 Gender Issues in Fuel wood Productivity

The perception of gender in rural communities is manifested in daily life through gestures, rights and practices(Rain tree J.B. 1985).

Women shoulder the labour for tasks vital for the provision of basic needs including fetching of water, gathering and grinding of food, collecting fuel wood and the numerous tasks involved in subsistence agriculture. Women shouldering heavy loads of fuel wood vividly portray one of the major roles females play in the developing world. Rural women with little or no formal education often know about qualities of wood and locations of supply (Lori-Ann Thrupp, 1982). When time and energy constraints become too great, many women report asking daughters and other family member for needed help. Some report describes daughters being taken from schools or family size increasing when more children are needed (FAO, 1983). Life styles or basic resource use begin to change. Substitute foods appear and others are seen less often. Foods formerly cooked are eaten raw or fewer meals are served. Dung may be substituted for fuel wood instead of being applied as manure. Small animals no longer have forage within access of the village and women give up raising of ruminants.

Women have less money as they have fewer resources and less time for producing surplus items for sale or trade. Many family members search for off-season employment (FAO, 1983, Hoskins).

The primary concern of women may be to find sufficient forest products to meet the subsistence needs of their family, while that of men may be to obtain forest products for sale (FAO, 1990; Diggelaar, 1995; Kemerwa *et al.* 1996). This is not to say that men never gather fuelwood like all generalizations; there are exceptions (The World Bank, Forestry Policy Review, 1991).

Argawal (1986) case studies of women travelling several kilometers and spend 3 or more hours a day for fuel wood collection. Fuel wood are smokier and dirtier than modern fuels, women's health may be detrimentally affected. In these and other ways fuel wood stress hit the health and environment of women harder than those of men in many parts of the Third World.

Even though women are often the central actors in fuel wood provision and use, they are rarely able to influence decisions on availability of fuel wood resources. Soussan (1988) and Munshow *et al.* (1988) provide evidence of the central role played by women in fuel wood production and use. Although women are usually the first to experience the effects of fuel wood shortages, it is the men who typically control the land and resources required to tackle the deficits.

2.12 Environmental Effects of the use of fuel wood

Charcoal production as practiced in Ghana is known to contribute greatly to the deterioration of the natural environment through deforestation, etc. (Nketiah *et al*, 1988). The removal of vegetation has several consequences. Some of these have been reported as increases in the proportion of solar radiation reflected into space.

According to Pearce and Turner (1990) desertification, changes in the hydrological cycle and localized edaphic factors (UNSO, 1985), and a decrease in the absorption of carbon dioxide (Tolba, 1991) also have severe consequences on the environment.

Some environmentalists object to the use of wood fuels because of deforestation which is associated with its production and use. For example Morgan and Moss (1981) objected to charcoal production describing it as a wasteful process.

FAO (1990) has cautioned that the emission of carbon dioxide through the burning of wood and charcoal has reached alarming proportions.

NAWAZ (1992) is particularly worried about indoor air population from the burning of wood and charcoal in rural Africa. FAO (1990) and Tolba (1991) cautioned that without action to reduce environmental pollution the earth's system could eventually pass a critical threshold beyond which life forms might not be able to survive.

2.13 (Consumption pattern of fuel wood) Kumasi Metropolis

Kumasi is expanding in all directions and the outlying indigenous villages have become the areas for residential suburbs (Edmundson 1996). The growth and expansion of the city obviously had implication on the socio-economic life of the people and natural resource management for the development of the city and fringe communities or its peri-urban interface (Nsiah Gyabaah 1995).

According to the development plan projections for the metropolitan area (1996-2000) the demand for firewood and charcoal is expected to increase from 1996-2010. In the year 2000 wood fuel requirement for both domestic and commercial consumption was estimated at 1579,708m^3.

Table 2.5: Projected wood fuel demand in the Kumasi metropolis.

Year	Estimated Population	Charcoal (kg)	Commercial Fuelwood (kg)	Equivalent Wood (m^3)
1996	801,458	129,299,220	51,485,662	1,362,073
2000	929,301	149,958,590	59,712,019	1,579,708
2005	1,068,950	170,067,840	68,685,334	1,817,098
2010	1,229,586	79,007,030	79,007,030	2,090,165

Basis: Per capita charcoal consumption:	0.52 kg/day
Per capita fuelwood	1.1 kg/day
Charcoal production efficiency:	16% by wt.
Wood density:	650 kg/m^3
Dependence on charcoal	85°C
Dependence of fuelwood:	8%

2.14 The leading Producer of Sawmill (Residue) in Ghana

According to Economic Survey Report (1984) about 44% of sawmills in Ghana are in Kumasi. Recent estimates indicate that the Ashanti Region generates the highest residue by volume of sawmill residue. It generated a total of 421,450 m^3 of sawmill residue in the form of sawdust slabs/edging and offcuts (KITE, 1995); this being the largest quantity of residue produced by a single region in Ghana.

CHAPTER THREE

MATERIALS AND METHODS

3.0 THE ATWIMA DISTRICT

The forest reserves of the Atwima district where forest fringe communities were selected included the following:

- Asenanyo Forest Reserve – 225.58 km^2.
- Tinte Bepo Forest Reserve – 144.29 km^2.
- Offin Shelter Belt Forest Reserve – 59.62km^2 .
- Tano Offin Forest Reserve - 397.57km^2
- Jimira Main and Extension- 63.36km^2
- Tano Offin Forest Reserve – 397.57km^2.
- Jimira Main and Extension Forest Reserve – 63.36 km^2.

The Atwima District being a source of fuel wood and raw material for sawmills in Kumasi and its proximity made it an ideal location for the project work. The area experiences a double rainfall regime with the major season from May-August and the minor season from September-October. It has a population of 234,759 (NPC, 2000).

The Atwima District has a total land area of 2582 km^2. The Atwima District Assembly gets its highest revenue from the exploitation of timber. In the year 2000 and 2001, the district earned ¢197m and ¢200m from timber revenue respectively (District Assembly Financial Report 2000-2001).

3.1 The Atebubu District

The Atebubu district is the largest of the seven districts within the Brong-Ahafo region and occupies the eastern-most part of the region. It has a land area of approximately 1300 sq. km. Atebubu (07° 46°N latitude, 00° 59°W longitude) is the administrative centre of the district. There are seven sub-districts in the Atebubu district namely: Abease, Amantin, Atebubu, Kajaji, Kwame Danso, Prang and Yeji. In this district the population is made up of the Akan speaking natives and immigrant northerners (Zongo people). NPC figures for the year 2000 puts the figure at 163,307.

This is the least developed district in the whole of the Brong-Ahafo Region in terms of infrastructure (water supply, electricity, feeder roads, etc), rural service (extension agents, agricultural service centers, health services) and general market organization. At the district level Atebubu is the highest producer of yam in the country. The district produced an average of 28,900 tonnes of yam giving an average yield of 15.1 t/ha (MOFA, 1996). In addition to yam production and other farming activities, there are off-farm activities such as game, firewood and charcoal for commercial and household purposes (MOFA 1996).

3.2 Procedure for data collection

Initial Fuel wood market surveys were conducted in the Kumasi Metropolis, where the source of firewood and charcoal were identified. The major source of fuel wood to the Kumasi metropolis was linked to the Atwima and other surrounding districts. The proximity of Atwima district thus made it easier for data collection as compared with the collection of data from other districts such as the Atebubu district.

3.3 Data Collection

The selection of sawmills was based on their size, ten (10) largest sawmills were selected and questionnaires were administered. The sawmills include:

- Saoud Brothers Ltd.
- Ridge Timbers & Co. Ltd.
- Logging & Lumber Ltd.
- MARC timbers & Co. Ltd.
- MAY Co. Ltd.
- Amansie Gh. Ltd.
- PAN Timbers Ltd.
- Paul Sagoe Sawmill Ltd.
- AG Timbers
- FABI Timbers

Two people from each sawmill were interviewed on:

- The types of wood residues that are produced;
- How the residues were disposed off;
- To what uses their residue were put;
- What quantities of residues were produced (on daily, weekly and monthly basis);

A survey of charcoal production from the sawmill residues was conducted.

A cross section of people in charcoal production and distribution who avail themselves were interviewed from each of the following areas:

- Kaase,

- Asokwa,
- Ahinsan and
- Akosombo (near the VRA transformers).

The first section consisted of questions on the personal data of respondents.

- Sources of raw materials;
- The frequency of raw materials;
- The quantities that they were able to produce and
- The marketing and distribution of their products.

City market surveys were conducted. The primary focus was on the prices of firewood and charcoal, sources of the product and problems encountered in their trade. Areas identified in the city survey included: Adum, Anloga, Aboabo, Tafo, Krofrom, Abrepo Junction, Sepebuokrom, Asuoyeboa, Tanoso, Abuakwa and Ayigya

The peri-urban communities identified included Amanfrom, Atasamanso, Anwomaso and Kagyasi. Fuelwood communities surveyed in the Atwima District were Bakoniaba, Adomakokrom, Diasempa, Antwikrom, Adiembra, Ofirikrom, Aboabogya, Okyerekrom, Sebekrom, Akentensu, Kramokrom, Mmehame, Mentukwa, Kobeng, Amanchia, Otaakrom, Fesaso, Kofi Nyamekyekrom, Baniakrom and Fufuo.

Identified village fuelwood markets in the Atwima district were Mmofra Mfa Adwen, Mpasatia, Mankranso, and Beyendenkrom.

The basis for the selection included.

- Those communities that trade in fuelwood were mostly near the roadsides (that is Kumasi-Bibiani road through Atwima district).
- Their nearness to Forest reserves and their remoteness due to unmotorable roads.
- Old and new settlements; this was determined by the size of the community vis-à-vis the population of the community.

In Atebubu district three (3) areas were selected as charcoal production sites. These were Gyato Zongo, Sulemana and Amantin. These were areas that produced yam and used the stakes for the production of charcoal. A cross section of people were interviewed from the areas identified (the communities and the markets identified). Individual interviews, households, group discussions were the methods used in the collection of data. The District Assemblies, and Forestry Offices were contacted for information.

At the peri-urban communities, firewood gatherers, farmers and food vendors were interviewed. In all 100 people were interviewed. It was only in a few cases that direct questionnaires were administered. The areas visited included Amanfrom, Apire, Kagyasi.

In the Atwima district 25 communities were selected for this exercise. The grouping of the communities was based on whether:

(a) They traded in fuelwood (b) they were located near to forest reserves, (c) they were nearn to roadsides, (d) there were available markets for firewood and charcoal, (e) whether the settlements were old or new, and (f) the opportunities for Agroforestry practices in the district.

On the average 10 people were interviewed from each community. However in some cases it was a focal group discussion as individual interviews were conducted. Structured, unstructured, semi-structured questionnaire and participatory rural appraisal techniques were some of methods used in data collection.

Descriptive statistics, mean percentages, tables, and graphs were used to analyze the data collected.

3.2 Constraints in data collection.

The group of people that posed a problem to the research was those associated with charcoal production.

The fear of tax assessment was rife with respondents especially the charcoal producers and sellers and in two instances firewood sellers. It took very lengthy explanation for them to understand that it was purely an academic exercise before the respondents finally opened up for questions and discussions. At the meeting point of charcoal vehicles, that is Tafo and Krofrom, some of the drivers were hostile assuming that they were being assessed for taxation. No explanation could satisfy their curiosity

what finally curbed down their tempers was my student identity card before they opened up for discussions.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.0 Introduction

The results and discussions are presented under the following headings fuel wood production as a livelihood option, age distribution of fuel wood dealers, ethnic composition of people in the fuel wood industry, gender issues in the fuel wood trade, accessibility of communities to urban centers fuel wood preference in communities, fuel wood production, deforestation and land degradation in the study area, trends in the fuel wood trade in the study area, pricing of mill residue, the supply chain of fuelwood,production of residue by sawmills in the study area, the demand for fuel wood, identified sources of charcoal in the in Kumasi,charcoal production methods, price fluctuation of charcoal, bottlenecks in the charcoal trade and opportunities and constraints for Agroforestry.

4.1 Fuel wood Production as a Livelihood Option

Fuel wood was the major source of energy for all communities under the project area. In the Atwima district 99% of all communities used fuelwood in one form or the other (Charcoal and firewood). This was used as household energy and also commercial ventures such as that of kenkey selling, chopbar operation and charcoal production. Fuel wood is the source of energy for most rural communities. The benefits of a well-planned fuel wood industry cannot be overemphasized. Earl (1994) enumerated the benefits of the fuel wood industry to include:

a) Creation of Employment

b) Provision of money in the rural sector

c) Saving in foreign exchange

d) Provision of a chemical fuel base industry

e) Increasing the total profitability of the forest

f) Provision of smokeless fuel for cities (Charcoal)

According to the survey conducted, the production of firewood for sale is mostly a by- product for farmers in the Atwima district. 80% of the people involved in fuel wood trade in the Atwima district were farmers. For some farmers it is purely a business that thrives during the preparation of their farmlands.

Secondly it serves as a source of income for farmers while they wait for their crops to mature for harvest. The peak of the fuelwood industry is during the hamattan when a lot of dry wood is available and the period between MARCH-APRIL when land preparation normally has already taken place. This could be determined by the number of fuel wood stands that were mounted along the Kumasi / Bibiani main road. The number of fuel wood stands can be as high as 100 while it decreased drastically during harvest periods. This period is normally between July to September.

In communities such as Wansanbre, AntwiagyeiKrom, Kufour camp and Debra camp charcoal production is developing very fast. The number of people involved may account for about 18-20% of the population in these areas.

In the Atebubu district communities such as Gyato Zongo Sulemana and Amantin were surveyed for charcoal production. Charcoal production was found to be

normally after the harvesting of yam in most of these areas. The stakes of yam, and other dead wood may be used for charcoal production. Here charcoal production was done to supplement the income from their farming activities. About 70% of the people interviewed were migrant farmers who engage in the production of charcoal after harvesting their produce. The production of fuelwood constituted a minor occupation of most rural communities.

On the other hand the urban dwellers interviewed in Kumasi responded that it was the sole occupation of 90% of the people that were interviewed. Especially with regards to those engaged in the production of charcoal from sawmill residue.

4.2 Age Distribution of Fuel wood Dealers

The age distribution of dealers in the fuel wood industry showed similar patterns in terms of age distribution in most areas that surveys were conducted. The minority groups were people below 18 years of age constituting approximately 10%. This age (below 18 years) group in most cases offered supportive role, they took over business in the absence of parents or during vacation periods. The dominant age group was 18 years to 45 years making up to 70% of the people involved in the trade. The next age group was those above 45 years. This age group makes up to 20% of people involve in the trade. The age distribution of fuel wood dealers in rural and urban areas showed similar patterns. Please refer to the list of plates, plate2 shows the active participation of children below 18 years in the fuel wood trade.

Table 4.1: The Age Distribution of Fuel wood Dealers

Age	Percentage Distribution
Below 18 years	10%
18 years to 45 years	70%
45+ years	20%
Total	100%

Source: Survey Data June 2001

4.3 Ethnic Composition of People in the Fuel wood Industry

The Ethnic Composition of producer's wholesaler's retailer's distributors and other stakeholders was influenced by certain factors. The location of the area in question whether rural or urban had a significant influence on the ethnic Composition. The Sisilas were the most dominant tribe in most areas of charcoal production. Whilst the fuel wood industry in Atwima district was dominated by Ashantis that of Atebubu was dominated by people from Northern extraction.

The same cannot be cited for the production and distribution and retail of charcoal in Kumasi. A mixture of tribes in the Kumasi Metropolis handled the charcoal and firewood industry, with people from northern Ghana slightly more than the rest of the tribes operating in the fuel wood industry.

Table 4.2. Shows the percentage ethnic composition in the fuel wood industry. People with Akan origin such as the Kwahus, Fantis Ashantis Akuampems constituted 45% while those from Northern Ghana were up to 55% with the Sisalas being the major tribe.

Table Table 4.2 The Ethnic Composition of people in the fuelwood industry in the Kumasi. (2001)

Tribe	Percentage
Akan Origin	
Fantis	**20**
Kwahus	**4**
Akuampems	**3**
Ashantis	**15**
Others	**3**
Sub-total	**45**
Northern Origin	
Grushie	**3**
Sisala	**35**
Dagartis	**4**
Hausas	**10**
Others	**3**
Sub-total	**55**
Grand Total	**100**

Source: Survey Data June 2001.

4.4 Gender Issues in the Fuel wood Trade

In the Atwima District the fuel wood women dominated trade. Their trade reaches it peak after land preparation and the planting season where there is less activity on the field. This period is normally from February to May.

The gathering of fuel wood was the major preoccupation of women and children who constituted more than 60% of suppliers to the village fuel wood markets. This confirms the assertion by Hoskins that women have less money as they have fewer resources and less time for producing surplus items for sale or trade. Many family members search for off-season employment (FAO, 1983, Hoskins).

School children on vacation assist their parents in the fuel wood trade. The plate 2 shows the active participation of children at Mpasatia. Children take over the business and while their mothers have to attend to urgent chores. Up to 90% of women in fuel wood trade are concentrated in the retail sector of the business.

However their men counterparts are mostly in the area of land preparation where the harvested residue is gathered as fuel wood. Please refer to the list of plates on gender issues (plate 13 and 14)

Up to 80% of men in the fuel wood trade are in the distribution of the product. Men transport fuel wood to their customers in cities. (Please refer to the list of plates 5and6) 90% of food vendors and fuel wood dealers have sources of fuel wood from their men counterparts. Men buy fuel wood cheaply from rural areas and sell them at windfall profits in the cities.

As high as over 60% of the work in the fuel wood industry is done by women. At the initial stage the felling of trees, that is preparation of farmlands is the preserve of men.

While the gathering and carrying of fuel wood is reserved mostly for children and women.

Junior Secondary School pupils on vacation assist their parents in the fuel wood trade. Plate 1 at Mpasatia shows the active participation of children. In Kumasi metropolis the active participation of children is aptly demonstrated in the production of charcoal. Children contribute significantly examples can be cited in charcoal production at Kaase and Asokwa in Kumasi.

Children take over the business when or while their mothers may have to attend urgent chores. However the bulk distribution of charcoal and firewood turn to be the preserve of men. Out of the number of food vendors, dealers in firewood and charcoal that were interviewed. About 98% had the sources of fuelwood from drivers with whom they have established a good relationship to ensure continuity in supply should the product become scarce? This is particularly relevant in the cases of charcoal from sawmill residue, which experiences intermittent shortages. Their men counterparts are normally drivers of KIA trucks, Benz trucks, tractors, and ford trucks. One charcoal seller at Ayigya indicated that the husband produces charcoal at Nkoranza and supplies it to her for sale. Up to 80% of men in the fuel wood trade are in distribution and 90% of women are concentrated in the retail sector of the business. In Atebubu District men dominated the production and the distribution of charcoal. Over 70% of the producers were men.

Table 4.4 below shows the sex distribution of charcoal producers in the Kumasi metropolis.

Table 4.3: Gender Distribution of Charcoal Producers in Kumasi

Age	Male	(%)	Female	(%)	Total
Below 18 years	6	5.4	15	13.5	21
18-25 years	3	2.7	17	15.3	20
25-40 years	5	4.5	45	40.5	50
40-60 years	2	1.8	18	16.2	2
Total	16	14.4	95	85.5	93

Source: Survey Data June 2001

The sex distribution of sawmill charcoal producers in the Kumasi Metropolis indicates high percentage of females engage in the production of charcoal 86% of women as compared to 14% of men.

4.5 Accessibility of communities to Urban Centers

The accessibility of communities to city centers, or roadsides had tremendous influence on its the participation in the fuel wood trade. The location of communities along the major Bibiani / Kumasi road in the Atwima District was a precursor for fuel wood trade. The majority of communities identified along the roadside actively participated in the fuel wood trade. The high population in some of these communities is also a contributory factor to the shortage of preferred fuel wood species in these communities.

The accessibility factor for fuel wood trade in the Atwima District confirms the assertion made by Nyarkoh (1982) that the extent to which wood is bought and sold on the market in the Ghanaian village is influenced by the nearness of the village to urban centers. The communities identified on the roadside showed shortage of most preferred fuel wood species. These communities also served as markets for urban demand of fuel wood in Kumasi. Some of those communities were Apenkro, Toase, Kobeng, Mofranfadwene, Serebuoso and Nyinahin.

The FAO (1984) clearly states that the urban demand for fuel wood will contribute to the disruption of rural energy supplies.

Table 4.3 shows communities that are accessible in terms of good motorable roads and their nearness to the main road/district capital. On the other hand communities that were remote and had bad roads turned out to have most of the preferred fuel wood species available. This can be attributed to the fact that some of these communities were new settlements compared to the later, their population was less and they hardly participated in the fuel wood trade (basically transportation was a problem in these communities.

Table 4.3 shows communities that served as enclaves for preferred fuel wood species had contributory factors such as well preserve forest reserves, unmotorable roads and smaller population.

Table 4.3 Indicating Enclave Communities for Preferred fuel wood species.

COMMUNITY	AVAILABILITY OF PREFERRED SPECIES	DISTANCES FROM DISTRICT CAPITAL	OTHER REMARKS
Kobeng	Not Available	7 km	Near Jimira Forest reserve
Mpasatia	Not Available	3km	Near Jimira Forest reserve
Amanchia	Not Available	21m	Near Jimira Forest reserve
Ottakrom	Not Available	48km	Along the Kumasi / Bibiani main road
Kyareyaso	Not Available	50km	Along the Kumasi / Bibiani main road
Toase	Not Available	2km	
Srebuoso	Not Available	18km	Near Jimira
Nyinahin	Not Available	40km	Center of most Communities in The district
Akwabraso	Available	58km	Near Tano Offin Reserve
Kramokrom	Available	70km	
Asuontaa	Available	58km	Near Tano Offin Reserve
Akentensu	Available	47km	Offin Shelterbelt
Esase	Available	26km	Unmotrable road Celtis species
Mentukwa	Available	73km	Near Asenanyo and Tano Offin
Adomako Krom	Available	52km	In between Asenanyo and

Continuation of Table 4.3 Indicating Enclave Communities for Preferred fuel wood

COMMUNITY	AVAILABILITY OF PREFERRED SPECIES	DISTANCES FROM DISTRICT CAPITAL	OTHER REMARKS
			Tano Offin
OfiriKrom	Available	79km	Near Desiri
Kyereyase	Available	51.7km	Middle of Offin
Pamoroso	Available	55km	Near Tano Offin
Diasempa	Available	68km	In between Asenanyo and Tano Offin

Source: Survey Data June 2001

Refer to the list of plates, plate7 shows the identification of species at Adomakokrom.

Plate 17 shows a roadside community (Kyereyaso) where firewood has been gathered from a farmland.

4.6 Fuel wood Production, Deforestation and Land Degradation

Fuel wood production has often been cited as a factor, which contributes to the mass decimation of tropical forest. Suggestions that the exploitation of wood for fuel has no adverse environmental consequence are also difficult to support (World Bank Forestry Policy Review February I, 1991, Page 13).

In the Atwima district fuel wood turns out to be a by - product of farming activities. In farmland preparation, trees are cut and some burnt, thereby causing deforestation, but also destroying the organic matter and killing useful soil microorganism. Burning in land preparation predisposes the land to agents of soil erosion making it agriculturally unproductive.

After the preparation of farmlands the larger trees that are felled are subsequently used for fuel wood. This according to data collected up to 80% of fuel wood turns to come from individual farms.

Another source of fuel wood is the by- product of loggers. After logging the dead wood may be used as fuel wood. It is estimated that as much as 45-55% of wood volume of felled trees is left in the forest after logging (KITE 1995). Please refer to the list of plates, plate 10 shows *Amphimas pertrocapiodes* at Diasempa a by-product of logging.

The virtual disappearance of trees from farmlands in the Atwima district can be attributed to increased pressure on land leading to shortening of fallow periods.

According to survey reports from the communities, fallow periods, which used to be 10 years or more has now been reduced to less than 5 years (2 to 3 years).

This has hindered natural regeneration of land making most of the fallow land being populated with "acheampong", *Chronolaena odorata* and elephant grass (*Panicum maxima).*

In the Atebubu district after the production of yam, which is a heavy crop that saps off much of nutrients from the soil, the farmers use the stake for fuel wood. The farmer leaves the land bare with nutrients of the soil sapped after heavy cropping with yam. The difficulty of 30% of farmers interviewed experienced the inability to find

staking material within their farms shows the gravity of the situation. They cut any available tree they will get to stake their yam, contributing much to deforestation.

Commercial exploitation for urban fuel wood and charcoal markets does have an impact in some regions. Fearnside (1989) cites charcoal production for iron smelting in Carajas region of Brazil as a threat to the forest of Eastern Amazon (Bird and Shepered, 1988 in World Bank Forestry Review 1991).

The acacia woodlands of the Bay of Somalia are being devastated by charcoal production for Mogadishu's markets (Bowonder et al 1987 in World Bank Forestry Review 1991).

A study by the International Centre for Research in Agriculture (ICRA) and Crops Research Institute, Ghana (CRI) on sustainable farming practices (2000) states that charcoal burning is a contributor to the depletion of the forest. Charcoal burners fell trees for charcoal burning mostly from the Forest Savannah Transition Zone (FSTZ) contributing tremendously to Savannah expansion. To date, however forests are threatened by the fast disappearance of trees (Kass Yirenchi 2000, Personal Communication).

4.7 Fuel wood Preference of Communities

A fuel wood preference survey was conducted in the Atwima district. While communities that had older settlements and higher population density and were active stakeholders in the fuel wood trade, had very little preference for fuel wood species

(limited in the choice of firewood). Examples of these communities include Kobeng Mpasatia,Mankraso, Amanchia, Otaakrom, Toase, Srebuoso and Nyinahin. Here the preferred species that were available were cocoagya *(Theoborama Cacao)*. This could be attributed to the fact that most of them were cocoa farmers, who collected the dead branches of cocoa as fuel wood.

Other issues that could be linked with the availability of preferred fuel wood species included the presence of motorable roads, nearness of the area to the city and the nearness of the area to a forest reserves whether the reserve is intact or degraded were influencing factors.

The most preferred fuel wood species that was identified were *Celtis species* (these included ***Celtis mildbreadii*** and ***Celtis zenkeri.*** Another specie that was ranked as a substitute for *Celtis* species was ***Citrus sinesis (ankaagya).***

This was followed by ***Theoborama cacao (Cocogya).*** Then followed in that hierarchy was ***Albizia zygia okro,Fiscus exparata (nyaukyerene), Terminalia ivorensis emire, Amphimas pterocarpiodes yaya, fiscus (anomani) doma, Rauwolfia vomilaria (kakapenpen)*** and ***Phyllanthus papea.***

Table 4.5 illustrates fuel wood preference by communities with *Celtis* species identified overwhelming by group discussions individual interviews as the most preferred fuel wood specie in terms of wood quality. The Plate 4.5 illustrates group discussions on fuel wood preference by communities. An individual farmer

identifying *Celtis* species is depicted at Kramokrom. Plates of other species are also shown in subsequent pages.

In Atebubu, in communities such as Sulemana and Amantin, the species of fuelwood identified included 1) *Pterocarpas erinaceous*, 2) *Daniella oliverii* and 3) *Isoberlina doka*.

Table 4.5: Preferred Fuelwood Species in Order of Preference

SCIENTIFIC NAME	LOCAL NAME
Celtis mildbreadii	Esa fufuo
Celtis zenkari	Esa kokoo
Citurs sinesis	Ankaa gya
Theoborama cacao	Cocogya
Albizia zygia	Okoro
Fiscus exparata	Nyankyerene
Terminalia ivorensis	Emire
Amphimas pterocarpoides	Yaya
Fiscus anomani	Doma
Rauwolfia vomitoria	Kakapenpen
Phylanthus discodiens	Papea

Source: survey data 2001

4.8 Trends in the Fuel wood Trade

The gathering of firewood was mostly from farmlands after land preparation firewood may also be gathered from reserves after the harvesting of logs has taken place over a period of time. Firewood may also be gathered from the wild. Some community fuel wood markets such as Mmofranfadwene admitted to having had to cover longer distances than they use to cover in the previous years. Normally fuel wood traders gather their firewood in small quantities, daily, depending on the head load that an individual can carry in a day gradually an individual builds his/her stand with his/her

entire family. Please refer to the list of plates, plate 13 and 14 show heads loads of firewood by individuals building their firewood stands.

The gathering of fuel wood is at its peak during the harmattan periods and during period that farmers have prepared their lands and it is an activity that sustain farmers while they wait for their crops to mature. Interaction with fuel wood gatherers indicated that they now have to cover longer distances than before together firewood.

The fuel wood situation in the peri -urban communities however has a different dimension. Here the future of fuel wood industry looked rather bleak. This was due to the fact that land was in high demand for residential purposes. In all situations individuals (traders) (both traders in fuel wood and food vendors) lamented on the eventual collapse of their trade in firewood since their current gathering areas would soon be given to Estate developers. The rapid expansion of residential housing in these areas meant the gatherers had to cover longer distances. According to Food vendors that were interviewed the price of firewood had been rising astronomically every year. One of the traders showed a quantity of firewood she bought for ¢50,000 which has double to ¢100,000 in just 8 months.

All the various groups that used the by-product in charcoal production also expressed shortage of sawmill residue used as fuel wood. These areas included; Asokwa, CMB Jute and Ahinsan, they expressed the fact that there were occasions that they could not get any supply of the mill residue.

Chop bar operators at Adum, Sepebuokrom and others also expressed this issue of shortage of sawmill residue used as firewood. Shortages in the supply of charcoal from transitional zones was a problem experienced especially during rainy season. This situation is supported by the fact during these periods the roads to charcoal producing areas are so bad that trucks find it difficult to convey the charcoal from the hinterlands also because of the rains large quantities are not produced thus creating shortages in the markets. (A plate depicting shortage of charcoal where market women are unable to get charcoal for retail is shown as plate 23).

Sawmill charcoal, which was not found at certain fuel wood markets, is now available in most areas. The areas identified with sawmill charcoal include Anwomaso, Adum, Ayigya, Asewasi, and Asokwa. In most cases sawmill charcoal was being sold side by side with charcoal from other areas.

Another development was that more and more communities in Ashanti were identified as producing charcoal, which formally was not the case. The areas that were identified included Sekyeredumasi, Sekyere west and East Effiduasi, and communities such as Antwiagyeikrom, Wansanbre, Kyekeyerewere, Kufuor camp and Debra camp in the Atwima District.

4.9 Pricing of Mill Residue

Sawmill residue was identified as raw material for fuel wood for both firewood and charcoal production in Kumasi. Data from the areas surveyed indicates that mill residue constitute about 10-15% of fuel wood markets. However emphasis on

quality and price per load of sawmill residue depends on the availability of the material, quality of the material (size, hardness of the wood). The cost of a tractor load of off cuts depended on the quality of the material and its availability. Whether the Off-cuts were of hardwood such as mahogany, odum, teak and etc. Depending on the material this could affect the quality of charcoal that was produced.

The following were prices given by various producers as price per tractor load, depending on the grade of the material. Table 4.6 indicates the quality, quantity and price of the product. It gives the various grades and prices the producers paid per tractor load. A to E shows the grades in quality in hierarchical order.

Table 4.6: Sources of Raw Material (mill residue) and their Prices

QUALITY	QUANTITY	PRICE OF PRODUCT
A	1 tractor load	¢150,000
B	1 tractor load	¢120,000
C	1 tractor load	¢100,000
D	1 tractor load	¢80,000
E	1 tractor load	¢60,000

Source: Survey Date June 2001

(A to E shows the quality in hierarchical order per tractor load.)

The pricing of mill residue was determined according to the quality of the by-product. The prices were higher when charcoal producers and food vendors expected it to be a good material for firewood or charcoal.

The table 4.7 shows the firewood price for the year 2000/2001 from the table it would be noted on the average there has been about 45% increase in the price of firewood over a year. The most stable market is that of Ayigya with less than 5% increase in price of firewood while the highest in the hierarchical order is Asuoyeboah, Abuakwa and Tanoso. The table shows the prices of fuel wood, year 2000/2001 and source of fuel wood.

Table 4.7: Firewood Markets in the Kumasi Metropolis (2001)

SUBURB	PERVIOUS YEAR PRICE LOAD YEAR 2000	YEAR 2001 PRICES PER LOAD	SOURCE OF FUELWOOD
Asuoyeboah	¢200,000 per KIA load	¢350,000 per KIA load	Mpasatia, Mankraso Kobeng
Abuakwa	¢200,000 per KIA load	¢350,000 per KIA load	Toase, Mpasatia, Mankraso, Amanchia, Kobeng
Tanoso	¢210,000 per KIA load	¢360,000 per KIA load	Atwima District
Sepe Buokrom	¢ 100,000 per tractor load	¢150,000 per tractor load	Sawmills
Anloga	¢ 30, per motor car	¢35,000 per motor car	Anloga
Adum	¢120,000 per Tractor load	¢150,000 to ¢160,000 per tractor load	Sawmill other sources
Asewasi	¢110,000 per tractor load	¢150,000 per tractor load	Sawmill
Aboabo	¢100,000 per tractor load	¢140,000 per tractor load	Sawmill
Fanti Newtown	¢250,000 per Benz 508	¢400,000 per load Benz 508	Nkwamtakese, Techiman road
Bohyen	¢250,000 per KIA load	¢360,000 per KIA load	Amanfrom Estate, Dabaa, Seidi
Ayigya	¢250,000 per KIA load	¢250,000 per per KIA load	Apeadu, Boadi, Kobeng

Source: Survey Data DEC-MARCH 2001

4.10 The Supply Chain of Fuel wood

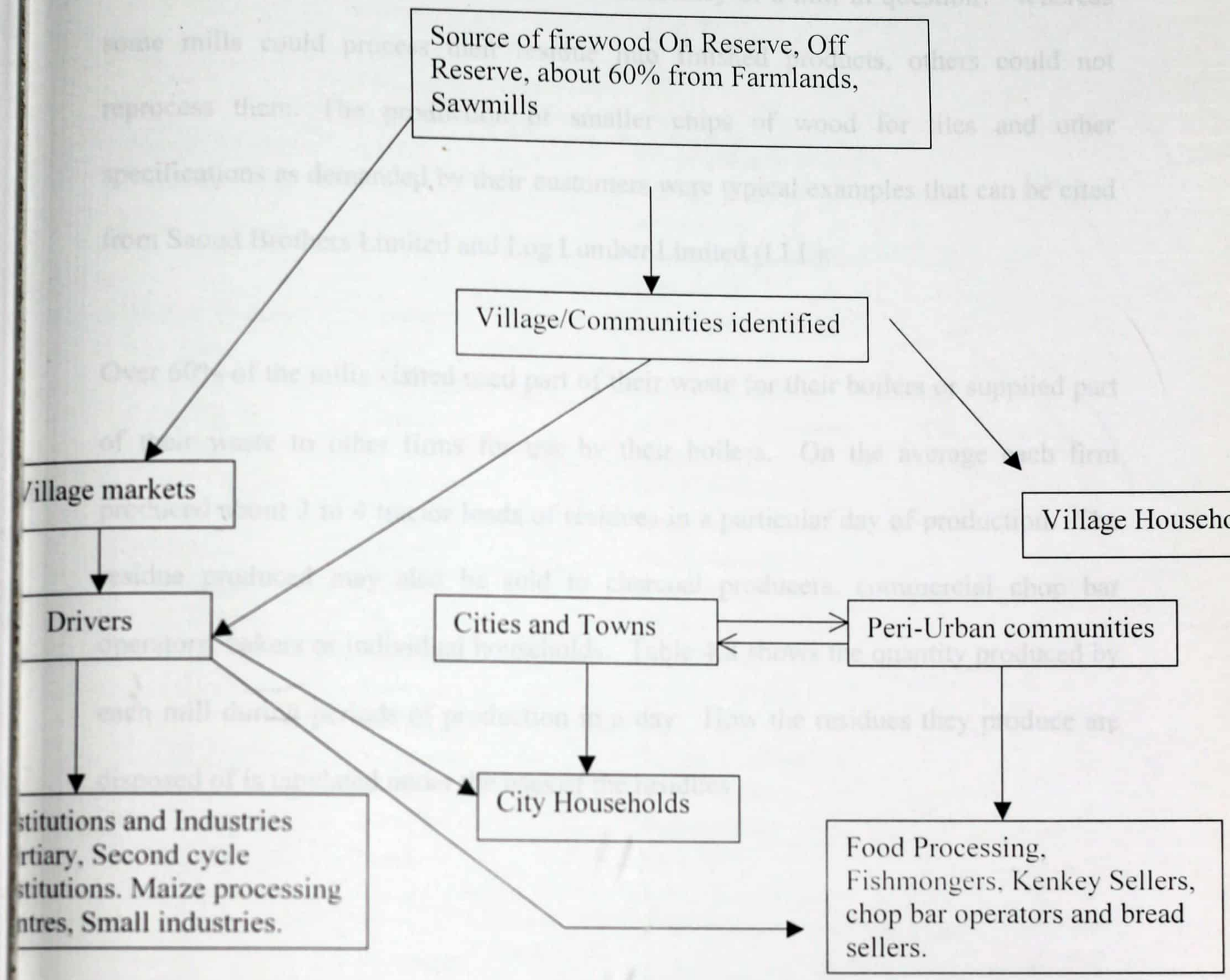
The supply chain of fuel wood is illustrated by using the diagram as illustrated in the figure 4.10. The figure identifies the sources of firewood in the study area as from on reserve, off reserve farmlands and sawmills with that from farmland constituting over 60% of firewood.

This was followed by villages/communities that were involved in the firewood trade; this is further linked up to village markets, which are mostly located along the main roads in village communities. Part of the firewood goes to household at the village level.

Drivers play a significant role in the supply chain since they turn to establish personal relationship between them and firewood market women, food vendors and institutions.

Some peri-urban communities may send their firewood to the city or towns. A household that need firewood in small quantities may buy from the market is also shown. Food processors such as groundnut sellers and etc. may get their supplies from the market (mostly small scale) traders.

Figure 2: The Supply Chain of Firewood



4.11 Production of Residue by Sawmills

What is termed as residue depends on the efficiency of a mill in question? Whereas some mills could process their residue into finished products, others could not reprocess them. The production of smaller chips of wood for tiles and other specifications as demanded by their customers were typical examples that can be cited from Saoud Brothers Limited and Log Lumber Limited (LLL).

Over 60% of the mills visited used part of their waste for their boilers or supplied part of their waste to other firms for use by their boilers. On the average each firm produced about 3 to 4 tractor loads of residues in a particular day of production. The residue produced may also be sold to charcoal producers, commercial chop bar operators, bakers or individual households. Table 4.8 shows the quantity produced by each mill during periods of production in a day. How the residues they produce are disposed of is tabulated under the uses of the residues.

Table 4.8: Production of Residue By Sawmills

SAWMILLS	QUANTITY PRODUCED DURING PRODUCTION PER DAY	USES OF RESIDUE
Saoud Brother Limited	5 tractor loads	Reprocessing boiler's Energy fuel wood for food processors Charcoal production etc
Ridge Timbers Co. Ltd.	1 tractor Loads	Burnt as waste used As firewood
Kumasi Logging & Lumber	4 tractor Loads	Boiler's energy for fuel wood charcoal and firewood
Marc Timber Co. Ltd.	2 tractor Loads	Sold to outsiders feel boiler etc.
Amansie Ghana Ltd.	4 tractor Loads	Boiler energy Fuel wood
Pan Timber Ltd.	3.5 tractor Loads	Sold to outsiders fuel wood
AG Timbers	5 tractor Loads	Boiler energy fuel wood
FABI Timbers	5 tractor loads	Boiler, Fuel wood
Paul Sagoe Sawmill Ltd	4 tractor Loads	Significantly for use of their boiler
L.L.L.	6 tractor loads	Boiler's energy. Fuel wood
Total	36 tractor Loads	
Average	3.6 tractor Loads	

4.12 The Demand for Fuel wood

Population growth and urbanization are changing the ways wood resources are managed and also producing new forms of fuel wood stress. Urban energy demand is increasing important and for many countries will be the dominant energy policy issue

in the near future. Urban growth rates of up to 10% per year are the norm in Africa. (World Bank Forestry Policy Review 1991).

The above mentioned, assertion is partly demonstrated at various fuel wood markets that is, village/community market, peri-urban markets and city markets. The higher frequency at the urban markets attest to an ever-increasing demand for fuel wood.

The demand for fuel wood is determined by the request for fuel wood at the various markets over a period of time.

At the community level there is hardly the demand from the fuel wood markets by individual households. Households mostly gather their fuel wood from their individual farms. However the only exception may be commercial food vendors. At the community level if one needs fuel wood, you have to make a request according to one's specification before one's demand is met. There may be isolated cases where a few bundles would be sold to individuals, but this is a rare incident.

In Table 4.8 the frequency of buyers at various fuel wood markets per week were recorded and it was realized that the frequency of buyers at the various market differed greatly.

The number of buyers per week at the village market was 20%, 30% at the peri-urban and 50% respectively at the city market/urban market. This indicates the cumulative demand fuel wood at the various market markets per week. This indicates the cumulative demand for fuel wood at the various markets per week. The wide disparity

Between the rural and urban markets can be attributed to wide range of factors. At the village market their products are bought by middlemen drivers in bulk thus the less the frequency of buyers.

At the peri-urban markets most people are switching from the use of firewood because most of their lands are now being used for residential purposes. Thus most people turn to use charcoal and gas. This accounts for the frequency of buyers at 30%. However at the urban markets cordial customer/client relationship established between buyers/sellers keeps the demand going. Most people that demand fuel wood turn to be commercial food vendors.

Table Table 4.9: The Frequency of Buyers at Fuel wood Markets

LOCATION	Average No. Of Buyers per week taken within a week	PERCENTAGE DISTRIBUTION
Village Community Markets Mpasatia Mfranfadwene	8	20%
Peri-urban Markets Anwomaso Amanfrom	12	30%
Urban market Ayigya Adum	20	50%
Total	40	100%

Source: Survey Data November 2001

4.13 Organization of the Charcoal Trade

The sources of materials for charcoal production; were identified as residue Off-cuts slab from the mill stakes of yam, wood from the farmlands and the forest.

The types of charcoal identified were soft charcoal and hard charcoal. The soft charcoal was mainly from residue from the mill (sawmill) while the hard charcoal was identified as charcoal mainly from the transitional zones. More communities in Ashanti Region are also emerging as areas of charcoal production. These areas include Mampong, Sekyeredumasi; and areas in Atwima district such as Debra camp, Wansanbre, AntwiagyeiKrom, Debra camp, Kufour camp and Kyekyewere. The areas of production identified for the production of sawmill charcoal were

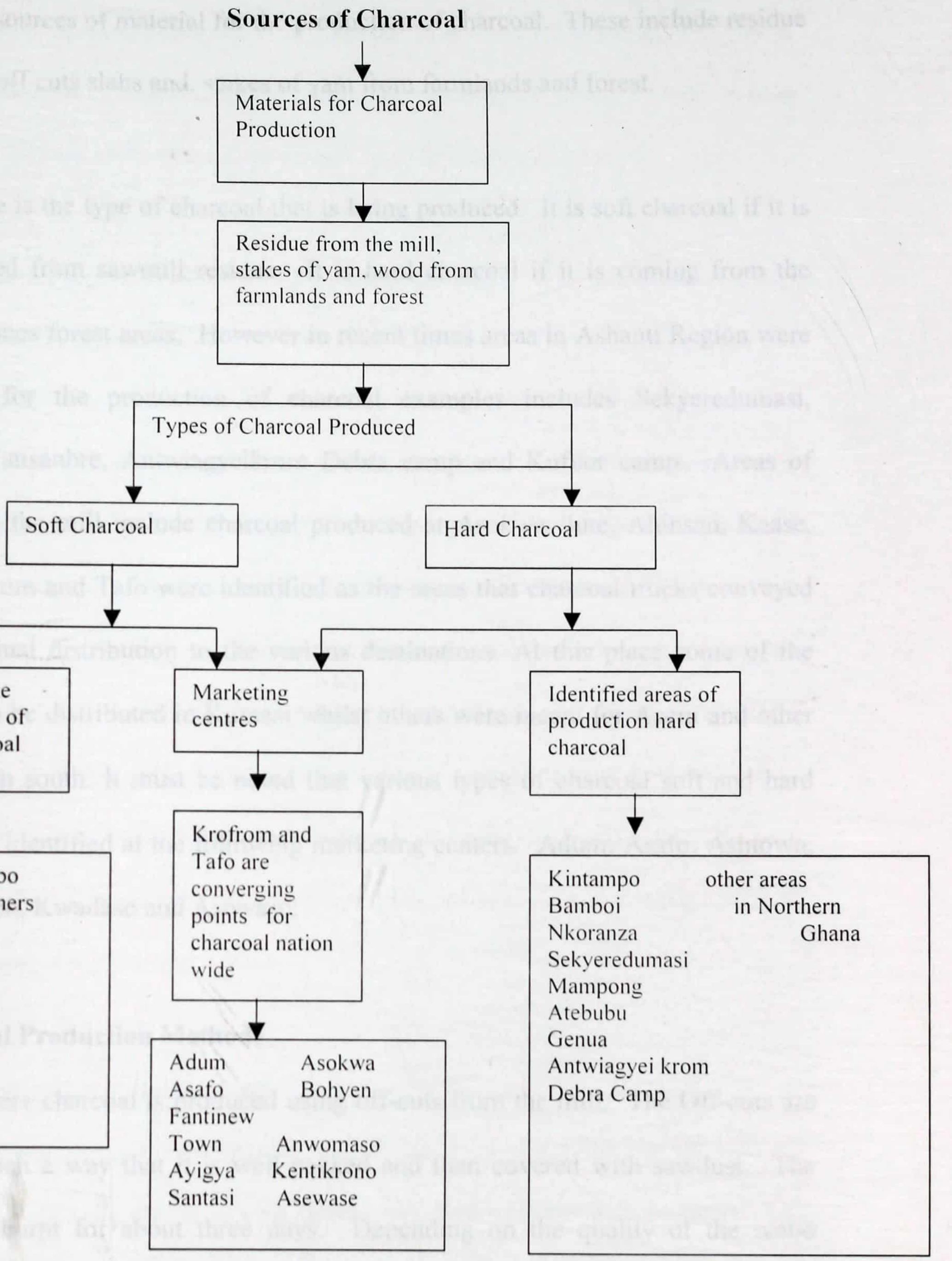
1) Akosombo VRA Transformers
2) Kaase
3) Asokwa
4) Ahinsan (Jute)
5) Anloga

The areas identified for the production of hard charcoal also include areas in the transitional zone such as Kintampo, Bamboi, Nkoranza, Techiman, Atebubu and other areas in northern Ghana.

The main marketing centers that were identified are Kromfrom and Tafo and these were identified as the converging points for drivers of charcoal vehicles. (Plate 23 shows groups of women coming to buy charcoal in bulk from the area.) There were some drivers in transit from these areas to other parts of the country.

Some of the marketing centers identified served as areas for trade in both charcoal from the mill and other sources (such as transitional zones, Nkoranza, Techiman and etc.) These market centers include. Adum, Asafo, Fanti Newtown Ayigya Santasi Asewase, Anwomaso, Bohyen, Kwadaso, Kentinkrono, Abuakwa, Tanoso Asuoyeboah and etc. The diagram in figure 2 illustrates the sources of charcoal, materials for production, types of charcoal produced, areas of production and marketing centers.

Figure 2: Organization of Charcoal Trade



4.14 Identified Sources of Charcoal in Kumasi

Figure 2 seeks to identify the sources of charcoal in the city of Kumasi. The figure identifies the sources of material for the production of charcoal. These include residue from the mill off cuts slabs and. stakes of yam from farmlands and forest.

The next stage is the type of charcoal that is being produced. It is soft charcoal if it is being produced from sawmill residue. It is hard charcoal if it is coming from the transitional zones forest areas. However in recent times areas in Ashanti Region were being noted for the production of charcoal examples includes Sekyeredumasi, Mampong, Wansanbre, Antwiagyeikrom Debra camp and Kufuor camp. Areas of charcoal from the mill include charcoal produced at Asokwa, Jute, Ahinsan, Kaase, Anloga. Krofrom and Tafo were identified as the areas that charcoal trucks conveyed before their final distribution to the various destinations. At this place some of the trucks were to be distributed in Kumasi whilst others were meant for Accra and other locations down south. It must be noted that various types of charcoal soft and hard charcoal were identified at the following marketing centers. Adum, Asafo, Ashtown, Ayigya, Bohyen, Kwadaso and Asewase.

4.15 Charcoal Production Methods

In Kumasi where charcoal is produced using off-cuts from the mill. The Off-cuts are arranged in such a way that it is well packed and then covered with sawdust. The materials are burnt for about three days. Depending on the quality of the wood however a whole load can be ready the next day if the wood is soft (example wawa).

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Their counter parts in the rural areas however use the pit method and are covered with sand. The wood burns gradually until the end product is ready. According to Kass-Yirenchi the charcoal burners use traditional method of preparation of charcoal, which are very inefficient. Only about 40% of the wood is obtained as charcoal and the rest goes to waste as ash or unburned wood (Kass-Yirenchi personal Communication).

4.16 Price Fluctuation of Charcoal

At the various charcoal markets identified the price of charcoal ranged from ¢14,000 to ¢20,000. This situation arises because of transportation and also charcoal dealers put a profit margin on each bag of charcoal they sell. The distance from the source of charcoal also accounts for the variation in prices of the product.

The minimum unit for the measurement of charcoal sold to costumers varied at various areas. Plate 28 shows the minimum unit of measurement at Asuoyeboah and Ayigya.

The prices of charcoal at Adum, Asuoyeboah, Aboabo, Ayigya and other areas the survey covered indicated that charcoal is sold to customers at ¢1000 per pan, pellet or the charcoal was already packed in rubber bags.

However in SepebuoKrom, Krofrom and Tafo charcoal can be bought in a quantity for ¢500 per pan/rubber bowl. Reasons assigned for this development was the financial situation of customers. The reason for this development was that charcoal retailers had their source of charcoal without having to incur further transportation cost. However another reasons accounting for this development is the fact that these areas are situated

at the main converging points of Tafo and Krofrom thus contributing to this price level. Table 4.10 shows the suburb, type of charcoal and the sources of charcoal. Price per bag of charcoal at Krofrom/Tafo was ¢15000 per bag. With price fluctuation all year round it was difficult to establish the present and previous year prices

Table 4.10: Charcoal Price Survey in Kumasi

SUBURB/TYPE OF CHARCOAL	SOURCES OF CHARCOAL	BAG PRICE PER CHARCOAL	MINIMUM PRICE
Adum Soft charcoal Hard charcoal	Asokwa Kaase Mampong Ejura Atebubu Northern Ghana	¢20,00 per mill charcoal ¢20,00 per hard charcoal	¢500 per rubber bowl for mill charcoal ¢1000 per bowl rubber for hard charcoal]
Anloga Soft charcoal	Residue from Capentry Shops Anloga	¢18,000 per mill charcoal	¢500 per pan
Tafo/Krofrom Hard charcoal	Mampong Ejura Nkoranza Kintampo Atebubu Sampa Genua Northern Ghana	¢15,000	¢500 per rubber bowl
Abrepo Junction Asuoyeboah Tanoso Abuakwa Hard charcoal	Tafo/Krofrom Wansanbre Debra Camp Techniman Kintampo Nkoranza	¢16,000 ¢20,000	¢500 per rubber bowl ¢1000 per pan/rubber bowl [in polythene]
Ayigya Hard & Soft Charcoal	North mill	¢20,000 ¢20,000	¢1000 per rubber bowl
Anwomaso	Mill/North	¢20,000	¢500 per rubber bowl

Source: Survey data 2001

During the rainy season when there is a shortage of charcoal, the retail price per bag of charcoal sells between ¢17,000 to ¢20,000 at the charcoal converging points of Tafo and Krofrom. However during the dry season when there is plenty of charcoal the price of charcoal drops to as low as between ¢14,000 to ¢16,000. This situation arises because of unmotorable roads to production areas also due to the rains charcoal producers are unable to produce enough quantities to meet the high demand for charcoal.

The prices of charcoal at Adum, Asuoyeboah, Aboabo, Ayigya and areas the survey covered indicated that charcoal is sold to customers at ¢1000 per pan or a rubber bowl packed in polythene bags.

4.17 Bottlenecks in the Charcoal Trade

Interaction with stakeholders of the charcoal industry was the most hostile. The producers and retailers were unwilling to give information about their business. This can be attributed to the difficulties that they go through before the charcoal finally gets to their final destination.

According to the drivers that were interviewed before they can load charcoal, they need to get a conveyance permit which cost ¢25000. There after they have to pay ¢1000 per each bag of charcoal to the District Assembly of the area. Sometimes personnel from the Forestry Services Division, Police and Customs Officials harass them. They some times have to bribe their way through these officials before the charcoal finally get to the retailers.

According to the drivers the shortage of charcoal during the rainy season can be attributed to the fact that during these periods the roads to the charcoal producing areas are normally in a very bad state. This situation is such that it renders the roads unmotorable and their trucks normally get stacked in the mud.

Another reason was that charcoal was normally produced under very dry conditions. Thus they are not able to produce much during the wet season.

A survey conducted during June 2001 at the major supply converging points of (Krofrom and Tafo) shows shortage of charcoal with majority of retailers unable to get the product in bulk. (Please refer to Plate 23)

4.18 Opportunities and Constraints for Agroforestry

Most farmers interviewed in both districts turned out to have considerable knowledge of Agroforestry practices. The use of shade trees in cocoa farming and the use of live stakes in some farms at Atebubu attest to the fact that there is indigenous knowledge for Agroforestry in both districts. A sampling of a group of farmers at the Atwima district indicates that most farmers have some knowledge about Agroforestry.

Table 4.11 indicates farmers' knowledge in agroforestry and majority of respondent farmers turned to have a fair idea of what agroforestry is about.

Table 4.11 Shows Farmers Knowledge in Agroforestry

KNOWLEDGE	NO. OF RESPONSES	% DISTRIBUTION
YES	41	82
NO	9	18
TOTAL	50	100

Source: Survey Data 2001

Yes: means whether they had some knowledge about Agroforestry.

No: means they had no knowledge of Agroforestry.

Out of 50 farmers from the districts (Atwima and Atebubu) 41 farmers had knowledge in Agroforestry while 9 had no knowledge in Agroforestry. Species like *Tectona grandis* were familiar because they have seen their colleagues benefit from agreement with timber contractors by establishment of teak plantations. The monies that accrue to farmers that get this kind of agreement turns to attract a lot of other farmers. However just about 5 farmers in five communities have actually benefited from this kind of agreement.

The issue of Taungya system is becoming a popular idea especially in forest fringe communities such as Kyekyewere Asuotaa and Akwabraso. The reason accounting for this phenomena stems from the fact that most of the lands in these communities turns to be small land holdings because of the presence of forest reserves and because any time one visits such a community they seize the opportunity to appeal to you to plead with the Forestry Service for the release of land for the Taungya system. Out of a 100 farmers interviewed in the Atwima district, less than 20% had animals. Even if

they had they were limited in number. On the average each farmer had between 5 to 10 sheep and or goats as well as 5-15 local breed fowls. The animal component in of communities interviewed was rather minimal.

In the Atebubu district the unavailability of stakes for yam in some farms indicates that some farmers are prepared to have their own woodlots. However the interest of the migrant farmers were less enthusiastic as compared with that of farmers who stayed permanently on their land. 70% of the farmers that were indigene were prepared to have their own woodlot as compared to 30% of migrant farmers. In Atebubu district the animal component was higher, that is on the average each farmer had between 10-20 sheep, or goats and 10-25 local bird fowls. Thus the tree component may also include fodder trees.

In some cases some farmers had cows. An Agroforestry system with a livestock component or fodder banks seems to have the necessary indicators for a take off.

However on the other hand there were certain problems that were identified as posing a limitation to the development of Agroforestry in the two districts.

The first problem is the land tenure system the ownership of land has tremendous influence on farmer's ability to practice Agroforestry technologies. In the Atwima district most lands are family lands and this accounts for about 60% of land holding in the district. The land belongs to a group of brothers and sisters father, wife and husband. This form of land holding makes it difficult for one party to decide as to whether one would like to incorporated trees in the farming system. The practice of shared cropping with tenant farmers was also common in the district. However the

most familiar tree crop was cocoa. There were cases of shared cropping for instance were the farmer divides the land into three parts and the landowner takes a third of the produce known as "abusa". There were situations where the land was divided into two and the landowner and tenant each had, half, this is referred to as "abunu" such land arrangement makes it difficult for Agroforestry technologies to be practiced since in most cases the tenants farmers are expected to leave the land after harvesting their agricultural crops.

In the Atebubu district most migrant farmers after 3 to 4 years of cropping the land with yam move to other areas. Hence bringing in a tree component turns to be a difficult task, in the sense that the migrant farmer would not see himself as beneficiary to the tree component.

The size of farmlands tends to be a hindrance to Agroforestry practices since the majority of farmers tend to have small holdings of land thus bringing in a tree component is perceived by farmers as a trade off with food crops production the table 4.12 indicates that majority of farmers tend to have small size of farm lands.

Table 4.12: Farmland Distribution

SIZE (In acres)	NO. OF RESPONSES	% DISTRIBUTION
1 – 5	22	73
6 – 10	3	10
11 –15	1	3
16 – 20	2	7
21 – 25	1	4
26 – 30	1	3
Total	30	100

Source: Survey Data: MARCH 2001

The table indicates that 73% of farmers have land between 1-5 acres of land this situation aptly applies to both Atebubu and Atwima district.

Records from the Atwima district and Atebubu district indicates past experiences of problems with agroforestry interventions. On site farm experiment by the German Technical Cooperation (GTZ) in the Atebubu district, on alley farming did not get support from farmers. One of the reasons given for the failure of the programme was that the farmers found the management practices too cumbersome to implement.

In the Atwima district there had been instances where the Forestry Services Division had failed to implement the Taungya system because farmers wanted to stay permanently on the land allocated for taungya system. The farmers decided to destroy the tree component in the Agroforestry system to enable them stay longer on the land.

There are a lot of reserves in the Atwima district and these include Asenanyo,Tinte Bepo,Tano Offin, Offin Shelter belt,Jimira main and Extension forest reserves. This means that the off reserves and lands allotted to communities along reserves should be used judiciously. Encroachment for new fertile lands is also rampant in the area. An Agroforestry system with fast growing nitrogen fixing trees such as *Leacena,Gilricidia sepium* would help greatly to restore the fertility of the land.

The accessibility of the Atwima district to Kumasi, the reliance of most fuel wood markets on the district as it source calls for great concern. This situation poses a threat to the districts Woodstock. The activities of illegal chainsaw operators and the rate of exploitation of the district's timber resource call for some kind of intervention. Fast growing fuel wood species such as acacias can go a long way to meet fuel wood needs. Farmers interest in economic trees like fruit bearing trees such as citrus can be incorporated in an Agroforestry system.

In the Atebubu district the provision of stakes for yam is a priority. Fast growing multipurpose trees in Agroforestry system is needed. A tree component is expected to provide fodder for animals, stake and mulch. The farmer's income can also be diversified by including fruit trees.

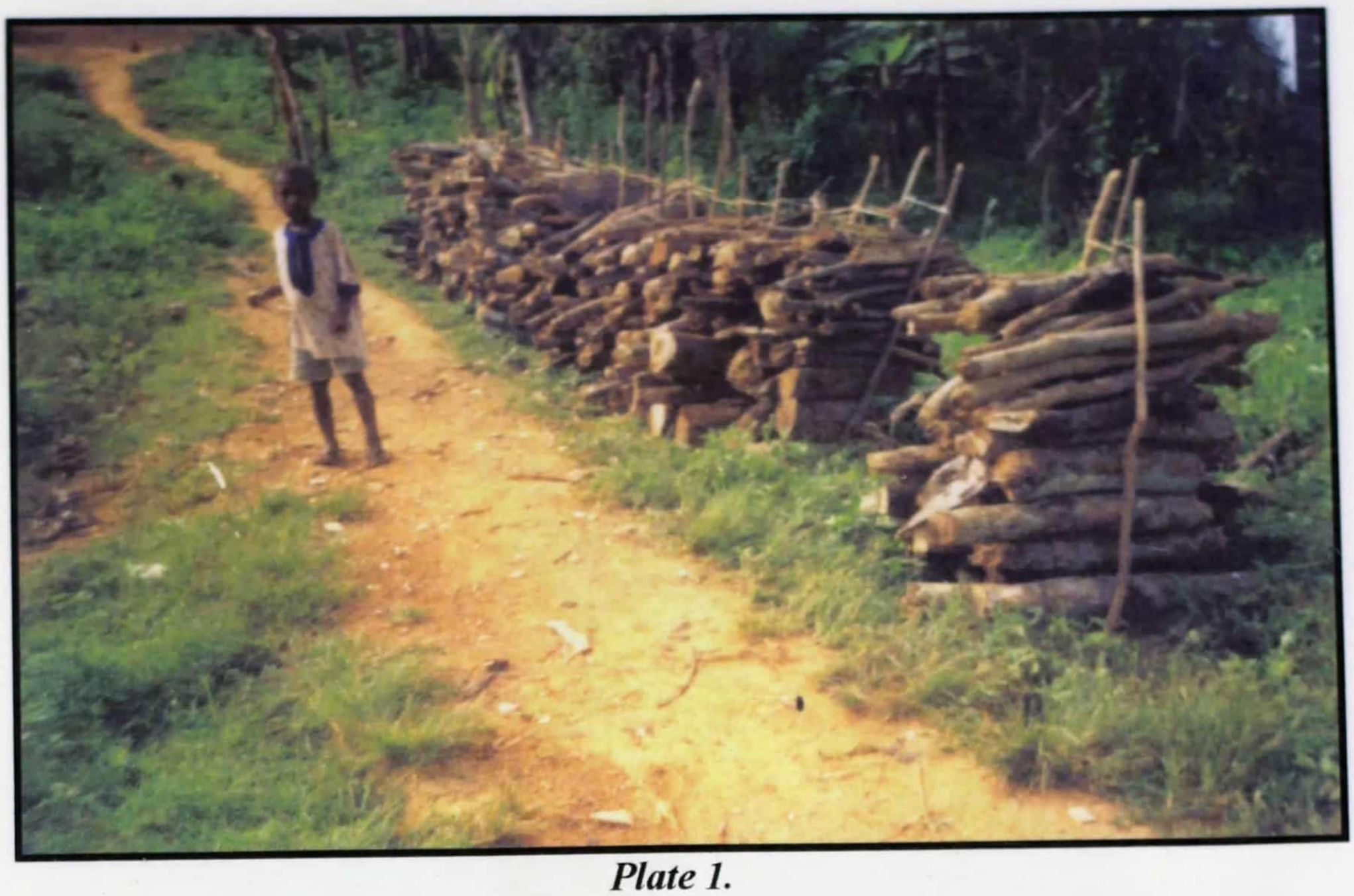

Plate 1.

Firewood market at Mofranfadwene, the stick stands is used to separate each range of firewood. (¢ 2000 per bunch)

Plate 2.

Mpasatia Firewood Market the stick stand was used to separate each range of firewood. (¢ 2000, per bunch)

Plate 3.

Firewood Markets at Anwomaso a periurban community. (¢2000 per bunch).

Plate 4.

Firewood at an urban Market, ¢2000 per bunch, (Tanoso)

Plate 5.
A Benz Truck load of firewood which cost ¢400,000 but cost ¢250,000 the previous year. (Fanti-Newtown)

Plate 6.
A KIA Truck load of charcoal: The KIA Truck was wide used in the transportation of both firewood and charcoal. (Tafo)

Plate 7.

A Woman being interviewed at her house. *Ficus experata* lies behind the woman, while *ficus anomani is the one in currently in use (Adomakokrom)*

Plate 8.

Focal group discussion on fuel reference with community members at Akentesu. The Chief in smock and community members.

Plate 9.
Celtis species being identified at Kramokrom.

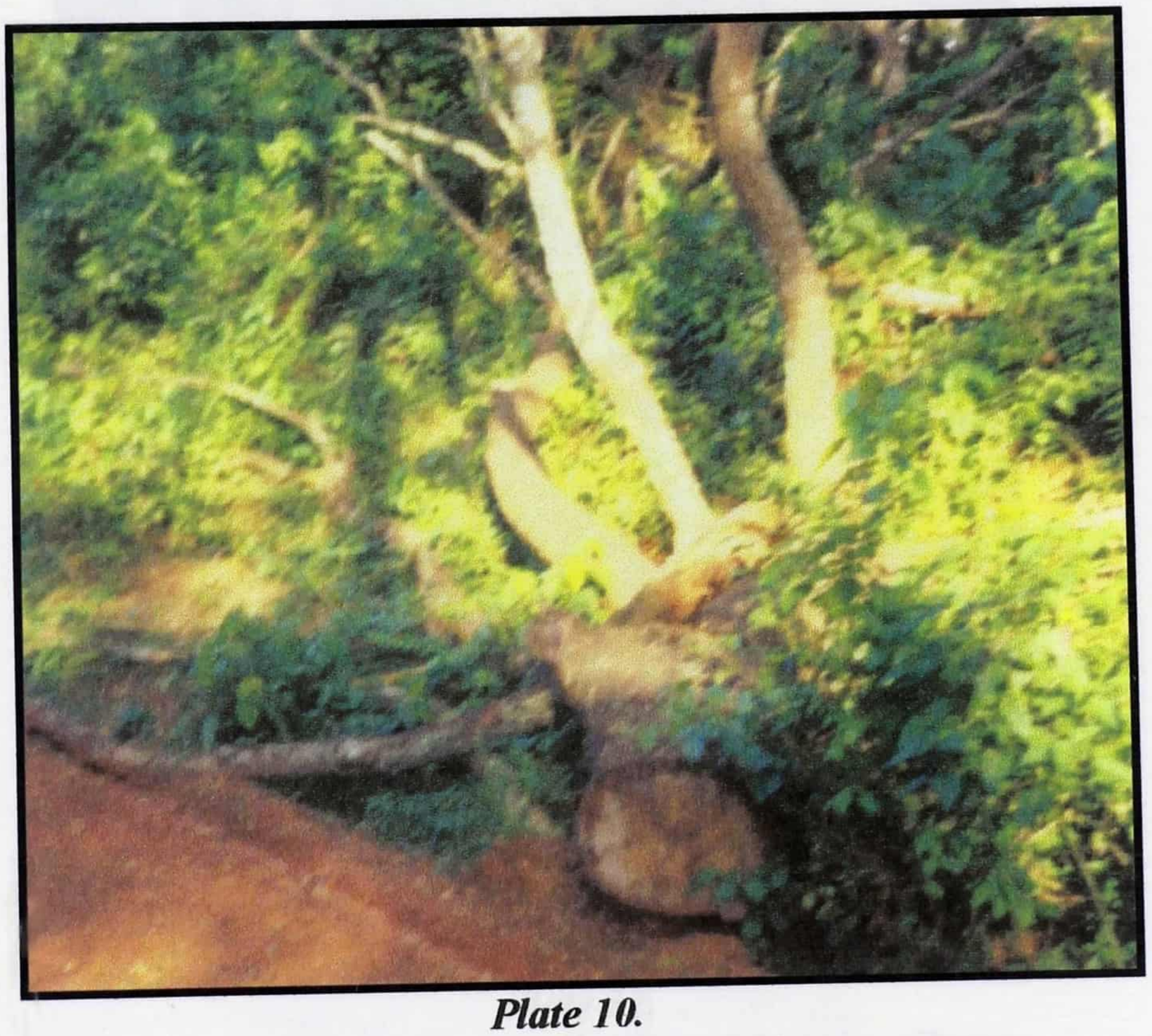

Plate 10.
Amphimas pertriocarprodes at Diasempa.
(By product of logging)

Plate 11.
PIT method charcoal production at Kufour Camp

Plate 12.
PIT method charcoal production at Antwigyeikrom.

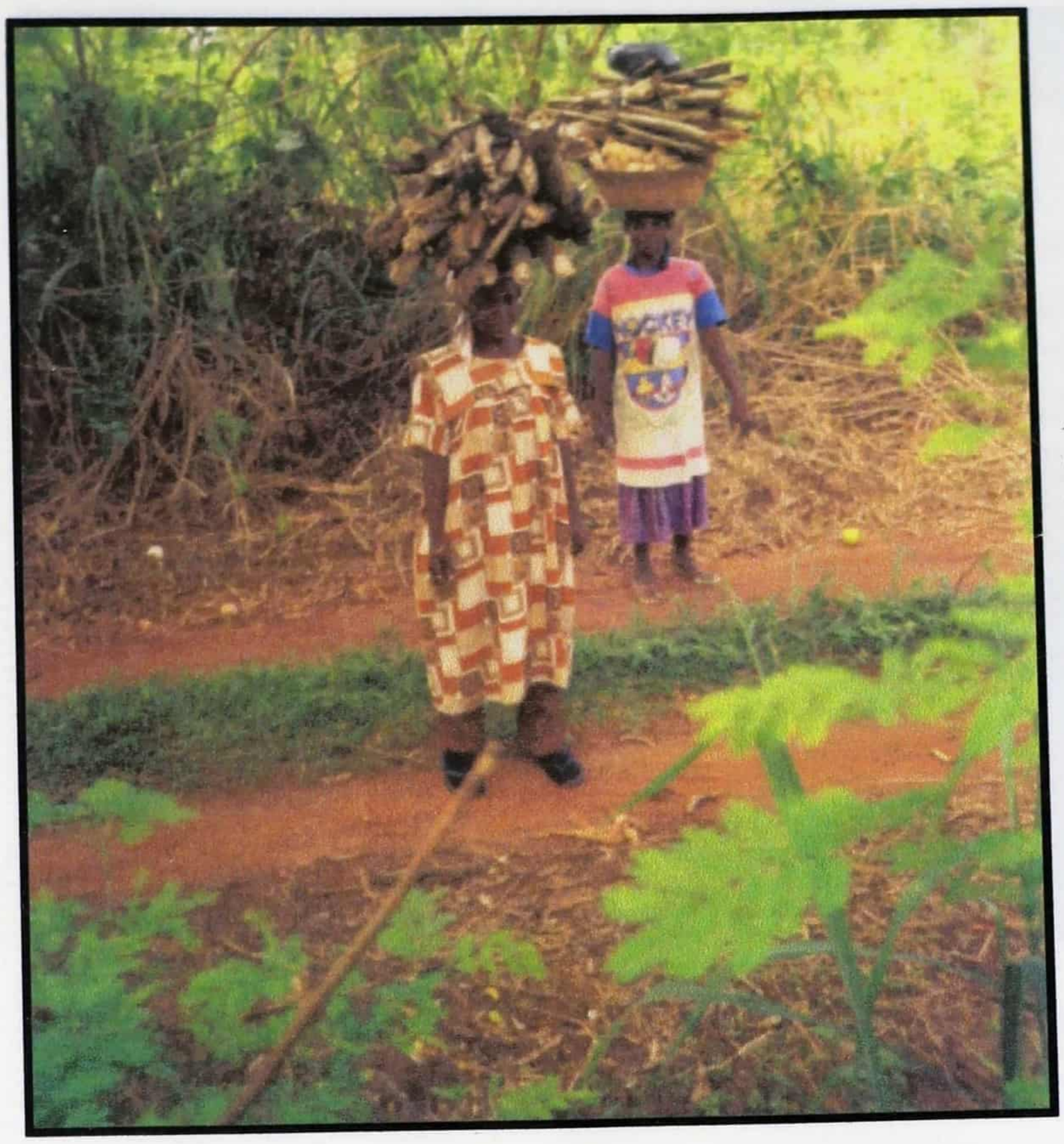

Plate 13.
Gender issues: Women carrying load of fire wood (Aman from)

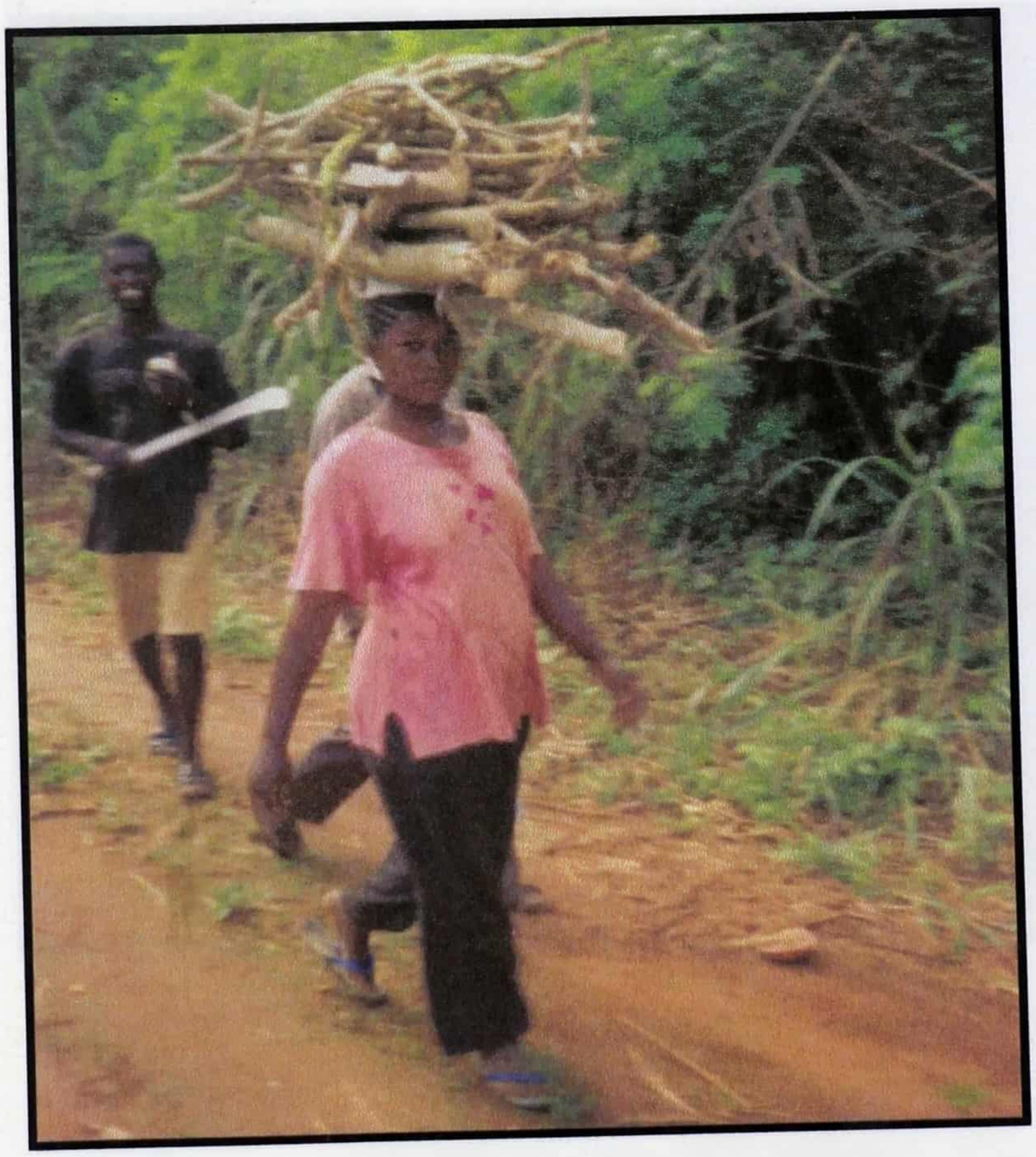

Plate 14.
Gender issues: the roles played by Men and Women in the fuelwood industry.
(MPASATIVA)

Plate 15.
Packed offcuts packed for charcoal production at Akosombo.

Plate 16.
Offcuts packed for charcoal production at Asokwa..

Plate 17.
Firewood from farmlands at Kyereyaso

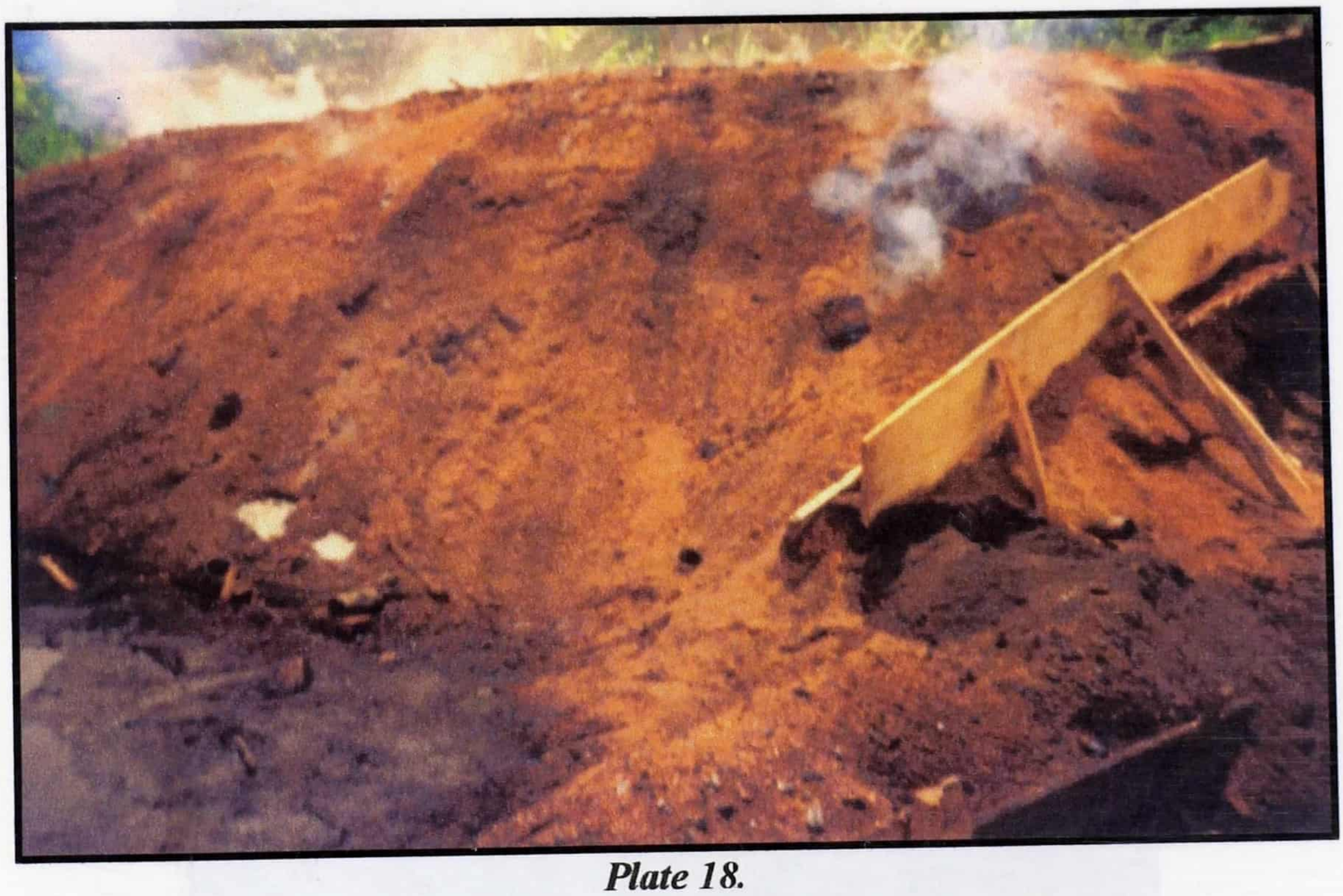

Plate 18.
Offcuts going through the process of carbonization.

Plate 19.
Women harvesting charcoal at Asokwa CMB.

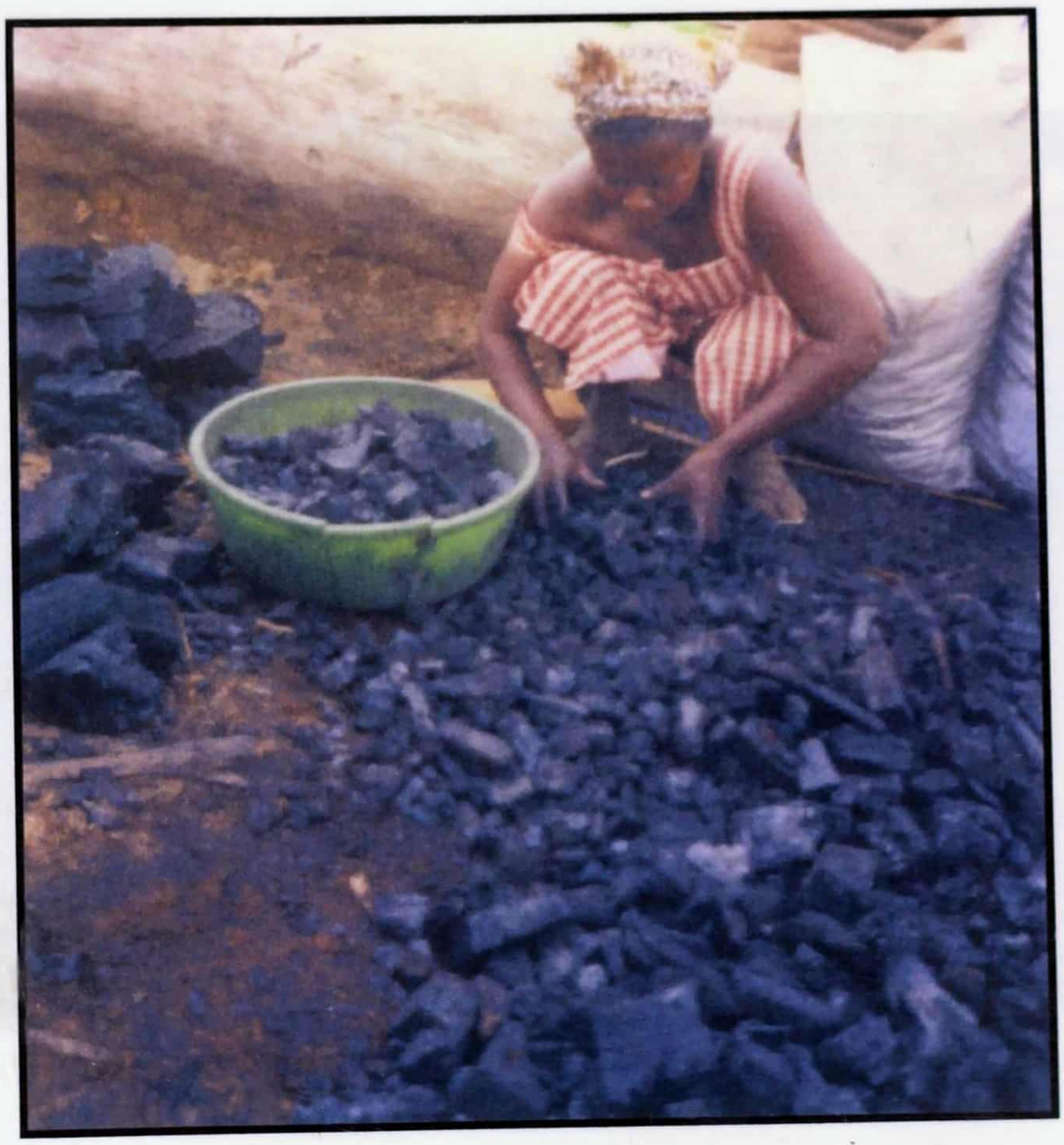

Plate 20.
The packing of sawmill charcoal at Kaase.

Plate 21.
Interview with firewood dealers to identify sources Asuoyeboah.

Plate 22.
Parking of sawmill charcoal at Ahinsan

Plate 23.
Shortage of charcoal, Women looking for charcoal for retail Krofrom.

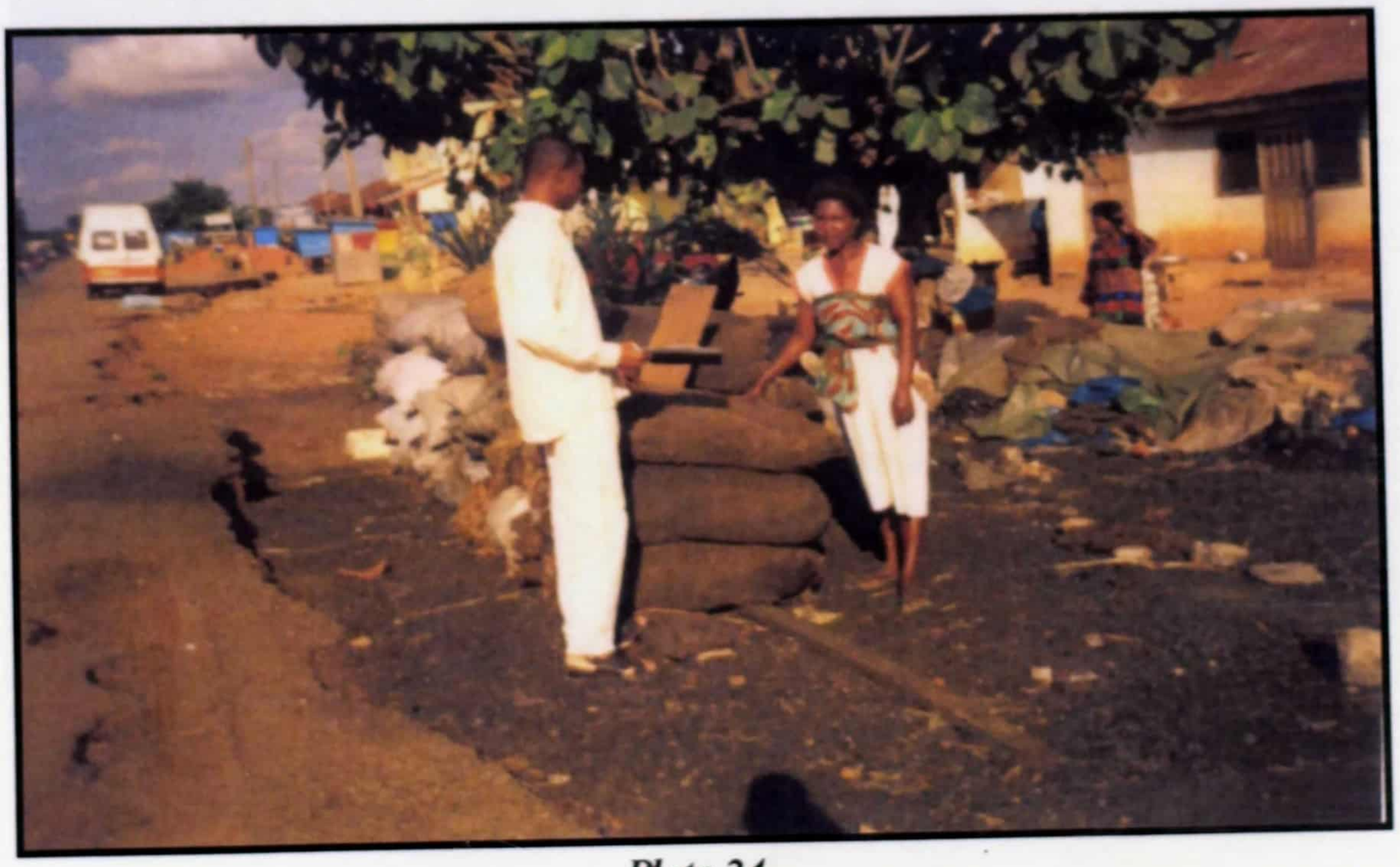

Plate 24.
Identifying charcoal source at Abrepo Junction.

Plate 25.
Charcoal from the mill side by side charcoal from Nkoranza (Ayigya Market).

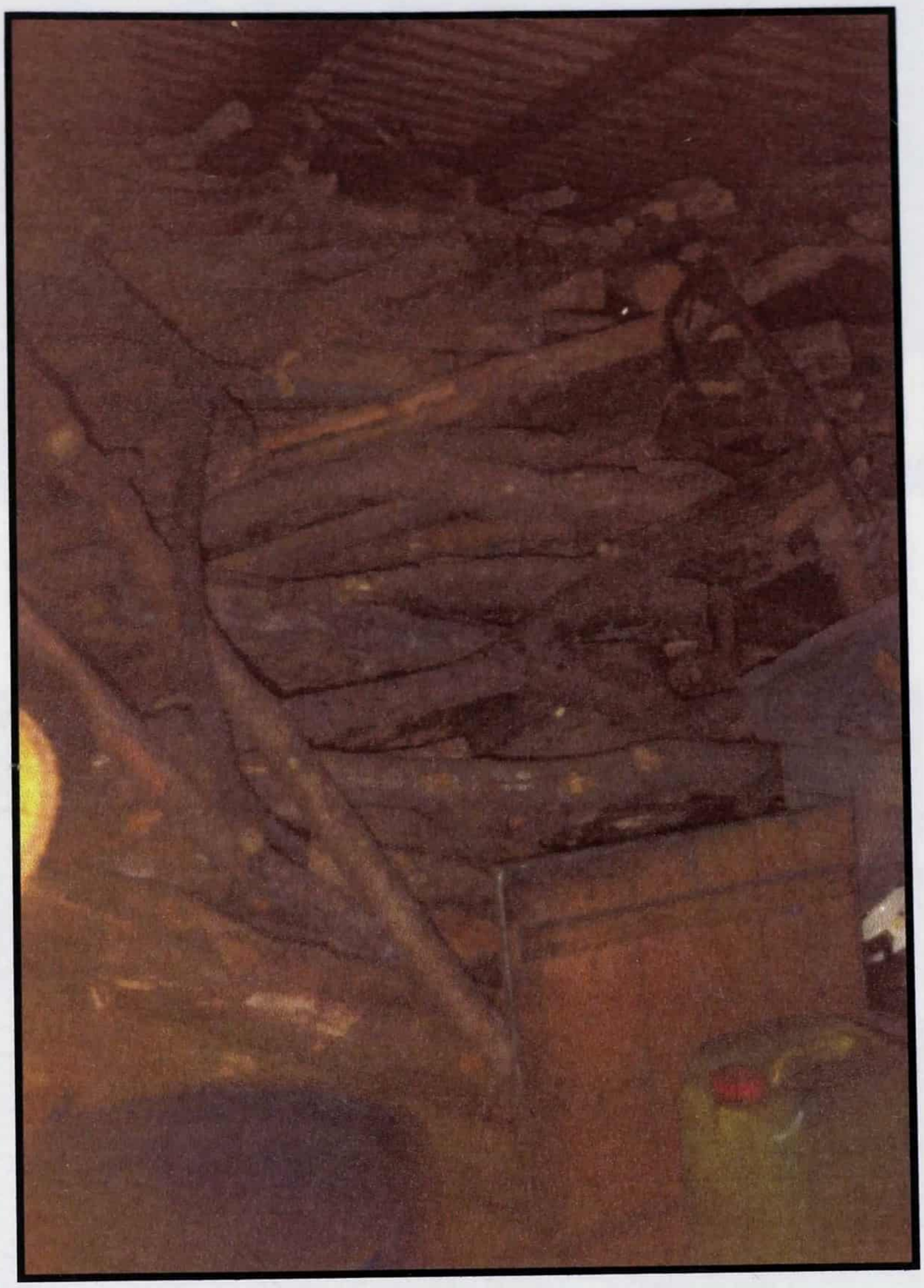

Plate 26.

The stock of firewood bought at ¢50,000 the previous year but now doubled.
(ANWOMASO)

Plate 27.
Researcher inspecting the minimum unit of measurement in rubber bags. (Tarosa)

Plate 28.
A rubber bowl used as a minimum unit of measurement.

CHAPTER FIVE

5.1 Conclusion:

In conclusion fuel wood production is the sole occupation of the majority of urban dwellers in the fuel wood industry. It was however a minor occupation for most rural areas, supplementing incomes during the off-farming season.

Fuel wood problems are viewed primarily as a consequence of the interaction of environmental and economic forces at the local level, which result in a number of resource stresses of which fuel wood is but one. Although specific details vary widely between the Atebubu and Atwima districts fuel wood problems are more clearly a manifestation of more fundamental failures in rural land, labor capital markets, urban energy markets in such areas as Kumasi and other regional capitals nation wide and of governments local and national failure to establish the fundamental conditions that would allow difficult and sustainable allocation of land and resources between forest and crop land as well as residential in peri-urban areas and food production.

Population pressure on forest resources, the increasing urban demand for fuel wood can easily be accounted for where research data indicates that communities in Atwima district which were mostly within 24km or more radius from Kumasi had fuel wood markets with the final destination of the products being the city markets. This may ultimately have resulted in such communities not having fuel preference as their counterparts in the interior in the Atwima district had, even the presence of forest reserves in near by communities such as Jimira forest reserve are said to be widely encroached by communities. The frequent shortages of charcoal experienced in the

Kumasi metropolis and the shortage of saw mill waste due to the non-availability of logs for the mills buttress the extent to which our forest resources have been depleted. The stressful conditions especially with regards to preferred wood species is an issue of uttermost concern, which can ultimately be addressed through a multifaceted approach that would embrace all the stakeholders that are immediate beneficiaries of our forest. These may include foremost the communities, timber firms, district assemblies and the forestry service.

The benefits of a sustainable farming practice such as Agroforestry cannot be over emphasized as a key factor to sustainable development of the fuel wood industry, examples of such Agroforestry technologies includes: woodlots, taungya, boundary planting and improved fallow.

5.2 Recommendations

Steps must be taken not just for the issue of afforestation but with special regard to the diversity of tree species that are planted. The attention that is currently being given to non-timber forest products should be applied to fuel wood issues. Rural folk's knowledge in fuel wood species could be tapped to help find sustainable means of sustaining the fuel wood industry. Measures at the district level such as taxes that is currently non-existent on firewood would help to reduce its consumption at the urban level. For the cheapness of fuel wood to the urban consumer would have a long term cost for future generations to come. The improvement of information base on which to base policies is required. A database at the district forest office, which should be reviewed periodically, is needed. The improvement of farming practices that would have a tree component such as Agroforestry would go a long way to sustain the fuel wood industry.

The efficient utilization of fuel wood is also highly recommended this may be referred to as demand management of fuel wood. The use of improved stoves, improved methods of charcoal productions and switching to modern fuels such as liquefied petroleum gas and solar energy would go a long way to reduce pressure on the forest resources.

AREAS FOR FUTURE RESEARCH

- Fuel wood preference for rural communities its impact on deforestation and species extinction.
- Management plans for regeneration and exploitation of fuel wood in off and on reserve communities.
- Alternative liveli hoods for fuel wood communities
- Participatory approach to improve Agroforestry systems using economic trees with forest fringe communities as key stakeholders.
- The potential of yam staking in an Agroforestry systems
- Efficient charcoal burning and the establishment of wood lots for charcoal production.
- The demand for fuel wood in urban areas and its impact on the fuel wood industry.

REFERENCES

Abbiw D, 1990. Useful plants of Ghana. Intermediate Technology publications London. Ad Hoc Panel of the Advisory Committee on Technology Innovation

Adjare, S.1981. The Golden Insect: A Handbook of bee-keeping for beginners.Advisory Committee on the Sahel BOSTID, National Research council. 1984. Agroforestry in the West African Sahel. National Academy Press. Washington, D.C.

Anane, Y. and Twumasi-Ankrah R. 1986. Woodlots: A profitable venture for Ghana smallholder farmers Agroforestry Today 10: I9-21.

Anokbonggo A. A., Berchie Nketia J., Echavez M. L, H. K. Dapaah, T. Kobede S., W. Njue, I. Paraoan, H. R. Labrada, 2000. Sustainable Farming Practices: Toward reducing the expansion of the forest savannah Transitional zone of Sekyere-west and Ejura-Sekyere Odumasi districts of the Ashanti Region of Ghana. (Report by International Center for Development oriented Research in Agriculture (ICRA). Netherlands and Crops Research Institute (CRI) Ghana.

Arnold, J.E.M. 1978. Wood Energy and Rural Communities Paper FRC/3-6; Proc.8th World Forestry Congress,Jarkarta,Indonesia.

Asare E. O. 1992. A note on the vegetation of the transition Zone of the Tain Basin in Ghana. Ghana J Science 2: 60 –73.

Asare, M. And Opam, M. 1986 Reconnaissance survey of Wood fuel production and consumption in Ghana Renewable energy research and technology vol. 1 147p.

Asum- Nyarkoh S. 1982. The use of Woodfuels in a Ghanaian village. A Thesis submitted to faculty of Agriculture. University of Science and Technology

Atta – Krah A. M. and Francis (P.A. 1987) 'The role of On-farm trials in the Evaluation of Composite Technologies: The Case of Alley Farming in Southern Nigeria Agricultural Systems 23: 133 – 152

Baumer, M.1990 Agroforestry and Desertification pp.63 CTA ICRAF

BOSTID. 1980. Firewood crops: shrub and Tree species for Energy production. National Academy of Science. Washington, D.C.

Brokenshal. D, Riley BW Carto A.P .1983. Fuel wood Use in Rural Kenya: Impact of Deforestation. Binghamton, 174, Institute for Development Anthropology, p 54

Bromley, D. W and M. Cernea 1989. The management of common property, natural resources: some conceptual and operational and facilities. World Bank Discussion paper No. 57. World Bank. Washington, D.C.

Burley, J. 1978, Selection of Species for fuel wood plantation. In proceedings 8th world forestry congress Jarkarta Indonesia.pp133-147

Catterson, T. M. 1984. The AID Forestry. Program in Africa: a status report. Paper presented at USAID Bureau Forestry Program Evaluation Workshop. Lome, Togo. May 7-11.

Community Forestry: Rapid Appraisal of Tree and Land Tenure.Prepared by Bruce John W. FAO Rome 1989

Corder, S.E.1973.Wood and bark as fuel wood research bulletin 14 August 1973 Forest research laboratory school of forestry Oregon State university Corvalles

Oregon
Dankelmen I and Davidson J .1987. Women and Environment in the Third World Alliance for Future.
District Assembly Financial Report 2000-2001
Dunkerly,J.M.Maculey,M. Naimuddin and P.C. Agarwal. 1990
Dupriez,H.and P. De Leener.Agriculture in African Rural Communities Macmillan Publishers.
Earl D.C.1975. Forestry and Economic Development London,Oxford University Press Quoted in Beijer Institute Proposal: A Fuelwood System Model for Kenya Annex A, p 31 Eckolm, E.,G. Foley, G.Barnard and Timberlake.1984.
ESMAP. 1990a Indonesia:Urban Household Energy Strategy.ESMAP Report.
ETC. 1987.SADCC Fuelwood Study. ETC Foundation,Leusden.The Netherlands.
Evans.J. 1982. Plantation Forestry in the tropics.Oxford University press New York pp 344-347.
FAO (1983b) Fuelwood Supplies in Developing Countries FAO Forest paper 42 Rome16p.
FAO (1983a) World Fuelwood Surveys. Forestry for Local Community Development Programme GCP/INT/365/SWE, Rome.
FAO, 1978 Fuelwood Supplies in developing countries.FAO Forestry paper 42.
Food and Agriculture Organisation,Rome Italy

Fearnside, P. 1989a.Spatial Concentration of Deforestation in the Brazilian Amazon in World Bank Forestry Review 1991

Fearnside, P. 1989b. The charcoal of Carajas: A threat to the forest of Brazil's Eastern Amazon Region. Ambio 18:14-143

Gentry, C. 1982. Small-scale Bee keeping, U.S. Peace corps. Fuel wood: an analysis of problems and solutions for less developed countries
Gyampo A.A 1985a.A URADEP report on Drought and Desertification in upper Regions of Ghana: Paper presented at the Workshop on the Effects of Drought and Desertification Accra, Ghana Mimeo 21.
Gyampo, A.A. 1985b."A URADEP Report on Drought and Desertification in the Upper Regions & Ghana" EPC, Accra pp. 95 – 121
Hartman, H.T. And Kester, D.E. 1968. Plant Propagation principles and practices. Prentice- Hall. Inc. Englewood Cliffs, New jersey.702 pp.
International Institute of Rural Reconstruction. 1992. Agroforestry Technology Information Kit. IIRR. Silang, Cavite, Philippines.
International seed Testing Association, 1995. International Rule for seed Testing. Seed Science and Technology. 13: 299-355pp.
Irvine, F.R.1961. Woody Plants OF Ghana. London, Oxford University press.
Kaho, F 1998. Evaluation of fuelwood and maize production in woodlot system of Leucaena leucocepthala and senna siamea M.S.c thesis IRNR UST Kumasi.
Kang .B.T and Lawson T.T. 1986. Alley Cropping, A Stable Alternative to Shifting Cultivation International Institute of Tropical Agriculture (IITA) Ibadan, Negeria.
Lewis L A and Berry L 1988.African Environments and Resources Unwin Hyman Ltd

London.
McNamara R.S. (1985) the Challenges of Sub-Saharan Africa. Sir John Gaerford Memorial Lecture for Consultative Group on International Agricultural Research, Published by World Bank.
Mercer Evan. D. Duke University and etc. the World Bank Forestry Policy Review February 1991.
Milner C and Douglas MG (1989) Problems of land Degradation in Commonwealth Secretariat, London 121 pp.
National Academy of Sciences 1980. Firewood crops; shrubs and tree species for energy Production Washington DC, National Academy of Sciences, 237 pp. National Archives of Ghana, Tamale ADM 1/295 A.W. Amherst, DC Lawra to Chief Commissioner of NTS October 17, 1940 and DC, Wa to Chief Commissioner 13 April 1940.
Nketiah. K.S. 1988: The charcoal cycle in Ghana-A baseline study pp. xiv, xv, 1.15, 16, 12-25, 101-102,36-49.

O'Keefe P. and Wisner B (1977) Land use and development, African Environment Special Report 5, London. Institute. OT.

Quashie-Sam,S.J.,K.O.Agyeman and M.Avila,1993. Agroforestry technologies and research priorities for development of the cocoa/food crop/oil palm system in the Humid lowlands of Ghana. ICRAF Nairobi Kenya.
Raintree J .B. 1985. Agroforestry, tropical landuse and tennure. Background paper for international consultative workshop on tenure issues in Agroforestry.
Raintree J.B. 1983a. A Diagnostic Approach to Agroforestry design paper presented to the International symposium on stratagies and design for afforestation and tree planting. Hinkellord, Wagenin (Holland) 19-23 September.
Rao MR And Wikey RW.1980. Evaluation of yield stability in intercropping. Studies on sorghum / Pigeon pea. In experimental Agriculture 16(2): 105:116.
Rocheleau D.1987. The user perspective and Agroforesry. Research Action Agenda, in (ed H Ghol2) Agroforetry Development.
Rocheleau, D. F. Weber and A. Field-Juma. 1988. Agroforestry in Dry land Africa. International center for Research in Agroforestry, Nairobi Kenya
Skerman, PJ, Cameron, DG and F. Rivores 1988. Tropical forage legumes. Second edition FAO, Rome, 692pp.
Taylor, C.I. 1960. Synecology and Silvicuture in Ghana. Nelson, Edinburgh. 418 pp.
The Fuel wood /energy crisis in Sub-Saharan Africa.
www.unu.edu. /unpress/unupbooks/80918e/80918EDU.htm.
UNEP (1986) environmental guidelines for Agroforestry projects. UNEP Environmental management Guidelines No. 11 UNEP Narobi.
Utilization of mill residue wasted for energy (A case study in Kumasi) by Kumasi institute of technology and the environment (KITE) (1995).
Von Caplowitz, PG 1986. Multi purpose tree and Shrub seed Directory First edition. ICRAF. Narrobi, Kenya 265pp.

Web.mit.edu/africantech/www/articles/Deforestaion.

Weiland (1984) the fuel wood Crisis and the people development and cooperation 4:25.

Willan R.L, 1985. A. Guide to Forest Seed Handling with special Reference to the Tropics. FAO Forestry Paper 20 (2) 879 pp.

World Bank (1980) sociological Aspects of forestry. Project design. Washington DC, world bank Agritech Note 3, 100 pp.

World Bank (1985) tropical forests. A call for action vol. I,II,&II Washington DC WRI 126 PP.

World Bank Resources Institute (1985) Tropical forest: A call for Action part I the plan. World Bank, Washington D.C.

Young, A. (1989) Agroforestry for soil conservation. ICRAF 12:10-13

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A SURVEY OF FUEL WOOD PRODUCTION IN THE ATWIMA DISTRICT

(1) **REGION ASHANTI**

(2) Community.....

(3) Name.....

(4) Age.....

(5) Marital Status.....

(6) Occupation:
Major Occupation:
Minor Occupation:

(7) How many years have you been trading in fuel wood?
.....

(8) What are your sources of fuel wood
(a) Off reserves (b) on reserves (c) Farms (d) Others

(8) In gathering of fuel wood
(a) Do you gather already dry wood
(b) Do you cut fresh wood to dry

(9) When timber is harvested what are the remnants used for
.....
...

(10) What wood species do you gather for fuel wood
.....

(11)What quantities do you gather at a particular time
(a) Day (b) Week (c) Month (d)Other specify

(12) Is there a particular period that you gather fuel wood
.....
.....
.....

(13) Do you find trading in fuel wood more lucrative than farming
(a) Yes Why.....
(b) No Why.....

(14) What importance does the gathering of fuel wood play in your livelihood

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

(15) How do you market the fire wood that you collect
.....
.....

(16) How often do people come for
it.....
.....
.....
.....

(17) Which people are involved in the trade of fuel wood
(a) Men (b) Women (c) Institutions (d) Others

(18) Where do they come
from.....
.....

(19)Do they request a particular kind of species of fuel wood and
why.....
.....
.....
.....
.....

(20) Does the quantity you gather now indicate that you would still be collecting fuel wood in the
future.....
.....
.....
.....
.....
.....
.....
.....

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KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

A SURVEY OF FUEL WOOD PRODUCTION IN THE ATEBUBU DISTRICT

(10) **REGION BRONG AHAFO**

(11) Community.....

(12) Name.....

(13) Age.....

(14) Marital Status.....

(15) Occupation:
Major Occupation:
Minor Occupation:

(16) How many years have you been trading in fuel wood?

.....

(8) What are your sources of fuel wood

(a) Off reserves (b) on reserves (c) Farms (d) Others

(17) In gathering of fuel wood
(a) Do you gather already dry wood
(b) Do you cut fresh wood to dry

(18) When timber is harvested what are the remnants used for

.....

...

(10) What wood species do you gather for fuel wood

.....

(11)What quantities do you gather at a particular time
(a) Day (b) Week (c) Month (d)Other specify

(12) Is there a particular period that you gather fuel wood

.....

.....

.....

(13) Do you find trading in fuel wood more lucrative than farming
(a) Yes Why.....
(b) No Why.....

(14) What importance does the gathering of fuel wood play in your livelihood
.....
.....
.....

(15) How do you market the fire wood that you collect
.....
.....

(16) How often do people come for
it.....
.....
.....
.....

(18) Which people are involved in the trade of fuel wood
(a) Men (b) Women (c) Institutions (d) Others

(18) Where do they come
from.....
.....

(19)Do they request a particular kind of species of fuel wood and
why.....
.....
.....
.....
.....
.....

(20) Does the quantity you gather now indicate that you would still be collecting fuel wood in the
future.....
.....
.....
.....
.....
.....
.....
.....
.....

INSTITUTE OF RENEWABLE NATURAL RESOURCES
KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

A SURVEY OF CHARCOAL PRODUCTION FROM SAWMILL RESIDUES IN KUMASI

QUESTIONNAIRE NUMBER

1. AREA.....LOCATION

2. NAME.....

3. AGE.....

4. MARITAL STATUS

A. SINGLE B. MARRIED C.DIVORCED

5. GENDER: A. MALE B. FEMALE

6.EDUCATIONAL STATUS.....

7.ETHNIC ORIGIN.....

1. MAJOR OCCUPATION.....

2. MINOR OCCUPATION.....

3. HOUSEHOLD SIZE.....

4. WHAT ARE THE SOURCES OF MATERIAL FOR CHARCOAL PRODUCTION.....
.....

5. HOW MUCH DO YOU HAVE TO PAY YOUR RAW MATERIALS.....

6. WHAT ARE THE QUANTITIES THAT ARE PRODUCED PER PRODUCTION.....

7. HOW MANY TIMES DO YOU PRODUCE CHARCOAL IN A MONTH.....

8. WHERE IS THE CHARCOAL SOLD.....

9. WHICH PEOPLE PATRONIZE THE CHARCOAL
   A. HOUSEHOLD B. COMMERCIAL USERS
   C. INDUSTRIAL USERS

17. WHAT IS THE DESTINATION OF THE CHARCOAL.....
.....

18.HOW MANY BAGS ARE BOUGHT IN A:
   A. DAY.....
   B. WEEK.....
   C. MONTH

19. HOW MUCH MONEY DO YOU MAKE FROM SELLING CHARCOAL IN A:
   A. DAY.....
   B. WEEK.....
   C. MONTH.....

INSTITUTE OF RENEWABLE NATURAL RESOURCES
KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

A SURVEY ON WOOD RESIDUE UTILIZATION BY SAWMILS IN KUMASI

QUESTIONNAIRE NUMBER

1. AREA.....LOCATION

2. NAME OF SAWMILL.....

3. WHAT ARE THE TYPES OF EOOD RESIDUE THAT ARE PRODUCED:
A. CHIPS B. SHAVINGS C.SAWN DUST D.OTHERS

4. HOW ARE RESIDUES DISPOSED OFF:
A. BURNT
B. BAKERS
C. CHARCOAL BURNERS
D. POULTRY FARM
E. OTHERS

5. WHAT ARE THE USES OF YOUR RESIDUE.....
.....

6. WHAT ARE THE QUANTITIES PRODUCED IN A:
A. DAY
B. WEEK
C. MONTH

INSTITUTE OF RENEWABLE NATURAL RESOURCES
KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

A SURVEY OF SELECTED FARMERS IN THE ATWIMA DISTRICT

DATE.....CODE NO... .....NO. OF QUESTIONAIRE

LOCATION.....REGION.....

ETHNICITY OF RESPONDENTS.....
SEX: MALE FEMALE AGE.....

1. HOUSEHOLD SIZE.....
2. SIZE OF FARM.....
3. YEARS OF FARMING.....
4. DO YOU HAVE LIVE STOCK.....
5. WHAT IS THE TYPE OF LAND TENURE SYSTEM.....
6. WHATARE THE TYPE OF CROPS YOU PRODUCE.....
7. DO YOU HAVE CHARCOAL PRODUCERS IN YOUR AREA?.....
8. IS THERE A COMMERCIAL FUELWOOD TRADE IN YOUR AREA?.....
9. HOW DIFFERENT IS THE FUELWOOD SITUATION FIVE YEARS BEFORE?.....
10. WHAT WOULD BE YOUR RESPONSE IF SOMEBODY PICKS FIREWOOD FROM YOUR FARM?.....

.....

11. WHAT FORM OF AGROFORESTRY ARE YOU INTERESTED IN?

A. WOODLOTS

B. GROWING OF CROPS IN ASSOCIATION WITH TREES

C. TAUNGYA

D. OTHERS

INSTITUTE OF RENEWABLE NATURAL RESOURCES
KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

A SURVEY OF SELECTED FARMERS IN THE ATEBUBU DISTRICT

DATE.....CODE NO..... .....NO. OF QUESTIONAIRE

LOCATION.....REGION.....

ETHNICITY OF RESPONDENTS.....
SEX: MALE FEMALE AGE.....

11. HOUSEHOLD SIZE.....

12. SIZE OF FARM.....

13. YEARS OF FARMING.....

14. DO YOU HAVE LIVE STOCK.....

15. WHAT IS THE TYPE OF LAND TENURE SYSTEM.....

16. WHATARE THE TYPE OF CROPS YOU PRODUCE.....

17. DO YOU HAVE CHARCOAL PRODUCERS IN YOUR AREA?.....

18. IS THERE A COMMERCIAL FUELWOOD TRADE IN YOUR AREA?.....

19. HOW DIFFERENT IS THE FUELWOOD SITUATION FIVE YEARS BEFORE?.....

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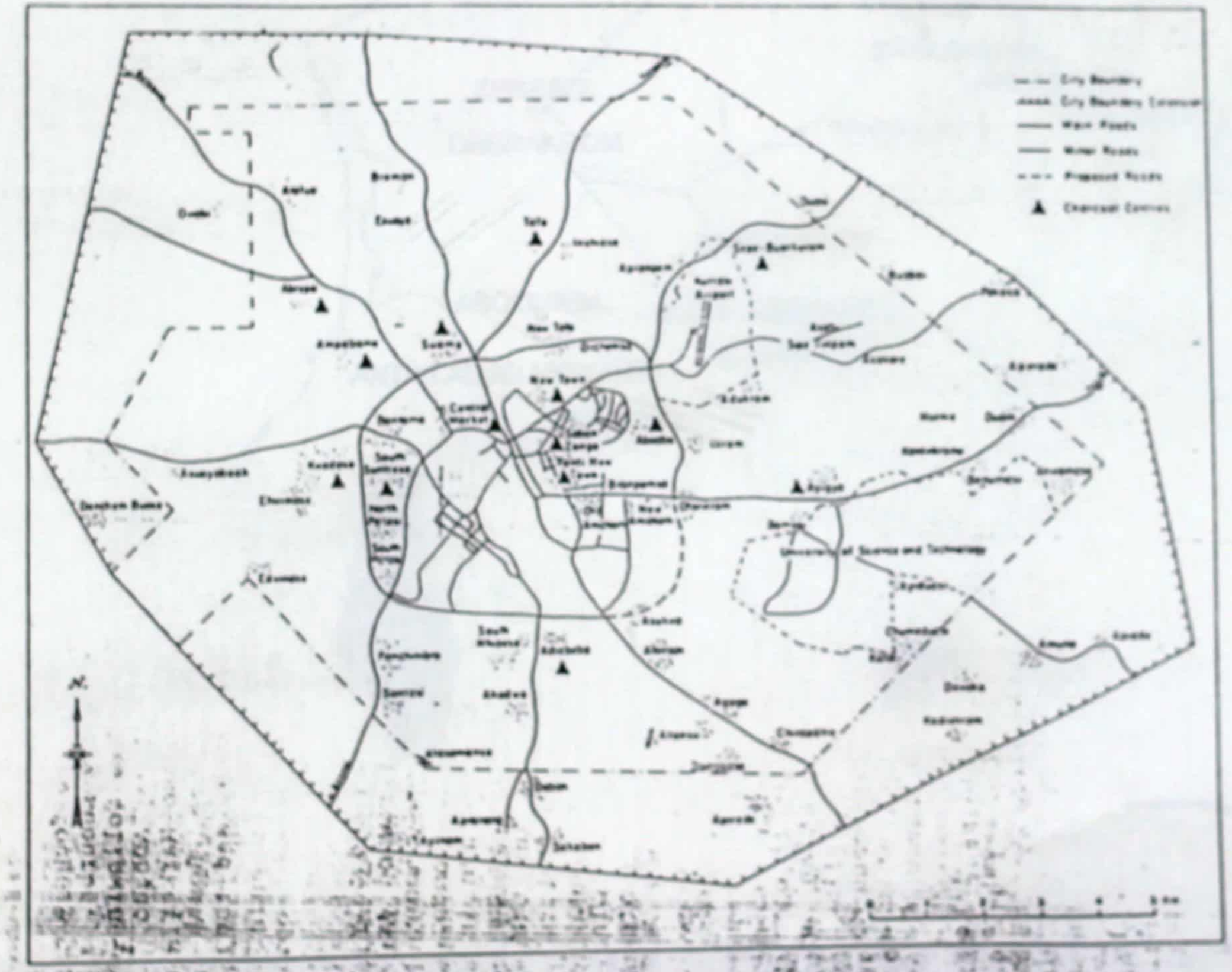
C. TAUNGYA

D. OTHERS

Fig 4 3 Main Charcoal and Fuelwood Marketing Centres in Kumasi



MAP OF ATWIMA DISTRICT

Title?

N
W
E
S

BAREKESE
KAPRO
AKWABOA
DAABAA
AKROPONG
ESAASE
NYAMEBEKYERE
AFERI
KYEREYASE
SEPAASE
MPASATIA
TOASE
SEDI
AMANKYEA
ADIEMBRA
MANHYIA
DOTIEM
ASUOKOO
KASOTIE
WANSABRE
OSAAKROM
ATASO
KOTOKUOM
AKANTANSU
BAAKONIABA
ANWIAFUTU
ADIEMBRA
NYINAHIN
SERESO
DEBRAKROM
BAANIEKROM
ABOODIEM
ANTWI ADJEIKROM
KANSAKROM
ANTWI ADJEI NKWANTA
KUFOUR CAMP

LEGEND

- Towns
- Rivers
- Roads
- Atwima District

Reserves

- Afram dawa
- Anwiaso East
- JIMIRA
- Jinmira Ext.
- TANO OFIN
- TANO SURAW EXTENSION
- Tano offin ext.

10 0 10 20 Kilometers

Yeji

Prang

Abease

Atebubu

Kwame Danso

Kajaji

Amantin

From
Kumasi

District [illegible] y

Subdi [illegible] dary

Primc [illegible]

Seco [illegible] d

Scale [illegible]5 00