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Woodfuel Use In Ghana: Its Nature And Impact At The Village Level

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WOODFUEL USE IN GHANA: ITS NATURE AND IMPACT AT THE VILLAGE LEVEL

by

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ABSTRACT

The thesis is an examination of the woodfuel energy situation in rural Ghana. Despite the high degree of woodfuel dependency, which may perpetuate a near-subsistence level of economic development and potential degradation of the environment, there is a lack of detailed information at the critical use levels of the farm village and its household units upon which to assess the situation and as a basis for energy planning. This thesis attempts to combine the need for detailed data acquisition and the need to describe and explain the actual woodfuel situation. The field study covered households in three villages in Eastern Ghana based on methods which included measurement, weighing, interviewing, observation, and diary keeping. Data was collected over a period of 10 months.

The basic data confirmed the overall level of dependence on woodfuel for virtually all energy requirements. However, whereas all three villages were broadly similar as to woodfuel use, there were important distinctions between them as to quantity and quality used and, especially, the local availability and sectors of use. Based on initial data presentation, further analysis was undertaken of a wide range of household variables using both univariate and multivariate analytic techniques. Although some postulated variable relationships were confirmed, the overall situation was found to involve a number of critical variables whose significance varied somewhat between villages and in relation to sources and uses of woodfuel. The underlying nature of the ecosystem and its overt reflection in terms of the farming system are strong determinants of woodfuel supply in

both qualitative and quantitative terms. Potentially, the most critical impacts of woodfuel use are those of an ecological nature-the loss and/or degradation of the natural vegetation. While the situation is not yet critical in terms of depletion, evidence suggested widespread degradation, especially in the two villages in the drier forest zones. The socio-economic impacts are more varied, including time and physical efforts spent collecting, as well as the actual and potential problems of development in a constrained energy situation.

The conclusion to the study stresses the complex nature of the woodfuel situation even at the relatively homogeneous farm village household level. Given this complexity and the level of dependency on woodfuel that will likely continue, energy planning must be undertaken at the rural village level, based on detailed acquisition and use of information.

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TABLE OF CONTENTS

LIST OF TABLES

List of Figures

CHAPTER I: THE STUDY

1. Introduction

The subject of this study is woodfuel use in rural Ghana. The study is intended as a contribution to current discussions on sustainable development and, particularly, to the need for detailed empirical information at the site level to benefit planning efforts in developing countries which are dependent on wood as the major energy source, with Ghana as the prime example.

The primary objective of the study is to determine the actual amount of wood used as fuel on a gross and a sectoral base, and the level of dependence on wood versus other fuels. The study is based on household investigation at the village level and includes investigation of the social and economic costs of fuel to the rural household. Another major objective is to investigate the impacts of woodfuel use, both in terms of social impacts on village society and activities and on the ecology of the region. In the latter case, the overall impact of woodfuel dependence and the problems of sustainability in relation to conventional energy resources, are explored. An integral part of the investigation involves the development and application of detailed woodfuel use survey methods to produce more accurate findings than heretofore and which would be duplicable in other study areas.

2. Basis of the Study

The question of energy resources for sustainable development involves a range of complex issues, including the state of the local natural resource endowment, together with the related state of human development in such areas as technology, economic viability, and social and political institutions. Local conditions are also subject to the influence of external circumstances. Generally, modern global production systems utilise technologies developed in advanced economies which are based largely on the use of fossil fuel energy. In order to try to become part of, and compete successfully in the international socio-economic system, developing countries seek to adopt many such technologies without regard to appropriate local capacities to support them on a continuing basis. As a result of constraints of access to adequate resources to meet the demands of modern socio-economic development, two parallel spatio-economic structures exist in many developing societies, namely;

i). a modern or formal sector, usually located in the primary urban centres, and which is serviced, as a matter of priority, with most of the available capital, scarce technology, managerial capacity, and the limited fossil fuel energy inputs, often imported; and

ii). a traditional or informal sector, usually corresponding to the majority rural (and to some extent, peri-urban and urban slum) areas, and which depends heavily on traditional local resources, including energy and, as a result, experiences little economic growth and is disadvantaged compared with the modern sector.

There is an overall high degree of energy-dependence on woodfuel in developing countries, especially in Sub-Saharan Africa and Andean Latin America. Postel and Heise (1988:16), have noted the high dependence on woodfuel by rural dwellers in most developing countries, including even oil rich countries such as

Nigeria. They add, that in most developing countries, apart from dominating the domestic sector, wood provides more than 70 per cent of energy used for all purposes. Moreover, Evans (1982:18) has asserted that "the gradual transition in developing countries from firewood to more sophisticated energy resources which was taking place before 1970, ceased as a result of the sharp rise in prices of petroleum fuel" [during the so called 'global energy crisis' of the 1970s]. Even though there has been recently a significant decline in world oil prices the economies of most developing countries are in such poor shape that falling prices bring no immediate relief. On the other hand, falling prices cause problems for oil producing developing countries such as Mexico and Nigeria. In the rural areas of Ghana, where almost 70 per cent of the national population lives, wood is the main source of energy, both for domestic and non-domestic needs, and supplies between 70 and 76 percent of total national energy requirements (Pluth, 1985; F.A.O., 1981; Howes and Gulick, 1981).

Many studies have established the inferior nature of woodfuel in relation to most other fuels and to all conventional energy sources (i.e., fossil fuels) in calorific terms (Table 1), and also because of the constraints to woodfuel use in modern production techniques. The implications of these factors to wood-dependent developing countries such as Ghana are that:

i). if woodfuel is inefficient, then serious constraints are potentially placed on the development capabilities of affected areas, to the extent that wood dependency may explain the general stagnation

TABLE 1: APPROXIMATE CALORIFIC VALUE OF SOME COMMON FUELS

FUELS	CALORIFIC VALUE (KCAL/GRAM)
Fuel oil	9.80
Charcoal	7.10
Coal (Butiminous)	6.90
Wood, oven dry 0% m.c.	4.70
Dung, air dry	4.00
Peat, air dry	4.00
Wood, air dry 25-30% m.c.	3.50

SOURCE. Modified from Earl, 1975:22

*Note: Ayite and Gogo (1973; also see Brookman-Amissah, 1981:12) estimate the heating value of Ghanaian timbers between 4.0 and 4.4 kcal/gr.

which keeps rural areas at a subsistence and/or a very low level of economic development, compared with the relatively vibrant urban centres. At an international level, this factor helps to explain the existing gap between developed and developing countries;

ii). Because of the rapid rate of population growth, an increasing amount of wood may have to be removed to provide required energy inputs for basic human needs. It is a major question whether local environments can sustain increased removals of wood for fuel on a long term basis without damaging effects on both natural ecosystems and human welfare.

Unchecked exploitation of wood resources may have implications for both environmental quality and socio-economic development. In environments where studies have been made, fuel use has been blamed as a major source of forest loss (U.N.E.P.,1984; Myers,1980; I.U.C.N.,1980). Inconclusive debates rage in forestry and woodfuel research, concerning the actual relationship between fuel uses and forest loss (Desai, 1984; Foley et. al 1984; Vidyarthi et. al, 1984; I.U.C.N., 1980). In human terms, the effects of woodfuel dependence on socio-economic conditions in rural areas are largely unknown, as are the responses needed to overcome any identified constraints. It is a paradox that, despite the long term and growing dependence on the wood resource for fuel, planning for woodfuel systems in most of the developing world is virtually non-existent and its promotion is handicapped by the absence of adequate and reliable information. This situation, in turn, reflects deficiencies in current research attention. Celceski et al. (1979:3), have noted that "there has been very little analytic study of how rapidly the energy consumption of the poor will rise in the future and how this [consumption] will be met". Postel and Heise (1988:17), also note that, "data characterising the fuelwood gap are as out of date and approximate as those on tropical forest trends." Many interrelationships exist in woodfuel systems which require effective information which can only be realised through detailed field investigation.

In common with most other developing countries, Ghana's energy supply is woodfuel dependent, especially in the rural areas (see Chapter IV for details). Notwithstanding this reality, there is a virtual absence of reliable information to assist planning efforts in the wood energy sector. Basic planning questions, such as how much wood is used for fuel, who uses it, and under what spatial and environmental circumstances, remain to be answered. This study seeks to provide answers to these questions at the key levels of wood use, namely, within the rural sector, for the village and by the household unit.

From the preceding discussion, it is obvious that woodfuel studies have broad significance and multi-disciplinary implications. For example, even within the discipline of Geography, the context for this study, questions related to woodfuel use unite several branches of the subject, notably: Resources and Environmental Conservation, Economic Geography with particular reference to Energy and Agriculture, Development Studies, and Biogeography. Full empirical and analytic treatment, therefore needs to be supported by a model framework that includes both socio-economic and ecological components and incorporates the availability, supply and demand aspects of wood consumption and the measurement of impacts.

Discussion of the concepts and design for such a model with which to guide this study, are presented in Chapter III.

Whereas the needs for accurate and empirical data mean that woodfuel study must be conducted at the level of use, nevertheless, there are dynamic links affecting both humans and the natural environment between any chosen area of study and factors emanating from the larger, national spatial system and, ultimately, with links to the global system. Any such spatial interrelationships including relationships between the energy sector and other factors of development, and links and influences between the woodfuel sector and total energy systems are part of the background to this study. Thus, the next part of this chapter examines the role of energy in sustainable development, including the effects of inequalities in the global allocation of energy resources for development, and the general constraints of woodfuel dependence in the energy mix of most developing countries.

3. The Problem of Energy Resources in Sustainable Development

Overview

Even though it is difficult to operationalise, the concept of sustainable development has three major interlocking parts namely, economic, socio-cultural, and ecological dimensions to development (W.C.E.D, 1987). Thus, in all endeavours to improve quality of human life, all three key elements of development require a balanced consideration, not only as a short term measure, but also as ongoing process and within a global interrelated spatial system. Sustainable development thus recognises the importance of the availability of key resources for development to help create the necessary bases for better living conditions for humans, not only in terms of material welfare, but also in terms of better socio-cultural and environmental settings.

Among the many problems of national development, energy (inanimate) appears to be one of the most significant. Many people regard energy as one of the "real problems" of the world alongside population numbers, food supply and pollution (Myers (1979:3). Energy issues have been identified explicitly in many world conference and commission reports issued during the past decade (e.g., W.C.E.D., 1987, Barney, 1982, I.C.I.D.I, 1981). The reasons for this emphasis includes the general dependence of the world economy on conventional fuels, the spatially skewed nature of energy distribution, the susceptibility to depletion due to the non-renewable nature of fossil fuels, and the environmental effects of increased use of both conventional and traditional fuels.

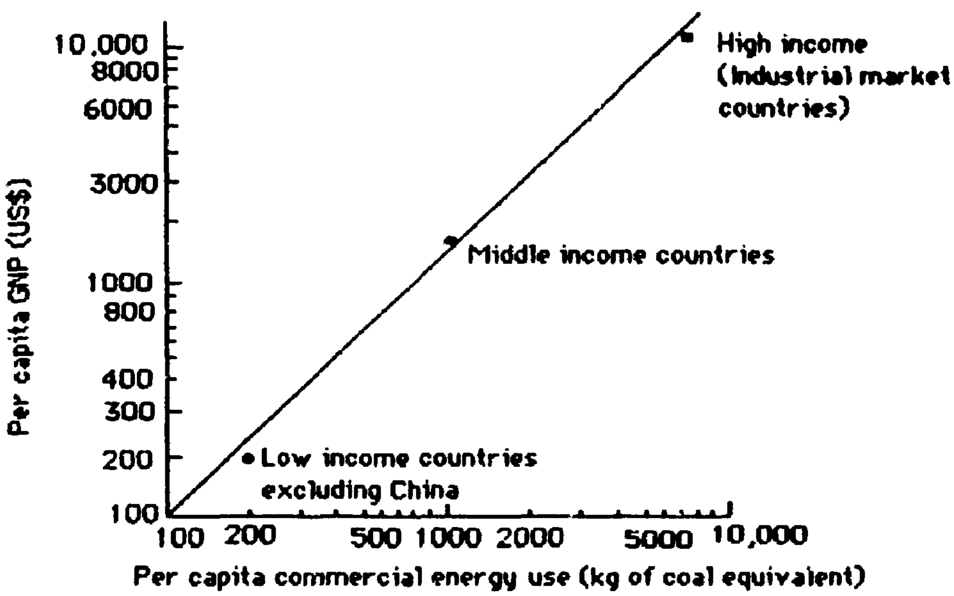
Energy availability, both by quality and quantity, is a key determinant of the economic productivity of most human systems. It is recognised, however, that for development to be sustainable, human welfare as well as the state of the natural environment has to be considered in a balanced manner, in all strategies and processes adopted to ensure development. For example, inputs such as fossil fuels that may help create short-term material welfare, may not enhance the overall or long term welfare of a society, in that, depending upon how they are used, they may degrade the environment and/or may not be available on a continuing basis.

Energy and Development

Slessor (1981) identifies three crucial roles of energy in any production system; these are a) providing heat to make a compatible environment; b) effecting the transformations of input materials to other forms; and c) providing a source of power available to workers. If one considers that any production process incorporates both distribution and consumer sub-systems, then energy, in its various forms, is important to the development process. Energy is particularly useful as an indicator of development, both because it forms a major part of the economy of all countries, and because it remains constant and comparable through time; a tonne of coal (of a particular grade) is a tonne of coal (without regard to techological changes that can improve efficiency levels over time), whereas a Dollar or a Franc changes in real value (Cole, 1981:41)

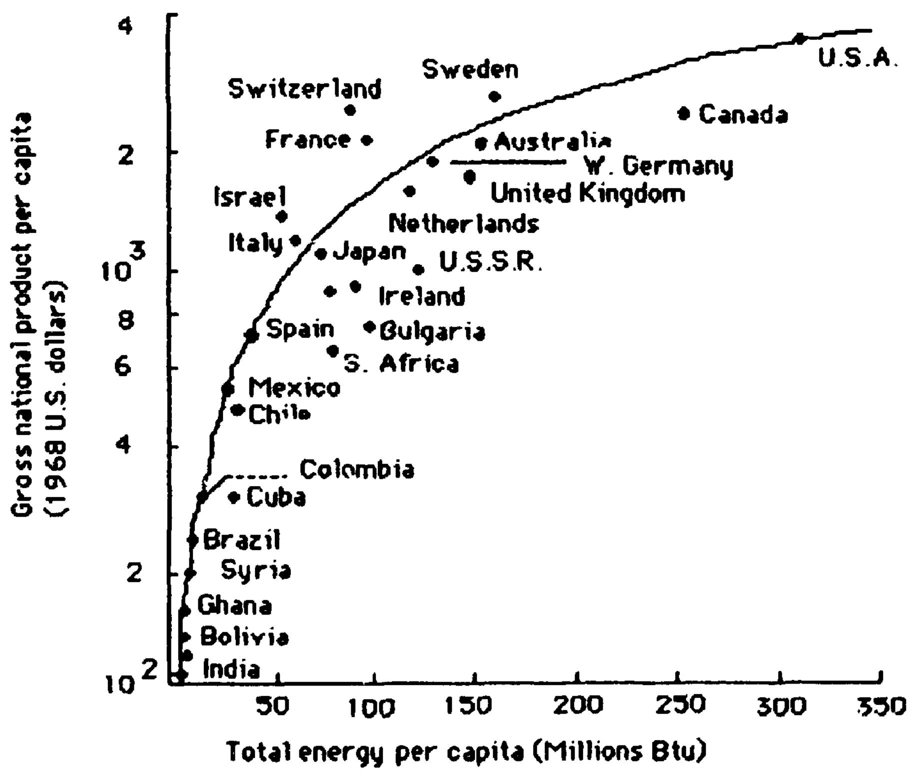
Many scholars have established that societies with high Energy Consumption Rates (E) show evidence of a high Gross National Product (G.N.P.) -(Munasinghe and Schramm 1983; Dunkerley, Ramsay et al. 1982, Foster, et al. 1981; Slessor 1978, Biswas, 1974). Gardel (1981:5) states emphatically, that the consumption of energy is a precise index of of the material wealth of a society and is directly correlated to the standard of living (defined by G.N.P.). Thus, the general relationship between energy and development helps to define the global-level dichotomy between developed and developing countries. For example, Figures 1 and 2 show developed economies such as the United States of America (U.S.A.), Canada,

FIGURE 1 : COMMERCIAL ENERGY CONSUMPTION AND G.N.P. PER CAPITA RELATIONSHIP BY COUNTRY GROUPS



SOURCE: After Munasinghe and Schramm (1983:6)

FIGURE 2: COMMERCIAL ENERGY CONSUMTION AND G.N.P. (COUNTRIES)



After Dorf (1978:95), adapted from Henry Symonds and others (1980.13)

Sweden, Switzerland, France, West Germany and Australia, at the top of the energy consumption ladder, while economies with low G.N.P.s, such as India, Bolivia, and Ghana, lie at the bottom.

In the long term, the use of energy as a criterion for assessing the economic performance of different socio-economic units may have certain limitations. In several developed countries, because of factors such as increased use of conservation technologies, plant efficiency or modernisation, definite policies to attain greater efficiency of use of energy resources both in industry and in the home, and relative maturity of the economies with regard to additional inputs of energy (compared to developing countries), have contributed to a decline in the E: G.N.P ratio. For example, a study led by Hirst at the Oak Ridge National Laboratories estimated that the U.S.A. uses almost 20 percent (gross) less energy since the inception of conservation mechanisms as cited by Chandler (1985:61). Table 2 also shows that, while Italy records a low of 0.65, Canada registers an energy elasticity ratio (coefficient) of 1: 40 even though they are both developed countries. On the other hand, Munasinghe and Schramm (1983) admit that the relatively substantial industrial base in China accounts for the high ratio of 1: 3.21 even though it has a low per capita income ($260). The actual situation shows that a decline of E: G.N.P. ratio in developed countries does not necessarily imply a slow-down in economic development and/or a deterioration in the standard of living. Variations do occur at individual country and regional level, in spite of global trends.

Concerning developing countries, Munasinghe and Schramm (1983:15) note that wide variations in E: G.N.P. ratios from a high

3.21 in China to a low 0.11 in Nepal (Table 2) may be attributable (also) to the fact that data covers only conventional energy resources to the exclusion of traditional ones, such as woodfuel, which may account for as much as 75-90 percent of total energy consumption. However, while the E: G.N.P. ratio is only a simplistic surrogate measure of development in different environments and does not incorporate adequate attention to other complex factors, such as different physical and human environments or the social goals of different cultures, nevertheless as a major quantitative indicator, it may be helpful for forecasting and planning purposes (Slessor, 1978: 9).

In spite of the limitations identified, both the quality and quantity of energy used correspond generally to the status of economic development. In calorific terms, conventional energy is superior to other forms of energy. For example, while fuel oil has a calorific value of 9.8 kilocalories per gram, air dry wood contains only 3.5 at the same unit weight (Table 1). Globally, it is estimated that, the distribution of conventional energy ranges from a maximum of 350 Gj/yr/capita for the U.S.A. to a minimum of between 0.3-10 Gj/yr/capita in the low income countries of Asia and Africa (Gardel, 1981:4-5). Since most developing countries utilise very limited amounts of conventional energy inputs, economic strategies requiring large quantities of high quality energy resources may be impaired. Writers such as Earl (1975: 60) note that areas using high percentages of low quality traditional fuels tend to exhibit low levels of economic development. Thus from the brief review of the relationship between energy and development, it may be concluded

TABLE 2 : AVERAGE AND HIGH/LOW PER CAPITA COMMERCIAL ENERGY CONSUMPTION RATES

Country or country Group	G.N.P/Capita (dollars)	Energy Consumption/capita (kilogrammes coal equiv.)	Energy/GNP (RATIO)
LOW INCOME COUNTRIES	230	463	2.01
High: China	260	835	3.21
Low: Nepal	130	14	0.11
MIDDLE INCOME COUNTRIES	1420	1225	0.86
High: Singapore	3830	6211	1.62
Low: Yemen, Arab Republic	420	73	0.17
INDUSTRIALIZED COUNTRIES	9440	7892	0.84
High: Canada	9640	13453	1.4
Low: Italy	5250	3438	0.65
CAPITA-SURPLUS OIL EXPORTING COUNTRIES	5470	1458	0.27
High: Kuwait	17100	6348	0.29
Low: Iraq	2410	692	0.96

SOURCE: Munasinghe and Schramm (1983:17)
Data applicable for 1979

that opportunities for sustained development in developing countries may be limited because of restricted access to conventional fuels.

Constraints of Energy inputs in Developing Countries

Within traditional or near self-sufficient agricultural societies, indigenous energy sources such as wood and animal dung often provided adequate fuel requirements for domestic and limited economic activities. However, in an expanding and modernising economy, as most developing countries hoped to become after attaining nationhood, traditional fuels, which are generally poor in quality (Table 1), could scarcely generate surpluses beyond the household level to meet new challenges of production and distribution.

Commercial agriculture, mining, manufacturing, general construction, commerce and service provision, which provide the backbone of modern economies, demand consistent and large supplies of high value energy inputs that the traditional sector in most developing countries cannot provide. Many countries, attempting to emulate the developed world, shifted in the 1950s and 1960s to take advantage of non-indigenous energy sources, especially of fossil fuels, the prices of which were relatively cheap at that time. This move was envisaged as the beginning of an era when use of traditional fuels would be curtailed completely, opening the path to a developed economy, free from energy constraints. However, the shift (even though never complete) suffered a severe jolt from the "oil crisis" of the 1970s when most Oil Importing Developing Countries (OIDCs) were virtually cut off from the world energy market due to rising prices and excessive import costs. The result was a collapse of the fossil-fuel based activity and a return to traditional fuels. The occurrence of an "oil glut" in the 1980s (Rycroft et. al., 1985) has not in any way ameliorated this situation because rapidly expanding populations and general pressures on national economies (including debt servicing) currently place oil importation beyond the financial capacity of most OIDCs.

As a group, developing countries, with about 70 percent of the world population, now use only about 20 percent of the world conventional energy resources. Even here use is highly skewed; only five OIDCs are estimated to consume 53 percent of total OIDCs oil imports (Grathwohl, 1982; Wionzek, et al. 1982; Moss and Morgan, 1981.). Consequently, the large number of other OIDCs, including Ghana, use very limited quantities of oil. Within the latter countries, access to fossil fuel and its distribution is very limited in nature. The general results are that scarce conventional energy resources, either imported or internally generated, are directed into sectors considered strategic by policy makers, who are faced with a number of critical choices within a fuel-scarcity situation. Transport and modern industries, some urban uses and other specialised activities that can potentially lead to capital formation, tend to be the favoured sectors. This leaves the other sectors, particularly, rural and urban households and small-scale rural industries, totally reliant on traditional energy sources.

Because most political and administrative institutions, as well as large scale economic and industrial activities are located in the urban centres, the energy-use space is further polarised between an energy-privileged urban core and an energy-starved rural periphery. India for example, has a per capita commercial energy consumption in its cities of nearly 20 times, and of electricity 28 times greater than in the rural areas (Foster, et al, 1981). A 1975 World Bank report, which is still indicative of the trend in most developing countries, gives rural electrification in Latin America as 23 percent; Asia 15 percent; and Africa 4 per cent, of total national power output (World Bank, 1975:17).

4. Woodfuel importance and constraints

Within the context of energy use patterns in developing countries, traditional sources of fuel are critical, and among these, wood is the most important in volume of use and numbers of users. Wood constitutes the principal source of fuel for an estimated 1.5 billion people, mostly in the developing world (U N E P, 1984). It is estimated that for the developing countries as a group, wood provided 21 percent of total energy output in 1982, while the proportion for the developed world was only 1 percent. Africa uses about 52 percent of global woodfuel, Latin America 16 percent and Asia 17 percent (World Bank, 1983). However, wood use varies widely between countries (Tables 3 and 4).

With regard to the importance of woodfuel in the economies of most developing countries, any energy crisis invariably affects the viability of national systems as a whole. For example, as a result of the increase in prices of modern alternatives such as electricity and petroleum-based fuels in the urban centres of most developing countries, many marginal income urban dwellers have been driven (wherever possible) to the use of woodfuel, whose prices are still

TABLE 3: ESTIMATES OF THE LEVEL OF WOOD DEPENDENCE IN SELECTED DEVELOPING COUNTRIES (*COUNTRIES LISTED FACE ACTUAL OR POTENTIAL FUELWOOD PROBLEMS)

PERCENTAGE OF NET OIL IMPORTS COMPARED WITH COMMERCIAL ENERGY DEMAND

0-25%	76-100%	
India	Benin	Liberia
Vietnam	Bhutan	Madagascar
Zimbabwe	Cambodia	Maldives
	Cameroon	Mali
26-50%	Cape Verde Is.	Mauretania
Bangladesh	Central Afr. Rep.	Morocco
Botswana	Niger	Philippines
Mozambique	Rep. of Chad	Sao Tome & Principe
Pakistan	Comoros	Senegal
Zambia	El Salvador	Sierra Leone
	Eq. Guinea	Somalia
50-75%	Ethiopia	Sri Lanka
Afghan.	Gambia	Sudan
Burundi	Grenada	Swaziland
Ghana	Guinea	Tanzania
Malawi	Guinea-Bissau	Thailand
Rwanda	Haiti	Togo
	Honduras	Burkina-Faso
	Kenya	W. Samoa
	Laos People's Democratic Republic	Yemen People's Republic
	Lesotho	

NOTE- Generally, the higher the percentage of imports the greater the fuelwood problem

* Countries where annual consumption of woodfuel is unlikely to be sustainable at minimum levels through the year 2000, without damage to the ecology. Many countries not included will have fuelwood problems in local areas.

SOURCE: World Bank, Energy in Developing Countries, August 1980; Adapted from Foster, Friedmann et. al, 1981: pp 233.

relatively cheap. This situation creates undue pressures on sources of wood which are mainly rural and, invariably, leads to problems related to depletion and scarcity, price increases, and changes in the normal collection patterns to accommodate the needs of long distance and specialised markets.

The OIDCs where annual consumption of fuelwood is unlikely to be sustainable at minimum levels through the year 2000, without damage to the ecology are listed as Table 3, while Table 4 reports wood use in the energy budgets of selected African countries for 1976. Almost all the countries listed in Table 3 have weakened economies, in terms of G.N.P. per capita (World Bank, 1987), and if the proportion of oil imports is greater, the economic squeeze may be worse, in which case, scarcity and high costs of imported fuels may drive most people, especially those in the rural and informal sectors to the use of traditional fuels, mostly wood. It is also revealed by Table 4 that, in 1975, about 93 per cent of total commercial energy used in the selected African countries, came from imported sources. The percentage of energy import dependence ranges from 76 per cent in Zaire to 100 percent in Niger and Burkina-Faso. An interesting observation on the import situation is that, while a high proportion of national budgets are used for procuring conventional energy resources, the proportion of such imported energy is smaller in terms of total energy used in the selected countries. For example, while energy imports took 54 per cent of merchandise export earnings in Kenya in 1975, imported energy resources accounted for only 26 per cent of total energy needs, the rest coming from

TABLE 4: ENERGY IMPORTS AND FUELWOOD DEPENDENCE IN THE ENERGY BUDGETS OF SELECTED AFRICAN COUNTRIES

COUNTRY	ENERGY IN NATIONAL ECONOMY			FUELWOOD DEPENDENCE Energy Consumption, 1976		
	Energy Imports As % of Total Commercial Energy, 1975	Exports Merchendise Trade ($U.S. Million, 1976	Energy Imports As % of Merchandise Export Earnings, 1976	Commercial Energy Consumption Per Capita kg/Coal Equiv.	Woodfuel Consumption Per Capita kg/Coal Equiv.	Woodfuel Consumption as % of Total Energy
Ethiopia	96	278	27	27	352	93
Ghana	78	804	18	157	452	74
Kenya	97	656	54	152	430	74
Mali	97	97	25	27	956	97
Niger	100	86	N/A	35	239	87
Senegal	96	426	15	156	265	63
Tanzania	100	459	22	68	1021	94
Burkina-Faso	100	53	19	18	274	94
Zaire	76	930	16	62	200	76

SOURCE: After Howes and Glulick, 1981 pp.34 (also, Friedmann et. al, 1981 pp.67, Osei, 1987:pp. 36).

woodfuel. This trend is common with all the countries listed, including Ghana.

The impact of global inflation and worsening terms of trade after 1975, have resulted in dramatic increases in energy import bills, while actual quantities of imported energy have stagnated or declined in many developing countries. Africa in particular is placed in a very tight situation because most countries are both poorly endowed in exploitable, conventional energy resources and do not possess the financial capability to import needed amounts to satisfy home demands. Except for some of the countries of North Africa, and in Nigeria, Gabon, Angola, and the Congo Republic in Sub-Saharan Africa, the rest of the continent is net-oil importing (Table 3). In addition, of the 37 countries with a population of more than one million listed as the World's poorest (G.N.P./capita less than US$400), 24 are in Africa (World Bank, 1987). In most cases, scarce conventional energy inputs lead to higher costs in affected countries and, subsequent use of traditional fuels especially, wood, whose prices are relatively cheaper compared to conventional fuels, but prices of which may eventually rise as demand increases. In the Sahel, it is estimated that 25 per cent of family incomes go to woodfuel purchases (Evans, 1981; World Bank, 1975). Throughout the Third World, Postel (1988: 18) estimates that working-class households typically spend between 20 and 40 percent of their meagre incomes to buy firewood and charcoal.

Ecological Problems

Pressures on wood resources for energy and for other life-sustaining demands continue to mount in most Sub-Saharan African Countries. For example, even in oil exporting Nigeria, Timberlake (1985), cites unpublished surveys in the Northern arid zone, detailing that farm trees have declined from 15 to 3 per hectare since the 1950s. Evans (1982:20), documents that in Malawi, between 1-3 hectares of the natural woodland is cut to supply enough fuelwood for curing one hectare of tobacco (French, 1986). As the tree-base is depleted, other forms of biomass are used, contributing to major environmental degradation and eliminating the possibility of tree regeneration.

Wood harvesting is noted to have extended far away from centres of demand, because of increasing needs and over-exploitation. In parts of Tanzania, about 250-300 woman-days are required per family to collect needed amounts of wood because of shortages (Arnold, 1978; Evans, 1982). The potential effects of over-concentration of efforts on wood collection may be detrimental to both the economic and physical health of affected people. Many other specific socio-economic and environmental effects resulting from woodfuel have been reported, although many effects are speculative due to lack of detailed empirical evidence.

Summary

The preceding discussion indicates the potential erosion of the fundamental basis of sustainable development in many developing countries. Both human welfare and the well-being of the natural environment are constrained because conventional energy inputs, which are needed for economic development, are not present locally and cannot be made available to all sectors of the economy or to the majority of the population in required proportions, and in a consistent manner, because of the high costs of importation. In turn, the woodfuel sector, which is over-used because of lack of access to alternative fuels, provides a setting for rapid surface destruction and general impairment of the natural ecosystem, even though, if properly maintained, trees are a renewable resource, unlike fossil fuels, which are non-renewable.

In the short to medium term, wood will continue to provide the bulk of energy supplies in many developing countries, because of slow growth of national economies, and stagnation in the provision of alternative energy resources. Detailed research into the wood energy sector is, therefore, a necessity, with particular reference to rural communities. Both the sustainability of the energy system and the necessary research have been constrained by lack of data and the appropriate methodology to collect such data, respectively. In the next section, the basis for this study is presented which is organised to yield information and findings for the key woodfuel use levels that require a comprehensive data base for planning purposes; namely the rural sector, and specifically the village and household units of demand and consumption.

5. Study Approach

As a developing country in sub-Saharan Africa, and with a low performance economy, Ghana exhibits most of the problems outlined above, concerning wood energy dependence. Of critical importance, is the lack of proper understanding of the wood energy sector and an urgent need for empirical data to determine the overall sustainability of woodfuel use; the lack and the need provide the rationale for this study, an outline of which is as follows:

Goal

The over-all goal of the study is to collect detailed empirical information on woodfuel at the village land unit and household levels for a set of villages within the rural sector in Ghana. The objective is to produce a comprehensive record of woodfuel demand and supply at the village level based upon an accurate and replicable approach to woodfuel research, the result of which could provide the basis for energy planning in the rural areas of Ghana and, hopefully, other Less Developed Countries. To this end, the study is undertaken on the basis of a series of formal objectives which combine both methodological and empirical requirements and which seek to examine a number of expected relationships. The study is based on detailed examination of each household in three sample villages. Information is collected for and presented at the household, village, and aggregate levels. Four objectives are presented, each with a series of expected relationships.

Objective 1

The primary objective of the study is to determine the actual amount of wood used as fuel per unit time by quantity (kilogramme) and volume (cubic metres) for individual households and villages. Quantity/volume of woodfuel used is also to be expressed on disaggregate quality basis as well as specific sectoral uses (domestic and non-domestic).

The expected relationships are that;

i. As household size increases, wood consumption is expected to increase. Variables required to measure this relationship are household numbers and wood quantity in kilograms.

ii. the closer a community lies to accessible fallowlands, especially forests, the higher the expected total consumption of wood. Variables required to measure this relationship are distance (km) and, vegetation type/status;

iii. As the frequency of use of wood for major commercial activities increases, the total amount of household/village wood consumption is expected to increase. Variables to be investigated include the number of commercial operations per unit time, commercial activities classified as major, and the quantity of wood used in (kg);

iv. the more households in a village have access to "free wood", the higher will be the expected total uses of woodfuel. Variables to be measured are, the number of households in a village who collect wood without paying money for it (and those who pay money for woodfuel), and total amount of wood utilised per household;

v. the larger the number of agricultural land owners in a village, the higher will be the expected amount of wood consumption. Variables to be measured are, the number of households in a village with title to farmland. Included in this category are farmers on permament and semi-permament care-taker land ownership arrangements. Quantity of wood used (kg) is also important as in all the preceding considerations

vi. the longer the distance to the source of wood the lesser the amount of wood used. Distance in kilometres to all the usual sites of wood collection, irrespective of vegetation type and/or status, is required, so is the amount of wood consumed (kg) by households per unit time.

vii. the higher the number of the non-farm population in a village the larger will be the number of households using alternative fuels. Of major interest are the number people/households in regular wage employment which involve at least 75 per cent of a normal daily work time, who use alternative fuels such as kerosene, electricity and bottled gas.

Objective II

The second objective of the study is to investigate economic costs of fuel to the rural household. The determination of economic costs considers such factors as income potentials in relation to fuel purchases for both domestic and commercial needs, the degree of sustaining commercial uses of wood, and labour cost substitution in terms of time lost on woodfuel gathering/use rather than for economic opportunities.

The expected relationships are as follows;

i. the greater the number of non-farm households in a village, the higher will be the incidence of wood purchases. The number of households with regular sources of income outside farming (as in vii in objective I) in a village have to be determined. The number of households in each village purchasing wood will also have to be determined;

ii. the more wood is required for economic activities, the greater will be the
number of households who purchase wood. The total number and freauency of use of wood by commercial ventures in a village should be known. The number of households purchasing wood for commercial ventures should also be known;

iii. the higher the number of non-land owning farmers in a village, the higher the possibility of wood purchases. The total number of farmer-households who do not own any or a minimum of 75 per cent of their farmland, and the total number of such households in a village who purchase wood at least once every mont, should be known.

Objective III

The third important objective of the study is to assess social and ecological impacts of woodfuel use dependence. Variables to be considered under social impacts include membership to groups and/or associations, personal security, religion, and traditional belief, tastes, preferences, health and aesthetics. Under ecological impacts, the study seeks to investigate general alterations and/or transformation of standing vegetation, depletion of species, and general surface exposure and consequences. The relationships expected include:

i. the greater the distance to sources of wood and the time required for wood collection, the greater will be the potential for human physical impacts. Variables of interest include, the number of hours and distance in kilometres to sources of wood, and the number of households in villages with reports of pains, injuries and general body and/or mental fatigue as a result of wood collection;

ii. the larger the number of households with limited supply of woodfuel in a village, the more the expected negative human effects through labour intensification and lowering of nutritional standards. The number of households in a village with evidence of wood shortages (by quantity and by expression), and evidence and/or reports of health, decrease in number of meals and monetary costs attributable to wood collection, must be determined;

iii. the higher the proportion of inferiors in gross wood mix, the greater the problem of wood supply in a village. The quantity of wood which is classified as inferior and quality has to be determined for each household/village. Wood scarcity situation has to be determined by criteria such as absolute quantity and/or a mix of quantitative and qualitative considerations;

iv. the higher the potential for local wood supply problems, the higher the probability of use of non-traditional and taboo species. The number of households in a village who cannot obtain the required quantity of usual species of firewood because of shortages should be established. As well, the number of households who use taboo species must be known;

v. As wood becomes more difficult to access the more will be the disruption in traditionally set household division of labour. The number of households with reports of wood shortages, and increase in distance and time for collecting wood must be known.

The intra-household division of labour for collecting wood must also be known;

vi. as more households find it difficult to obtain adequate firewood, more standing vegetation will be destroyed. The number of households in a village reporting wood shortages must be known. The number of households using live standing vegetation must also be determined.

Objective 4

The fourth objective of the study is to identify conservation and/or planning needs .

Relationships outlined in association with the first three sets of objectives, especially those with relevance to demography, occupation, individual and ecological welfare, are deemed requirements for rural energy planning.

Organisation of the Thesis

The work is organised into eight chapters; the rest of the chapters are set out as follows;

Chapter II, provides a detailed literature examination of some existing woodfuel research, with the objective of helping to formulate the appropriate model of the study and operational methods used in this study.

Chapter III provides information on concepts and ideas associated with the complex and dynamic nature of woodfuel systems in Third World village settings, necessary for the formulation of the study model. The chapter provides the conceptual framework for studying and assessing the sustainability of village fuel systems.

Chapter IV introduces the study area and the methods used to gather woodfuel information. A detailed examination of the energy sector of Ghana is provided. The basis for selection of the specific village study settlements is then presented, together with details about each study village. Methods which attempt to provide for consistent and accurate data, covering households and village units and which cover both quantitative and qualitative measurements, are described. The field limitations within which the methods were applied and the necessary adjustments to make them reliable are also described. Finally, the procedures for analysing the study results and mechanisms for establishing impacts are provided.

The presentation and analyses of the results of the study actually begins in chapter V. Specific field information on demography, occupations, fuel use types, spatial distribution of regularly used tree fuels, and results of experimentation on charcoal conversion are provided. As the primary empirical results, the chapter presents, in detail, household-based comprehensive woodfuel use and acquisition patterns for each of the study villages (with particular reference to the first objective of the study).

Using statistical and analytical procedures, Chapter VI explains the patterns of woodfuel consumption in the study villages identified in Chapter V Information provided in Chapter VI is within the framework of objective one of the study and related relationships. A number of variables are analysed to consider their role in explaining variations in wood consumption in the area, first by univariate and then by multi-variate procedures.

Chapter VII examines in detail any possible impacts, both ecological and human (social) resulting from the use of woodfuel. This chapter attempts to meet requirements for the second and third objectives of the study. Apart from identifying and discussing ecological impacts, a criterion for establishing wood shortages is considered, and individual villages rated on potential scores of relative scarcity. Specific social impacts are also exhaustively examined. The nature of responses to identified impacts is discussed.

In Chapter VIII, the significant results of the study with planning implications are discussed. Projections are made to match existing consumption trends with future needs. Pertinent recommendations are made to benefit planning efforts in the energy sector in Ghana.

CHAPTER II: PROBLEMS IN WOODFUEL STUDIES

1. Introduction

The rationale for the study of woodfuel use in Ghana, presented in Chapter I, includes the overwhelming importance of woodfuel as the source of energy for the rural sector, the potential impacts, both ecological and socio-economic, of increased demand for and use of woodfuel, and the fact that, despite its quantitative significance and impact potential, there exists virtually no detailed information on woodfuel use on which to evaluate the current situation or to plan for the future.

This chapter provides a critical review of issues involved in woodfuel studies, and assesses the utility of existing methods for investigating woodfuel consumption in village situations. The major objectives of the chapter, with regard to the preceding statements, include; i). the identification of key variables which will lead to the development of an appropriate model for the study, and ii). to identify particular concerns and aspects of the methodology of investigation which need to be incorporated to make the present study valid and useful.

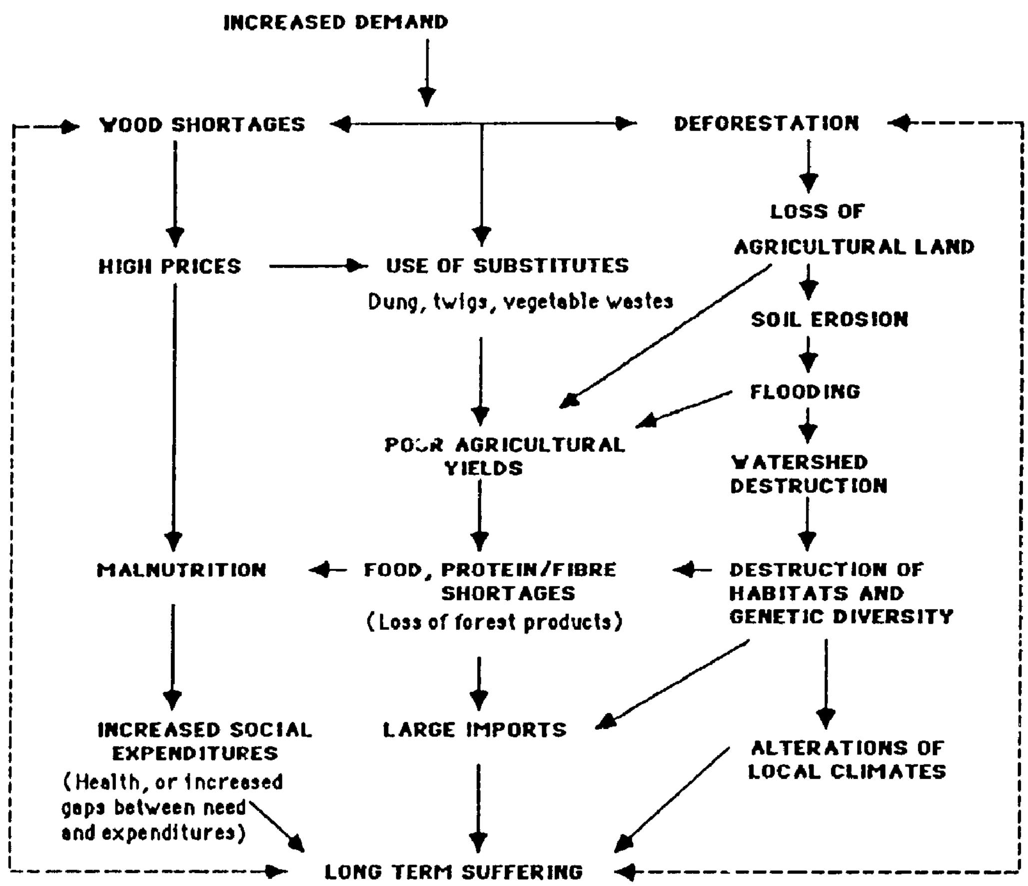
The chapter is organised into two parts. The first part critically examines the applicability of some existing reports on woodfuel use, as well as providing further consideration of areas to be included in woodfuel studies. The second part examines the relative strength of methods used in most existing woodfuel studies.

2. Existing Woodfuel Studies-Issues and Needs

The ability of woodfuel systems to sustain rapidly growing rural populations in the developing world, is a central concern in most woodfuel investigations. The World Commission on Environment and Development (WCED) (1987:8) has suggested key elements of sustainable energy use. These include; i). sufficient growth of energy supplies to meet human needs ii). energy efficiency and conservation measures, such that waste of primary resources is minimised; iii). public health...; and iv). protection of the biosphere and prevention of more localised pollution. In the presence of high demands and inappropriate management mechanisms, either to regenerate wood for fuel on a sustained basis, or to provide cheaper and more viable alternatives to wood, or both, the harvest of wood for fuel has the potential for negative ecological and human impacts. Figure 3, provides a basis for reviewing potential problems with woodfuel use in this "unrestrained use" context.

As illustrated by Figure 3, unrestrained use of woodfuel, potentially, carries negative consequences in both human and ecological terms. For example, increased demand for woodfuel may lead to deforestation and wood shortages. Once deforestation occurs, valuable agricultural land may be lost, leading to decreased food production, leading to possibilities either of famine or large imports, with the ultimate result of long-term suffering. At the same time, the incidence of wood shortages may lead to high prices of woodfuel. People may either use less wood to avoid paying high prices for it, thereby compromising nutritional standards and long-term health

Figure 3: Dynamics in the Woodfuel System Under Unrestrained Use



SOURCE: AUTHOR

status, or avoid paying for woodfuel by using substitutes such as dung, twigs and vegetable wastes. This, in turn, could rob agricultural lands of the needed natural nutrients and therefore lower productivity. Food shortages, malnutrition, and long-term suffering may arise. Large imports can offset poor yields but scarce resources for other needs of balanced development may be sacrificed. Deforestation may also lead to soil erosion, flooding, watershed/habitat destruction and alterations of local climates. In this direction too, both the long term productivity of the natural environment and the support base for human lives is destroyed. Various linkages in Figure 3 demonstrates a chain reaction in the system once certain negative processes are set in motion. Useful as it may be, however, Figure 3 is intended only to represent an extreme situation where no containment mechanisms ensure a halt to the spiralling effects of negative characteristics of woodfuel use. It provides, however, a useful frame of analysis for examining problems related to wood energy over broad regional environments, as the next section discusses.

Several reports indicate extremely adverse characteristics associated with woodfuel use in many developing countries. More adverse reports may be expected because demand pressures on wood resources are heavy and in some cases excessive. Whilst such reports are varied in content, depending upon area, scale and purpose of study, an extract from the World Conservation Strategy (WCS) drawing on 1978 F.A.O. studies, summarises these effects on the ecosystem and socio-economic conditions. Among other things it states;

> ... Around one fishing centre in the Sahel region of Africa deforestation [resulting from fish smoking using wood] extends as far away as 100 km. Fuelwood is now so scarce in the Gambia that gathering it takes 360 woman days a year per family....in the poorer parts of the Andean Sierra and the Sahel [heating and cooking costs] can be as high as 25% [of household budgets] (IUCN,1980:4; UNEP,1984; Eckholm, 1976, Postel and Heise,1988:17).

Recently however, controversy has arisen over the validity of reports such as these. Some researchers, especially those working at the basic level of consumption, maintain that most studies over-state negative impacts associated with woodfuel use in some areas. For instance, one recent study states "while researchers did not visit the forest areas... the quantity [of fuelwood] consumed is so large as to indicate deforestation is possibly severe" (Monsoor et al. 1985:205). Unsubstantiated statements of this sort suggest the speculative nature of many reports. In a parallel observation, Desai (1985:17), states in the case of India that reports associating rural energy shortages to nutritional problems or deforestation are just alarmist, and invalid, because they assume that there is no substitute for firewood, and that firewood is obtained by felling trees, conditions which it is said do not exist in India. Foley et al. (1984:11) write, "it is often assumed that trees are disappearing because people are using too much fuelwood... The fallacy... lies in the fact that it ignores the root causes of deforestation". Evans (1982:15), has also drawn attention to woodfuel consumption estimates forecasts which assume no increment , no regeneration and no planting at all.

Research in Africa also supports skepticism about exclusive dependence on wood for fuel. Moss and Morgan (1981) have reported that sorghum stalks are as important as wood in extreme Northern Nigeria, Niger, and Burkina Faso. Ernst (1978), has concluded that millet stalks are used half the year and wood the other half, contrary to previous reports that projected wood as the only major traditional fuel in Burkina Faso (Also see Howes,1985). Foley et al. (1984: 34), indicate that investigations have revealed discernible seasonal shifts between wood and dung as fuels, in villages in Lesotho, Kwazulu, and Transkei in South Africa, wood principally in the summer, and dung in the winter. The general argument is that even where wood is the principal fuel, the standing vegetation is not affected significantly because twigs, small branches, and deadwood provide the bulk of supplies (Desai, 1985; Vidyarthi, 1984; de Lucia and Tabors, 1982; Dunkerley, et al. 1981).

Positive reports on rural energy in the developing countries should be regarded cautiously. While such reports correct some of the overstatements and exaggerations of other work, woodfuel-related problems contribute to some of the widespread socio-environmental degradation in parts of the developing world, including the most recent cases in the Sudano-Sahelian belt of Africa, exemplified by the widespread famine in Ethiopia and southern Sudan. Similarly, optimistic reports placing emphasis on traditional wood alternatives tend to discount long-term ecological and economic trade-offs through soil productivity and surface cover. It is also to be mentioned that it is where the tree resource has been seriously depleted that traditional alternatives are widely used (Osei, 1987:37; Postel and Heise, 1988: 18).

For the greater proportion of the population, especially those in rural areas, there are no real alternatives to wood. Wood is, generally speaking, the potentially reliable source of fuel for most energy-starved, developing countries both now and in the future. But at the present time, data on woodfuel are inadequate and too inconsistent for conclusive statements and for planning purposes.

Requirements for woodfuel research

For most developing countries, energy consumption surveys appear to represent the vital starting point for any comprehensive wood energy research strategy. A conference report by the United States Academy of Sciences states, that, "the role of an energy survey is to provide a firm information base for analysing energy decisions and ultimately improve those decisions" (US Academy of Sciences, 1980:9). Analysing and improving upon existing and future decisions involve a whole range of issues including technology, research and development. Thus, field-based energy surveys for instance, provide a bridge between decision making institutions, energy users, producers, scientists and technicians.

Due to the multiple nature of interrelationships within woodfuel systems, the basis of research has to recognise important questions related to all key elements necessary for their continued existence. Answers to any such questions have to be vigorously investigated to avoid conflicting reports. For example, in what context are the actions of poor rural dwellers with no access to fuels other than wood, to be condemned as destructive with regard to vegetation loss? When and how may deforestation be attributed to fuel use, if there is disagreement among professionals such as ecologists on one hand, and foresters on the other, over the whole process of deforestation? (Myers, 1980, Foley et. al., 1985, Allen et. al., 1985).

U.N.E.P. sources have reported that a recent survey in India found that women who burnt wood and other biomass fuels consumed benzopyrene equivalent to smoking 20 packs of cigarettes a day and, that as a result of long use of these fuels, they are exposed to 700 micrograms of particulates per\m^3 compared to acceptable limits of 75 (UNEP,1985:2; Smith, 1986). Potentially, the negative effects of woodfuel on women is found to be disproportionate. In the past, very little attention was paid to possible health impacts from the use of biomass fuels.

As has been observed in this section, woodfuel research hinges on many considerations which have not been adequately addressed by existing project designs. The issues, some of which have been theoretically examined, generally parallel methodological problems.

3. A Review of Woodfuel Research Methods

The objectives of a detailed review of existing studies are i) to establish working parameters for detailing a model to guide this study in terms of existing study reports, and ii) to help make for proper design of methods for this study, to overcome any weaknesses associated with existing studies that potentially reduce their utility for planning uses.

It is interesting to note that, whatever the basis for study, woodfuel surveys have increased tremendously in number over the last decade. A variety of methods have been used, which range between the use of survey contacts (such as interview survey and participant observation) and direct physical measurements (Howes,1985; Pluth, 1985; Cline-Cole, 1984; Ernst, 1979, etc.). Critical deficiencies in most woodfuel data, however, still exist. While the source of such short-comings may be varied, several of them can be traced to the means by which information was gathered in the field.

Global estimates of a national or regional nature, which usually are not backed by any detailed empirical studies, provide the bulk of existing data in most developing countries (Arnold, 1979; Openshaw,1978; Earl, 1975). Many such estimates have been found to be subjective and imprecise since they are generally derived from some arbitrary criteria and may have little practical relevance to actual users of wood.This also contributes to most of the conflicting reports on the impacts of woodfuel systems.

Even where detailed local studies have been made, however, specific problems with research methodology continue to downgrade survey data. These problems are discussed as follows:

Improper Definition of Concepts and Working Models

Most researchers working among traditional populations tend to over-look subtle variations in certain popular concepts or show inadequate understanding of others, from place to place. Where a proper definition of concepts is not made in relation to target populations, the whole research loses its focus.

Among common examples are: (i) the concept of household. The household provides the basic unit for wood consumption studies and increasing numbers of researchers are adopting it. However, a possibility of double counting or omission of members of some households exist depending upon definitions among different ethnic groupings (Howes, 1985 provides interesting examples from Africa and New Guinea).

(ii) User preference through ranking. It has been established that, without reducing various fuel alternatives to a common base understood by respondents, they tend to rank highest those fuels that are cheap and easily obtainable and that may not necessarily be the best alternative (Desai, 1985; Cline-Cole, 1981, 1984). This will tend to render invalid any studies aimed at testing the viability of alternative energy resources;

(iii) age structure identification; in most parts of Africa for example, the concept of children and adults differs from place to place, and under various circumstances. "Children" may be used to refer to all dependent occupants of an extended family home, without actual numeric/legal age discrimination. In other situations where certain traditional rites initiate children to adulthood, a minor may be considered an adult, so far as a particular rite has been performed. Many reports are liable to fall prey to such realities, where careful consideration is not given to project definitions;

(iv). species identification; It is extremely difficult to keep track of local names of specific tree species, especially, in ethnically heterogeneous regions, where a single tree may be given different names. The situation is complicated when a significant proportion of the population in a region are recent migrants who originated from contrasting ecological regions (such as migrants from the Sahel to coastal West Africa). Since most trees may then be unfamiliar, non-standard names may be adopted and at worst, no proper identification of certain tree species may be made, to the frustration of a researcher. When this happens, it is possible for a researcher to count the same species several times, or leave out several species for lack of adequate information.

(v). Energy Another definition problem concerns the concept of energy itself. Most researchers maintain a narrow view of energy, and this generally affects the manner in which research is designed and its general usefulness to society. The National Research Council (N.R.C., 1984), for example, maintains that "the way a society thinks of energy affects the way society makes decisions about energy". The N.R.C.'s view of energy as constituting a "commodity", "ecological resource", "social necessity" and as "strategic material" provides a useful guide to differentiating studies, so that relevant relationships for positive planning and undistorted and accurate policy choices can be made (N.R.C., 1984:14-31).

In addition, very few working models exist to guide new studies. Existing models mainly relate to relative costs, either in terms of labour or price dynamics (Howes, 1985). Apart from their limited applicability in different environments, they do not account for non-directly priced but equally important variables such as local preferences, tastes, external influences and ecological significance. Also, a major problem with economic/normative models is their limited application in semi-subsistence economies. A conceptual model for woodfuel studies should identify and be relevant to all key elements involved in woodfuel systems.

Aggregation of Data

Conclusive analyses of the woodfuel system can be made only when relevant data, both aggregate and sectoral in form, are provided. Aggregate woodfuel data is necessary to provide composite information concerning use trends in an area that will also aid appropriate management intervention. However, aggregate figures deny users of research information a detailed knowledge of internal differences. Many of the existing reports never give such breakdowns (Desai, 1985; Howes, 1985). Three segments of woodfuel information are crucial to all aggregated data. These include i) total (including quality range); ii) domestic and iii) non-domestic.

Domestic use of woodfuel extends over several activities. These include food preparation, food processing for storage, boiling water for washing, drinking, and health reasons., space heating in cold and hilly areas, providing light and warmth for family socialisation, as well as some evening entertainment and gatherings.

Most researchers assume erroneously that household fuels mainly go to cooking and thus do not try to establish any sectoral distributions and interrelationships at that level. While it may prove a difficult task to separate various uses at the domestic level, these cannot be overlooked in gross use terms, in any attempt to collect detailed and useful information on wood consumption. It is admitted that usually, it is difficult to totally isolate the various uses of wood for household purposes. As an example, a single fire set may be used for cooking, smoking of fish and meat for storage, provide live embers for ironing etc.. It is also a common example in West Africa, for example, for a family to derive part of its meals from food being prepared in the household for sale to outsiders. Ernst (See Howes, 1985:19) discovered in Burkina Faso that, in one day out of three, more than half of the households in her survey used more fuel to produce goods for the market than for their own requirements. Howes (1985:19) cites Siwatabau's work in Fiji, which revealed that households may be using about 30 per cent of their total fuel consumption for copra drying (Siwatabau, 1981). These examples indicate that it is also sometimes difficult to separate purely domestic uses from commercial ends.

Many writers fail to mention commercial and industrial use of woodfuel at the household level. However, there are a number of cottage industries, ranging from cooked food enterprises to distilleries, that rely solely on woodfuel. As these industries expand their activities, a great demand can be placed on available fuel resources. Studies have to note this factor since it is vital in energy planning.

Many researchers also do not provide a breakdown of woodfuel type or quality form. The impression created by most reports is that solid wood and, for that matter, live trees provide the main source of woodfuel. This may be true in some localities but generally it is not the case. Desai (1985); Moss and Morgan, 1981; and Ernst, 1979, have all noted the importance of twigs, branches and even roots in the fuel mix.

Improper Basis for Selecting Study Areas

The wood consuming environments differ in terms of population (both density and internal diversity), source area (ecological or vegetation types), economic opportunity, and climate. Only detailed background knowledge of such information can assure the proper selection of representative areas for study, to enable meaningful extrapolations to made. Whereas workers such as Fox (1984) and Donovan (1981) have emphasised the lack of application of sampling techniques in most woodfuel studies and have commented on the general variability of woodfuel data, they have not with equal force mentioned the need for a detailed pre-study information base, which might help make any sampling procedures adopted more realistic with respect to the study area, so that information gathered may be unbiased. In most cases, no reliable sample framework exists to draw upon. Until detailed information of a physical and socio-economic nature concerning the study area provides a basis for selecting study areas, biases in information will persist and this will limit the over-all usefulness of research data.

4) Dominance of Qualitative Information

While quantitative data may not be an end in itself, it offers precise, definite, and useful information to enable resource planners to make an objective assessment of resource situations and thereby choose more wisely from alternative actions.

A comprehensive review of the literature on woodfuel surveys has indicated that the bulk of all existing work is based on qualitative procedures that rely mainly upon user memory recalls

(Howes, 1985; Marsinko et al., 1984). A major advantage of this method includes convenience and speed, especially, where large numbers of respondents are involved. Its most serious defect, however, is that it lacks accuracy and reliability. For example, in some studies that used phone or interview surveys, respondents were asked to recall the number of pick-up truck loads, bullock carts, bundles, headloads and several other relevant units of wood consumed over a unit time. An average figure was obtained for one such unit, to derive total consumption (Marsinko, et al. 1984). Among major disadvantages with such methods are that they, erroneously, assume that the wood resource is homogeneous, and they place an over reliance on people's memory. Such methods are also silent, for instance, about standards required to assess such units of observation as bullock cart/bundles/headloads/pick-up truck loads, which may be variable both in time and space. Marsinko et al. (1984:364) reveal that a study in North Carolina indicated that pick-up trucks will hold from less than 1/5 to slightly over 1/2 cord, depending upon the size of the truck and how the wood is stacked. Note also that the cord is a variable unit -long cords, short cords, and face cord, all meaning different volumes (the standard cord is approximately 3.623 m^3 or 128 ft^3).

Again, specific information is often lost- for example, about species composition (especially, with multi-species tropical environments), quantitative quality mix and supply trends, which are necessary for on-site planning. de Lucia (1980), citing some much publicised studies in India, Nepal and Bangladesh, has maintained that in most cases researchers did not actually measure use, but recorded users' estimates and recollections.

Other methods also extrapolate from studies in developed economies, based on modern fuels, such as electric power, to estimate a basic minimum energy requirement for each individual per annum. An arbitrary cut-off figure is assumed, and a conversion standard applied to estimate equivalent amount in terms of wood (Pluth, 1986; and F.A.O., 1985). Apart from suffering from the preceding disadvantages, this method suffers from additional limitations associated with inter-fuel comparisons and unnecessary application of standards with suspicious applicability for different site conditions (physical, economic and socio-cultural conditions).

Direct physical measurements at the user level appear to be the most appropriate technique because their proper application can yield information that is verifiable and relatively accurate. However, precise instrumentation for quantitative wood consumption surveys has not been developed to the same extent as in other areas of research. The most widely accepted quantitative method currently in use is the weight survey, using scales (Chapter IV). Even here the result, however, can be seriously affected by the nature of measurement, differences in such areas as form, type, and moisture level of wood, other biomass alternatives, and cyclical influences of a socio-economic, technical or physical nature. These conditions and the manner in which they potentially affect results are usually not fully taken into account by researchers. Hammer (in Ay, 1981;17), apparently considering difficulties associated with quantitative information gathering in a foreign environment has recommended that "for action-oriented research, there should be a large reliance on qualitative rather than quantitative data which are obtained through methods developed in and for Western countries". Hammer's proposition falters on the grounds that, due to the many problems associated with qualitative information, it should not be a substitute for quantitative information even though it may be easy and convenient to use. Wherever possible, qualitative information should be used more as a back-up, to check the accuracy and relevancy of quantitative information.

Short-Term and Small Scale Nature of Studies

Time and spatial considerations usually become secondary issues in most research designs, even though different conditions have been noted to influence wood use both over time and space. Many studies have, therefore, been noted to be temporally and spatially limited, making their findings difficult to replicate.

Studies that do not repeat surveys of the same or similar population over a series of time periods, have been described by Desai (1985:3) and Howes, (1985:40) as "one-shot" surveys and those that are single settlement-based "one-spot" surveys. Howes agrees that substantial day-to-day variations can arise in domestic levels of fuel consumption, so that repeated surveys are needed to yield long term mean data to help find reasons for such variations. Desai has also impressed that,"one-shot surveys are not appropriate for establishing transitions, which take time" (Desai,1985:3).

Different short, medium and long term influences affect wood consumption, such as the influx of relations for a short visit, travels, festivals and celebrations, seasonal commercial activities, farming season, and many others. It is beneficial for such reasons, to design studies to encompass seasonal variations. "One-spot" surveys on the other hand, cannot perfectly substitute for a wider region. However carefully a community is selected, notes Howes (1985:134), there will always be severe limits to the extent to which it may be claimed to represent a wider entity. As much as possible, studies need to be continuous and or long term and must consider a broad coverage of settlements.

Lack of Institutional Support

It is of interest to note that, in spite of the heavy dependence on wood in most developing countries, definite official programmes to support the wood energy sector rarely exist. Few studies have been internally initiated or funded. Ojo has noted that "even where the smallest sample is selected ... the financial resources required to conduct the survey are not always available [and] invariably, the researcher has to compromise with less than adequate data" (Ojo,1981:17). Ay (1981) has reiterated that even where some field research has been done, data are rarely easily available; "in most cases they exist in only a few copies resting on some book shelves untouched for years and unused and forgotten" (Ay, 1981:173).

When wood is recognised at the official policy level as a viable fuel and given necessary institutional backings it will offer motivation for increased studies since not only will resources for research be more easily obtainable, but there will be in existence both a coordinator for research and users of research findings.

Summary

By critically reviewing reports of many existing woodfuel studies, certain inconsistencies and methodological flaws are identified with regard to the goal and objectives identified for this study. A major example is the little or no consideration to the nature of the key units of woodfuel use, the village and the household, in project designs. It is difficult to do any meaningful investigation into village woodfuel systems without the proper understanding of the local area, in terms of the state and dynamics of the ecosystem, total population, including growth rates, households and their internal structures such as age and gender differences, land use types, land tenure systems and size of holdings, traditional and social relationships, woodfuel use type, sources, methods and dynamics of accessing woodfuel, linkages of the village, ecological, social and economic, with the external environment, and identification of sources and nature of impacts resulting from woodfuel use. Generally, most existing studies fail to establish the various dynamic relationships involved in rural energy systems which form integral parts of village functions. Because most woodfuel studies are undertaken in isolation of related village activities, vital information needed for effective planning in the wood energy sector, remain untapped.

With regard to constraints associated with most existing studies, especially as they relate to village conditions, it is the aim of Chapter III to develop an appropriate model for this study which will recognise the complexity of village woodfuel systems and, identify key elements necessary for the study.

CHAPTER III: THE STUDY MODEL

1. Introduction

The key goal to this study is to gather and analyse data in relation to the critical units of woodfuel use, namely, the village and the household. The village, including its land area, is the source of aggregate supply and demand of most, if not all, traditional energy, especially of woodfuel. The household is the specific unit of demand and use and its members are the agents of supply. Consequently, the aim of this chapter is to develop the conceptual/model framework of village/household based woodfuel use including the range of factors that influence demand and supply, and which must be combined in any comprehensive model of the use system, and incorporated in subsequent analysis.

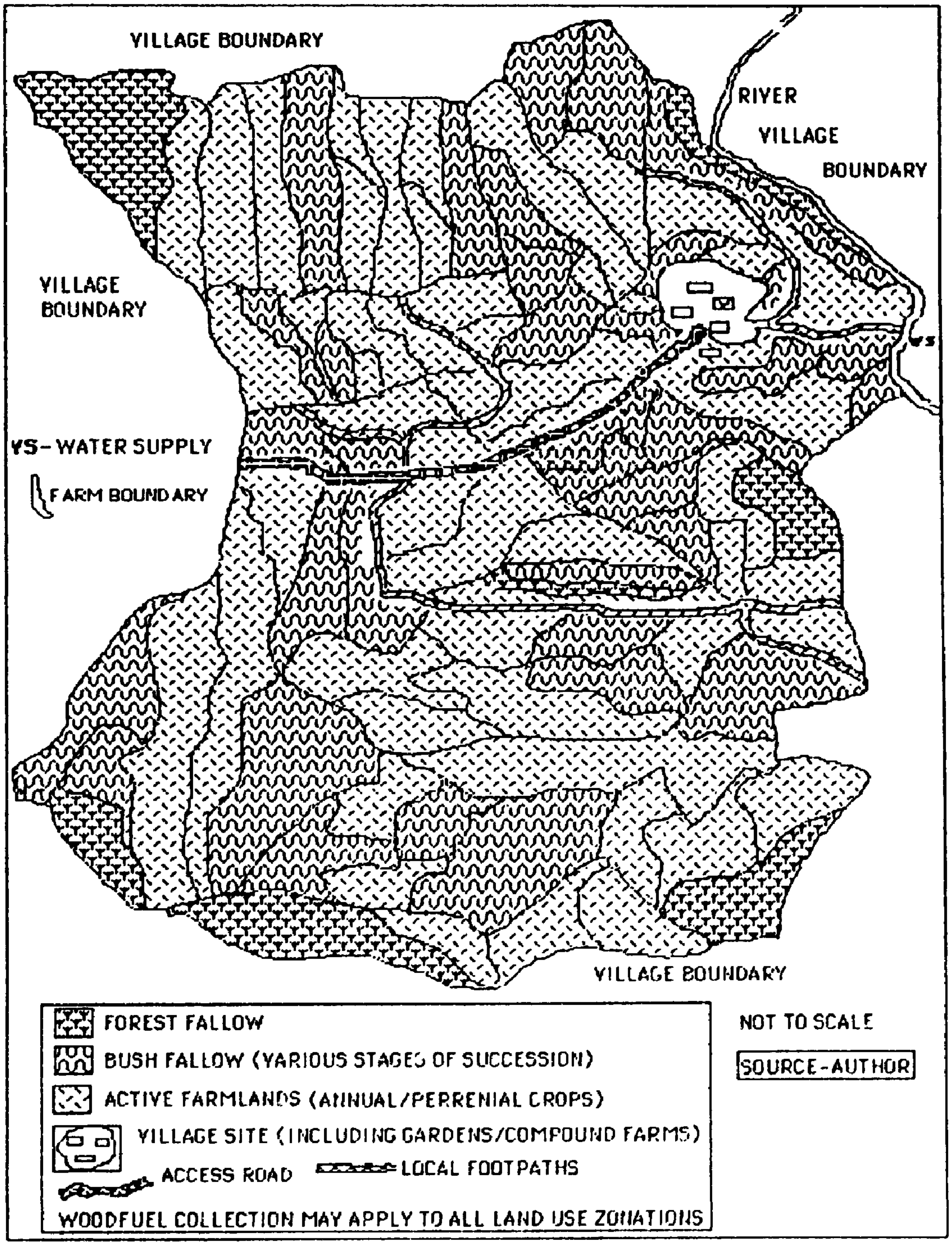
2. The search for a conceptual model/framework

A Background: The village and the woodfuel system

Since the village is the basis of all wood supply and consumption trends, it provides the key basis for the development of a conceptual model to guide this study. In Ghana, as in most developing countries with relatively low levels of urbanisation, the village unit is the major component of rural settlement and land use. A village is made up of the settlement and its land area. The fundamental unit of observation in the village is the household, which is the basic unit of production and consumption. The sum of the set patterns of production and consumption of individual households give character to the village.

As Ghana is primarily an agricultural country, the village is the predominant unit of economic as well as social organisation and in aggregate, the basis of the national economy supplying the food and raw products needed for national socio-economic development and including export revenue. Some village agricultural production systems are unique, but most are very similar, especially within broad ecological zones. In the practical sense, each village exists more or less as a separate entity, with defined boundaries. Within its boundary, the village strives to be self-sufficient, both for local support and for external exchanges. For example, the village and its land area must provide a place for habitation, a source of food, cash crops, fuel, and other miscellaneous needs. To provide such basic functions, villages are organised into series of land use zones as illustrated by Figure 4. Land use zones include: i) active farmlands, which are perennial and/or annual. Perennial farmlands involve tree crops such as cocoa (Theobroma cacao), oil palm (Elaeis guineensis), and food and fruit trees such as plantain (Musa paradisiaca), banana (Musa sapientum), oranges (Citrus sinensis), Cola (Cola nitida), avocado pear (Persea americana) coconuts and others, depending upon local growing conditions. Annual crops include grains, root crops and vegetables such as maize (Zea mays), cassava (Manihot utilissima), cocoyam (Xanthosoma mafaffa), yams (Dioscorea spp.), tomatoes (Lycoperisicum esculentum), pepper (Capsicum annuum and C. frutescens) and egg-plants (Solanum melongena); ii) farm fallows, which are usually old farmlands temporarily idle, between use. The rate at which active farmland revert to fallow depends upon the cropping length and the ease of pressure on agricultural land.

Figure 4: Generalised Village Land Use Zonations



Generally, farmlands with annual crops such as maize, cassava and vegetables, may be used every 5 to 8 years, while such perennial crops as cocoa, oil palm and coconuts may be under continuous production for 20 to 30 years; iii) forest fallows, mainly secondary forests and/or old growth farm fallows, usually close to the village boundary. Forest fallows have relatively longer idle/regeneration period. In areas with high demands for agricultural land, forest fallows are far less in size compared with farm fallows; and iv) the settlement site, which also includes garden plots on which households raise vegetables and some food crops on a continuous basis: Fuel collection zones include/overlap all the land use zones. These zones do not generally fit under conventional concentric land use zonations (Figure 4). Morgan (1969), observed that "within West Africa, concentric rings are frequently absent, even around well-developed villages". Different patterns such as the "Huza" or strip system usually emerge, reflecting land ownership and cropping patterns (Dickson and Benneh, 1970).

In the traditional fuel supply system, the size of the village land and the status of its original vegetation are the major determinants of woodfuel supply. However, in a broader sense, access to land and the state of the natural ecosystem, are just part of complex interrelationships in the village fuel system. To fully understand the village fuel system, the various intricate elements involved need to be examined.

Elements of the village fuel system

i. The state of the vegetation system

As mentioned in the preceding discussion, the village vegetation system is the basis of virtually all fuel supply to the village households. For many villages in Ghana, as is the case in most areas on the African continent, much of the original vegetation has been transformed into various stages of succession as a result of increased human use. Under such conditions, any reference to the village vegetation applies to the humanly modified vegetation system, which in most cases is impoverished woodland, and/or derived savanna near the villages, and/or secondary forests toward the outer reaches of the villages. It is argued that since village vegetation systems are the chief sources of fuel for most village locations, when and where the status of vegetation is known to be under precarious conditions, human dynamics will appear to be the most significant factor in determining the efficiency of village woodfuel systems. Human elements considered important in determining the efficiency of woodfuel systems include; the household unit, which is the basic level of demand and supply, land use type, land tenure/ holding type, and social and economic exchanges. The relevance of each human element to village fuel systems and for the formulation of a model for this study is now discussed.

ii. Household units

While the village together with its complementary land area is defined usually as a single unit, it is the presence and activities of individual households within a particular village that determine its operational function and overall character. For example, within each household, there are various possible production and consumption situations based on the number of people and on individual and aggregate household decisions. The nature of demand of woodfuel in any village system, largely depends upon the characteristics and activity types of individual households. The size and structure of households affect woodfuel demand and supply levels. In villages where some households also engage in commercial activities, the general requirements for wood may be higher. Also, the ethnic and religious composition of households may be crucial in terms of the manner in which wood is collected and used. For example, ethnic affiliation may affect quantity of wood used by different households in village units, because of differences in meal types and the differences in woodfuel demands of specific meal types.

However, in most cases, because the village also functions as a unit, there are various messages and signals generated at the aggregate village level which affect individual household units. These help to shape the village identity. For example, overall characteristics of the village unit includes the general land area immediately available for wood collection, which in turn determines the manner in which wood is accessed and the kinds of wood available for use. The household is thus a sub-system of the village unit, which also relates to the modified eco-sub-system. The recognition of this structural fact is important for any analysis of village fuel systems, hence the need to collect data on both the household and an aggregate village basis.

iii. Dominant Land use types

With regard to village fuel systems, agriculture and wood supply/ gathering are the most significant and related activities on village lands. Considering the number of households involved, percentage land coverage, time input, and economic returns, agriculture is the most dominant activity in most villages in Ghana and contributes to characteristic land use patterns. In the southern parts of the country where this study is based, cropping is the main agricultural land use type. The cropping systems include cash and/or subsistence. Currently, subsistence farming in its purest form no longer exists in any part of Ghana, because of the necessity for cash for certain basic items including food, clothing and health, usually supplied from outside the village to households on daily basis.

The blend between raising crops for cash and/or for subsistence takes many forms and varies from one location to another. Cash cropping may involve perennial/tree crops such as cocoa. Other cash crops, especially foodstuffs, are temporary in terms of the use of the land. Together with food for subsistence (including vegetables), the food cropping system is mainly undertaken as a bush fallow system. Many of the perennial crops such as cocoa and coffee are also established initially through the bush fallowing system (Webster and Wilson, 1980; McLoughan,1970; Thomas and Whittington, 1969).

As a major farming practice, the bush- fallowing system has relevance to the long term efficiency of village fuel systems and to help develop an applicable conceptual model and a better strategy for the field study, the dynamics of the bush-fallow system require specific details.

Bush-Fallowing Agriculture

Bush-fallow is an agricultural system characterised by the rotation of land. Technically, bush- fallow differs from shifting cultivation because the settlement does not move with the rotation of the land. Moreover, the density of population under bush-fallowing is high enough to reduce fallow periods considerably, usually below 10 years, and in many of the heavily populated villages of Ghana, to 5 years or less. This compares with pure shifting cultivation systems, where population densities may be low enough so that fallow periods may extend between 10 and 30 years, or more. Barke and O'Hare (1984;10) have documented that under the bush-fallow system in most developing countries, the percentage of land cultivated at any one time ranges between 33 and 66 per cent, and that the system can support up to 250 persons/km^2. Fallow periods may range between 5 and 15 years depending upon local pressure on land. Gleave and White (1969:276) have argued that there is no absolute rule for establishing bush-fallow cultivation systems. For example, the system as practised in South-eastern Nigeria supports population densities which exceed 234 persons/km^2). On the other hand the Kokombas of Northern Ghana with a population density under 25 persons/km^2 maintain individual rights over the fallows for limited periods of time. The system has various adaptations with respect to place and time, and particularly with population numbers. Local traditions and social organisations, and influence of commercialisation are basic to such variations. In spite of any variations in the system, the practice of land rotation, small holdings, and general absence of modern technology, is basic.

Under bush-fallowing, farmers open new farms when productivity in existing farms declines. The old farm is allowed time to naturally regenerate its fertility. In the past, when land was plentiful (in relation to demand), farmers returned to the original plot only when some natural indicators, such as a particular tree species, showed that the original plot had regenerated sufficiently to be re-used. In many cases, secondary successions managed to approach climax vegetation. However, the present high demand for crop lands, has shortened the fallow period, and, old plots are not allowed adequate time to restore their natural fertility before re-use.

Average farm sizes are small, generally less than one hectare. Farms are also fragmented. For example, a single farmer may cultivate two or more farms simultaneously at different locations within one season. The system operates under very high population densities exceeding 100 persons per hectare in the New Juaben and Krobo areas in the Eastern region and the Agona areas of the Central region (Boateng, 1966; Dickson and Benneh, 1970). The bush-fallow system, as it is practised, destroys forests on village lands and retards natural tree regeneration through frequent cultivation and soil degradation, with implications for potential supply of woodfuel. The link between agriculture and the fuel system is crucial for this study.

Wood supply/collection

Within the village wood supply-demand system, fuelwood supply is the other most important use of the land. The system of wood supply follows several patterns. Wood for fuel is complementary to the cropping system and/or as a derived benefit from the cropping practices, while in other cases, wood exists as independent land use activity, albeit sharing most/or all potential village land with agriculture (Figure 4).

In general terms, woodfuel is a direct output from the farming system. In most areas, wood is collected from farm fallows, during farm clearance, crop residues and from the forest fallow. Agriculture and the standing vegetation provide the main sources of wood.

Other land uses

Other minor uses of the land in terms of households involved, time input, and economic returns, include hunting game for "bushmeat" and gathering of certain fruits, vegetables and seeds. In most cases, such minor uses of the land have little or no effect on wood supply. An exception is when fire is used for hunting, as occurs during the dry season in many locations of savanna woodland. Fire generated through such hunting expeditions can sometimes get out of control and do extensive damage to standing vegetation (Dorm-Adzobu, 1982; Ampadu-Agyei, 1988).

iv. Land ownership/tenure

Land tenure is an essential feature in the village ecosystem an can determine general access to, efficiency and intensity of use of land resources, including woodfuel. In many developing countries, including Ghana, land tenancy types range from complete private ownership with legal title, to communal and collective ownership. In southern Ghana, the major land tenure systems include private ownership and operation and various types of tenancy including cash rental, caretaking/share cropping, pledges, gift and a degree of communal ownership. These tenurial arrangements are each examined to show their relevance to the village fuel system.

Private ownership

Most privately owned lands have been inherited as traditional family land, or purchased. For example, in the cocoa growing areas, most of the land under cultivation has been purchased by migrant farmers (Hill, 1963; Dickson, 1969). Agricultural land may be purchased in all parts of the country through the authority of the local traditional ruler and his council of elders. In the past, title to such land was guaranteed through traditional observance, mutual trust, and effective occupation. However, in many recent cases, land was sold by people without proper title to them, often with contested titles and ill-defined boundaries. Such negative trends in the agricultural land market have resulted in the involvement of registered surveyors and legal contractors, to avoid litigations. Nevertheless, in many rural areas, land is sold without any legal contract.

Depending upon the area and the period of acquisition, purchased farmlands are usually limited in size because of possible financial constraints. Such lands are usually acquired with a primary objective of developing them for particular high yielding crops such as cocoa, coffee, or maize. In most cases, cash cropping uses the best and the largest proportion of the land, leaving very little or no land area for subsistence farming and/or woodfuel supplies. As observed elsewhere, this tendency may result in intensified use of the remaining area of the land reserved for subsistence, and serious alteration of surface cover may result.

Privately owned land may also be acquired through inheritance. For example, among the Krobos of South-Eastern Ghana, where the system of inheritance is patrilineal, a piece of property is divided among all the surviving sons of a deceased father (Boateng, 1966; Dickson, 1969; Dickson and Benneh, 1970). Depending upon the size of the original plot of land, and the generations of inheritance, individual plots of land may become very small and fragmented.

Generally, the size and the nature of use of privately acquired lands can affect the potential supply of fuel to the household, and the village unit as a whole. For example, in a short-fallow maize growing area where the land is also limited in size, the tree cover may be destroyed, both because of the frequency of use and the practice of cutting down standing trees to remove excessive shade to help ensure high productivity.

Caretaking/share cropping

The care-taker system and the share cropping tenurial types usually imply the same system. Both systems allow farmers with limited land resources the benefit of cheap access to surplus and/or unused resources. Under both systems, the working farmer may have complete charge of all operations of a piece of property without paying any original fee. Sharing of produce is fundamental to both systems. The farmer shares defined products from the property with the landlord on a pre-arranged proportion basis. The sharing system may be 1:1, 1: 2, 1: 3, in favour of the landlord, or a fixed percentage of output. The specific details of such arrangements depend upon the negotiation terms, and particularly upon the stage at which the caretaker/share cropper entered into the development of the piece of property. The underlying differences between the two relate to the time dimension and the degree of freedom of use of resources from the holding. Most care-taker systems have longer durations (generations in some cases), and access to all resources on the land is unlimited. On the other hand, share-cropping tenurial systems are usually limited in time and the use of resources other than that to be developed is usually restricted.

In villages with a large number of care-taker households/share croppers, the land would be better managed because of the direct interest of the farmer and/or a fear of possible loss of the piece of property when inappropriately utilised. In terms of wood production, the nature of the cropping system, and the state of the original property before occupation by a particular care-taker/share cropper, determine the potential supply situation. For example, if the cropping type requires a complete removal of shade, then tree destruction may be just as bad as under other forms of tenure. Also, if the land being worked has already been degraded prior to occupation, short term wood production would suffer.

Rental land

Land may be rented to supplement that privately owned or as a separate means of acquiring agricultural land. Rental fees are paid for the use of the land to cover a specific time period. Once the agreed period of time elapses, the renter ceases to have entry rights to the piece of property. Also, during the period of effective use, the renter may not have rights to resources on the land other than those specified in the original agreement. Typical rentals periods are short in Ghana, with a maximum tenure of 10 years.

Where the farmers rent land, the frequency of cultivation tends to be high in order to maximise output (profits). Probably because of short-term motives, regard for long term sustainable use of the land is usually ignored or not perceived at all. In many cases, renters do not return to a piece of land, so there is little or no incentive for better use of the land to ensure long term balance between human sustenance and ecosystem maintenance. Such rental characteristics potentially lead to greater modifications of the village ecosystem, with regard to rapid destruction and depletion of the wood cover which is the basis of fuel supplies.

Pledges

Strictly speaking, land that comes in a pledge form is not very common under the traditional land tenure system. Under the pledge system, a farmer may have exclusive use of a piece of property for a specified number of years, as payment in kind, for a loan granted to the owner of that piece of land. In some cases, such a piece of property may have been used as a collateral for a loan, and where there was a default in payment, the lender held that land in trust, until the loan was repaid fully.

Pledged land usually suffers from similar negative characteristics associated with rented land. In most cases, there is no commitment on the part of the user to use the piece of property in a sustainable manner during the period of tenure. There are many examples in the cocoa growing areas of Ghana of pledged lands left in a bad state.

Gifts

In some villages, landlords offer farmland free of charge to people who require them. Such "free" offers usually have tied obligations. For example in certain instances, users are obliged to plant cash crops while they continue to use the piece of land for subsistence. Tenants usually lose the right of use of the land only when the cash crop is well established and the subsistence crops are displaced. The owner of the land is entitled solely to the cash produce. Continued benefit on land provided as gift, usually depends upon the degree to which owners perceive its "just use". In certain cases, beneficiaries are denied further rights of use when landowners perceive that such land is being over-used and/or recklessly used.

While the effects of some tenurial arrangements on the village ecosystem and the potentials for wood supply have been examined in relation to individual access, the effects of land holding patterns on village property use may be incomplete without a consideration of the property/resources within the village system that are commonly owned.

Common property aspects of the tenurial system

In the broadest sense, common property resources may refer to those resources that are collectively owned by a group, which may include extended family, community, tribe, clan, or nation. Rural resources that are owned commonly include agricultural land (arable and pasture), forest and water resources such as fuelwood, wildlife, and water resources and fish. Common ownership of resources in a given area, has implications for resource use-efficiency and long-term sustenance.

Group ownership may either be restricted to a narrow range of resources such as wildlife and fish or unlimited in a defined area. By definition, collective ownership of resources implies open and unlimited access.

In most parts of Africa, including Ghana, group ownership of resources exists in several forms. Apart from that of the extended family, group ownership may include certain "stool" lands, fetish groves, and some seasonally wooded river courses. Firewood, poles, ropes and other needs may be taken freely in many such areas. Unregulated use of wood resources may accelerate depletion and environmental destruction, as well as undermining potential sources of fuels for a village unit. As a result of the trend of vegetation loss, ownership of common lands is declining in many villages in Ghana. Such situations notwithstanding, common use of resources is still significant at various scales and over particular resources.

The general consequences associated with uncontrolled use of communal resources are represented by Hardin (1968) in the "Tragedy of the commons". Hardin identified two main consequences from such unrestricted use of common property resources: i) a positive component resulting from a function of the increment of one animal, since the herdsman receives all the proceeds from the sale of the additional animal and thus the positive utility is nearly +1; and ii). a negative component which is a function of the additional overgrazing created by one more animal. Because the effects of overgrazing are shared by all herdsmen, the negative utility for any particular decision-making herdsman is only a fraction of -1.

Under the preceding set of conditions, if every rational herdsman sharing the common decides to add one more animal, overgrazing eventually results and the pasture is lost to all. Hardin concludes that a tragedy of the commons results from unlimited freedom of herdsmen, each of who is locked into a system that compels him to increase his herd without limit in a world of limited resources- eventually bringing depletion and a ruin to all (Hardin 1968:254).

In spite of certain criticisms of inherent shortcomings of the "commons", theme, such as the wholesale application of a medieval practice to modern circumstances (Stamp & Hoskins,1963; Cox, 1985), O'Riordan (1981:29), states that "the key to the tragedy theme is the nature of ownership (and associated bundles of rights and duties), the scale of management responsibility and the degree of collective trust existing in the polity". The commons idea has greater relevance to this study because group ownership of resources is common in many developing societies, including Ghana. The existence of any such collective use of land resources, and the possible effects it has on the woodfuel sector need proper attention.

v. Other Socio-Economic elements

The village woodfuel system is influenced by a number of socio-economic conditions and relationships operating from within the system and from external sources. Population dynamics (including total numbers, growth rates, age-sex distribution) within the local area, have great implications for the village fuel system. For example, within the local area, high population numbers may result in immediate increase in demand for fuel and for farmlands, which invariably affects woodfuel supply potentials (Boserup, 1975; 1981; Maitra, 1980). Uses of the village ecosystem, such as cropping, may lead to depletion of wood, reduce soil productivity for plant growth, and affect the efficient flow of (solar) energy through the vegetation system, while at the same time, increased human numbers place more need on the vegetation for fuel supplies. Similarly, high demand levels from the external environment for rural land-based products such as agricultural produce, firewood and charcoal and/or products based on them may accelerate problems within the village fuel supply system, especially, when any such flow of goods and services between the village and the external region is largely one-way, in favour of the larger region/nation.

The efficiency of the village fuel system can also be influenced by certain cultural practices. For example, elaborate traditions and observations sometimes help to protect the over-use of species. In almost all tribes and clans in Ghana, certain tree species are regarded as taboo and are never used. In some areas, fetish groves are sited on sensitive sites, such as sources of village water. Elsewhere, special burial grounds for chiefs and royalty protect the vegetation cover. In all such special sites, entry is controlled and most of them now persist as islands of mature forests in otherwise degraded vegetation systems (Dickson, 1969; Anquandah, 1982). The size of such protected sites may be considerable especially in the case of some fetish groves. In the past, fetish groves took up to 15 per cent of village lands. Most of the groves have however either declined in size or been lost completely. In certain cases, they formed the nucleus for official forest reserves. In many villages, households are permitted to collect deadwood for fuel, strings and poles for light construction work, but only on specified dates. Infractions to rules of entry and/or use are severely sanctioned by traditional penalties, in the past by pain of death. Where such local traditions exist, cultural relationships operate to mitigate the effects of wood demands and ensure some protection for the sources of wood supplies.

Within individual villages, economic exchanges exist in terms of crop and food-related sales, sales of woodfuel, crafts and artifacts and general services, farm and non-farm, between and within households. Marriages and the dynamics of the extended family system are among social relationships that sometimes help to re-distribute incomes and services to benefit individual households. Generally, favourable socio-economic relationships may help boost the income potentials of individual households and thereby help to relax the degree of direct dependence on land resources, especially, woodfuel. Similarly the degree of social exchanges can also determine the degree of access to woodfuel in a village.

3. The Model

Information provided in the initial part of this chapter indicates various intricate relationships between supply and demand in village fuel systems and provides a comprehensive basis for postulating a detailed model for use in this study. On the basis of the complex relationships described, the model for the study is developed within the framework of the ecological principle which stresses linkages and interaction between elements, exchanges, and drive of elements towards a balance state within a defined environment.

The ecological principle is adopted only as a useful frame of reference for the model because village ecosystems which are heavily used for human needs cannot meet the strict context of natural biological systems which the ecosystem principle perfectly applies. The model is therefore concerned mainly with the humanly modified ecosystem while general principles derived from ecological concepts are applied in its formulation.

The Ecosystem Principle and the Model for the Study

The ecosystem framework is discussed in terms of its operationalisation and relative utility for woodfuel studies, especially in environments that have been heavily modified by human use.

Billings (1978:5), describes the ecosystem as ..."a community of plants and animals together with the environment that controls it". Smith (1986:344), also states that;

> an ecosystem is basically an energy-processing system whose components have evolved together over a long period of time. The boundaries of the system are determined by the environment-...by what forms of life can be sustained by the environmental conditions of a particular region.

Odum (1971:9) maintained that the main function in ecological thought is an emphasis on obligatory relationships, interdependence and causal relationships--the coupling of components to form functional units.

As a summary, ecosystems can be considered as the interactive existence of plants, animals, and non-living elements such as soils and minerals, within defined boundaries, and at various spatial units. There are interrelationships between components of the system to provide support and continuity. The unit is not totally isolated since it depends on the sun's energy for all its sources of food and continued existence. Migration between spatial units is also common bridges from isolation. The structure of a natural ecosystem which is made up of two principal components, namely the biotic (living) and abiotic (non-living) components, and showing various interactions, flows, and relationships within the system, are further illustrated by Figure 5.

Many researchers, and development agencies advocate the ecosystem principle in most areas of resources management and development work due to its relative ease of applicability (U.N.E.S.C.O. 1978:9; Jorgensen, 1986:21; Kates and Burton 1986:172, Environment Canada, 1988:1). The most practical and comprehensive application of the ecological principle to resources management is provided by the World Conservation Strategy (W.C.S.) (I.U.C.N, 1980). The W.C.S. aims at global sustainable development, through the conservation of living resources through three main objectives, which are based on the ecological concept. These are;

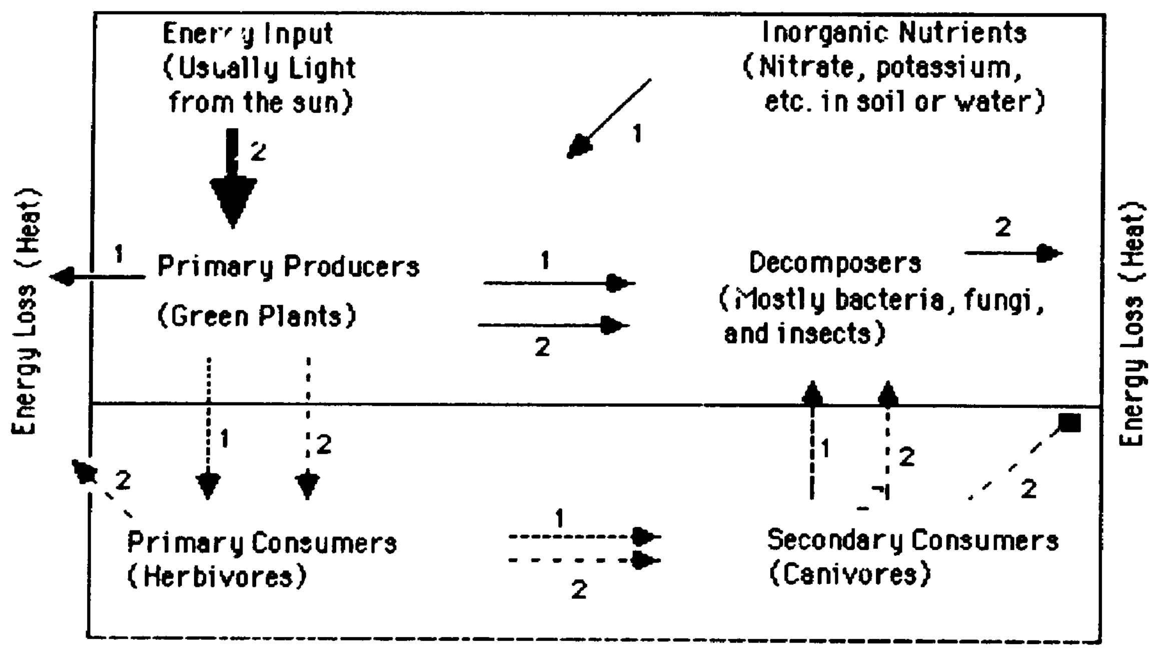
a). to maintain essential ecological processes and life-support systems;

b). to preserve genetic diversity; and

c). to ensure the sustainable utilisation of species and ecosystems.

The document advocates a strategy which is intended "to stimulate a more focussed approach to living resources conservation and to provide policy guidance on how this can be carried out" (I.

FIGURE 5: THE ECOSYSTEM



General pattern of energy flow [arrow 2 broken & solid] and nutrient cycling (arrow 1 broken and solid) in an ecosystem. The solid line encloses the minimal components required for a self-sustaining ecosystem. In addition to these, most ecosystems contain primary, secondary, and even higher levels of consumers. Energy is continuously lost from the ecosystem in the form of heat produced by metabolism.

Adapted from Arms and Camp, 1982.

U.C.N., 1980). The recent WECD report, 'Our Common Future' (1987), also supports this principle. The W.C.S thus provides a framework for individual countries to design resources and environmental management practices within the limitations of their local settings.

Comment

As already stated, in most locations, such as in the villages of Ghana, the natural ecosystem no longer exists in its original state within the productive reach of village communities, as a result of continued human intervention. Within a heavily modified ecosystem, the wholesale use of the natural ecosystem as a basic framework for the study may be misplaced, because in the real sense, the ecosystem is no longer natural. In a modified ecosystem, stability of elements is a misnomer, as are uninhibited functional relationships and drives towards self-maintenance-- major characteristics of the ecological principle.

In addition to the preceding observations, the ecosystem principle is silent on such crucial factors as human skills, cultural influences, economic potentials of a society (Harvey and Gary, 1981), the state of population-resource relationship, and external influences in policy a d resource provision; factors which generally determine the rate at which the ecosystem is used and/or modified in village communities. It is with such general weaknesses of the natural ecosystem concept in mind that this work rather emphasises the human modified ecosystem as the basis for the model used in this study.

The model for the study

Synonymous to the natural ecosystem framework, the village ecosystem is composed of both biotic elements, including human beings (organised by households), flora and fauna, and abiotic elements such as soils and soil nutrients within their functional environment. Energy from the sun is the major drive for all functional activities within the system. In the village ecosystem, human pressure looms so great that there is a constant threat of possible disruption of the basis for any functional relationships between elements of the system for its self-maintenance. The conceptual model for the study, which is provided as Figure 6, indicates the general interrelationships involved in village woodfuel systems in humanly modified ecosystems. For purposes of explanation, the model is developed in four stages. Stages 1 to 3 provide comprehensive description of the development of the model, while stage 4 represents the model in its complete form. In stages 1 and 2, the village fuel system is considered to exist as and independent ntity, while stage 3 adds the reality of external flows and linkages to the system.

Stage 1 (Figure 6.1)

Stage 1 of the model indicates that the sustainability of village fuel use system is a function of the degree of efficiency between fuel supply and demand patterns of its constituent households. In typical farming villages, fuel supply is dependent generally on vegetation dynamics, such as size, quality and diversity of species on one hand, and population dynamics such as numbers, age-sex distribution,

Figure 6 : Sustainability of Village Woodfuel Systems (in Humanly Modified Ecosystems)

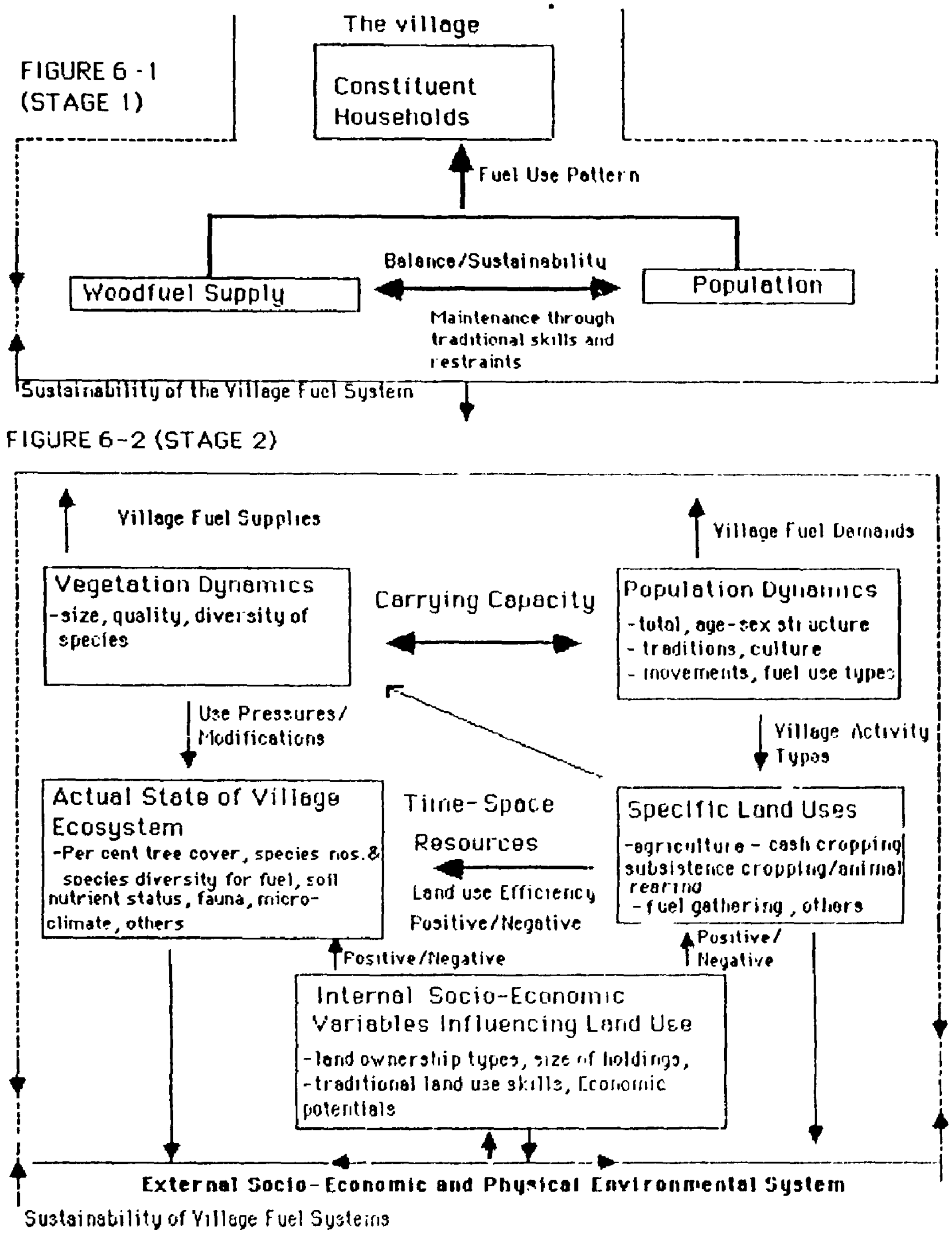


FIGURE 6-3 (STAGE 3)

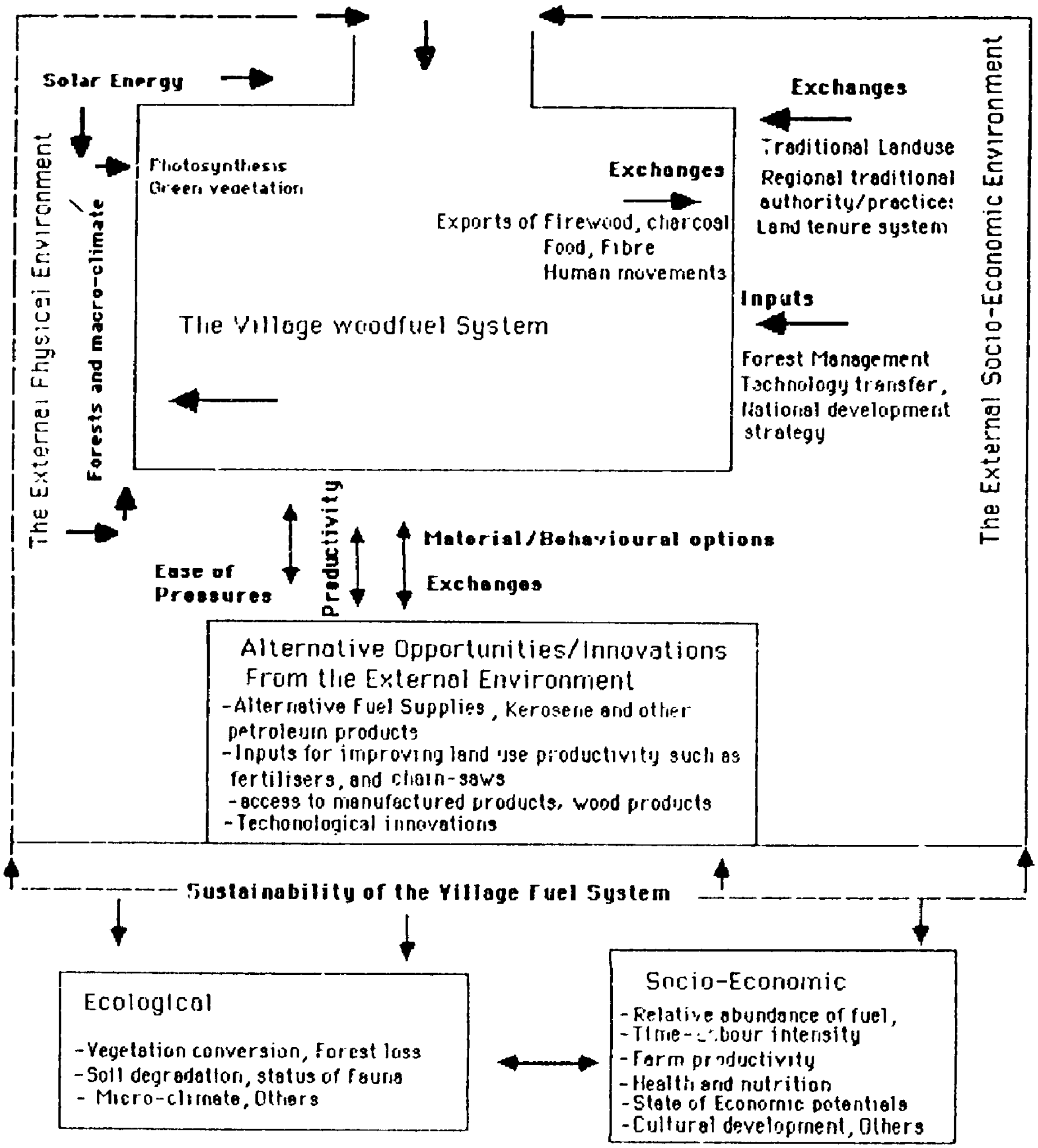
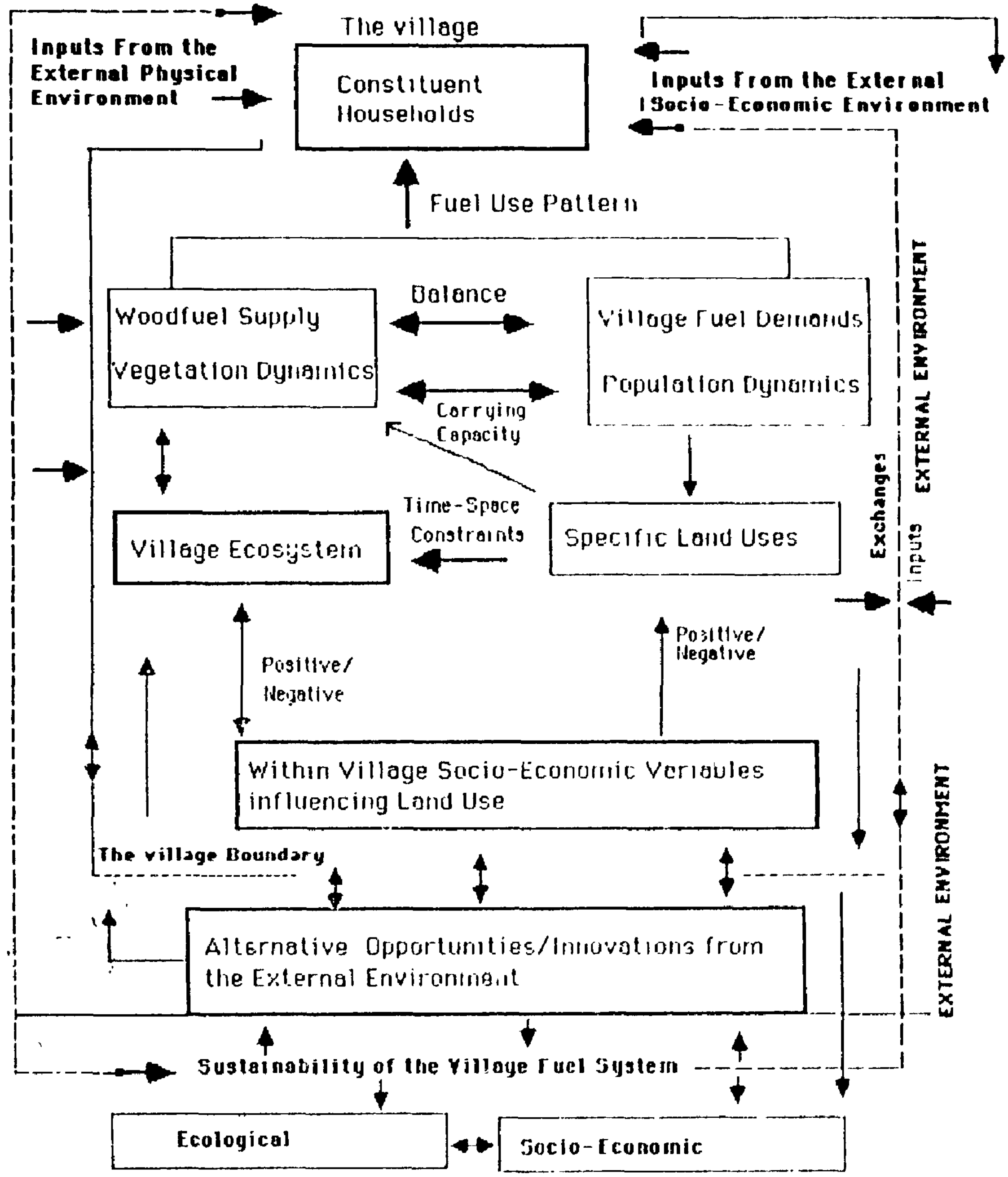


FIGURE 6-4 (STAGE 4)



occupations, ethnicity and fuel preferences. Where the population level is optimum in relation to the vegetation resources, a balance between supply and demand will exist. The existence and application of certain village traditional skills and general restraints on the use of land resources, may further help to maintain such a balance. Stage 1 of the model thus represents a steady and ideal state where the relationship between the population (demand) and the ecosystem (supply) is balanced and positive.

Stage 2 (Figure 6.2)

In stage two of the model, it is indicated that the vegetation system which is required to provide for village fuel needs is also used to support agriculture and other land use types. The implication is that wood collection is only part of a number of activities making demands on vegetation space. The actual relationship between population (demand) and the vegetation (supply), is determined by two major processes namely, carrying capacity dynamics and time-space organisation of village activities. In addition to these two processes, certain social and economic structures of villages further account for the relative efficiency of existing fuel systems. These processes are elaborated to aid understanding of the model.

Carrying capacity

With regard to earlier observations, most villages in Ghana exist as virtually closed systems so far as fuel needs are concerned. Pressures on wood resources are, therefore, potentially high, especially in situations where the land area and/or the quality and quantity of land resources is outstripped by human demands. The relationship between vegetation space/resources and human populations (demand) for any spatial unit at any particular time, will either be positive or negative, depending upon whether human needs are adequately met and/or supply base (vegetation space) is maintained unimpaired. The concept of carrying capacity describes such relationships with regard to the ability of given ecosystems to support dependent organisms. The concept is a valuable analytical tool for evaluating and monitoring the use of resources in defined environments and at various spatial levels to prevent imbalances (Westman,1985; Smith, 1986).

Writers, including neo-Malthusians such as Hardin (1968), have addressed the dangers of rapid population growth in relation to the fixed nature of most natural systems such as land resources. However, while they address the potential of human misery resulting from a situation of resource scarcity, possible negative environmental impacts from such scarcity are not addressed adequately (Boserup,1965, 1981:19, Maitra 1980; O'Riordan; 1981: 47, Barke and O'Hare, 1984:192-193). As an analytical and management tool, the concept cannot be underestimated, even though it is difficult to operationalize with regard to human processes. In terms of village production systems, the implication goes beyond real population numbers to include technological adaptations, rational use of resources, conservation, planning and management of resource use. With regard to the model, the concept of carrying capacity helps draw attention to potential sources of pressure to woodfuel systems. For example, even though population dynamics have direct influence on the carrying capacity of village ecosystems, inefficient land use, including stagnant technologies and low productivity, and the absence of access to basic goods and services may rather provide major underlying causes for the over use of village ecosystems. In the case of Ghana, land use and land tenure systems are identified in the preceding discussions as major sources of pressure.

Time-space implications in the village ecosystem

While the relationship between general land use and pressure on resources is relatively easy to identify in a village production system, time constraints may constitute an additional dimension. The time available for production and distances to such production sites within a village can reduce the effective reach of a population to required resources. This process may succeed in reducing the carrying capacity of such resources within the limited area of concentration, even though unlimited supply of particular resources may exist in the larger region and set the pace for rapid alteration, depletion and/or destruction of resources. For example, if wood collection competes with other household activities for time, distance may be sacrificed because of the lack of adequate time for wood from distant locations (since most rural households walk to their places of work). This will lead to concentration of wood collection near the village with resultant effects on the ecosystem even though wood may be plentiful further away from the village. The process of Time-Space limitations in resources exploitation, has been formalised into the Time-Space Model or Time-Geographic model, by Hagerstrand and the Lund School of Geography (Hagerstrand, 1982; 17-55; Carlstein 1982; Parkes & Thrift, 1978; Lenntorp, 1976).

Lenntorp (1976:11) demonstrates the basis of the model by using a mathematical representation, PPA= Π $(VT)^2$; where PPA= Potential Path Area (Activity realm, Potential Action Space); T= available time interval; and V= maximum speed, to express the degree of restriction of area of work available to an individual or a group in a production system. Lenntorp's demonstration generally indicates that, even though resource opportunities may be unlimited in a region, physical reach may actually limit accessibility to resources. For example, individuals or groups with faster mode of transportation and more available time, may be capable of extending their activity realm to tap resources over a wider space. On the other hand, in villages where most work, including wood collection is done by walking, the area of work necessarily has to be close enough to dwellings (settlement site) to offset travel time loss and fatigue for covering long distances. This leads to concentration and intensification of resource use in specific areas of greatest proximity.

The time-geographic model identifies various constraints on individual and group time-space activities leading to possible restriction of activities close to village settlements. Hagerstrand summarises these as capability constraints, coupling constraints and authority constraints (Hagerstrand 1969: see Carlstein, 1982:46).

By capability constraints, Hagerstrand refers to those general physical constraints on humans by virtue of their biological construction, such as obligatory time for nutrition, rest/sleep, and health care or the tools they command, including mode of transportation. These demands imply a shortening of available time for such crucial and supportive non-biological activities as farming, fuel collection and trading. Any increase in distance to farms (places of activity) and time for farm-work (activity) may be made only to the extent that they do not affect time required for other important activities.

The second set of constraints associated with the time-space model is termed *coupling constraints*, which are a set of constraints which arise because of the need for people and organisations to come together to fulfil some common purpose which are coordinated in both space and time (Goddall, 1987; Carlstein, 1982; Janelle *et al*, 1981). Hagerstrand terms the co-ordination of activities with others in both time and space as "bundling". Coupling constraints place limits on the range and type of activity for both individuals and groups concerned. The third, *authority constraints*, involve "... institutional channeling and regulation of activities". Authority constraints "determine who has or does not have access to specific spaces (places) at particular times" (Goddall 1987: 30 ff.). In a village situation for example, several rules and traditions limit available time for farming and other related activities such as wood collection. Where wood collection is derived simultaneously with agricultural activities, and certain rules regulate agricultural practices, there will be constraints to access to wood. For example, households collecting woodfuel on daily basis will have to turn to over-used sites near settlement nuclei, not regarded as farmlands, to collect twigs and wood remains to fill the void.

Generally, Stage 2 of the model highlights the utility of incorporating time-space characteristics of village land use on woodfuel studies.

Internal socio-economic structures

As illustrated in Figure 6.2, even though population-resource relationships and time-space limitations are crucial to village fuel systems, certain internal socio-economic variables (such as access to land, land holding/ownership types, size of holdings, traditional land use skills and income potential of households) can work either positively or negatively for the village fuel system. For example, where farm sizes are small and access to alternative land is difficult within the boundary of the village land, pressure will be placed on vegetation space for food production and for fuel. Both ecosystem and land use efficiency may be compromised. On the other hand, extended families and friends may provide land for farming and woodfuel to help ease pressures on limited holdings (see Chapters V to VII for analytic details).

Stage 3 (Figure 6.3)

In stage 3 (Figure 6.3) of the model, the village is shown to have certain external relationships with the regional-national-international physical and socio-economic systems. The primary external linkage is that of solar energy inputs. Solar energy is the sole source of energy flow through the village fuel system. It promotes primary production, which is the source of sustenance for all consumers, especially food and fuel for the human population, and also by facilitating biogeochemical cycling within the system to maintain its productivity. From the traditional regional environment, land use influences, traditional authority and migration patterns, may further shape land use pattern within the village, with implications on the sustainability of the village fuel system. Likewise socio-economic flows from the modern external environment may bring innovations and opportunities, such as inputs for improving food production, alternative fuel supplies, access to manufactured products, economic infusions, general institutional support, such as skills and tools for vegetation management, and general development policies aimed at sustainability in the rural environment.

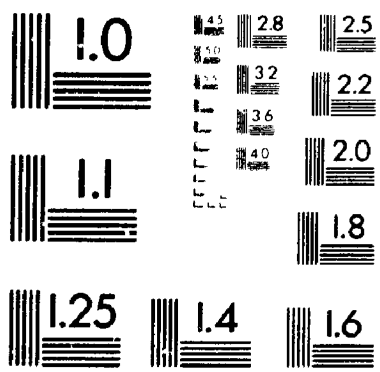
The success of such external flows may depend upon their suitability to the local environment, i.e., whether they are adopted and become accepted and the general, long term behavioural responses to them. They may thus be either positive or negative to the village woodfuel system. Positive responses to external linkages may help to ease pressures on local fuel sources, by reducing direct demands on the land, and by improving productivity in the use of the land. When the fuel system is sustainable, a balance between household fuel supplies and demands will exist, meaning that the welfare of both humans and ecosystems are maintained. Where negative responses to such linkages result the sustainability of the system will be impaired, through energy losses, by rapid vegetation conversion/loss, soil degradation, depletion of fauna, and depreciating human welfare through fuel scarcity, time-labour intensity, decreased farm productivity, lowering health and nutrition standards, loss of economic potentials and cultural degeneration.

<u>The Actual Model</u>

Stage 4 of Figure 6 combines all the developing stages of the model to show linkages and relationships involved in village woodfuel environments. A calibration of the model to appraise the degree of sustainability of woodfuel systems requires proper identification of specific human and ecological variables basic to woodfuel systems. Once these have been isolated, they can then be subjected to rigorous examination, using objective and valid field information, as well as detailed analytical techniques to help determine the state of impacts and/ or sustainability.

For specific procedures to determine human impacts, the following human concerns, most of which are suggested by the Scientific Committee on Problems of the Environment (SCOPE) of the International Council of Scientific Unions (ICSU) are found useful (Munn, 1979:24). These include: economic and occupational status, social pattern or lifestyle, psychological features, physical amenities (aesthetic), health, personal security, religion and traditional beliefs. Ecological concerns apply to soil quality (i.e., structure, fertility, depth, and arable land influences), air (quality indoors, and free atmosphere), water (quantity and quality), and plant and animal life (abundance/scarcity of species, diversity of species, abundance. (Munn, 1979:22). In the study, elements of impacts may not necessarily be discussed as itemised, or in such a strict order of presentation. Basically, analysis will be made under related headings to incorporate a group of elements.

A report to the Institute of Ecology on Environmental Impact Assessment by Andrews and others (Duinker and Beanlands, 1986:


1.0
2.8
2.5
3.2
2.2
3.6
4.0
2.0
1.1
1.8
1.25
1.4
1.6

3), which provided a number of criteria to be incorporated into a context for determining the significance of environmental impacts, is considered for adoption. This is made up of:

a) magnitude of impacts;

b) spatial extent of the impact;

c) duration of the impact;

d) probability of occurrence of the impact;

e) confidence in the impact prediction;

f) the existence of "set values" (e.g., air or water quality standards);

g) the controversy surrounding the development proposal.

This study adopts the preceding criteria to a high degree, except for the criteria on confidence in the impact prediction and the existence of "set values" (e.g., air or water quality standards). In the case of the criterion on "confidence in the impact prediction", long term studies are required for this to be absolutely possible. In the case of the "existence of 'set Values'", there is a general absence of the appropriate instrumentation in the current study, and above all, set standards do not exist for Ghana or for the study area.

Key elements of the model for the study

The model identifies significant elements of village fuel systems which provide bases for both the development of the methods of investigating woodfuel use which is provided in Chapter IV, and also subjects for the field investigation itself.

From the model, operational and significant variables for the study are classified under; village population dynamics, wood supply environment, wood use and acquisition, and external variables. These are described below:

i). population dynamics: Specific variables of interest include, total village population, household size, age and gender distribution within households, occupations, income levels, traditional and cultural practices, land tenure systems, and existing traditional and cultural practices with relationship to woodfuel use;

ii). wood supply environment: Variables considered include, vegetation type, species composition, wood supply potentials, and agricultural land use;

iii). wood use and supply variables: These are also related to population dynamics and concern, domestic uses of wood, commercial uses of wood by type, intensity, and frequency; fuel types, sources of wood, bundles of wood collected per unit time, tools for wood collection, distance to sources of wood, time for wood collection, number of days per unit time for wood collection, household distribution of labour for wood collection.

iv). external factors to be considered for the study include the introduction of new techniques, presence of manufactured inputs and food products, both to improve village production and to relieve pressures on village ecosystem.

Summary

The comprehensive analysis of woodfuel research in Chapter II provided invaluable information for the detailed manner in which the model for this study has been developed. The model is realistic to village conditions by showing key relationships in woodfuel systems. Together, the development of the village/household woodfuel model and the identification of the needs of meaningful investigation (Chapter II) provide the basis for the introduction of the selected village study units and the specific methodology employed in Chapter IV.

CHAPTER IV: THE STUDY AREA AND METHODS OF INVESTIGATION

1. Introduction

Chapters II and III provided a discussion of the manner in which this study could overcome previous problems associated with meaningful woodfuel research and established a framework for the investigation of woodfuel use at the household/village level in Ghana. The objective of this chapter is to complete the methodological framework for this study by, first, introducing and describing the study setting in Ghana, with special reference to the specific choice of the sample villages selected for investigation, and second, the details of the procedures of investigation employed, including the methods of data gathering, verification and analysis, such as to comply with the ideal set out in Chapters II and III.

2. The Study Area

The country overview

Details on the village woodfuel system provided in Chapter II showed that in terms of fuel consumption and production, the village maintains a somewhat independent existence from the larger country, including the hundreds of other villages and the urban centres. It was also established that, even in the seemingly most isolated village, there is some exchange of goods and services between the various spatial levels, such as from village to village and/or village to urban area. For instance, woodfuel may be exported from one village to another or to an urban centre, while alternative fuels, such as kerosene, may reach a village from an urban centre.

The existence of such interrelationships provides a link between the village and the larger spatial system. This dynamic co-existence implies that the external environment may have far more influence on a village's fuel system than is generally considered.

The objective of this part of the chapter is to provide a brief analysis of the energy sector in Ghana, including major factors that lead to woodfuel dependency in the rural areas. The analysis begins by providing a general overview of significant socio-economic and ecological characteristics with major implications on the energy sector and woodfuel dependency in particular. A detailed discussion on the energy scene and constraints are then provided. This stage of the work provides the necessary guide to selection of the study settlements and the methods of the study.

Socio-economic and Ecological characteristics

Ghana is a West African country which covers an area of about 238,533 km^2. According to the 1984 population census, there were about 12.2 million people in the country, and the population growth rate has been at or above 2.6 per cent per annum during the last decade (C.B.S, 1984:50).

Nearly 70 percent of the population is considered rural. While the classification of settlements into rural and urban may involve several factors, including size, function, and morphology, population size is the major criteria used to designate towns into rural and urban in Ghana. For example, the 1984 population census classified settlements of 5,000 or more people as towns/urban centres, and those below that figure as rural, irrespective of other factors.

Generally, the rural population of Ghana has experienced major movements since the beginning of the present century, due mainly to economic reasons. For example, in the period before the 1960s, migration was mainly rural to rural, to take advantage in the production of export crops, predominantly cocoa. Since 1960, there has been a net-outflow of the rural population to urban areas, to take advantage of employment opportunities, such as the construction of the giant Tema Harbour and adjacent Tema township, the Akosombo (Volta) dam project, and expanded administrative, commercial, and service functions in the rapidly growing urban centres, which also created the need for increased labour. However, most migrants retain their rural connections, including family ties and land holdings. However, the high rate of population growth in the country has also helped to sustain the rural population and the absolute numbers of rural dwellers has not declined.

The Ghanaian economy is typically neo-colonial. It is mainly export-oriented, and dominated by a few major primary products, principal among them being cocoa, timber and minerals (gold, diamond, manganese, bauxite). Alumina and electricity are also exported. Cocoa alone, however, provides more than 60 per cent of all the country's export earnings. Within the agricultural export sector, cocoa is usually serviced by some fossil fuel-based products such as petrol for powering sprayers/blowers and insecticides.

In the rural areas, crop production offers employment to the vast majority of the people. Apart from the agricultural export sector, an internal-market-based cash crop sector co-exists simultaneously with a dominant subsistence sector. In most cases, the internal cash crop sector is supplementary to the subsistence sector. In terms of crop production for the local market, only a few large scale holdings have access to petroleum-based products, mostly fuel for farm power, lubricants and chemical fertilisers. The vast majority of producers, especially, those in the subsistence sector, have no access to modern fuels. This sector is the most dependent on woodfuel.

Vegetation Divisions and Characteristics.

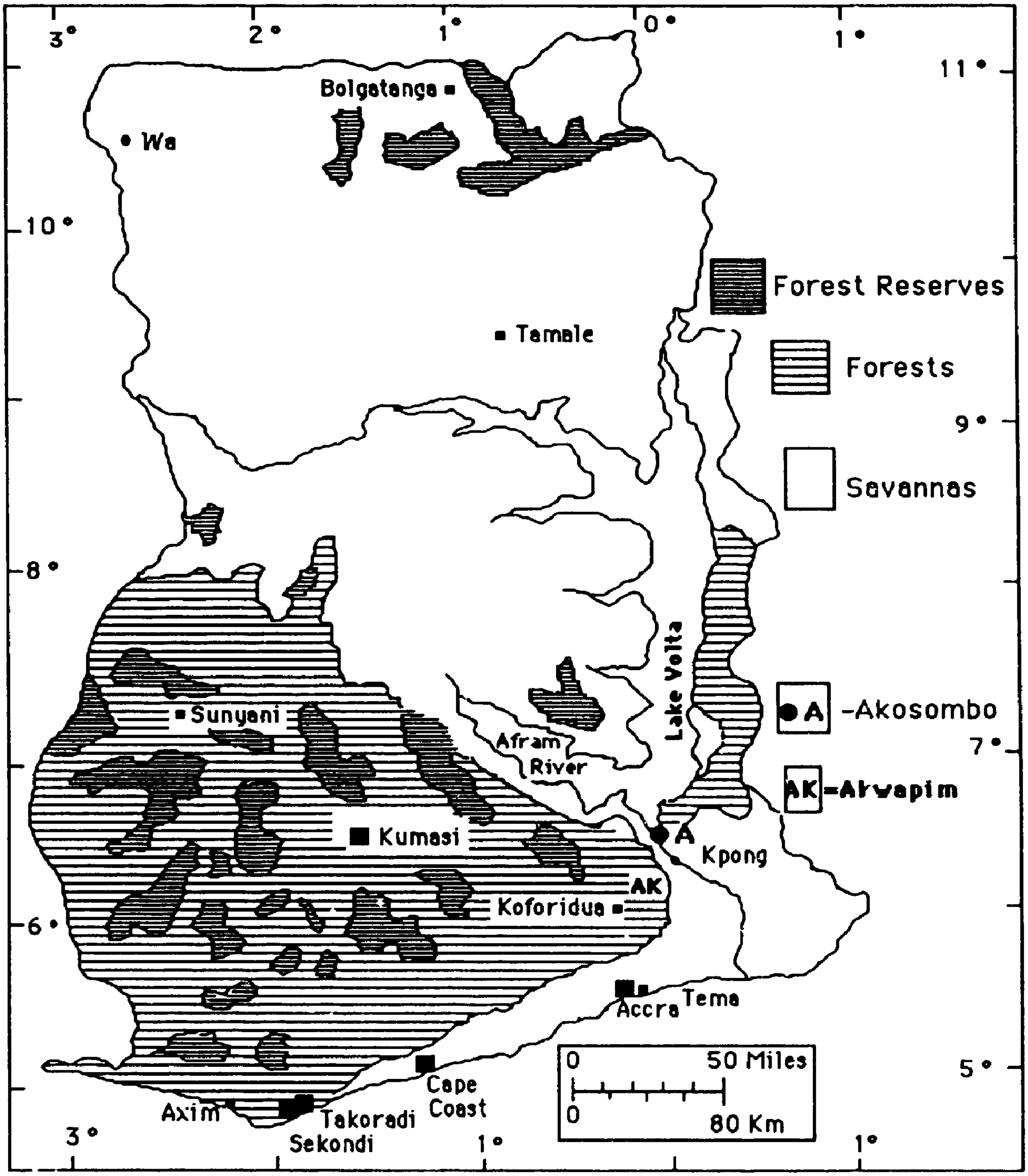
In general terms, latitude 8° N tends to divide the country into two broad ecological zones, forests and savannas, which lie to the south and north of the parallel, respectively (Figure 7). Except for the Sudan Savanna type, almost all the vegetation types in the country are exhibited south of 8° N. The forests show considerable internal diversity. Based upon physiognomic-environmental characteristics, Hall and Swaine (1981) have identified four major forest types. These are, the Evergreen, which lies to the south-western parts of the country, the Semi-deciduous, the most extensive and most diverse of the forests, the Southern Marginal which is a narrow belt of relic forests hedged between the forests and the Coastal Savanna zones, and the South-east Outlier, which is the smallest and the driest of the forests. These and sub-types, which occur within and between them, are shown as Figure 8 and extensively described by Hall and Swaine (1981). They are bordered by the savannas.

According to the 1984 population census, the forest zone contains over 70 percent of the national population, with mean densities above the national average of 51 persons/km^2. Most of the larger settlements in the country are located in the forest zone, which is well served by roads and railways. However, the narrow Coastal Savanna belt, running just east of Takoradi to the Volta river, is the most densely populated, carrying between 100 and 200 persons/ km^2 (Figures 8 and 9). The least populated areas can be found in the Middle and Northern Guinea savanna belts. The extreme western parts of the evergreen forests also indicate lower population densities (Figures 8 and 9). Generally, the forest zone of Ghana is the centre of the primary economic activities such as agriculture, mining and lumbering. The forest-savanna boundaries were among the earliest settled, and have been the scene of dynamic land use practices and past economic exchanges. The introduction of export crops, especially cocoa, towards the end of the 19th century, saw a rapid expansion and colonisation of the forests. Intensive use of the forests for cocoa growing, began in the eastern section of the forest zone (in Akwapim where the cocoa bean was first introduced) and expanded westwards (Figure 7).

The Energy Scene and Constraints

Ghana provides a typical example of a situation where wood provides the bulk of national energy needs and under conditions that call for concern. Table 4 clearly sets out the over-all dependence on wood. Various sources put the contribution of wood in the over-all national energy budget between 70 and 76 percent (Pluth,1985:2; Howes and Gulick,1981:34; Foster, Friedmann et. al.,1981:67). A 1981 FAO report indicated that wood was being consumed at a per capita annual rate of 1 m^3 of fuelwood and 0.2 m^3 charcoal (FAO,1981). But no accurate figures exist because no detailed studies have ever been

Figure 7: Ghana- Forest-Savanna Boundary



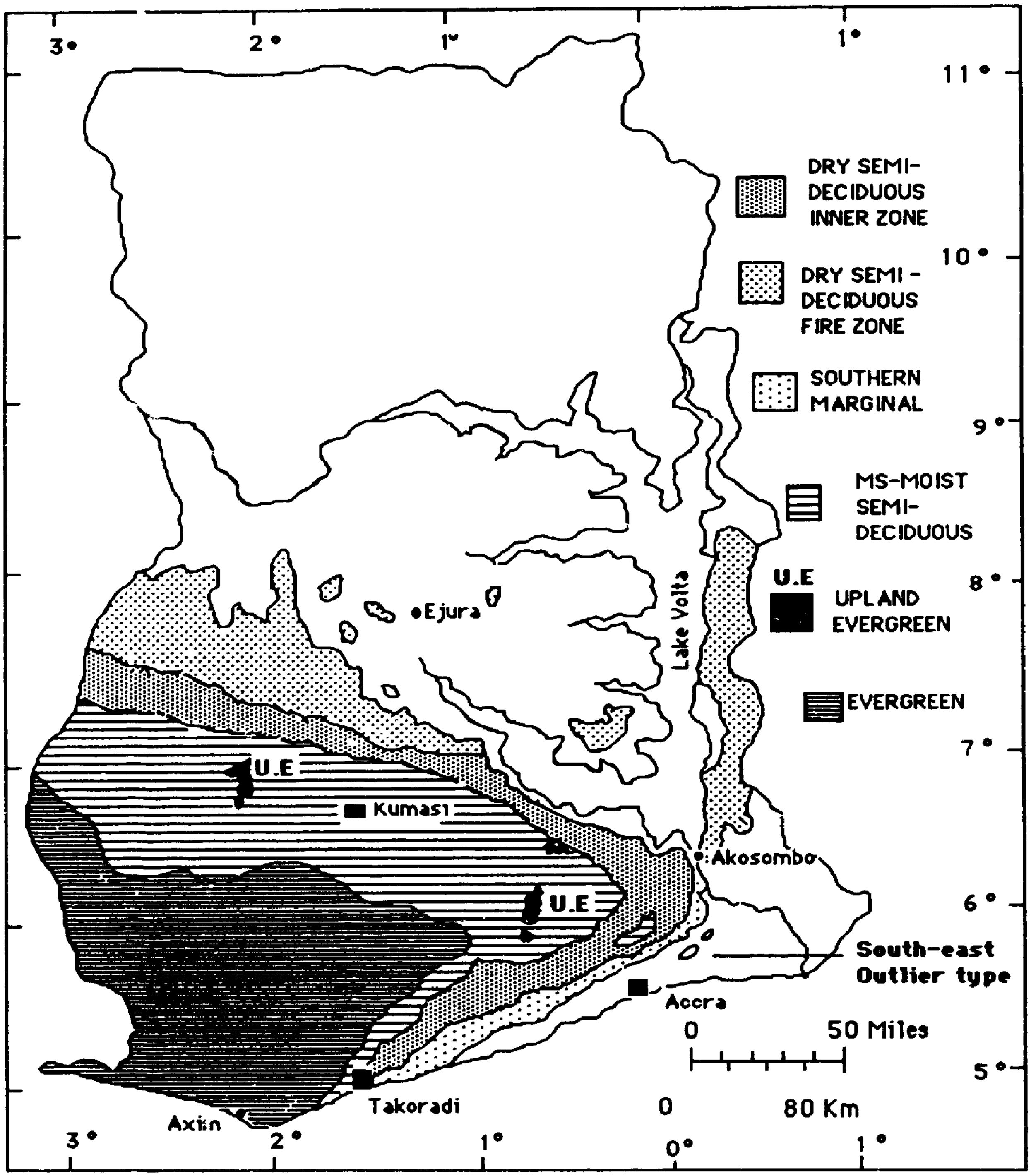
SOURCES

Boateng E.A. (1966)

Dickson & Benneh (1969)

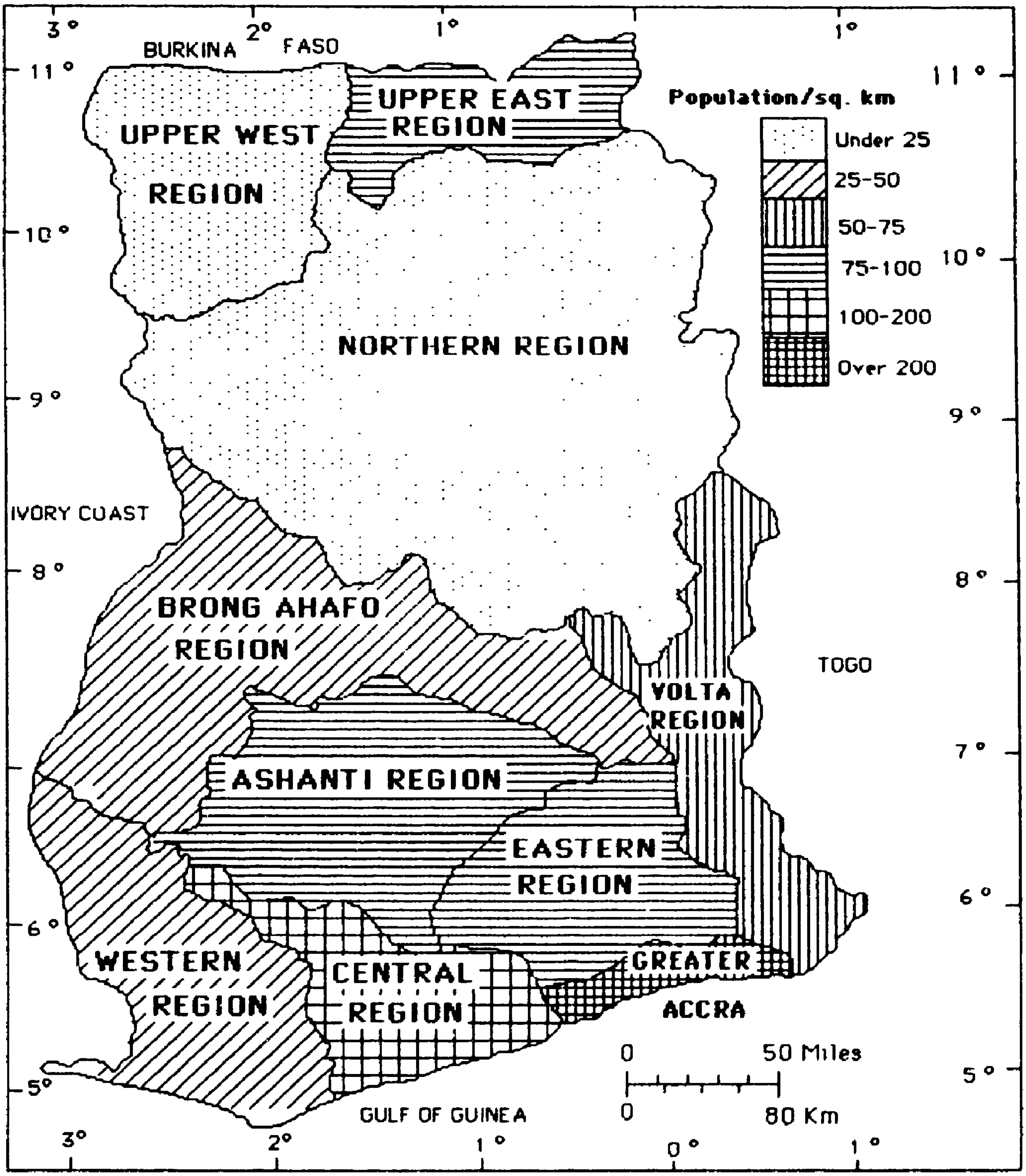
Hall & Swaine (1981)

FIGURE 8 : GHANA-FOREST TYPES



SOURCE- ADAPTED FROM HALL & SWAINE (1981)

FIGURE 9 POPULATION DENSITY MAP OF GHANA
(BASED ON 1984 POPULATION CENSUS-CBS, ACCRA)



undertaken. a situation which this study seeks to remedy. The reality is that wood is the main fuel for most of the people and for virtually all of the rural population.

The country is poorly endowed in conventional energy resources. There was limited exploitation of an off-shore oil deposit, which yielded an average of about 1,200 b/d near its peak, but work on the drilling site was suspended in 1986 due to rapidly falling output. As yet, no commercial deposits of any other fossil fuels have been found, even though oil prospecting activities, both off-shore and inland, are being intensified with concessions granted to many foreign oil companies, including Petro-Canada International.

The modern sector of the economy is petroleum-dependent, but all petroleum products must be imported. Pluth (1985:10) has noted that in 1983, due to a shortage of foreign exchange, crude oil imports were limited to less than 500,000 tonnes (700,000 tonnes short of demand). He further states that, since 1970, petroleum import value has risen to about 50 percent of total exports, while actual imported quantities have fallen by 50 percent (see Ghana Commercial Bank, 1985:3). A summary of both short and long term potential of the Ghanaian economy provided by Pluth (1985:6-8;10-12...) is basically pessimistic as far as the energy outlook is concerned. The nation is currently involved in an Economic Recovery Programme (E.R.P.) under massive loan infusions from the International Monetary Fund (I.M.F.). Modest gains in the G.N.P. have been reported. However, the economy is in such a state that any real gains may take a decade or more to trickle down to the whole population. For the short to medium term, problems in the energy sector are likely to persist.

To some extent, hydro-electric power (H.E.P.) holds some promise for the country, if additional sites, both on the Volta and other relatively smaller rivers, can be developed. Currently, H.E.P. is the source of about 99 percent of generated power, but contributes only 9.4 percent of total national energy needs (Pluth,1985:11). The sources of hydro-electricity, the Akosombo Dam and to a lesser extent that at Kpong (Figure 7), both on the Volta River, are running at almost full capacity. Until recently, over 66 percent of total power from Akosombo went to the Volta Aluminium Company (VALCO), the rest going to the mining and manufacturing industries, and to some urban areas, mainly in the southern parts of the country, such as Accra, Kumasi, Sekondi-Takoradi and Cape Coast. A recent power renegotiation arrangement by the government of Ghana with VALCOs principals has reduced the amount of power sold to VALCO from Akosombo.

Unusually low rainfall amounts in the catchment areas of the Volta dam, especially within Ghana, in the past several years severely incapacitated the hydro-electric plant at Akosombo resulting in large scale power cuts and some rationing which began in December 1983 and continued for almost a year (power supply was reduced by 45 percent, affecting both local consumers and power exports) with significant effects on the national economy (Ghana Commercial Bank, 1984:3-4). Even though this situation has improved considerably, the level of the Volta lake is still close to the safe minimum operation level and any prolonged abnormalities in rainfall could reactivate the problem.

Currently, electricity from all sources is estimated to reach less than 25 percent of the population, mostly those who live in the urban centres. In 1980, for example, 83 percent of total monthly aggregate demand of power from the Electricity Corporation of Ghana (sole distributors of power) went to only 4 main urban centre: Accra, Tema, Kumasi and Sekondi-Takoradi (CBS,1981). Thus the rural population is almost totally neglected and has to depend upon traditional energy supplies, mainly wood.

Isolating the rural (and informal) sector from the national economy, one may be tempted to assume that any shortfalls in supply of conventional fuels in rural areas is of minor economic significance. The urban, more advanced sectors of the economy benefit most from any scarce modern fuels. For example the transport sector, which is basically urban-oriented, takes up to 75 per cent of imported petroleum products (Pluth, 1985:10). On the other hand, woodfuel, in addition to supplying almost all domestic rural energy needs, wholly fuels a variety of rural production systems and crafts.

However, it would be misleading to state that wood is used solely in the rural areas of the country. Thousands of marginal income urban dwellers, especially those living in the slums, have always used wood (both fuelwood and charcoal) and more have lately been driven to it as a result of shortages in kerosene, the major alternative cooking fuel. Charcoal is the most widely used form of woodfuel in the large towns and cities. Charcoal for Accra, for example, may originate from production centres up to 400 kilometres away. The Forestry Department of Ghana estimates that about 90 percent of the urban population use some charcoal for domestic purposes (Brookman-Amissah,1981:6).

Brookman-Amissah (1981:8), again quoting records of the Forestry Department of Ghana, estimated an industrial charcoal demand for the country in 1990 of about 300,000 tonnes. Among potential industries to depend on charcoal are projected iron and steel industries, and limestone works earmarked for the production of Portland cement and calcium carbide. While woodfuel may be used in both the modern and traditional sectors, the situation in the rural areas (traditional sector) is rather more acute since alternatives are nonexistent or very limited.

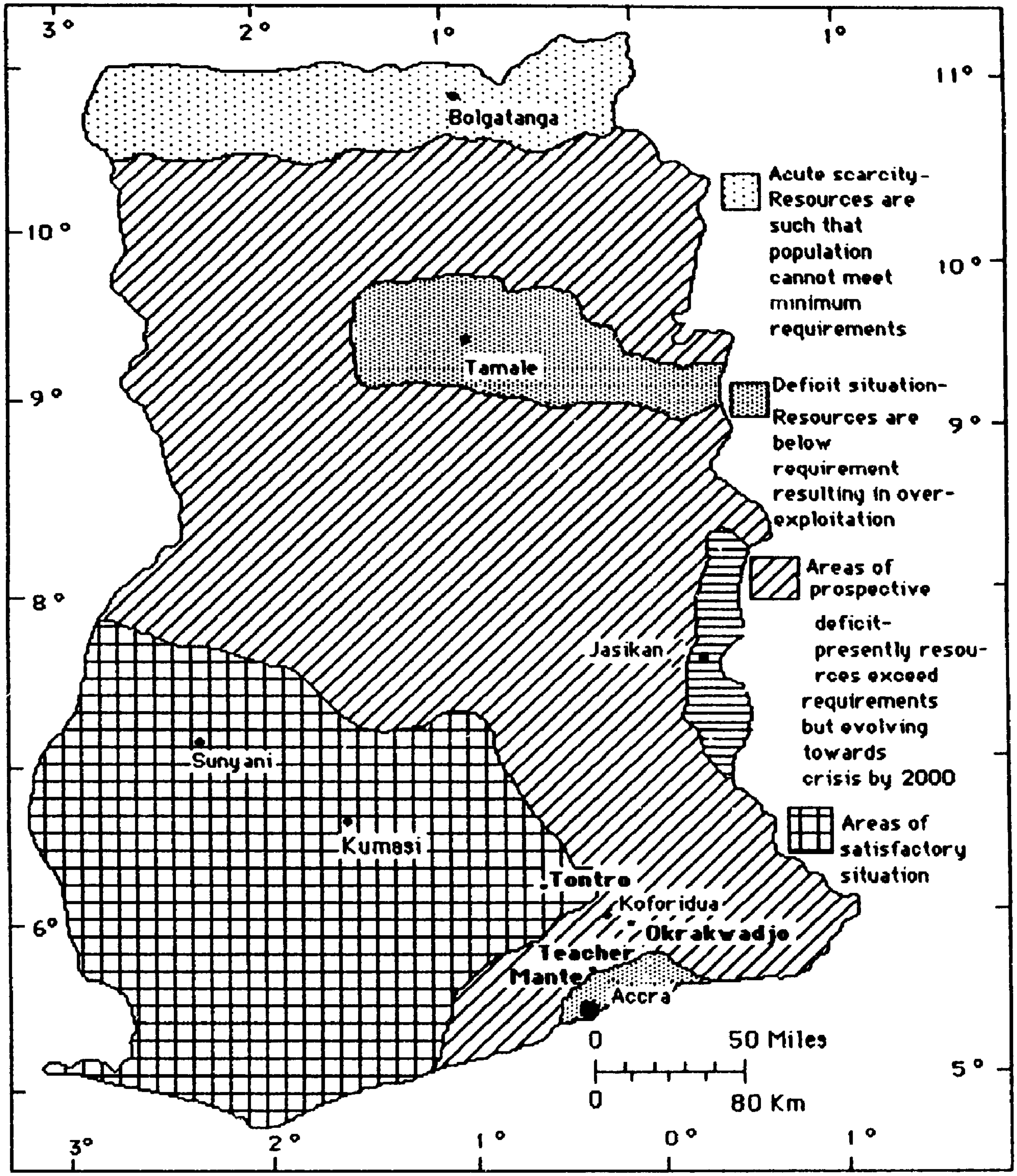
It is interesting to note that since woodfuel use is predominantly in the informal sector, very few effective records have been kept about its use. No official monitoring is done to assess possible supply and demand imbalances and associated problems. There appears also to be a general complacency that Ghana, being largely a tropical lowland forest environment, is in no immediate danger of wood shortages.

Surveys in the first two decades of this century revealed that about 34 per cent of the total land area of the country was covered with closed forests, with the rest classified as savanna and savanna woodland. By 1977, only about 21 percent of the closed forest region remained as true forests. Out of this, 84 per cent was in forest reserves administered by the Forestry Department (Osei, 1984:116; Forestry Dept., 1982; Ghana, 1977; Figure 7). The remaining stands outside the forest reserves are threatened by a deforestation rate of about 22,000 ha\annum (FAO,1981). However, since no definite legal statutes protect most of the established reserves from future utilisation, their existence is also threatened. Similarly, the same F.A.O. study established a deforestation rate of 20-30,000 ha\annum for the much larger savanna woodland.

There are indications that wood shortages are imminent. The rapid downward trend of the timber industry in the country, which is often explained as being due to technological, transportation and marketing difficulties, can be accounted for principally by the diminishing number of merchantable trees in the forests. Hall and Swaine (1981:65) have noted that the decline since 1961 of the most expensive Ghanaian timber, Afrormosia elata, is a reflection of the exhaustion of stocks in the forest. While forest reserves supplied about 51 percent of timber in 1958, by 1978, 78 percent of supplies came from that source (Hall and Swaine,1981). The high percentage of timber provision from the forest reserves in recent times indicate the degree of tree and forest loss in unreserved lands. Increased research will likely reveal many other ecological stresses, including droughts, soil losses, and wildlife depletion and also, the extent to which woodfuel use and woodland loss contribute to such negative impacts.

A reconnaissance map of the fuelwood situation in Ghana, published by the F.A.O., indicates that many areas of the country face imminent problems of woodfuel shortages (Figure 10). The advent of the power-saw, organised entrepreneurs with bulk haulage facilities, and a booming market in the urban centres have made the threat to live trees a reality. The general shortage of alternative fuels will accelerate this trend. A report citing a United States Agency for

FIGURE 10: GHANA - THE FUELWOOD SITUATION



Adapted from F.A.O.
See Ardayfio-Schandorf, 1986

International Development (USAID) publication, states that a full day is now required to gather 3 days wood requirements in Northern Ghana (E.P.C., 1985). Costs in human labour and health are likely to increase if shortages continue and/ or are intensified.

There is no doubt that there is a heavy dependence on wood for fuel in Ghana. The importance of woodfuel in the energy mix of the country and the implication of its over-all sustainability for a balanced development of the country requires that detailed empirical information be devoted for planning needs. While general information shows that the problem of wood dependency is country-wide, for the purpose of this study, only representative settlements of the forest zone are selected for detailed empirical observation. The next part of this section considers the conditions for targeting a designated region from which the study settlements are selected.

3. The Study Area Selection

The overall goal of the study is to collect empirical information on woodfuel at the village and household levels and, thereby, produce a comprehensive record of woodfuel demand at the village level, which will provide both an accurate and replicable approach to woodfuel research and the basis for energy planning in similar rural areas of Ghana and other developing countries. A central concern is the selection of the study villages. In order to meet this goal, the spatial unit from which the study settlements are selected has to be representative in terms of the larger country and within the objectives set for the study.

The primary criteria for choice of representative areas/villages is ecological/vegetation diversity. It is assumed for the purpose of the study that, because the use of woodfuel is noted to be heavy everywhere in the rural areas of Ghana, significant differences in consumption and related impacts will be associated mainly with ecological differences, in terms of relative abundance of wood. Socio-economic factors, such as population distribution and economic activities, provide secondary considerations.

In terms of the primary consideration of vegetation diversity, the most suitable and generally representative area is, the south-eastern region, corresponding to the Eastern Region (administrative unit) of the country (Figure 9). The vegetation of this area of the country is particularly significant from a study point of view, because it is almost a microcosm of that of the whole country. For example, a transect made either from south to north or east to west in the region yields profiles of the vegetation systems that approximate the whole of the southern part of the country. The eastern and southern boundaries run into drier savanna environments, while the western fringes border the humid environments, resulting in differences in biomass productivity.

Although the region is the second highest populated in the country, it also reflects broader regional differences in population distribution. For example, while population densities run as high as 300 persons/km^2 in certain locations, they fall below 25 persons/km^2 in others, providing different distribution characteristics (Figure 9). The region contains a rural population which is about 73 per cent of the total regional population and which is well distributed across a variety of agricultural areas.

The region is located centrally in relation to the hub of population and economic activities in the country, and potentially, becomes the setting for any ill-effects associated with external pulls on woodfuel, especially, to service key urban centres such as the Accra-Tema conurbation. As the pioneer zone of the cocoa industry in Ghana, the Eastern Region attracted a large influx of migrant farmers from all parts of the country who now form ethnic pockets within an otherwise Akan dominated area. Thus, apart from vegetation and population diversity, cultural considerations add to the representativeness of the area.

Even though the target region is representative of the larger country in terms of its ecological and socio-economic conditions, other considerations, such as the need to get appropriate village sites to meet the objectives of the study and logistics problems, called for further procedures to be applied to isolate a smaller representative sample unit within the larger region from which the study settlements were finally selected.

The Study Settlements

Introduction

This section describes the procedures for selecting the study settlements and also introduces the specific settlements chosen for the study. As an initial attempt at selecting appropriate study settlements, a grid of approximately 43 km by 43 km, corresponding with 30' intervals of latitude and longitude, was drawn on a base map of the Eastern Region of Ghana. The grid was used as the basis for evaluation of vegetation diversity within each cell. Cells with three or more vegetation types/sub-types, including ecotones, were considered for selection. Six cells, between latitudes 5^{o} 30' and 7^{o} N and longitudes 0^{o} and 1^{0} W met the criteria (Figure 11). The rest lay in single major vegetation zones, especially, forests to the west of 1^{o} W which are also sparsely populated, and savanna woodland to the north of 6^{o} 30'N, which constitute the most sparsely populated areas in the Eastern Region .

Three cells located between longitude 0^{o} and 0^{o} 30' W were the most representative of the larger region and were accepted. Each of the selected cells traverses two broad vegetation zones and contain two or more vegetation types and sub-types (Hall and Swaine, 1980; also Table 5). This selected zone forms a corridor of 43 km wide, runs north to south (Figure 11), and is representative of almost all the vegetation types of the country, with the exception of the Sudan savanna type (Figures 7 and 8). The accepted cells contain some of the most densely as well as sparsely populated areas of the country, with a large number of close settlements. The cells have the potential to contain evidence of both wood abundance and extreme scarcity, as well as any probable evidence of impacts. The FAO map of Ghana (Figure 10), generally classifies the corridor selected, along with the savanna belt of Northern Ghana, as areas of possible wood deficit, evolving towards crisis by the year 2000 (Ardayfio Schandorf, 1986:22).

FIGURE 11 : THE STUDY AREA (STUDY VILLAGES UNDERLINED)

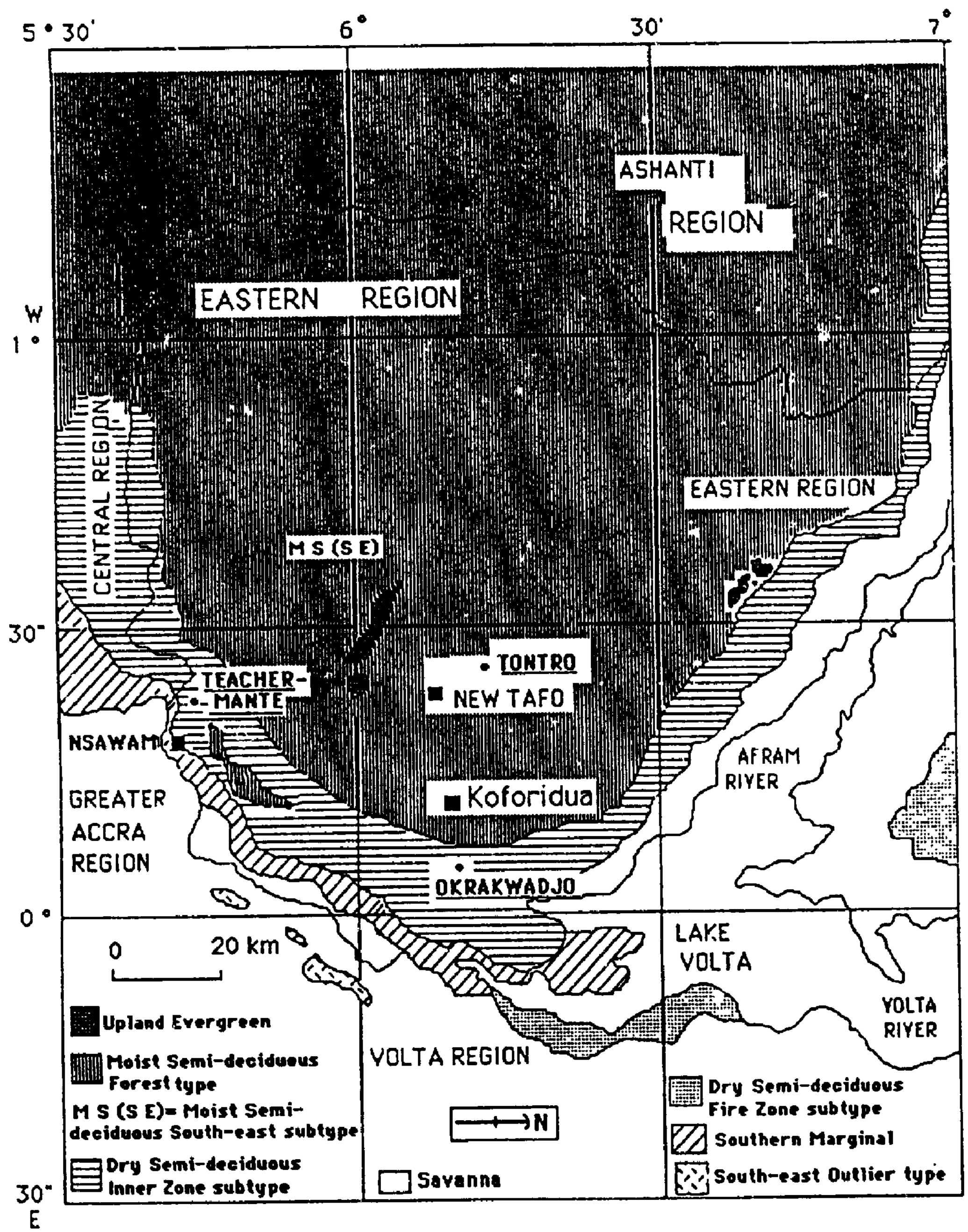


TABLE 5: SUMMARY CRITERIA FOR SELECTING THE STUDY VILLAGES

	Tontro	Teacher-Mante	Okrakwadjo
ECOLOGY	Moist Semi-deciduous South-east subtype	Dry Semi-deciduous Inner Zone subtype Point of contact- Moist Semi-deciduous Southern Marginal & Coastal Savanna	Dry Semi-deci duous, Inner Zone subtype Derived Savanna
SETTLEMENT	Population Size:	Population Size:	Population Size:
Size/Function	305 (1970) 546 (*1986) Functions:	780 (1970) 1076 (1986) Functions:	822 (1970) 1100 (1986) Functions:
	Cocoa Farming Food Cropping i.e. Plantain, Cocoyam, Oil- palm products Timber Commercial Firewood	Food Cropping i.e. Maize & Cassava Fruits i.e. Orange & Pineapple	Food Cropping i.e. Maize & Cassava Vegetables i.e. Tomatoes, Pepper Egg-plants
HUMAN DYNAMICS	**Ethnic Groups	Ethnic groups	Ethnic groups
	Krobo Akim (orig.) Akwapim Ewes Fante Asante Ga-Adangbe Kwahu Dagomba Frafra Grunshie Mossi	Akwapim (orig.) Ewes Akim Ga-Adangbe Fante Dagomba Frafra Nzema Kwahu Akwamu Grunshie Akwamu Krobo Brong	Ewes Akwapim (orig.) Krobo Dagomba Frafra Akim Mossi Asante Kwahu Fante Ga Adangbe Kusasi Mossi Grunshie

* Population Estimated
**Ethnic groups in order of (numeric) importance
Orig. : Original settlers
Source: Field Data

Basis for selecting the specific settlements

Having pinpointed the appropriate area for the study, the next task was to select the appropriate study settlements. In considering an effective and appropriate procedure for selecting the target settlements for this study, reference was made to several existing studies related to rural and energy concerns. The previous study which was found to be most helpful in choosing appropriate settlements for this study was a Canadian International Development Agency (C.I.D.A.) sponsored survey on the energy sector of northern Ghana (Pluth, 1985:22). To be precise, the most useful part was the section of that study dealing with traditional fuel and informal sectors which suggested criteria for selecting study locations on the basis of:

i) providing representative geographic coverage of the Northern Region;

ii) accessibility;

iii) providing a range of population size from very small to very large; and

iv) history of previous cooperation with...surveys.

Among the four preceding criteria, the conditions of geographic coverage and settlement size were considered important for this study. However, since both criteria seemed to be stated in vague terms, they were operationalised into specific and identifiable variables (within the objectives of the study) to form part of the three major criteria used for selecting the representative villages for this study. The criteria for this study are based on;

i). ecological diversity;

ii). settlement size/function; and

iii). human dynamics

Ecological diversity: Each settlement was distinct from the other in terms of situation within at least a vegetation type/sub-type, and/or an ecotone, as illustrated by Table 5 and Figure 11. Vegetation types and subtypes considered include; types - Evergreen forests (wet, moist, upland), Semi-deciduous forests (moist, dry), Southern Marginal forests, South-east outlier forests, Sudan savanna, and Coastal savanna; sub-types- Moist Semi-deciduous South-east subtype and the Dry Semi-deciduous Fire and inner zone subtypes.

Size and function : The operational definition of a rural settlement adopted for the study departs from the figure of 5000 provided by the Central Bureau of Statistics of Ghana. Rural settlements in Ghana exhibit various forms. For example, an ideal rural settlement in Ghana, may apply to any spatially concentrated collection of dwellings with population between 50 and under 2000 people, where the predominant occupation is farming and/or fishing. In certain cases, especially in the cocoa growing areas, a number of dispersed settlements (hamlets of less than 50 people) in a given area may collectively constitute a village, irrespective of the dispersed nature of dwellings over space.

To satisfy the goal and objectives of the study, the settlements had to be farming villages with very little non-farm activities and less urban functions and services such as electricity. A population threshold of 2000 maximum, and 200 minimum was adopted for the study. Generally, a farming village with under 2000 people will evidence minimal administrative and non-agricultural commercial functions, relatively few non-farm occupants, and few or no modern facilities such as electricity. It is also usual for settlements of that size to have most of the farming activities contained within their land area. Below 200 people, and especially where the village is made up of spatially fragmented hamlets, socio-economic variables tend to be uniform. For example, each hamlet will be made up exclusively of one family group, with the same pattern of fuel acquisition and utilisation. It is difficult to extrapolate findings based on such uniform groups to apply over multi-family/ethnic conditions elsewhere.

Human dynamics; In order to represent the diversity of use of woodfuel by different groups of people, the study settlements had to be multi-ethnic by nature. A minimum combination of ten ethnic groups, preferably representing the major tribes of the country and from different ecological zones was adopted as the cut-off line for the selection of the study settlements. Table 5, lists ethnic representation in the three selected villages.

For a comprehensive survey to be possible within the period of time available for the field work, logistic considerations and reasonable proximity were a matter of priority taken into account in deciding upon the number and the specific settlements to be selected from the representative compact study area. A minimum number of three villages was regarded as necessary to meet the goal and objectives of the study. All village settlements within the accepted cells were closely studied with the help of the 1970 census reports and large scale maps, including vegetation maps, as well as topographical maps at scales of 1:50 0000. On the basis of the preceding criteria, the villages of Tontro, Teacher-Mante, and Okrakwadio were found to be the most appropriate for the study (Figure 11).

In spite of certain fundamental differences which set these villages apart, there are some similarities between them For example, they are all rural settlements below 1,500 people in which farming predominates and wood is a major fuel, and all of them have gone through periods of growth as well as decline.

Tontro

Tontro is located within the Moist Semi-deciduous forest zone, which is the most extensive forest type in Ghana. Rainfall amounts are between 1500 and 1750 millimetres per annum and are of double peak in distribution (June and September). The soils in this area are described as Forest Ochrosols or more appropriately, impoverished moderately desaturated ferralitic soils (Hall and Swaine, 1981, Thomas and Whittington, 1969). Including the village itself, most activities in Tontro are defined in an area of land of about 35 km^2.

Tontro lies on the eastern arm of the Ghana railway. It was for long, an important "halt" on the railway, when rail was the only link to the village with the outside world. By 1970, a road reached the village from New-Tafo, (about 6 kilometres), and competition for freight began to reduce the viability of the railway sub-station and eventually the "halt" was abandoned for lack of business. The loss of the "halt" resulted in a temporary decay of the settlement, when railway workers and their dependents, who formed a key segment of the settlement, had to relocate. In due course, however, villages within the complementary region of the settlement increasingly began to use the road system, and traders from all parts of eastern Ghana and Accra began to reach it. A number of people have moved from the less accessible interior to settle in the village proper, helping to sustain rapid growth in the past decade. Tontro also has the advantage of lying close to major urban centres in the eastern region (such as Koforidua, 54,400-1984 and New Tafo, 12,800-1984 (Figure 11). The only major disadvantages are that it lies 4.8 kilometres away from the major trunk road and that the feeder road that links it with New Tafo is also often subject to wash-outs during the rainy season.

The population of Tontro was given as 305 in 1972 (the Gazeteer, 1972).. In the real sense, the population of Tontro proper is difficult to extrapolate from previous censuses, because it was not properly identified as a census unit and came under various names. The present population is estimated at 500 people. The Tontro area was and is still a major economic zone of the country, producing cocoa and food crops such as plantain, cocoyam, and palm products. It is also a timber producing area. Tontro has a large cocoa purchasing centre, run by agents of the Ghana Cocoa Marketing Board, and has one mill (for corn and cassava). Most commercial purchases are done at the market at New-Tafo which is only 6 kilometres away. It has one Primary and Middle school, and two small open shops. It is endowed with a perennial stream, flowing from the hills about 6 kilometres to the north of the settlement, and does not experience any of the water shortages of the other two settlements. In terms of modern conveniences, however, it is the least developed among the three villages. Apart from the Akims who are the original settlers of the area, Tontro is settled by a large number of ethnic groups (Table 5).

Teacher-Mante

Unlike Tontro, Teacher-Mante is located close to the boundary between the forest and the coastal savanna zone. It is sandwiched between a small southerly extension of the Moist Semi-deciduous zone and a point of contact of the Southern Marginal forest (at its narrowest with the coastal savanna zone (Figure 11)(Hall and Swaine, 1981:17). However, most of the land of Teacher-Mante can be said to lie within the Semi-deciduous dry inner zone. Vegetation around the village is now generally bushland, with some evidence of derived grasses. Secondary forests can be encountered from aoout 2 kilometres north west, and east of the settlement. Teacher-Mante experiences an average annual rainfall of between 1200 and 1500 millimetres. It lies towards the edge of the forest ochrosols on the main Accra-Kumasi road.

Teacher-Mante was originally settled by two main sections of the Akwapims (Larteh and Akropong) who now rule separate parts of the village. Teacher-Mante was known to be one of the most prosperous centres of rural Ghana during the cocoa boom years of the 1930-50s. Many of the present non-Akwapims originally arrived to work as labourers/caretakers and/or to purchase property in the area to take advantage of its success and prime location. Post 1950 saw a great deal of migration to the urban centres for regular employment. As is the case in most villages, many migrants kept continuous ties with the village and usually returned permanently to upon retirement from urban jobs. The land area of Teacher-Mante is about 38.5 km^2.

The population of the settlement in 1970 was 780. The population in 1986 was estimated at 1076. The main economic activities in the settlement now include maize, cassava and fruit farming. Under a pilot cocoa rehabilitation project, some farmers are trying to re-establish cocoa farms. Farms that are responding well to this project are however further away from the settlement. The settlement has two primary and middle schools, a postal agency, five small shops, an open market place, a small private dispensary operated on a weekly basis, two milling plants (for corn and cassava), and a modern communal toilet. Water is a major problem, especially, during the dry season, when all the village's wells dry up. It is not uncommon for the women to walk for distances of up to 4 kilometres for water.

Teacher-Mante's proximity to Nsawam (population, 31,900 in 1984) has been both positive and negative. In the past, Teacher-Mante has taken advantage of its location in relation to Nsawam (Figure 11) which has a fruit cannery, a modern distillery, minor bottling plants, a vehicle assembly plant, pharmaceutical plants (modern and traditional), the largest prison facility of the country, a secondary school and hospitals, all of which provide employment. It was a major supplier of freight (mainly cocoa and foodstuffs) to the railways and the population of Nsawam. In the past, it drained a large complimentary region, which it served as a commercial nerve centre. This function is at a low level, at present due to road linkages to the hinterland to the main commercial centres of the country. Teacher Mante has a large composition of ethnic groups (Table 5).

iii. Okrakwadjo

Okrakwadjo lies within a dry sheltered area of the Semi-deciduous Dry Inner Zone which has generally undergone intensive modification. Most of the present day vegetation around the village is a mixture of derived- savanna and bushland, but about 5 kilometres away to the west, dry secondary forests are encountered, especially on hilly sites. Even though Okrakwadjo's location corresponds with the 1250-1500 millimetres isohyet, annual rainfall amounts seem to be lower because soil moisture deficiency and general aridity are a common feature. Including the village site, Okrakwadjo is made up of a land area of about 32.7 km^2.

The village was a hub of one of the major pre-modern commercial trade routes (trails/paths) from the forest interior to the shores of the Volta and the coast before the advent of modern roads. It was founded on land belonging to the people of Adukrom-Akwapim. Limited agricultural opportunities, in terms of arid and impoverished soils, swampy conditions, and above all, pressure on limited land, saw a mass emigration of most of the original settlers, to take advantage of lucrative cocoa growing in the rich forests in other parts of the country. In most cases, the movement was outright. In others, however, wives and minors were left behind to maintain property so that emigrants maintained continuous ties with the village (there are other situations in between the two extremes). The vacuum created by the emigrants was filled by new immigrants, most of them originally from the Volta region, who now plant mostly maize, cassava and tomatoes- annual food crops with high demand. Tobacco growing was experimented some years ago, but could not be sustained. Even though the area may have been forested in the past (as evidenced by relic forests), cocoa growing appears never to have been popular within the immediate region of the settlement. The sandy nature of the soils result in soil moisture problems, as well as scarcity of surface water for human and agricultural consumption.

The population of Okrakwadjo in 1970, was 822 and for 1986, about 1100. The village seemed to have suffered a major decline. Population has been lost, especially, among the youth, to nearby urban centres in search of employment. In recent times, however, there have been some noticeable immigration from several depressed hamlets in the hinterland of the settlement, to help maintain its growth.

Okrakwadjo, has two-streamed Primary and Middle schools, a fairly large and modern government-operated health centre, a postal agency, a police post, a market, a small multi-purpose drug store, five small shops, an oil palm plantation, a well-defined "strangers quarter" (zongo), and three mills. But for the rapid decline in the recent past, Okrakwadjo would have all the trappings of a town. Currently, migrants, particularly the Ewes, almost outnumber descendants of the original founders of Okrakwadjo the Adukrom people, a condition different from the two other settlements.

3. Methods and analysis of the study

Introduction

Analysis of most existing woodfuel study reports (Chapter II), indicated many methodological shortcomings which potentially reduce their utility for planning purposes. The main objective of this section, is to describe appropriate methods of collection of wood consumption data designed for and applied at the village/household level in this study. The critical requirement was that the methods yield accurate and consistent data, which could be verified, and/or replicated both in time and space, within its given constraints. Included in this description are details of the analysis, as well as problems and precautions in connection with the field information. Since the study is based mainly at the household level, the discussion begins with a proper definition of households and respondents. This provides the setting for the discussion on the methods for measuring woodfuel use.

Household identification

As preceding information indicated, the study is based on three villages, namely, Tontro, Teacher-Mante and Okrakwadjo. Within each village, the study sought to derive detailed information for the individual household unit, in order to assemble overall consumption at the aggregate village level.

Households

The main study in the field, other than the acquisition of certain secondary information such as that dealing with vegetation observation and official policies and programmes, was based on the household. A household was operationally defined as the number of people who have their regular/main meals, from the same catering source on a regular basis, (defined as at least, 20 days per month and including supper) and not necessarily blood-related and/or located in the same house.

The major household demographic information included the size and structure. In terms of size, absolute numbers were recorded. No standardisation of household size, such as Lusk's coefficient, League of Nations coefficient, or that provided by F.A.O./W.H.O. (Howes 1985:17) or any others, were attempted in the field.

With respect to structure, individuals within households were categorised into three age-size groups namely, the 15 years and over group, the 10 to 14 years group, and the 0-9 years group. Any member of a household, who upon attaining a certain age/traditional rite, is absolutely free to decide when to use woodfuel and/or is obliged to partake actively in domestic activities involving woodfuel, is categorised as an adult. On this basis, all household members from the age of 15 years onwards are considered as adults. All others who are occasionally called upon to help in some aspect of cooking and wood gathering and who largely depend upon the decisions of the adults for all wood uses and acquisitions, were classified as minors. Two specific age classifications were however, derived from the minor group. These were the age of 10 to 14 years group, observed to be frequently coopted into use and acquisition of wood, and children, corresponding to the 0-9 year group, largely dependent upon the other age categories for household services. Note however, that in certain households, children may be co-opted into household duties at an early age. Households were also classified on the basis of gender/age.

Survey goals for household coverage

Ideally, the survey aimed at achieving a 100 per cent coverage of households to attain a complete information base for each village. However, because of certain specific local constraints, including, relocation, deaths, long leaves, and insufficient data coverage for some households during the term of the survey, the average percentage coverage in the field was reduced to about 80 per cent over-all, and 100 per cent in Tontro.

Household respondents

Heads of household, namely adult females and/or males, who regularly provided for and took all final decisions concerning the organisation of the household affairs, including especially, the utilisation and acquisition of fuels, were targeted as the main respondents. This categorisation included some exceptions. For example, in some homes, commercial operations were completely divorced from mainstream household organisation, because they were owned independently by members other than the household head. In such a situation, the operator of the commercial activity, was interviewed separately, but only on commercially related questions. In all cases, such operators were regarded as part of the aggregate household.

Data Acquisition and results

The woodfuel study covered both aggregate and sectoral information. Aggregate information covered households/villages, without discrimination into sectors of wood use, quality types, and demographic differences. On the other hand, sectoral information broke down wood use into activities and quality types. Results are organised on the basis of such aggregate and sectoral considerations.

4. The survey Method

Overview

The survey at the household/village level involved physical measurements, questions and observations covering woodfuel acquisition and use. In terms of utilisation, the survey methods covered specific details on how much wood is used and by type, for both domestic and commercial (non-domestic) purposes. Domestic uses involved all those wood use types without immediate monetary motives. On the other hand, commercial uses involved the use of wood for whole or part of production for commercial exchanges, irrespective of product type, output, unit of production, or continuity of production. For acquisition, methods were used to elicit information covering such details as, supply type (purchased or/and self-acquired), collectors (labour contributions), where (supply sites, land ownership patterns), how (equipments for collection, time and distance implications) and costs

Methods

Methods designed for the study aimed at collecting both quantitative and qualitative information. Quantitative methods involved physical measurement of wood acquisition and consumption. Some aspects of non-physical measurement procedures, especially, the interview method, also produced numeric information such as; age, household size, number of meals per unit time, frequency of commercial operations, frequency of wood collection per unit time, expenditures on fuels, distance to source of wood and time involved in wood collection. On the other hand, qualitative information covered such areas as vegetation types, preferences, habits, traditions and cultural practices, derived mainly through non-physical measurement procedure (Appendix 1). Methods for collecting both quantitative and qualitative information are described in detail below:

Physical measurement -The weight survey

To achieve the goal of accuracy and consistency of data on wood consumption, a direct physical measurement system, the Weighing Method, was adopted. The primary equipment for determining weight/quantity before other conversions take place, is the weighing scale. Other equipments required are the gasoline chain-saw, cutlass, sisal rope, measuring tape, safety boot, hard hat/broad hat (sun) and rain coat.

Two 100 kg capacity scales were made available in each study settlement. Wood intended for fuel purposes was systematically weighed on this metric scale and its use monitored over time (see below). Care was taken to isolate the influence of varying moisture content, shapes and sizes, equipment malfunction, and accuracy of readings on measurement. In all cases, the date of measurement, household code, number of potential users, origin of wood (purchased/collected) and species of wood, were recorded as complementary information to the numeric measurement. Generally, when closely supervised, the weighing method provides basic quantitative information that can both be replicated and verified.

The direct quantitative measurement process was set up in all three villages 4 days after another, to meet uniform periodic weather and economic conditions, as well as maximising the data base to be collected. The measurement spanned a period of 10 months to cover the rainy (May-September) and dry (October-April) seasons.

Assumptions for the Weight Survey

All wood was considered to be air dry weight. Field experiments to convert wood of fairly high moisture content to air dry weight (25 percent moisture level) was carried out. Earl (1975:24), estimated that, for 3-4 months in the tropics, and 6-12 months in temperate zones, moisture content of freshly cut wood for fuel should be reduced to 25-30 per cent (which is the air dry range). In the field, it was realised that this rule applied well for wood sizes ranging from twigs to medium branches, and in relatively continuous dry weather. For logs, and bigger branches, they may already be dead for the moisture loss process to have set in for several months or years, before the rule worked.

Permission was sought to weigh and store bundles of wood in selected wood-surplus homes, for a maximum period of 4 months to meet air dry conditions. The author also bought 9 bundles of wood in the three villages to expand the observation frame. Experimental wood was re-weighed after the 4-month period, and the bundles were found to weigh between 15 and 30 per cent less than the original weight. All earlier readings with high moisture characteristics, were accordingly adjusted by a corresponding mean weight from the experiment in the respective wood type and form class. (A faster experiment which involves reduction of the moisture content of wood to oven dry weight basis, thus, increasing its calorific value to 4.7 (Table I), and using the formula (Earl, 1975);

$$\text{m.c. (moisture content)} = \frac{(\text{weightfresh} - \text{weight oven dry})}{\text{weight oven dry}} \times 100$$

was found to be time consuming for a (non-laboratory) large scale study. Practically, all wood used in the area is air dry, which makes Earl's system appropriate for this study, rather than the oven dry basis.

Specific weight measurement procedures

Procedures for measuring each category of wood use are spelled out in the following sections under aggregate and sectoral.

Aggregate/Gross measured weight of wood

i. Bulk Measure

Where the household unit to be investigated had a pile of wood for use over time, the whole pile was weighed including twigs, wood wastes, small branches and logs and bamboos. Commencement and completion of use was monitored. Cooperation of respondents was sought so that no wood was added to, or used apart from that measured. Any fresh supplies were stored in a separate zone. Assistants frequented households, to measure any new stores, before use began.

ii. Measuring when supplies came in

In households where a discernible pattern of collection and/or supply existed (such as weekly), measurement was timed to coincide with the main supply times. Where additional wood was purchased to supplement self-collected sources, this was recorded. Precautions were taken to record all wood borrowing and/or communal pools. Information was collected on wood that left the settlement, even though this was assumed not to be part of the village's gross consumption.

iii. Others

Using a modified version of a procedure used by Best (1979; also, Howes 1985:38), households were requested to set aside several days' equivalence of wood. These were weighed, with the remainder to be re-weighed at the end of a stipulated time. Unlike Best, however, the author requested assistants to reduce the number of days to monitor completion, using a rule of thumb of x-1 days; implying that if a household sets 4 days as the completion date, an assistant was to show up on the third day. Alternatively, or as a complementary measure, assistants were advised to add more wood to piles set aside by respondents themselves. These safety measures were taken to ensure that at least measured wood did not run out before assistants showed up, and before new wood was used to complicate the monitoring process. Some families did not have a pile of wood at the start of a day; such households were closely monitored and any wood supplies measured as soon as they were available, irrespective of the time of day.

Closely related to the preceding method was one used by Ernst (1979) which was also useful for the study. A bundle was weighed and set aside each day for a household. The bundle was re-weighed at the end of the day to determine consumption (see Howes, 1985:38). All precautions in the preceding procedure were also followed.

Sectoral

i Form/quality type

Wood available for measurement was first divided into logs, branches, twigs, wood wastes, and others (i.e.. bamboo). Each type was then weighed separately and a record kept. Numeric information on established/locally perceived quality and inferior species were also established under this procedure.

ii. Segmenting wood into piles for separate activities

Subject to the availability of wood and the co-operation of households, wood was weighed into separate piles and marked clearly (not necessarily in written language) for various end uses. One or two piles were not marked so that uses that are not routine could be noted (the judgement of the researcher was used to allocate more wood to activities such as cooking that are repetitive and wood demanding).

iii. Measurement at meal preparation times

Since meal and meal-related activities are the most important users of wood on continuing basis in village situations, it was necessary to determine daily amounts of wood that went to such activities. At each meal preparation time, wood available for the whole cooking process was measured. Wood that remained after the cooking was re-measured so were any additions brought in to complete the cooking. This aspect of the survey was the most time consuming. Because research assistants were not sufficient to assist the author (principal researcher), it was undertaken randomly to cross-check information derived from other procedures. This part of the study also benefitted from participant observation.

iii. Monitoring/Measuring wood that moved between household activities

In homes where wood for non-domestic uses were purchased, and kept at work sites, measurement took place at such sites either over time, or at the commencement and close of each operation. Left overs transferred for domestic uses were also measured; in the same way, any transfers from domestic to non-domestic uses were closely monitored and measured.

Experimentation- Wood conversion to charcoal

An experiment was undertaken to find out the ratio of wood input to charcoal output using the traditional earth kiln method (details and findings are provided in the report in Chapter V). The aim for this experiment was two fold; (a) to verify conflicting figures quoted for wood-charcoal conversion; and (b) to determine wood equivalence of charcoal used in the study settlements.

Non-physical measurement procedures

The principal method under this category was interviewing. Others are, the diary method, participant observation, visits to source areas and official/documentary information. Each of these methods are described.

i. Interviewing

Where it precedes and/or carried out simultaneously with physical measurement, interview surveys may help provide background information on such important variables as household units, occupants, occupation movement of respondents, and a general introduction to life and functioning of households and the community at large. It may therefore help to save time and costs and, generally improve quality and reliability of information.

Under the interview method, specific questions were used to extract information related to wood supply, such as; species, amount, distance, time labour requirements, monetary costs, use patterns, social and ecological impacts. The interview method thus provided both quantitative and qualitative information. Heads of household were the direct respondents, while other members of the household were coopted to assist. The interview was repeated in the dry season to check on the consistency of some responses given during the original interview in the rainy season. Appendix 1 sets out in detail, the range of questions for the interviews. The interview stage helped to check on the accuracy and/or consistency of the directly measured information.

ii. Diary method

In randomly selected homes, notebooks were left for participants to record a wide range of activities relating to woodfuel use. Information covered included (a) wood supplies; arrival, purchased and/or self collected, number of people involved in collection, cost, origin, and how long it took to collect; (b) wood use- commercial uses-by kind, domestic uses-types, number of cookings/unit time, main and subsidiary; (c) visitors; how many?, arrival, departure; and (d) travels; how many?, when? for how long?.

iii. Participant observation

This covered many areas, including cooking, commercial operations, and wood collection. These processes were observed closely and the principal researcher took part directly in some activities. Vernacular names of various trees were noted, and wherever possible matched with live ones. Preferences were observed, and various saving practices closely watched.

iv. Visits to source areas;

Such visits were made to gather on-site information on supply situations, such as relative wood abundance, collection type, equipment used, hours expended on collection, distance to collection site (s), ecological stress and for sample species. Fresh leaves and barks of trees that were difficult to identify, were collected and sent to the Herbarium at the University of Ghana. Similarly, various names of trees were recorded for proper scientific nomenclature, with the help of a local faculty member at the Herbarium.

v. Official/personnel and documentary

Several contacts were made with appropriate agencies in Ghana for cooperation and assistance with regard to the acquisition of information and for some logistical support. Some information on official policies on the energy sector, forestry programmes, renewable energy projects, and rural electrification were derived. Most convenient, due to proximity to the research area, and the direct relationship of research interests, two major organisations, The Environmental Protection Council, and the Department of Geography of the University of Ghana, provided avenues for official information on energy issues in Ghana, resources management in general, and existing related studies. Other agencies, such as the Forestry Department, the Forestry Commission, and the National Energy Board were also very helpful.

The Field Investigation-Problems and Adjustments

Specific methodological problems and adjustments in the field, are described under physical and non-physical measurements. As much as such problems are categorised under either of the two, in most cases, problems overlapped.

Physical measurement- Problems

i. Instrumentation and Dwelling unit

Generally, housing in most rural areas of Ghana, has a high percentage of local material components. As a result of the perishability of most of such local building materials, upon exposure to the weather and pests, and paucity of maintenance, dwellings are at different stages of withstanding external stress.

The condition of a house structure is relevant to quantitative weighing methods in the sense that, in the absence of any mobile mechanical support in the equipment list of a researcher, it is the sole source of support for the weighing scale. Theoretically, a problem of aerial support may be avoided by using a low-bed scale, such as the ordinary "bath" scale type or the heavy-duty commodity scale ("cocoa scale"). Disadvantages with the bath scale type are that, readings cannot be taken easily because of a small holding surface, and wood may have to be cut into tiny lengths to adjust properly to scale width, resulting in too many bendings and cutting work. A bath scale may also not be robust enough to withstand rough heavy logs and other types of wood. The heavy duty commodity scale type, even though useful in terms of surface area, weight pull and ease of reading, is least appropriate for a mobile survey due to its weight. As a main weighing instrument, it may be extremely costly in terms of labour time and expenses for labour.

For this study, a light and robust "spring balance" scale was used. This was simple to carry and easy to attach to any free hanging horizontal beam in the front or back of a house, a shed or a barn, through a nail, or tied with a strong rope to the beam. It was distressing to note however, that in most households, it was not possible to use the spring balance because, the house was structurally weak and/or had no free lying beam support for the roofing structure. In other cases, vertical supports to horizontal beams were so close to each other that, bundles of wood or logs did not have free hang for correct readings to be taken.

Proper adjustments were made for such contingencies, such as carrying the wood to a nearby measuring point.

ii. Nature and form of wood and instrumentation

Various forms and shapes of wood were returned to the household. These included, rough mixture of twigs, small and medium branches in bundle form, piles of neatly cut wood on top of loads of foodstuff, pole-like lengths of brancnes and logs, split wood, short logs to be split, knotty, thorny, smooth, charred, wet and dry wood. The characteristic of the wood, including twigs, affected the ease of measurement and reading.

Considerable slowdown to the rate of research occurred because of the necessity for intensive ancillary work to prepare the wood input into a form appropriate for instrumental readings. Depending upon the survey environment, there was not enough room to accommodate the length and /or contorted shape of the wood. The wood could also tip to influence reading results.

Cutting equipment such as the chain-saw (gasoline type) and cutlass were used to prepare wood into appropriate lengths for all measurements.

iii. Dilemma in measurement

A number of wood use and/or supply situations tended to frustrate accurate measurement procedures.

In certain households, wood was collected only at specific meal times. In others, wood for household purposes were derived from left-overs after commercial uses. For most times of the day, no wood was available for measurement. There was also a kind of pool use of wood within and between certain houses. It was common to find firewood stores running out at rapid rates in supply households, giving erroneous impression of greater use there, whilst dependent households for most times had no wood to show a researcher, because they took wood from the pool only when needed and when incidentally, the researcher was not around. Parallel to the above are practices of wood borrowing and food sharing. The researcher was faced with an array of tricky situations in the field. For example, the principal investigator required a period of up to three months in some cases, to detect the use of wood for commercial purposes in some households. Respondents usually did not readily volunteer information on commercial activities for fear of taxation. Commercial activities that were intermittently undertaken, were the most difficult to track.

Many homes in the sample list may have gone unstudied if the survey were to be short-term, and non-repeat. There was also the possible problem of measuring the same wood several times over in different households.

By integrating quantitative methods with qualitative methods, and also by repeating studies over seasons, and using a reasonable number of research assistants to reach households in a consistent manner, such problems were largely avoided.

iv. Assistants and quantitative measurement

There was no doubt the work of measuring wood was physically involving. Bending, stretching, lifting, carrying, throwing and storing wood, were some of the routines of the work. The wood was often unpleasant to handle - thorny, rough sharp edges, mud contaminants, powdery soot from charred wood, poisonous insects and reptiles that constantly showed up in piles of wood. Bundles being measured often snapped under weight as occasionally did some house structures. The hot sun and rain made it a tedious out-of-doors activity. It was tempting for assistants to skip some rounds, presented shoddy work and complained of fatigue and illness.

In the study, the principal investigator detected early, that, resident assistants consistently left out some households. Reasons such as courtship, social standing and pride, petty feuds, unpleasant surroundings, and relatively difficult measurement environments, actually kept some assistants away from some households. Principal reasons provided by defaulting assistants when confronted however, were the alleged uncooperative nature of inmates, long hours in the farm/market, and/or paucity in the use of wood. None of those reasons were confirmed when the author supervised work in those homes.

An equally crucial aspect of the measurement process that tended to suffer was the monitoring stage. This provided information on use over time. Many visits to households were required to monitor use. This exercise was usually boring, especially, where no new stores of wood were available to measure until current ones ran out. Where there was a slack in frequency of visits, however, old stores could be replenished once or twice and the date of completion of use reported to a monitor, could actually refer to a first or second addition or both. Assistants were also to monitor interchange of use between activities.

The principal researcher established a good working relationship between himself and members of households. In this study, residents often reported assistants who defaulted in monitoring use. Children in some households also consulted with assistants whenever a measured store ran out. Records of transactions were clearly kept by each assistant to make it easy for the principal researcher to follow up all previous work, and to enable easy detection of shortcomings and loopholes. Such records included dates, house numbers, contact persons and type of wood. The principal researcher was involved practically, in all aspects of the measurement since a lot more useful information may have been lost if this was not done. A minimum of two assistants were required to operate each weighing scale. A back-up assistant was necessary. A hard hat, safety boots, and work gloves were provided, even though budget for the study was limited. Assistants were not only academically sound, they were able to adapt to rural life, and stood up to the frustrations and physical demands of woodfuel research.

Non-physical measurement- Problems

i. Proper targeting of respondents

Targeting of respondents was a complex matter under various village circumstances, especially, for the interview survey. For example, members of households (heads particularly) with authoritative information on acquisition and use of wood were sometimes absent on survey rounds. On some occasions, such heads were available but chose to delegate relatively uninformed minors to answer survey questions, on the pretext of engagement. Without care and good intuition, the quality and consistency of information derived under such circumstances became suspicious.

It was also difficult for a lone person in the household to provide complete picture of the woodfuel system and for that matter, responding well to all survey questions. The female segment generally showed expertise in questions related to supply and use, while adult males were excellent with species names and land use history of the area. Children were assets in questions requiring memory recall. Naturally, group questioning appeared the best option but this was often fraught with contradictions, confusions, and engendered unnecessary arguments to slow down or derail the research agenda.

To overcome such problems, the researcher settled on heads of household (female as principal, assisted by male) as principal respondents. Other members were consulted only on specific questions. Where by judgement, answers to questions were found to be unsatisfactory, due to lack of cooperation, experience with the use of wood, absence of adults, indisposition, or suspicion, the interview was postponed or repeated several days or weeks later. A random repeat of all interviews for consistency checks proved to be useful. A cheap option was to use part of the measuring and monitoring time to verify answers to some questions (actually, most intricate answers and observations came out freely during informal conversations with residents at the time of the physical survey). The principal researcher therefore had to maintain complete coordination of all interviews.

ii. Isolating specific wood using units in multiple dwelling houses

There were a number of complex residential arrangements in the villages that made it difficult to detect household units.

A common living arrangement was that of the immediate extended family, sharing the same compound with married adult sons and their families who constitute their own cooking units, but cooperate with the larger group in the share and development of certain common resources such as land. In polygamous homes, even though there was one male head, each wife and siblings, maintained a separate kitchen-in practice, constituting separate households. At the other extreme, unrelated and disparate groups of occupants in one house, cooperate so closely that, they decided to cook together and identify themselves as relations when in contact with strangers. It was a prime task to detect such realities in the first instance, in order to target wood using units.

The principal researcher's consistent definition of a household unit, helped to make such detections relatively easy. This notwithstanding, it took several weeks for proper identifications and corrections to be made for different households. There was always the possibility of reshuffling earlier surveys to take care of changes detected. In addition, the researcher was on the look out for people who are served with food from homes in which they do not maintain residence to avoid the problem of double counting.

iii. Temperament/Deception

Many petty family squabbles existed in all forms in most of the multiple dwelling homes. Ironically, most conflicts stemmed from such seemingly simple household circumstances as the right to use and /or supply responsibilities of firewood, and cooking. For example, it was noted that, children and/or other dependent occupants shirking responsibility in gathering woodfuel, cooking and other general household chores, attracted the anger of the adult head when found answering questions on those very topics. The researcher was admonished by an elderly woman during the pilot stage of the survey, for daring to interview a grand daughter (living on her own) who had defaulted in cleaning the house and showing contempt to her. Rival wives in polygamous homes also generally declined to answer questions that relate to one another and/or even failed to mention the existence of other women at all in the house.

As a precautionary measure, the principal researcher consulted with the owner each house/head of household first, for approval before interviewing. Valuable pieces of information about the set up in the house were derived at this stage. Several visits were also necessary to help observe any contrary conditions to one recorded in the first interview.

iv. Official suspicion and indifference

Problems with official sources of information ranged from the need to safeguard official information to outright contempt for the research.

In some government departments, past problems, and mostly perhaps, improper definition of what constitutes classified information, made it difficult for most needed information through the official channel. Most of such information that were available, were found to be out of date, inconsistent, or insufficient for this work. For example, a request for information on such items as forest volumes and vegetation growth rates, that normally may be considered as academic in many countries, was never provided- either they were not available or they were not to be disclosed or both

A better way to overcome such problems, was to use researchers directly involved in most of such programmes, and who were current with data, rather than government departments, which must operate within some limitations concerning divulging of official information.

In addition to the problem with official information, certain high placed academics apparently regarded the study as having robbed them off future research potentials, or undercut their broad area of research interests, which for financial constraints have lay dormant. Little or no help was received from such academics in terms of existing related work and/or other useful information to benefit the project. In some cases, comments were hurtful to the initiatives involved in this research. To gain the confidence of some of such academics, the principal investigator had frequent briefs with and shared information from the field with them.

5. Analysis of the Field Information

The data output is analysed in terms of aggregates of households at the composite three-village level, and households in the individual villages. The analysis involves two major considerations, wood consumption patterns, and impacts.

Sequence of analysis

i. The analysis begins with the assembly of field information in chapter V. The main objective is to provide information on how much wood is used for fuel, including form and quality type and how is it accessed. A descriptive statistical package, covering frequencies, measures of central tendency and dispersion and graphs, are employed to summarise the raw data for a preliminary presentation of wood acquisition and consumption patterns, and to provide a basis for more advanced analysis, and explanations in chapters VI and VII.

ii. In chapter VI, the main objective is to explain the pattern of wood consumption both at the composite level and in the individual villages. Relationships tested include demographic effects on wood use, specific meals and wood use, commercial operations and wood use, time and distance effects on wood use, access to wood and use trends, occupation and wood use, amount of wood collected and use, and land ownership type and wood use. Tests of variation, including, analysis of variance, are used to determine the degree of variability of use within and between the three settlements. Statistical methods of association, including the Pearson correlation coefficient, and bivariate regression models, are used to establish individual variables with strong relationship with wood consumption, by gross, and by sector use, to cover the composite study villages, as well as the individual villages. This provides the basis for a cut-off line to select significant individual variables to help explain variations in wood consumption in a univariate manner.

For a multivariate analysis of consumption patterns, a Step-Wise Multiple Regression Analysis, is used as both an explanatory, and predictive tool, to help determine the composite influence of significant variables among a number of variables, considered at the Univariate stage. Parallel to the statistical packages mentioned, the impact of sub-population differences on wood consumption is considered. This involves a re-ordering and classification, principally of household occupants (based on age, numbers and gender), and comparing these with overall use, including performance of simple tests of association and regression. Simple block diagrams are used to show graphically, the contributions of each class in influencing consumption.

iii. Impacts resulting from the use of woodfuel are analysed in Chapter VII. Impacts cover ecological and Human (social) variables. Ecological questions to be answered include, the effects of wood collection on standing vegetation, soils, air, animal life, water quality, and fuel scarcity. Human impacts include economic costs of wood use, tradition and culture, human labour, and social development. In Chapter III, details on impact determination used in this study were described. Such identified impacts, are rated upon a 4-step scale, similar to one first used by the Imperial Oil Limited, in 1978 (Duinker and Beanlands, 1986:4) and modified and adapted for this study to rate both human and ecoiogical impacts. The rating of impacts which range between major to negligible, apply when;

"major" refers to a situation when impacts affect entire households/ species.

"moderate" when impacts widely affect some households in a village to the extent that fuel availability/use may be affected over time. In terms of the ecosystem, impacts affect a portion of the population/species, and may bring about a change in species abundance and/or distribution over one or more generations

"minor" when impacts affect a specific group of localised individuals within a population over a short period".,

"negligible" when impacts are below the minor category.

Summary

This chapter has introduced and described the study setting in Ghana, including details of the selection and description of the specific study villages. A nethodological framework for the study has also been provided giving specific details on procedures of data gathering, verification and analysis. Problems and precautions associated with the methods of data gathering described, are also presented. The next chapter begins the report and analysis of the field findings.

CHAPTER V: RESULTS OF FIELD INVESTIGATION-WOOD CONSUMPTION AND ACQUISITION PATTERNS

1. General Introduction

In reference to Chapter I, the overall objectives of this study are stated as an attempt to determine the actual amount of wood used as fuel based upon an accurate and replicable method of investigation, assessment of economic, social and ecological costs of woodfuel use and, identification of conservation and/or planning needs. While the first four chapters provided the rationale, conceptual and methodological basis for the study, the next three chapters present and analyse findings from the study. Chapter V serves as the first analytic chapter. It assembles the results of basic data derived from measurement and survey in the villages and presents partial findings from the data presented. In chapter VI, an attempt is made to provide comprehensive explanation of the pattern of wood consumption established in Chapter V. Impacts from woodfuel use, both ecological and socio-economic, are presented and analysed in Chapter VII.

This chapter is organised into two key sections. In the first section, the general basis for and the key to the presentation on wood acquisition and consumption, including procedures for establishing quantitative standards for comparing wood consumption among the three villages are described. Variables regarded as central to wood consumption, such as those related to demography, woodfuel types and wood use types are described. The second section provides actual figures on wood acquisition and consumption patterns for the three villages, and on which further analyses of wood consumption are made in chapters VI and VII.

2. Consumption variables

Variables regarded as basic to wood consumption generally fall under population structure, woodfuel type, and woodfuel use type. In this section, specific variables of interest under each of these categories of variables are described to provide a basis for and easy understanding of information described in the next section as well as analyses in subsequent chapters.

i. Demographic Structure of Households (Villages)

The demographic characteristics of the households and villages are the basic denominators for all estimations, analysis and projections in this study. Variables considered under demographic structure include, the number of households in a village and the number of people in household/village by total, gender, age, and by occupation. No current published census data, other than that of 1970, was readily available during the time of the study, thus, population figures provided in this chapter, refer to those directly derived during the field investigation in 1986 and which are compared with the 1970 census.

ii. Woodfuel Types

Under woodfuel types, information is provided on wood composition, fuel importance and acquisition patterns and, woodfuel categories. The framework for quantitative measurement is also described. Specific variables to be investigated under woodfuel types are described as follows;

Wood composition

Detailed information was collected on all kinds of woodfuel species including their sizes, shape forms, and quality characteristics. Such information also covered wood wastes, and biomass with varying degree of woody matter, including agricultural wastes.

On the basis of relative burning property (such as smoking, flame concentration and length of time of burning), durability of embers, quantity of ash residues, size of wood, and local perceptions of prized wood types and forms, all wood (biomass-generic) for fuel was classified into Quality (especially logs and branches of all sizes and shapes including those of species identified as of quality) and Inferior (ranging from twigs and bamboos to agricultural wastes). Table 6 provides a listing of common species of wood used as fuel in the study villages. The discussion in the second section will consider in detail, the quality range of species available in the individual villages, and the relative access to quality wood species by households.

Fuel importance and acquisition forms

Fuel importance is defined by the number of households involved in the use of particular fuels- the larger the number of users of a particular fuel in a village, the more important that fuel to the local area. Detailed information on sources of wood, the amount collected per unit of time and tools involved, location, distance and temporal factors in wood acquisition, household labour distribution for wood

TABLE 6: POPULAR SPECIES OF WOOD USED AS FUEL AND THEIR AVAILABILITY/USE FOR EACH OF THE STUDY VILLAGES

SPECIES	VILLAGES TM	ITOR	IOKR
1.* Margaritha (Phyllantus) discordea (Opapea)	YES	YES	YES
2. Drypetes floribunda (Duabo),	YES	NO	YES
3. *Corynanthe pachyceras (Pamprama)	YES	YES	YES
4. * Dialium guineense (Osnafu)	YES	NO	NO
5. *U Nesogordonia papaverifera (Odanta)	YES	NO	YES
6. Mansonia altissima (Opono)	YES	YES	NO
7. Ficus species (Nyedua)	YES	YES	YES
8. Gliricidia sepium ("Agriculture")	YES	NO	NO
9. * U Celtis milbraedii * U Celtis zenkeri (Esa)	NO	YES	NO
10. Ficus asparifolia (Nyankyeren)	YES	YES	NO
11. * Trichilia prieuriana (Kakadikro)	YES	NO	NO
12. Chlorophora exelsa (Odum) C. regia	YES	NO	NO
13. Theobroma cacao (Cocoa)	YES	YES	NO
14. Psidium guajava (guava)	YES	YES	NO
15. Ficus (Oketew Amforo)	YES	YES	NO
16. *U Terminalia ivorensis (Emire)	YES	YES	NO
17. Alchornea cordifolia (Agyama)	YES	NO	YES
18. Trichilia monadelphia (heudelotii) (Tannuro)	YES	NO	NO
19. *U Cola gigantea (Owataku)	YES	YES	NO
20. Alstonia boonei (Nyamedua)	YES	YES	NO
21. Persea Americana (avocado pear)	YES	YES	NO
22. Mallotus oppositifolius (Setedua)	YES	NO	YES
23. Citrus sinensis (Orange tree)	YES	YES	NO
24. * U Triplochiton scleroxylon (Wawa)	NO	YES	YES
25. Afzerlia africana (Papao)	NO	YES	NO
26. *U Terminalia superba (Ofram)	NO	YES.	NO
27. Funtumia africana Funtumia elastica (Ofuntum)	NO	YES	NO
28. Holarrhena floribunda (Osese)	NO	YES	YES

29. *U Cylicodiscus gabunensis (Dengya)	NO	YES	YES
30. Vocanya africana Rauvolfia vomitoria (Kakapenpen)	NO	YES	NO
31. Musanga cecropioides (Odwuma)	NO	YES	NO
32. Macaranga species (Opam)	NO	YES	NO
33. Mangifera indica (Mango tree)	YES	YES	NO
34. Lannea welwitschii (Kwamanini)	NO	NO	YES
35. * Albizia zygia (Okoro)	YES	YES	YES
36. Ceiba Petandra (Onyina)	NO	NO	YES
37. Datura innoxia (Pepediawuo)	NO	NO	YES
38. Glyphaea brevis (Ofoto)	YES	NO	YES
39. Oxytenanthera abyssinia (Bamboo)	NO	NO	YES
40. Manihot esculenta (Cassava sticks) (Cassava sticks)	NO	NO	YES
41. Elaeis guineensis (Palm branches)	YES	NO	YES
42. Chromolaena (Eupatorium) odorata ("Achampong")	NO	NO	YES

TM TEACHER-MANTE
TOR TONTRO
OKR OKRAKWADJO
* Excellent woodfuel
*U Upper storey
Local names in parentheses
Yes: Popular fuelwood. Found in area and/or regularly purchased from
outside the village.
No: Not Popular. May not be found in the area.

SOURCE: FIELD DATA

collection and household income potentials in relation to fuel purchases are comprehensively examined. This information provides the basis for better understanding on discussions on wood consumption trends, since fuel must be available in the home in the first place before it can be utilised.

Woodfuel categories

Woodfuel covers both firewood/fuelwood and charcoal. The terms firewood and fuelwood, are used interchangeably.

Firewood

Firewood involves any dry woody material which may be utilised as a source of fuel for household activities. Non-woody materials such as crop remains are included in this category.

In the study, firewood was measured on a bundle basis per lunar month of 28 days. A standard figure of 28 kg/bundle was adopted for all three settlements. Bundles may however, in real case situations, range from 17 kg to 35 kg depending on the village (general availability of wood and market) and season (shortage, moisture influences). To derive the standard figure of 28 kg/bundle. a number of test weighing experiments on standard bundles offered for sale in the individual villages were made. At Tontro and Teacher-Mante, the mean figure for a bundle was 28 kg, while that at Okrakwadjo was 26 kg. Bundles for Okrakwadjo are corrected to meet the standard figure of 28 kg. Any weight for logs was also corrected into bundles based on the 28 kg standard.

Volumes of wood per capita per annum are provided in cubic metres (m^3), based on conversion figures of 600 kg/m^3 (minimum), and 700 kg/m^3 (maximum), to accommodate figures used in several past studies, and those recommended by foresters, including those used by the forestry department of Ghana (Earl, 1975; Openshaw, 1979; Arnold, 1979; Pluth, 1985). By providing the volumetric figures as a range, its application is made more useful and universal-applicable to users from different environments, and for specific planning considerations.

<u>Charcoal</u>

Charcoal is produced by burning wood under high temperature conditions and in environments with no or very negligible oxygen. Figures for charcoal consumption were derived indirectly through a series of field experiments. A test weighing experiment of 10-cedi (Cedi is the currency for Ghana $1 U.S.= approximately C160 in 1987) heaps of charcoal at ten different locations and over different species and seasons was made to derive a mean weight per heap. This yielded a mean weight of 0.78 kg/heap. In addition, a number of direct charcoal conversion experiments were made in the field spanning a period of 9 months beginning June, 1986, at different locations and over different species (chapter IV). The experiments involved those made by the author, assistants, and those made by professional charcoal makers as well as amateurs (trying to get some charcoal for domestic uses or trying to enter the charcoal business). Depending upon the scale of operation, converting raw wood to charcoal takes anything between 5 and 28 days.

The local technique of charcoal burning using the pit/earth kiln method was employed. Generally, wood input to charcoal output ratios tended to be lowest with those experiments conducted by the author. These yielded a mean ratio of 4:1 meaning that, for every 4 units of raw wood burnt, one unit is derived as charcoal. Probable reasons for such a high achievement include over-caution with the experiment (which is scarcely the case in a normal day to day operation) and/or that the experiment did not cover a longer period of time and/or that a great number of species were not involved. Commercial operators who purchase the wood input for their operations gave the next best results of a mean ratio of 4.7:1 over different species. All other experiments ranged between a ratio of 5:1 (minimum) to 7:1 (maximum).

A conversion ratio of 5:1 was adopted as reasonable for this study in recognition of the fact that charcoal production in all the study villages is now becoming a commercial venture, run by a few producers. In line with such development, almost all charcoal sold on the regular market is commercially produced. Manufacturers pay for all production inputs and services, including the raw wood product, motorised chain-saw, gasoline, and labour. With production costs increasing, and to ensure profitable operations, wastes are avoided as much as possible, helping to improve the over-all productivity of conversions. The adoption of this ratio was also to consider possible weight loss in relatively moist charcoal upon drying and shrinkage. High conversion ratios of up to 12 (raw wood):1 (charcoal output), implying wastes, have been reported in many countries, including those in Africa (see Openshaw, 1979, Arnold, 1979, for details).

iii. Description of woodfuel use types

Woodfuel consumption covers both domestic and non-domestic uses. While certain uses can be clearly categorised under domestic and/or commercial, the borderline between and within such sectors of wood use, is generally a fine one. For example, part of food prepared for sale in the market place, may be used in the household as a regular meal and the same firewood used to preserve maize for sale, may be used for domestic needs. In most cases then, the use of firewood is indivisible and cannot be categorised into rigid compartments. For purposes of this work however, any use of wood where the end purpose was wholly for pure domestic consumption was classified as domestic, while on the other hand, any use of wood where some monetary exchange resulted, no matter the proportion, was categorised as commercial. Details of sector uses of woodfuel are presented in this section to provide a frame of reference for the report on figures of consumption provided in the next section.

Domestic Uses

Domestic uses of wood are categorised into Food and Food Related, and Non-Food Related.

Food and Food Related -Cooking related Activities

Cooking related activities are the most important uses of wood for food purposes, involving more than 80 per cent of all wood for domestic purposes. In all the villages, meals are routinely eaten in the home. It is common on some occasions, for breakfast and/or lunch to be bought at the market, but this practice is regarded as occasional, in the sense that, whenever time permits, and relevant foodstuffs are available, meals are preferably prepared in the home. Supper is almost exclusively prepared in the house. It is regarded as the most important meal of the day in a typical farming village, and accordingly, the most demanding on woodfuel. In certain farming homes, supper is the only meal taken in the house by adults, within the farming week (see Chapter VI).

Food preservation

Preservation for domestic uses take several forms. Maize and cut cassava (for cassava flour or "kokonte"), are exposed to smoke and gentle heat from fires to assist drying, prevent moulding, and infestations. Fresh fish may also be smoked over fires to prevent decomposition. Households at Okrakwadjo and Teacher-Mante are more likely to use wood for crop preservation because of the heavy dependence on maize and cassava as the chief agricultural products.

Using woodfuel to assist drying becomes a strategy for food storage, and at the same time, provides a medium for alternative and varied uses of food items, which otherwise have restricted and marginal uses in their fresh state. For example, in all the study villages, fresh maize is taken either boiled or roasted. Traditionally, these forms of cooked maize are regarded only as snacks. Most of the traditional staple dishes are derived from dry corn.

Non-Food Related

Non-food related domestic uses of wood involve a variety of requirements, ranging from health to socio-cultural needs. Among these are;

Heating of water

Water may be heated for sanitary and health purposes, such as bathing, massaging, treatment of sores, medicinal steam for fighting bouts of fever, cold and chest pains and for post-natal uses by women. Use of woodfuel for heating water for health purposes tend to be regular in all the study villages.

Protection

Fires may provide major means of protection for humans from diseases and attacks from dangerous reptiles. For example, smoke from fires may act as repellants to insects which are a nuisance and/or health risk, especially in early mornings and evenings in homes close to bushes. Smoke and mild heat may flush out dangerous reptiles such as snakes and some kinds of lizards, and rodents such as rats and mice that hide in ceilings/barns/and/or cracks and hollows in buildings.

Preservation of building structures

In certain villages, a fairly large number of house structures are built of local components such as poles, which may deteriorate through attacks by insects and pests and by exposure to the weather. Fires provide a traditional means of protecting such structures from rapid deterioration. For example, thatched and straw roofings and/or poles are kept from pest infestation or rotting, under the normally humid conditions through the preservative role of wood fires.

While some use of woodfuel for preservation may be independent from other uses, such as some large maize barns, most uses of wood for preservation and protection are derived benefits from other more regular and obligatory uses, such as cooking and/or sanitary and health needs.

Seed crop preservation

Seed crops such as okra, beans, and freshly cut seed water yams are kept dry and preserved by smoke and mild heat from fireplaces before the planting season.

Space heating

This is usually not an independent function. Some mornings and evenings in December and January may be chilly and fires may be used to provide heat. It is found in most households that, at the same time as people gather around a fire for warmth, food may also be roasted or cooked.

Socialisation

Fires provide a forum for both family and community gathering after a hard day's work. On cool evenings they provide an atmosphere for older members of households to gather younger children for story telling. Such occasions are also used to narrate family and community histories, educate children on values, traditions and customs of a clan and other general information. It was realised during the survey that, almost all social gathering around fires in the homes provided other functions as well.

Big fires may also provide for community meetings for both entertainment and mutual discussions. Most uses of fire for socialization in the study area are likely to occur during the dry season, when fewer rains are expected to disrupt activities that by nature are mostly open air. Within the duration of the study, no big fires were used for community meetings. This custom is dying out as access to woodfuel becomc difficult in the communities. Increasingly, large kerosene lamps and timing of activities to coincide with full moon phase are providing for light, rather more than fires.

Mutual tributes

Firewood is a common product of tribute to chiefs during annual festivals. At Tontro, during the survey, friends and relations of a bereaved family provided or helped to provide fuelwood as a gesture of help towards the entertainment of out-of-town mourners. This practice is common in the study villages.

From the preceding information, it is realised that domestic activities requiring woodfuel tend to be uniform in all the villages, a condition which makes it relatively easier to predict those domestic activities with proportionately heavy demands on daily gross demands (for example, cooking and heating of water). If domestic consumption trends are potentially similar between the villages, then most differences in wood consumption between households within and between villages, may potentially be attributed to non-domestic or commercial uses.

Commercial Uses (Non-domestic)

For purposes of predicting wood requirements of individual commercial activity types, commercial uses of wood are classified into Major and Minor activities, on the basis of quantity of wood involved per average unit of operation. Based on this criteria, all commercial activities requiring at least, 40 kg of wood for a normal one-time operation, are classified as major. Those below 40 kg are classified as minor.

With regard to specific commercial uses of wood, almost all such activities fall under, Food or Drink related and non Food or Drink related. Details under each of the commercial activity categories are discussed as follows;

Major Food or Drink Related Commercial Activities

Distilling of alcohols

Local gins ("Akpeteshie"-affectionately dubbed "Ghana Gin"), with high alcohol levels, are widely distilled, wherever the appropriate raw materials are available. These raw materials (apart from firewood) include, fermented palm-wine (oil-palm mostly, but also raffia palm), yeast or any sugary syrup that is fermentable, such as drippings from cocoa beans collected during the process of fermentation. Distilleries are wood intensive. As a major oil-palm growing area, Tontro is potentially the most important distillery centre among the three study settlements, while the potential at Okrakwadjo, outside the Government run oil-palm plantation, is almost zero.

Local/traditional beer

Variety of traditional beer are found in various parts of the country with different raw material requirements. The most widespread and mostly used both in the country, and in the study area and which require woodfuel as a major input, is "Pito". "Pito" is brewed from guinea corn (Sorghum spp.). It has a very low alcohol content. The demand of wood for Pito brewing is considerable. The largest brewery, among the three villages is found at Tontro. It supplies both the settlement, and the nearby urban centre of New Tafo (Figure 11).

Manufacturing of Vegetable Oils

Palm oil

Palm oil is the main cooking oil in the country and in the area. It may also be used for soap making. The raw material is palm nuts. Palm oil making is mainly by the traditional method in the study area, as in many parts of the country. It involves two major processes of preparation, cooking the raw palm fruits and cooking the pulp to get the oil, with each stage demanding a great deal of firewood. Lying in the palm oil belt, Tontro potentially has the highest concentration of commercial palm oil manufacturers.

Palm kernel oil manufacturing

This is the next most important local vegetable oil source. It may be regarded as a by-product of palm oil making which provides the kernels. Apart from cooking, it is the main source of oil for frying foods for both domestic and commercial ends. It may also be used for soap making. Palm kernel oil also involves two major processes-frying the kernels and cooking the pulp for the oil. Both stages take a great deal of firewood. Like palm oil, palm kernel oil has a country-wide market.

Minor Food or Drink Related Commercial Activities

Activities under such commercial woodfuel use types include;

Semi-finished processed market products

Chief among them are dry cut cassava (for cassava flour or "kokonte"), maize and "garri" (fried fermented cassava dough). Several households maintain separate storage and/or dry areas for "kokonte" and use separate fires from the normal domestic ones. In most homes, however, "kokonte" may be dried on a shed above the fire place, so that heat may be provided by the normal domestic activities. Frying of fermented moisture-squeezed cassava dough is a major process in "garri" making. As a result, wherever it is intensively manufactured, its demands on fuelwood is significant.

Ready cooked food

This includes fried food (yams, cocoyams, red plantains, sweet potatoes and flour base delicacies including bread), boiled food (yams, rice, kenkey, fufu, maize) and roasted food (yams, cocoyams, green and red plantain). For a single operation, these uses usually do not require large amounts of wood, but where the frequency of operation per unit time is high, it can affect the gross use of wood significantly.

There is a high demand for ready cooked food, especially in settlements near trunk roads such as Teacher-Mante and those with large school population and regular employment opportunities such as at Okrakwadjo.

Preservation for commercial ends

Large quantities of maize may be stored in barns outside the normal kitchen shed for adequate storage space. Under such situations, independent fires are usually set to provide heat and smoke. Other food products which may be stored for commercial ends include seeds of vegetables such as pepper, and tomatoes. Some farmers raise pepper seedlings for sale and the seeds have to be preserved, usually by remote heat and smoke from fires. This category of wood use sometimes benefits from domestic activities.

Non Food/Drink related -Major activities

Soap manufacturing

This is the most wood intensive activity under the Non-Food/Drink related Commercial Category. Local soaps play a major role in filling the gap for shortages of standard manufactured soaps and detergents in the rural areas. In some households in the study villages. They supply about 50 per cent of soap needs, even in periods of abundance of standard soap. During a major soap supply problem in the country between 1982 and early 1984, traditional manufactured soaps supplied both rural and urban areas. The soaps are made from a number of local sources including palm oil/palm kernel oil and sodas derived from a specialised process of burning dry cocoa shells, dry plantain peels and other products. Sodas are also available at the market place. A variety of soaps are produced in the study area both for home use and for the market.

Non Food related activities-Minor

Medicine and herbal preparations

Bottled traditional medicine which is sent to markets for sale is doing a booming business in most parts of the country, especially in the urban centres (in the rural areas, families have easy access to to those plants that are medicinal and so they may prepare their own concoctions). Firewood use for traditional pharmaceutical purposes is not considerable in the study area on the basis of households involved.

3. Woodfuel Acquisition and Consumption trends: Data and Analysis

This section of the work provides data on specific field-based research findings utilising the sequence provided above. The initial data concerns population and occupational structure. Thereafter, findings with respect to fuel acquisition and consumption are presented on the demographic base.

Population/Occupation data

Population

There is a combined total of 450 households and 276 continuously occupied house structures in the three study villages. The mean number of households per house is approximately 1.63, with an occupancy rate of approximately 10 persons per house. This gives a population of about 2760 for the three settlements together. Alternatively, using the 1970 population census, and a growth rate of 2.8 per cent per annum (0.2% above the national population growth rate of 2.6%), the population for the three settlements in 1986, is approximately 2820- a difference of about 2.1 per cent (Table 7).

As noted in chapter IV, the original intent of the investigation was to cover the whole population in each village, but due to specific field constraints the coverage varied by village from 72 percent at Teacher-Mante to 100 percent at Tontro. For the study villages together, a total of 371 households (82.4%) with a population of

TABLE 7 DETAILS ON POPULATION SURVEYED

DETAILS	STUDY VILLAGES: TEACHER-MANTE	TONTRO	OKRAKWADJO	ALL THREE
NO OF HOUSE STRUCTURES	105 (100%)	46 (100%)	125 (100%	276 (100%)
*HOUSES SURVEYED	76 (72%)	46 (100%)	105 (84%)	227 (82%)
TOTAL HOUSEHOLDS	180 (100%)	81(100%)	189 (100%)	450 (100%)
TOTAL HOUSEHOLDS SURVEYED	130 (72%)	81 (100%)	160 (85%)	371 (82%)
MEAN NO OF HOUSEHOLDS PER HOUSE	1.71	1.76	1.51	1.63
MEAN SIZE OF HOUSEHOLD	5.96	6.74	6.00	6.14
**ESTIMATED TOTAL POPULATION	1071 (100%)	546 (100%)	1133 (100%)	2760 (100%)
POPULATION SURVEYED	775 (72)	546 (100%)	952 (84%)	2273 (82%)

*Applicable to continuously Occupied Houses. Many House Structures are Unoccupied Most Part of the Year.

*Applying a Constant Population growth Rate of 2.8% per Annum from 1970 (most recent published population data in use in 1986 to cover the villages), the population of the three villages together, is about 2820 (a difference of 60 people).

SOURCE: FIELD DATA

2273, were covered. In the individual villages, 81 households were covered at Tontro (100%), 160 households at Okrakwadjo (85%) and 130 households at Teacher-Mante (72%).

Household size varies both between and within the villages. The largest household in the study area, found at Okrakwadjo, contains 22 people, and the smallest households (18 of them), contain only one occupant. The mean household size is slightly above 6 persons. Table 8 and Figure 12 provide specific details of population structure for each of the villages. Okrakwadjo has the highest surveyed population (952) and Tontro the smallest (546). The surveyed population for Teacher-Mante is 775. The village of Tontro has the highest mean household size of approximately 7 persons, and Teacher-Mante, the least at 5.96 (6) persons, just less than that of Okrakwadjo.

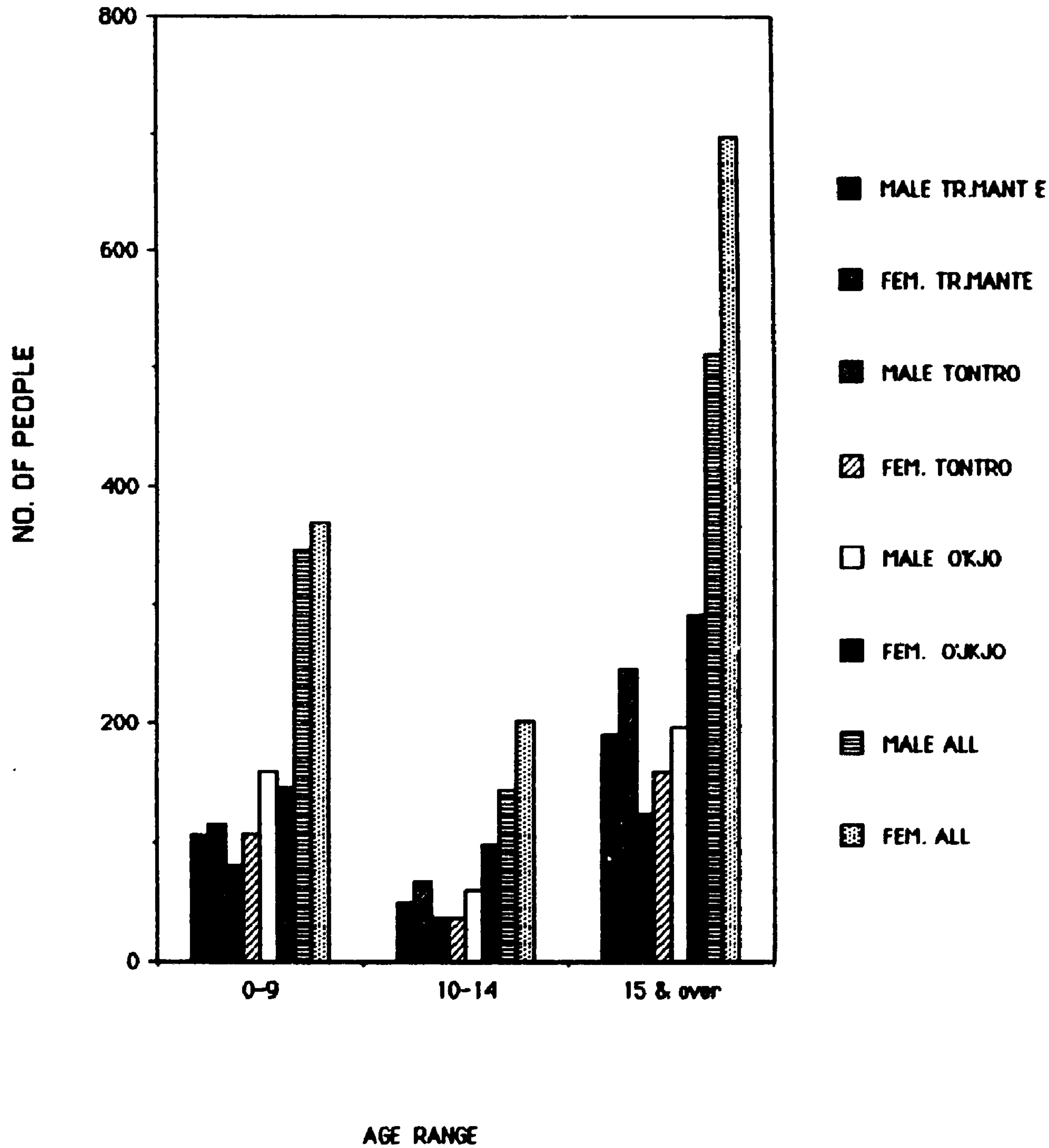
The female population is significant in all the three villages, constituting almost 56 per cent of the total population (Table 8). At Teacher Mante, females from 15 years and above constitute approximately 32.5 per cent of all household occupants, while at Okrakwadjo, they constitute about 31 per cent of households/village population. Tontro has the lowest 15 years and above female group at about 21 per cent of household occupants. Over all, the minor population (under 15 years) is highest at Okrakwadjo, at about 49 per cent of the total village/household population. At Tontro, the minor population is about 48 per cent while at Teacher-Mante, they constitute about 44 per cent of the surveyed village population (see Chapter IV for basis of age classification).

TABLE 8: POPULATION STRUCTURE OF SURVEYED HOUSEHOLDS

POPULATION VARIABLES		VILLAGES: TEACHER-MANTE	TONTRO	OKRAKWADJO	TOTAL STUDY VILLAGES	*NATIONAL
0-9 YEARS	MALE	106	81	159	346 (15.2%)	
	FEMALE	115	108	147	370 (16.3%)	
ALL		221	189	306	716 (31.5%)	
10-14 YEARS	MALE	50	36	59	145 (6.4)	
	FEMALE	67	36	98	201 (8.8%)	
ALL		117	72	157	346 (15.2%)	
ALL 0-14	MALE	156	117	218	491 (21.6%)	
	FEMALE	182	144	245	571 (25.1%)	
ALL		538	261	463	1062 (46.7%	0-14 (46.8%)
15 AND OVER	MALE	191	125	196	512 (22.5%)	
	FEMALE	246	160	293	699 (30.7%)	
ALL		437	285	489	1211 (53.3%)	15-64 (50.5%) 65 & ABOVE (2.7%)
TOTAL	MALE	347 (44.8%)	242 (44.3%)	414 (43.5 %)	1003 (44.1%)	
	FEMALE	428 (55.2%)	304 (55.7%)	538 (56.5%)	1270 (55.9%)	
ALL		775	546	952	2273	
MEAN HOUSEHOLD SIZE		5.96	6.74	6	6.14	

SOURCE : FIELD DATA
* WORLD BANK, 1984, xi

FIGURE 12: POPULATION STRUCTURE



Occupations

Detailed information of the occupation structure of households in all the villages is provided as Table 9. About 76.5 per cent of the surveyed households in the three villages combined, consider farming as a major occupation. At about 85 per cent, Teacher-Mante has the highest percentage of households with farming as a major occupation. Tontro is the second highest with about 76.5 per cent of the households, while Okrakwadjo is the lowest, with about 69 per cent of households. Government employment (generic term for regular wage employment), is the next highest occupation category considered as major by households. In the study villages combined, about 14 per cent of all households have people in regular paid jobs. The percentage is highest at Okrakwadjo (about 19%), followed by Tontro (11%), and then Teacher-Mante (9.2%). Cooked food sales is the most important secondary occupation in all the villages involving about 18.2 per cent of households followed by trading in agricultural products. Trading and cooked food sales constitute an important occupation at Teacher Mante, involving about 25 per cent and 23 per cent of households respectively. Okrakwadjo has about 16 percent and 12 per cent in cooked food sales and trading in agricultural goods respectively and at Tontro, about 14 per cent and 17 per cent of households in that order.

Most of the occupations labelled as minor are dominated by females. They involve trading, manufacturing and processing of produce, often using woodfuel. They are labelled minor only because they are perceived by households as subsidiary activities, and not upon a basis of income generation. Major and minor activities co-

TABLE 9: OCCUPATION STRUCTURE OF VILLAGES (BY NUMBER OF HOUSEHOLDS)

TEACHER-MANTE

Occupation Type	Occupation Classification	
	MAJOR	MINOR
1. Farming	111 (85.4%)	12 (9.2%)
2. Trading/manufactured and general products	1 (0.8%)	5 (3.8%)
3. Trading/agricultural products	- (0%)	32 (24 6%)
4. Cooked food sales	3 (2 3%)	30 (23.1%)
5. Government employee	12 (9.2%)	1 (0.8%)
6. self-employed artisan	2 (1.5%)	4 (3.1%)
7. Animal rearing/poultry and/or livestock	- (0%)	- (0%)
8. Other Wage labour	- (0%)	- (0%)
0. Inapplicable situations	1 (0 8)	46 (35.4
Total number of households	130 (100%)	130 (100%)

TONTRO

Occupation Type	Occupation Classification	
	MAJOR	MINOR
1. Farming	62 (76.5%)	8 (9 9%)
2. Trading/manufactured and general products	3 (3.7%)	10 (12 3%)
3. Trading/agricultural products	3 (3.7%)	14 (17 3%)
4. Cooked food sales	1 (1.2%)	11(13.6%)
5. Government employee	9 (11 1%)	- (0%)
6. self-employed artisan	2 (2.5%)	1 (1 2%)
7. Animal rearing/poultry and/or livestock	- (0%)	- (0%)
8. Other Wage labour	- (0%)	- (0%)
0. Inapplicable situations	1 (0%)	37 (45 7%)
Total number of households	61 (100%)	81(100%)

OKRAKWADJO

Occupation Type	Occupation Classification	
	MAJOR	MINOR
1. Farming	110 (68.8%)	28 (17.5%)
2. Trading/manufactured and general products	3 (1.9%)	17 (10 6%)
3. Trading/agricultural products	4 (2.5%)	19 (11.9%)
4. Cooked food sales	6 (3.8%)	26 (16.3%)
5. Government employee	30 (18.8%)	1 (0.6%)
6. self-employed artisan	4 (2.5%)	4 (2.5%)
7. Animal rearing/poultry and/or livestock	- (0%)	1 (0.6%)
8. Other Wage labour	1 (0.6%)	4 (2.5%)
0. Inapplicable situations	2 (1.2%)	60 (37.5%)
Total number of households	160 (100%)	160 (100%)

COMBINED VILLAGES

Occupation Type	Occupation classification	
1. Farming	263 (76.5%)	48 (13%)
2. Trading/manufactured and general products	7 (1.9%)	32 (8.7%)
3. Trading/agricultural products	7 (1.9%)	65 (17.7%)
4 Cooked food sales	10 (2.7%)	67 (18.2%)
5. Government employee	51 (13.7%)	2 (0.5%)
6. Self-employed artisan	8 (2.2%)	9 (2.4%)
7. Animal rearing/poultry and/or livestock	- (0%)	1 (0.3%)
8. Other Wage labour	1 (0.3%)	4 (1.1%)
0. Inapplicable situations	4 (1.1%)	143 (38.5%)
Total number of households	371 (100%)	371 (100%)

SOURCE. SURVEY DATA

exist simultaneously in several households. For example, in a typical farming household, the chances are that the men-folk will put in more hours into farming than the women-folk who require some time off farming to engage in secondary occupations (Chapter VII).

The structure of the village/household population and occupations provide the framework for consumption patterns presented in the next part, and also based on the field survey results.

<u>Woodfuel- Its Importance in the village</u>

The main purpose of this part of the chapter is to provide a forum for detailed reporting on empirical information on wood consumption from the field study, from which subsequent explanation of patterns and trends within and between the study villages are made.

Empirical evidence from the field study, confirms a general dependence on woodfuel in the study villages and for each individual village. For example, out of a total of 371 study households in the three villages, 356 (96%) regard firewood as a major fuel while charcoal is regarded as a major fuel by another 13 households (3.5%). The only alternatives to wood, gas and kerosene, are regarded as major fuel in one household each. Table 10 provides information on specific fuel- type distribution in the villages. The main purpose of this part of the chapter is to provide a forum for detailed reporting on empirical information on wood consumption from the field study, from which subsequent explanation of patterns and trends within and between the study villages are made.

Table 10 Major and Minor Fuel Use By Number of Households

VILLAGE	MAJOR FUEL TYPES				*TOTAL (MAJOR)	MINOR/OTHER FUEL TYPES				*TOTAL (MINOR)
	fuelwood	charcoal	kerosene	gas		fuelwood	charcoal	kerosene	gas	TOTAL
TR MANTE	126	2	1	1	130	2	20	0	0	22
TONTRO	80	1	0	0	81	0	14	0	0	14
OKRA'DJO	150	10	0	0	160	3	37	0	0	40
TOTAL	356	13	1	1	371	5	71	0	0	76

Note The Frequency of charcoal use in one household at Tontro is less than 3 times in a year. All calculations involving minor use of charcoal in that village, apply to 13 households.

SOURCE-FIELD DATA
*BASED ON A SURVEY OF 371 HOUSEHOLDS

At the village of Tontro, 80 households (99%) regard firewood as a major fuel. Charcoal is regarded as a main fuel in only one household. There is no need for a secondary fuel in 67 households in the village. Firewood is regarded as a major fuel by 126 households (97%) at Teacher-Mante where two households regard charcoal as a main fuel. Also, the only use of gas and kerosene, as main alternative fuels, is found at Teacher-Mante. For 108 households in that village, there is no minor or other fuel, apart from firewood. Charcoal is a widely used minor fuel. At Okrakwadjo, 150 households (about 94%) regard firewood as a principal fuel. Okrakwadjo has the highest number of households using charcoal both as a major and minor fuel- 10 and 37 households respectively. Households with no need for a secondary fuel apart from wood, total 120 (Table 10).

Comment

Firewood is a major fuel for more than 96 percent of the households, ranging from 99 percent at Tontro to about 94 percent at Okrakwadjo. Charcoal. also fron wood, is the secondary fuel. Okrakwadjo has the highest number of charcoal using households, whilst Tontro has the lowest. The only alternative fuels to wood, gas and kerosene, are used as major fuels in one household each at Teacher-Mante.

Specific Supply and Use Characteristics

With the overwhelming importance of woodfuel in the village fuel mix established, the next part of the work is aimed primarily at the first and major objective of the study namely, provision of detailed information to determine the amount of wood used for fuel and the sectors of use by villages/households. In the process of providing information to satisfy this objective, basic clues to the general relationships established in association with the first objective, as well as detailed background information on the second and third objectives with their associated relationships (Chapter I) are implicitly provided.

Even though the primary goal of the study is to determine the use of woodfuel and its associated impacts, such information may be incomplete without comprehensive data on the supply side. Data on wood supply therefore precede that of wood use.

Supply

The discussion on wood supply characteristics is made under the sub-headings of; wood composition, sources of woodfuel, quantity collected per unit time and principal tools used for collection, location, distance and time for wood collection, household labour, and expenditures on fuels.

Wood Composition

A large number of species are supplied either through self collection or purchase (a comprehensive list of species is provided in Table 6). Species such as "Duabo" (Drypetes floribunda), "Odanta" (Nesogordonia papaverifera), and "wawa" (Triplochiton scleroxylon) which are perceived in the area as quality wood, are found in the fuel mix of most households, while "Esa" , (Celtis milbraedii, Celtis zenkeri), considered the best woodfuel in the area, is almost a rarity at Okrakwadjo and to a greater extent at Teacher-Mante, because of the state of forest loss in those two settlements.

Based on the definition of woodfuel into quality and inferior types (section on woodfuel types), almost 40 per cent of all wood used in the study villages is composed of inferiors (Table 11). The highest proportional use of inferiors is at Okrakwadjo (about 57%) while the lowest use is the at Tontro (10%).

There is a high degree of use of quality forest species at Tontro. Almost all the prized species such as "Esa" (Celtis mildbraedii, C Zenkeri), "Emire" (Terminalia ivorensis), "Opapea" (Magaritaria (phyllantum) discoidea) and "Ofram" Terminalia superba are available for use (Table 6). Log and branches are the major forms of wood used. Wood under the classification of inferiors is mainly twigs, rather than agricultural remains and/or wood wastes as found in the other two settlements. On a monthly basis, quality wood accounts for about 90 per cent of total use of wood in Tontro on a monthly basis (Table 11).

At Teacher-Mante, principal wood forms used include logs, branches, twigs and roots of all types. Few of the species listed as quality wood in Table 6, are still found around the village. Also, most of the species listed as upper storey are absent. Forest species are becoming a rarity in the settlement due to a rapid loss of the forest vegetation and/or degradation of the standing vegetation. It is possible that most of such species existed prior to deforestation and degradation due to the village's past association with the cocoa industry. Common wood species harvested are "agriculture" (Gliricidia sepium), "Nyedua" (Ficus species) and "pamprama" (panpan) (Corynanthe pachyceras). Such species as "Opapea" (Margaritaria (Phyllanthus) discoidea), "Duabo"(Drypetes florinda)

TABLE 11: WOOD CONSUMPTION BY QUALITY FORM (VALUES IN KILOGRAMS (KG))

WOOD QUALITY CONSUMPTION/ MONTH (KG)	TEACHER-MANTE		TONTRO		OKRAKWADJO		ALL THREE VILLAGES	
	KG	% TOTAL	KG	% TOTAL	KG	% TOTAL	KG	% TOTAL
INFERIORS	14405.7	44.2	3046.1	10.2	23260.8	56.9	40712.6	39.3
QUALITY	18211.1	55.8	26893.9	89.8	17649.7	43.1	62754.8	60.7
TOTAL	32616.8	100.0	29940.0	100	40910.5	100	103468.4	100

SOURCE: BASED ON A SURVEY OF 371 HOUSEHOLDS and "Odanta" (Nesogordonia papaverifera) are commonly cited by households as the most prized woodfuel. These are purchased mainly to supplement depleting sources. "Esa" (Celtis spp.) is cited as the best woodfuel species but no longer found in the village. Small sizes and mainly twig forms of trees are used. Wood wastes from fences, collapsed barns and dwellings are also used.

As inferior species, bamboos (Oxytenanthera abyssinia) are used to a limited extent at Teacher-Mante. The principal agricultural waste used is the dry corn cob (Zea mays). Some use of dry cassava sticks (Manihot esculenta), fronds of oil palm tree (Elaeis guineensis), shells of palm kernels and husks of coconuts (Cocos nucifera) is made whenever available. On a monthly basis, the use of inferiors in the settlement amounts to about 44 per cent of total fuelwood used. Quality wood on the other hand, accounts for almost 56 per cent of the total (Tables 6 and 11).

At Okrakwadjo, species listed as quality/and or upper-storey are non-existent in properties within 3 kilometres of the settlement. Most users of quality trees are those who depend on the market place and whose farms are located on the outer boundaries of the settlement. The most common large upper canopy species which breaks the monotony of a more or less derived savanna environment is the "onyina" (Ceiba petandra). It is deciduous and yields kapok and, traditionally, is not regarded as a good firewood source because of its thorny surface. Young forest species are obtained for fuelwood only when the young bush is cut for farming purposes. Through such means, some perceived quality species such as "Duabo" (Drypetes floribunda), "Pamprama" (Corynanthe padyceras), and "Okoro" (Albizia zygia) are derived.

Bamboos (Oxytenanthera abyssinia) head the list of inferior species after twigs at the village of Okrakwadjo. Wood wastes derived from fence structures and from other activities such as carpentry and carvings are also used. The researcher observed remains of animal feed (leaves on tree branches) stored for future use in one household even though woody parts seemed very small. Dry cobs of Maize (Zea mays) are the most important agricultural wastes utilised (there are exceptions in some homes which regard corn cobs as taboos). Dry stems of the Cassava plant (Manihot esculenta) are used whenever available. Stalks of vegetable plants such as okra (Hibiscus spp.) are also used. Inferiors take approximately 57 per cent of all wood used as fuel in this village (Table 11).

Comment

There are variations between the villages in terms of wood quality forms. The largest number of households using wood classified as quality, are located at Tontro while most households at Okrakwadjo mainly use wood classified as inferiors.

Sources of Woodfuel

Wood sources are described in terms of how wood reaches the home for both sectoral and aggregate uses and the origin of such wood. All sources of wood are then classified as primary and secondary, where primary sources refer to supply sources that provide at least, 75 per cent of regular wood needs whilst secondary sources refer to other sources providing less than 25 per cent of wood needs and not on a continuing basis. Detailed information on sources of wood in the settlements is provided as Table 12.

In the three villages combined, 268 surveyed households (74%) collect their own wood for domestic purposes. For commercial purposes, 89 commercial operating households (49.7%) collect their own wood. Only 14 households (3.8%) purchase wood for domestic purposes, while 50 (28%) commercial operating households purchase woodfuel for commercial ends.

For domestic purposes, 68 households (85%) at Tontro collect their own wood. The other relatively important supply type is, part collection/part purchase, by 5 households (6%). Only one household (1.3%) completely purchases wood for domestic needs. For commercial purposes, 45 operating households or 83% of the total, collect their own wood (Table 12).

At Teacher-Mante, 101 households (78%) collect their own wood for domestic purposes. The next significant domestic source-type is part collection/part purchase. Only 5 households (3.8%) completely purchase wood for domestic needs. The least significant source of wood is gift wood (Table 12). For commercial uses, purchases are the most significant supply type. Twenty-four commercial households (39%), purchase all their wood needs for commercial uses, followed by own collection at 23 households (37%). Exact proportion of various source-type contributions are presented in Table 12.

At Okrakwadjo, 99 households (62%) collect their own wood needs for domestic ends. The other noted significant domestic supply type is part collection/part purchase which applies to 36 (22.5%)

TABLE 12. WOODFUEL ACQUISITION PATTERNS - SOURCES OF WOODFUEL

ACQUISITION VARIABLES	STUDY VILLAGES (BY NUMBER OF HOUSEHOLDS)							
	TEACHER-MANTE		TONTRO		OKRAKWADJO		ALL VILLAGES	
1. DOMESTIC SOURCE	NO.	%	NO.	%	NO.	%	NO.	%
Self collection	101	77.7	68	84.0	99	61.9	268	74.0
Purchase	5	3.8	1	1.3	8	5.0	14	3.8
Part collection/part purchase	13	10.0	5	6.3	36	22.5	54	14.6
Gift	1	0.8	1	1.3	4	2.5	6	1.6
Part collection/part gift	8	6.2	4	5.0	6	3.8	18	14.9
2. COMMERCIAL SOURCE								
Self collection	23	37.1	45	83.3	21	33.3	89	49.7
Purchase	24	38.7	1	1.9	25	39.7	50	27.9
Part collection/part purchase	8	12.9	6	11.1	9	14.3	23	6.2
Gift	1	1.6	0	0	0	0	1	0.6
Part collection/part gift	4	6.5	1	1.9	1	1.6	6	3.4
3. PRIMARY SOURCE								
Own property	93	71.5	65	80.2	88	55.3	246	66.5
Friends	16	12.3	8	9.9	17	10.7	41	11.1
Property of extended family	5	3.8	4	4.9	10	6.3	19	5.1
Purchase	11	8.5	1	1.2	26	16.3	38	10.3
Gift only	3	2.3	1	1.2	1	0.6	5	1.4
Gift/part collection	0	0	1	1.2	8	5.0	9	2.4
Communal property	0	0	0	0	2	1.3	2	0.5
4. SECONDARY SOURCE								
Own property	11	19.0	7	19.4	30	28.6	48	24.1
Friends	6	10.3	18	50.0	21	20.0	45	22.6
Property of extended family	2	3.4	2	5.6	8	7.6	12	6.0
Purchase	28	48.3	5	13.9	17	10.6	50	25.1
Gift only	7	12.1	3	8.7	0	0	10	5.0
Gift/part collection	1	1.7	0	0	4	3.8	5	2.5
Communal property	1	1.7	0	0	17	16.2	18	9.0)

SOURCE: FIELD DATA

households. Purchase provides the bulk of wood needs for commercial purposes. Twenty-five (40%), commercial households have to purchase all their commercial wood needs. This is followed by self collection, which involves 21 (33%) households (Table 12).

The primary wood supply source for 246 (66.5%) surveyed households in the combined settlements is their own property. Own property as used here, also includes exclusive use of a piece of land without legal title, including, care-taking, lease, rental, and share cropping or any combination of those tenurial types. The next major primary source of wood is the property of friends which caters for 41 (11%) households. Purchases provide a main source of fuelwood for only 38 (10%) households.

At Tontro, 65 (80%) households collect wood from their own property as a primary source. Other less significant sources include, friends and property of the extended family. Also, the most significant primary source of wood for households at the village of Teacher-Mante is their own property, involving 93 (72%) surveyed households. Other important sources are, property of friends, and outright purchases. As a primary source, 88 (55%) households at Okrakwadjo collect wood from their own property. Other significant primary sources in order of importance are, purchases, friends, extended family, and gift /part collection (Table 12).

As a secondary source, 48 (24.%) households in the three villages together, derive wood from their own property. On the other hand, 50 (25%) households purchase wood as a secondary source. The other important secondary source of wood is the property of friends, which provides wood for 45 (23%) households.

In the individual villages, purchases provide the single most important secondary supply source at Teacher-Mante, where 28 (48%) of all those households that require a secondary source of wood have to go to the market place. At Okrakwadjo on the other hand, households' own property provide the most important secondary source of wood involving, 28 (29%) households. This is followed by friends, purchase, communal property and extended family (Table 12). At Tontro, the main secondary source of wood is friends property, which caters for 18 (50%) households. Other noted secondary sources are, own property and purchase.

Comment

Most households collect their own wood for domestic purposes. There is however, a high percentage of purchases for commercial uses. The highest percentage of households that purchase wood for both commercial and domestic purposes can be found at Okrakwadjo, while the lowest occurs at Tontro. The property of households is the major source of fuel in the study villages, ranging from 80 percent at Tontro to 55 percent at Okrakwadjo. Property of friends also provide a significant supply source. Only about 10 percent of households purchase wood as a major source. At Okrakwadjo, own property contributes relatively small percentage of wood as a major source compared to the other villages.

Amount of wood collected per unit time and principal tools for collection

The quantity base for measuring wood collected, is by 28 kg bundle, covering any wood form such as twigs, branches and logs or any mixtures of these. Table 13 gives details of number of bundles of wood collected by individual households per 28 days (lunar month).

A mean of 8.6 bundles of wood are collected per month by each household in the three villages considered together. The maximum amount of wood collected in a single month by a household is 40 bundles, and the lowest is one bundle.

An average of about 15 bundles of wood are collected by each household per month at the village of Tontro. The maximum amount collected by a single household, is 40 bundles/month (including in log form). Wood collection by households in this village is quite heavy, compared with the two other villages. For example, 69 per cent of all households collect up to 16 bundles of wood per month. At Teacher-Mante, a mean of 7.3 bundles of fuelwood of all kinds are collected by each household per month while the maximum amount of wood collected by any single household in a month is 16 bundles. The average amount of wood collected per month by each household at Okrakwadjo is about 6.2 bundles. This is the least among the three villages. Unlike Teacher-Mante however, one household collects as much as 24 bundles per month and about 96 per cent of all households collect up to 16 bundles per month (Table 13).

The cutlass is the main tool for firewood gathering in all the study settlements. An axe is also a major asset, particularly with logs and big branches. Motorised chain-saws are new innovations. There are few of them in the villages because they are expensive to buy and run. Above all, for many households, the wood forms collected

Table 13 Bundles of Wood Collected Per Month by Number of Households Households

No of Bundles	TEACHER-MANTE		TONTRO		OKRAKWADJO		ALL THREE VILLAGES	
	NO.	%	NO	%	NO.	%	NO	%
1	2	1.7	0	0	8	5.6	10	2.9
2	4	3.3	1	1.3	8	5.6	13	3.8
3	5	4.1	1	1.3	8	5.6	14	4.1
4	23	19.0	4	5.0	34	23.6	61	17.7
5	3	2.5	2	2.5	5	3.5	10	2.9
6	24	19.0	4	5.0	19	13.2	47	13.6
7	1	0.8	0	0	8	5.6	9	2.6
8	26	21.5	12	15.0	35	24.3	73	21.2
9	2	1.7	1	1.3	3	2.1	6	1.7
10	6	5.0	8	10.0	1	0.7	15	4.3
11	0	0	0	0	1	0.7	1	0.3
12	18	14.9	11	13.8	10	1.4	39	11.3
13	2	1.7	0	0	0	0	2	0.6
14	1	0.8	3	3.8	1	0.7	5	1.4
15	1	0.8	2	2.5	0	0	3	0.9
16	3	2.5	6	7.5	2	1.4	11	3.2
18			3	3.8	0	0	3	0.9
20			5	6.3	0	0	5	1.4
21			1	1.3	1	0.7	2	0.6
24			4	5.0			4	1.1
26			3	3.8			3	0.9
28			1	1.3			1	0.3
30			1	1.3			1	0.3
32			5	6.3			5	1.4
36			1	1.3			1	0.3
40			1	1.3			1	0.3
MEAN BUNDLES/MONTH	7.34 (28 kg)		14.79 (28 kg)		6.21 (28 kg)		8.6 (28 kg)	

SOURCE: FIELD DATA

are such that they do not require chain-saws. When needed, households mainly rent them and/or enter into wood sharing arrangements with owners.

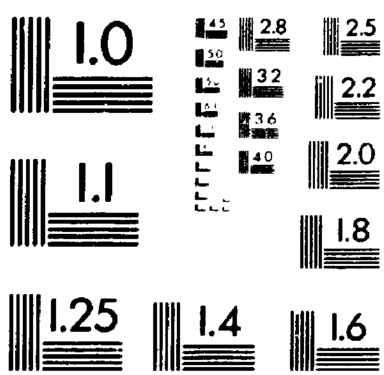
For specific villages, the cutlass and the axe are the main wood cutting implements at Teacher-Mante. Less than 3 per cent of the households, mainly those who sell woodfuel as commercial product and/or households with farms in secondary forests or farmlands with big trees may use motorised chain-saws, acquired mainly through rentals and/or wood-sharing arrangements. The cutlass is also the principal wood gathering implement at Okrakwadjo, principally because, wood-form sizes are generally small. Occasionally, an axe may be required to cut and/or split logs which are rare and/or stumps and roots. At Tontro, because of the relatively large wood size-forms, the axe is a principal tool, assisted at all times by the cutlass. The axe may be used to fell large dead standing trees, help to cut up logs and large branches and also help to split them to make them easy to carry. Several households use the motorised chain-saw in the area. A number of fuelwood contractors also work near the village, offering chain-saw rental opportunities to households and at the same time, cutting live wood and processing it for the urban market especially, Accra and Koforidua (Figure 7).

Comment

Households at Tontro collect the highest amount of wood per month, while those at Okrakwadjo collect the least. Wood collection is generally non-mechanised.

Location, distance and time for wood collection

3



This part provides information on where wood is collected, how long it takes to get there, and how long it takes to collect wood

Location, distance

Households collect wood from varied and scattered locations depending upon property location and general availability of wood. Details on distance to usual sources of wood in the villages is provided as part of Table 14 and Figure 13. The longest distance to a firewood source in all the settlements is approximately 6.4 km. However only 4 households walk that far for wood. The mean distance covered for wood is 2.8 km. Almost 99 per cent of all households get their wood from within 4.8 km of the settlements (Table 14).

At Teacher-Mante, households collect wood from a mean of two principal sources. The number of sources tend to be greater with non-farming, and non-land owning households. For example, some teachers in the village with no property were found to get wood from about four different property owners, depending upon availability on a designated collection day. The longest distance covered to the most common site for wood at Teacher-Mante, is approximately 5 kilometres. The mean distance is 2.8 kilometres, (Table 14).

Firewood gatherers at Tontro also require a mean of two principal sources but the number of collection sources is uniform for all users, including "alien" residents. The longest distance covered to the usual firewood source is approximately 6.4 km. Only 2 households go that far to look for wood. The mean distance covered is 2.2 km. About

Table 14: Wood Acquisition Patterns By Number of Households

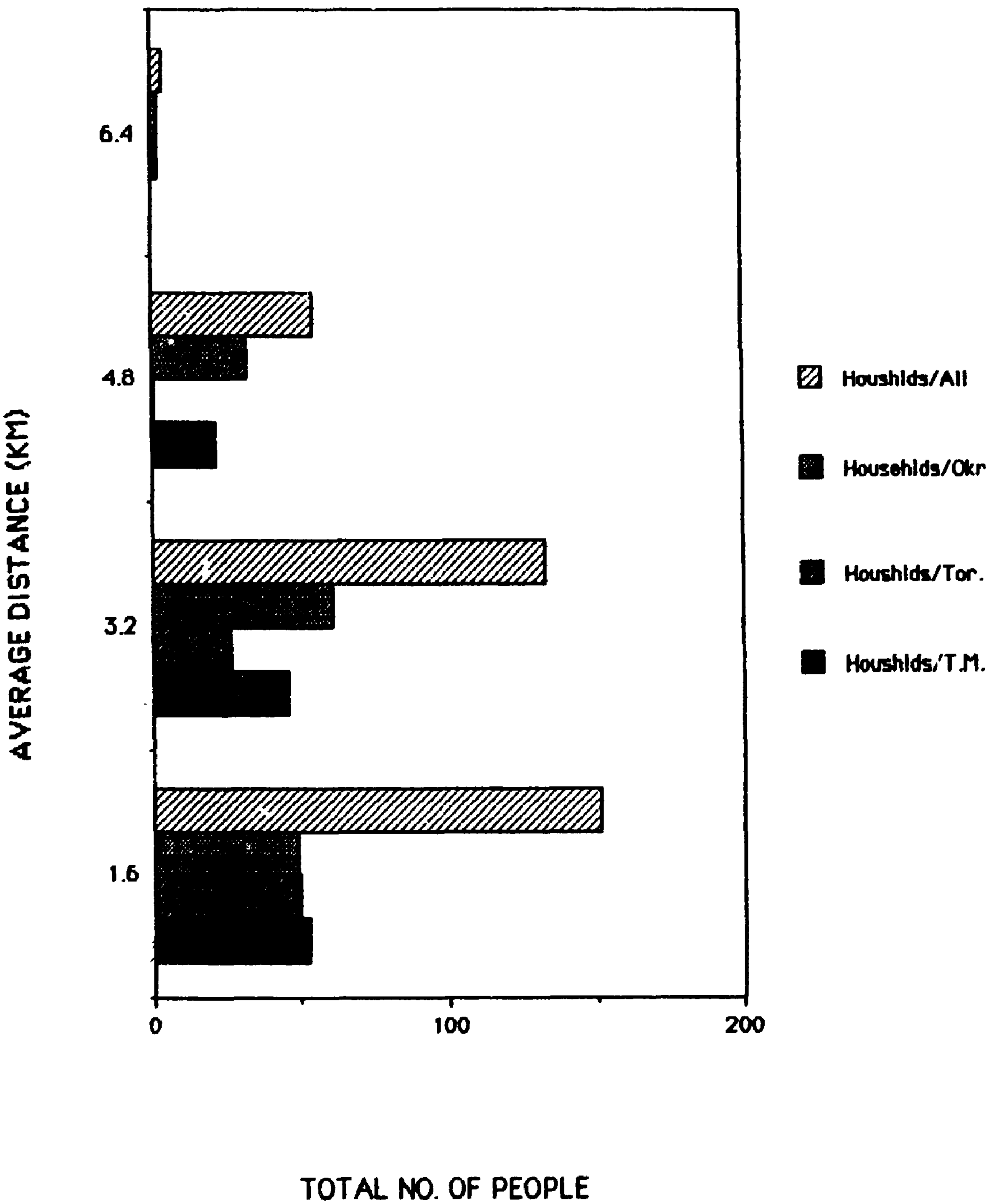
AQUISITION VARIABLES	TEACHER-MANTE		TONTRO		OKRAKWADJO	
1. DISTANCE TO SOURCE (KM)	NO	%	NO	%	NO	%
Up to 1.6 km	53	43.8	50	63.3	49	33.6
3.2 km	46	35.4	26	32.9	61	41.8
4.8 km	22	6.9	1	1.2	32	21.9
6.4 km	0	0	2	2.5	2	1.3
MEAN DISTANCE	2.8 km		2.3 km		3.03 km	
2. COLLECTION DAYS/MONTH (RELEVANT DAYS ONLY)						
1	0	0	0	0	3	2.1
2	6	5.0	6	7.6	11	7.6
3	2	1.7	5	6.3	2	1.4
4	36	29.8	21	26.6	41	28.5
5	1	0.8	4	5.1	2	1.4
6	6	5.0	9	11.4	2	1.4
7	2	1.7	0	0	0	0
8	38	31.4	17	21.5	38	26.4
9	0	0	1	1.3	0	0
10	7	5.8	2	2.5	3	2.1
12	16	13.2	11	13.9	26	18.1
16	6	5	3	3.8	12	8.3
20	0	0	0	0	3	2.1
Mean days/Mo	7.26 days		6.71 days		7.74 days	
4. MEAN HOURS PER COLLECTION DAY	1.06 hours		1.88 hours		1.24 hours	

*Percentages apply to number of households in each category against the Total number of households within that category for a village or the three villages together as appropriate

SOURCE: Based on 371 Surveyed Households

FIGURE 13: AVERAGE DISTANCE TO USUAL SOURCE(S)

BY NO. OF HOUSEHOLDS



96.2 per cent of all firewood consuming households collect wood from within 3.2 km of the settlement (Table 14).

At Okrakwadjo, required woodfuel is collected from a mean of three separated sources. As with the case at Teacher-Mante, non-native and non-land-owning households depend (for convenience) upon several sources. The longest distance to a firewood source is about 6.4 km. The mean distance is about 3.03 km. About 76.7 per cent of all households collect wood within a radius of 3.2 km of the settlement (modal distance).

Comment

Firewood sources are close to all the settlements. Nowhere do households travel more than 7 kilometres to get wood. Distances tend to be slightly longer at Okrakwadjo than the two other settlements.

Temporal

Many reports have been issued on the significance of the number of days and time used per unit time for wood collection (chapter I). Generally, it is indicated that where wood shortages tend to occur, both the number of days and time required to collect needed amounts of wood increases. The presentation of empirical evidence will throw much light on this reality.

In the study villages, a mean of approximately 7.3 days/month is used by each household for wood collection. The maximum number of collection days in a month recorded is 20 days. Note that a mean collection day may also involve multiple returns of wood to the house. About 74 per cent of all households use between 1 (one) and 8 days/month to collect wood. The greatest number of households, 98 of them or 29%, collect wood on 4 days in a month. Specific details of the time structure for wood collection is provided as part of Table 14.

At Okrakwadjo, a mean of about 8 days/month are used by each household for wood collection. The highest number of collection days is 20 (by 3 households). Collection is mainly by a single return per day. It may however involve two or more carriers at a time. Each Household at Teacher-Mante uses slightly below 7.3 days in month for wood collection. Most households collect all wood needed on between one and 8 days/month. The maximum number of effective collection days is 16 days, appropriate in the case of only 6 households. At Tontro, wood collection is carried on in 6.7 days in a month by each household. The maximum number of collection days in a month is 16 days, involving 3 (3.8%) households. 78 per cent of all households collect wood between 1 and 8 days/month. A number of households, especially, those involved in commercial activities, make multiple returns in a collection day.

A mean of approximately 1.3 hours is expended on the wood collection process itself within each collection day in the the study villages. The maximum amount of time spent is 5 hours. This time includes wandering over an area for wood, actual collection, including felling, cutting, splitting, roping and other general preparation of the wood to be returned to the household, whether in bundles or single logs and branch forms. About 72 per cent of all households use 1.5 hours or less to collect wood in a typical collection day. Based on the mean figure of 1.3 hours, 9.7 hours will be spent on wood collection in a 28-day month. The mean time here disregards travel time to and fro the collection source. Allowing for an average minimum time of 1.5 hours round trip/collection day which is normal for a practical walking distance of 6.4 km (the total mean distance to and fro), then the actual effective time expended on wood collection per month is approximately, 20.7 hours-5.18 hours/week or 12.9 per cent of comparable average 40-hour work week.

Travel Time and Wood Collection Type

In connection with the travel time (Table 14), most firewood gatherers in the study villages gather almost all wood from their principal farming points, so that the primary reason for walking to the point may be farming rather than wood gathering. An examination of wood gathering forms may help the analyst/researcher, to infer the influence of the commuting factor in actual time expended on wood collection. For example, if all or most wood gathering is done independent of any land use activity at or near the collecting point, then one may be reasonably safe to add time for travel. Even here, the primary motive for movement may have to be mostly wood gathering. On the other hand, if collection is increasingly integrated with other activities, the time factor becomes difficult to isolate.

For 206 (59.5%) households in the villages combined, wood is collected independent of other activities, but for 125 (36.1%) others, wood is collected with other activities. Households which collect woodfuel both with and without other activities total 81 (23.9%) (Table 15).

TABLE 15: WOOD COLLECTION TYPES

TYPE	TEACHER-MANTE NO	%	TONTRO NO	%	OKRAKWADJO NO	%	ALL THREE NO	%
Independent of other Activities	68	54.8	64	79.0	74	52.5	206	59.5
With other Activities	53	42.7	15	18.5	57	40.4	125	36.1
Both indep and with others	41	33.9	26	32.5	14	10.1	81	23.9

TABLE 16: WOOD COLLECTION-DISTRIBUTION OF HOUSEHOLD LABOUR

COLLECTOR	TEACHER-MANTE		TONTRO		OKRAKWADJO		ALL THREE	
Women	57	43.8	23	28.8	79	53.4	159	45.6
Women and Children	45	34.6	49	61.3	50	33.8	144	41.3
Women and Adult Males	8	6.6	4	5.0	4	2.7	16	4.6
Adult Males	8	6.6	2	2.5	3	2.0	11	3.0
Children and Adult Males	1	0.8	1	1.3	0	0	2	0.6
Children	4	3.3	1	1.3	11	7.4	16	4.6

* In Both Tables 15 and 16, Percentages apply to number of households in each category against the Total number of households within that category for a Village or the three villages together as appropriate

Based on a sample of 371 Households
SOURCE. FIELD DATA

At Tontro, 64 households (79%) collect wood independent of agricultural activities, while 15 (18%) collect with agricultural activities. On the other hand, 26 (32%) households collect wood both independently, and with agricultural activities. At Teacher-Mante, a total of 68 households (52.3%) collect wood independent of agricultural activities and, 53 (40.8%) collect with agricultural activities. Households at Tontro who may collect wood on the basis of both independent of and with commercial activities number 40. In 74 (52%) households at Okrakwadjo, wood is collected independent of other activities while in 57 (40%) others, it is collected with other activities. Only 14 (10%) households collect wood independently of and/or with other activities (Table 15).

For purposes of providing a complete picture of the wood collection process, travel time is considered for each of the villages. The reasonable time of 1.5 hours is also applied. Such addition of travel time is made under caution, especially, for Teacher-Mante and Okrakwadjo where increased percentage of households combine wood collection with agricultural activities (preceding information).

The mean time per operational wood collection day at Teacher-Mante is about 1.1 hours. About 85 per cent of all households use about 1.5 hours or less to collect wood in a typical operational collection day. Thus, for a typical operational month, fuelwood collection takes about 7.6 hours. Allowing for the average minimum time of 1.5 hours round trip/collection day, the total effective time expended on wood collection per month is approximately (8 + 10.95 hours) 18.95 hours-a mean of about 4.7 hours/week or 11.7 percent of comparable average work week of 40 hours.

At Okrakwadjo, each household uses about 1.2 hours to collect wood in a typical wood collection day. As evidence in the field indicated, much of this time is spent on scavenging and movement over a large area to reach different sources of wood within a broad collection area. For an average month, a household will use a mean of 9.6 hours to collect wood and adding 1.5 hours commuting time/day, the actual time involved in wood collection/month is approximately 20.7 hours or 5.18 hours/week-12.4 per cent of comparable average 40-hour work week.

At the village of Tontro, about 2 hours are expended on the actual wood collection task. Here, much of the time for wood collection is utilised on felling, cutting, and splitting of logs and big branches rather than on scavenging or wanderings for wood over a wider area as the case in the other two settlements (especially, at Okrakwadjo). It is also a common practice for a day to be set aside for cutting and processing the required wood, and another day set to do the carting home. As in all the villages however, wood is brought home from the collection sites by head carriage. In a typical month, wood collection at Tontro will take about 12.7 hours. When a mean travel time of approximately 1.5 hours/day is included, actual collection time/month amounts to 22.8 hours-5.7 hours/week or 14.2 per cent of comparable 40-hour work week. At Tontro, the inclusion of commuting time generates minimal controversy, because wood collection is mostly done independent of other activities (Table 15).

Comment

An average of 7.3 days/month are involved in wood collection by households in the study villages (Table 14). On annual basis, approximately 95 days will be used for wood collection, or 1 out of every 4 days will be used for wood collection. For the specific villages, Okrakwadjo experiences the highest mean number of collection days/month of 8 days or 104 days in a year (1 out of every 3.5 days in a year). The lowest number of days for wood collection, which is 6.7 days/month or 87 days/year (1 out of every 4.2 days), is experienced at Tontro, where incidentally, the greatest use of woodfuel per household occurs. Wood collection days at Teacher-Mante corresponds to the combined villages average.

With travel time inclusive, no more than 3 hours are used for wood collection in a single collection day in the study villages, assuming that the trip to the wood collection site was made solely for wood collection. The village of Tontro which utilises the least number of days/month to collect wood, uses the most time for wood collection at about 3.5 hours/collection day. Both Okrakwadjo and Teacher Mante fall slightly below the average study area time for wood collection (with Teacher-Mante experiencing the least number of hours).

Household labour distribution for wood collection

The section on fuel collection indicates that, self collection is the major means by which wood gets to the house for use. Contribution of labour within households towards wood collection is provided in Table 16.

In 159 (45.6%) households in the study villages, women are the only collectors of wood. In another 144 (41.3%) households, women and children constitute the main collectors of wood. The over-all importance of women and children in the wood gathering process in the villages is indicated by Table 16.

Following the pattern of the combined villages level, the involvement of households in wood collection at Teacher-Mante, appears to be specialised by sex and age groups. In 57 (44%) households, the only collectors of wood are women. Women and children follow that order in 46 (35%) other households. For any combination, adult males are involved in wood collection in only 17 (14%) households. At Tontro, contributions towards household collection of woodfuel, mainly fall on women and children also. In 49 households (61%), women and children are the only collectors of wood. This is followed by women only in 23 (28.8%) households. For all combinations of wood collection, males are involved in only 7 (9%) households. In 79 (53%) households at Okrakwadjo, women are the only collectors of wood. In 50 (34%) other households women and children form the main collecting group.

Comment-labour distribution

There is no doubt that wood collection is carried out, first and foremost, by women, assisted by children. The contribution of adult male labor is seen to be insignificant. As a single group, the percentage for woman- labour is highest at Okrakwadjo, and least at Tontro. Because women are involved in a number of socio-economic activities, the additional task of wood collection may have significant effects on their socio-economic status and physical well-being. Again, by involving children, there are possible effects on their education and physical well being such as absenteeism, and health problems.

<u>Expenditures on fuel</u>

As mentioned elsewhere in this chapter, most needed wood in the villages tend to be self-collected and for free, so that time and labour costs appear to be very significant in wood collection. Such costs are however, regarded as impacts, and are comprehensively discussed in Chapter VII.

Nevertheless, in spite of free collection of most wood in the villages, for many households, and depending upon the sector of use, wood purchases are increasing. Also in all households, kerosene, the main lighting fuel has to be purchased, usually to be used for domestic activities other than for lighting alone. In this section, households income potential are assessed in relation to fuel purchases.

<u>Income sources</u>

To provide a background information on the general ability of households to pay for fuels on the open market, a description of income sources is provided. Farming activities appear to bring the bulk of incomes to households as about 76 per cent of households in the villages cite farming as the major economic activity in terms of time and earnings (Table 9). A general inference of farm incomes in the individual villages reveal very low income potentials.

Where farming households are involved in intensive commercial activities, incomes may rise considerably above the government stipulated minimum wage level, which is estimated for 1986 at C3,000/month. Note that this minimum wage applies mainly to those regularly employed, and does not apply to farmers, and other non-regularised type of employment found in the villages. The minimum wage is thus applied only for illustrative purposes. Government employees on regular pay cheques, as well as big land owners, especially of cocoa farms, tend to be relatively better-off economically. This group, however, constitutes less than 20 per cent of the surveyed population.

A quick look at the occupational structure in the villages provided as Table 9, indicates that, farming is the principal occupation at Teacher-Mante, where about 86 per cent of the surveyed households are involved. Holding other factors constant, farmland ownership is a major determinant of economic potential in a typical farming household. According to Table 17 however, only 63 per cent of households at Teacher-Mante fully own their land, leaving as many as 37 per cent to look elsewhere for farmlands under various tenurial arrangements. The favourability of specific tenurial arrangements will determine the level of income generation. Using the mean annual gross yields of maize and cassava (major market crops in the area) as surrogate measures of income for households who mainly depend on subsistence cropping, more than 80 per cent of the households are found to earn below the government minimum monthly wage in 1986 .

In addition, the majority of households with additional income from other sources, i.e. mainly commercial, are at or just below the minimum wage level. Government employees, especially teachers,

TABLE17 : FARMLAND OWNERSHIP

TENURIAL TYPE	STUDY VILLAGES (BY HOUSEHOLDS)						ALL THREE VILLAGES	
	TEACHER-MANTE		TONTRO		UKRAKWADJO			
	NO.	%	NO.	%	NO.	%	NO.	%
1. Full Ownership	82	63.1	49	60.5	73	45.6	204	55.3
2. Own part Rent part	1	0.8	1	1.2	5	3.2	7	1.9
3 Lease, Rent/Rent and/or Lease	2	1.5	6	7.4	24	15.2	32	8.7
4. Share cropping (including care-taking)	38	29.2	15	18.5	35	22.2	88	23.8
5. Gift	3	2.3	5	6.2	7	4.4	15	4.1
0. No farmland	4	3.1	5	6.2	14	8.9	23	6.2
Valid Cases		130		81		158		369

BASED ON A SURVEY OF 371 HOUSEHOLDS

SOURCE: FIELD DATA

earn the highest- a mean of about $6000.00/month (1986). The above illustration may help provide a basis for estimating households general ability to get wood from the market place.

At Tontro, farming involves approximately 76 per cent of the surveyed population. Most of the farmers are involved in cocoa production as owners, care-takers with 50 per cent rights, labourers, and/or with other arrangements (Table 17). For the real landlords residing in the village or abroad, annual incomes may go as high as C100,000 or more (1986). The income of other operators depend upon size of farm and operation arrangements. The next best group are those farmers operating on a 50 per cent sharing basis. They may earn up to C50,000 or more. Commercial activities such as distilleries and oil palm making can generate incomes close to or more than cocoa operations. Upon the basis of farming and commercial activity types, about 45 per cent of households may generate incomes above the minimum wage level. Note that this analysis does not reflect distribution of incomes within households .

An investigation of occupation types at Okrakwadjo provides an insight into probable income performances of households in relation to expenditures on fuels. As in the two other villages, farming is the most predominant economic activity (about 69 per cent of all households are involved). According to Table 17, only about 46 per cent of such farming households completely own their farmlands. The greater majority depend upon other tenurial arrangements. Maize is the principal income generating crop followed by cassava. About 80 per cent of households produce a net (gross less production costs) of less than 12 bags (50 kg) of corn and less than 20 baskets of cassava/annum. Thus, it can be inferred that 80 per cent or more of households who depend on farming alone, lie below the minimum income level for 1986. More households derive additional money from commercial operations to supplement their incomes. However, most of the commercial activities in the village are less intensive, netting less than 100 cedis a week in contrast with Tontro and Teacher-Mante.

There is a relatively large presence of government employees at Okrakwadjo (Table 5), made up of mostly teachers, nurses and workers for a nearby oil palm plantation. The teachers and nurses make relatively high salaries. While workers on the oil palm plantation are mainly on the minimum wage, they are also mostly farmers and traders. The large users of charcoal can be found within the ranks of the group of nurses and teachers

Fuel Expenditure

A mean monthly household expenditure of C387 (maximum of C4201) is made on firewood in the study area. This is equivalent to 13 per cent of the government stipulated monthly minimum wage. In 53 relevant households, average monthly expenditure on charcoal is about C155 or about 5 per cent of minimum wage/month equivalence. Woodfuel purchases total C543 or 18 per cent of minimum wage equivalent/month.

Kerosene purchases by all households amount to a mean of C100 As already noted, all households require kerosene for lighting purposes, and notwithstanding the fact that only one household depends upon kerosene for domestic uses in the study area, most households may use undetermined amounts of kerosene to help set fires. Adding all fuel types together, an average expenditure/month/household of C643 is made- 21 per cent of the national minimum wage/month.

At Teacher-Mante, a mean expenditure/month/household of C441 is made on firewood purchases. This is equivalent to 15 per cent of the monthly minimum wage. In the 17 households in which charcoal is purchased, approximately C120 (4 per cent of minimum wage) is spent by each household per month. A mean of C92 is spent on kerosene every month. For woodfuel only, about C561 or 19 per cent of minimum wage is spent every month. Adding the burden of kerosene acquisition to woodfuel purchases, appropriate households spend about C652.67 or 22 per cent of minimum wage/month on fuel purchases.

At Okrakwadjo, a mean of C369.02 or approximately 12 per cent of the national monthly minimum wage equivalent is spent on firewood. Charcoal purchases net a mean of C174 or 6 per cent of monthly minimum wage equivalence. Kerosene purchases average C107 Combining charcoal and fuelwood, a mean of C543 per month or 18 per cent of minimum wage equivalence is spent by appropriate households on fuel purchases. Considering households that purchase woodfuel for domestic and/or commercial uses in addition to the mandatory demand for kerosene, approximately C650 or 22 per cent of the national minimum wage equivalent is spent on fuels every month at Okrakwadjo.

At Tontro, a mean of C220 or 7 per cent of minimum monthly wage equivalent is spent on wood purchases, the lowest in all the villages. Two households that purchase charcoal spend a mean of approximately C90.00 a month. Kerosene purchases per month average C101 per household/month. Adding fuelwood and kerosene which are the main fuels bought in terms of number of households, monthly expenditure is approximately C322/month or 11 per cent of minimum wage equivalence.

Comment on incomes

Income potentials are generally restricted. Overall all, households at Tontro indicate the highest potential for income generation, while those at Okrakwadjo shows the least potential.

Summary- Wood acquisition patterns

Firewood is the overwhelming fuel type in the study villages with some minor use of charcoal. Since most charcoal users go to the market place, it is with fuelwood acquisition that a number of discernible patterns emerge. About 40 per cent of wood used in the study villages are inferiors. Okrakwadjo records the highest percentage of inferior uses while the village of Tontro records the highest proportion of quality wood use.

From the trend at both individual village and composite village levels, most households collect their own wood for domestic purposes while purchases are important for commercial uses. Purchases constitute the leading source of wood for commercial purposes. Okrakwadjo leads such purchases at about 40 per cent of relevant households with Tontro recording the lowest, at only about 2 per cent.

Ownership of property (66.% of all sources) seem to be important in determining access to wood because large number of households collect wood from their own property. The visible trend is that most households do not walk far from any of the villages for wood. Almost 83 per cent of all wood collected come from within 3.2 km of the settlements. Approximately 1.8 days in a week is set for wood collection, taking a mean of about 2.8 hours (3 hours) for each wood collection day. Women and children together tend to account for over 92 per cent of all wood collected.

Combining woodfuel purchases to kerosene which is a mandatory lighting fuel, appropriate households spend approximately C643.14 or 21.44 per cent of minimum wage/month. Comparison between villages at this level appears superfluous due to the marked differences of number of user households contributing to the mean consumption costs/month in individual settlements.

Use patterns

The preceding parts to this section have provided specific details on woodfuel types, and information on the structure of wood supply in the villages. This section of the chapter, provides data related to specific woodfuel use-patterns and is directly related to the first objective of the study, which seeks to determine the amount of wood used as fuel and the sectors of demand. Data on woodfuel use covers both firewood and charcoal separately, and together, and considers specific use between the two main aggregate sectors namely, commercial and domestic. Figures on consumption, were derived quantitatively in the field, following the methods of study outlined in

Chapter IV. Information is provided on Gross (total/aggregate household use), Sectoral (domestic and commercial uses), Per capita (covering specific category users and the surveyed population) and Total woodfuel (to cover both firewood and charcoal and village level extrapolations) .

Firewood use trends

Gross

Detail of firewood consumption is provided as part of Table 18, which also includes information on charcoal consumption. For the three settlements together, a total of 361 fuelwood consuming households or approximately 97 per cent of total households covered, used about 103,468 kg/month of firewood (in 1986). On annual basis, such consumption rates amount to approximately 1,345,084 kg or 1345.1 tonnes. Per monthly household gross use of firewood is approximately 287 kg or a mean daily use of 10.2 kg/household. For the three villages together, a total of about 3695 kg of wood is required on a daily basis.

At the village of Teacher-Mante, 128 fuelwood consuming households (98.5%) make use of approximately 32,618 kg or 32.6 tonnes of firewood per month. On annual basis, such a consumption figure amounts to about 424,034 kg or 424 tonnes. Mean household monthly consumption is approximately 255 kg or 0.25 tonnes. About 1,165 kg of firewood is consumed per day. Thus, each household utilises a gross of approximately 9.1 kg/day.

For Okrakwadjo, a total of 40,910.5 kg or about 41 tonnes of fuelwood is consumed monthly by 153 main fuelwood consuming

TABLE 18: HOUSEHOLD CONSUMPTION OF WOODFUEL

CONSUMPTION VARIABLES	STUDY VILLAGES (STUDY AREA)			
	TEACHER-MANTE	TONTRO	OKRAKWADJO	ALL THREE
FUELWOOD				
Mean monthly use (kg)	254.83	374.83	267.39	286.63
Gross daily use (kg)	9.10	13.37	9.55	10.24
Daily domestic (kg)	6.66	7.68	7.14	7.09
Commercial monthly (kg)	150.63	240.26	188.05	191.64
Commercial Daily (kg)1	2.44	5.69	2.42	3.15
Per capita/daily (kg)	1.53 (1.50)a	1.98 (1.96)a	1.59 (1.53)a	1.67
Per capita/annum (cu. m)	0.93-0.8	1.21-1.03	0.97-0.83	1.012-0.87
CHARCOAL				
Per capita daily/kg	0.043 (0.007)a	0.02 (0.004)a	0.06 (0.017)a	0.047(0.011)a
Per capita annum/cu.m	0.026-0.023	0.013-0.011	0.036-0.033	0.28-0.025
FUELWOOD+CHARCOAL				
Per capita daily/kg	1.54	1.97	1.54	1.67
Annual per capita/cu.m	0.93-0.8	1.21-1.03	0.93-0.81	1.02-0.87

SOURCE- Based on survey data
1-Gross figure applying to all wood using households
a -Figures in bracket apply to village irrespective of appropriateness of fuel type

households of the 160 households covered for the study. Based on the monthly village consumption figures, annual uses approximate 531,837 kg or 532 tonnes. Mean monthly household use is about 267 kg with a daily gross of approximately 1461.1 kg, giving a mean household use of 9.5 kg/day.

As a unit, the village of Tontro consumes a total of 29,939.4 kg or about 30 tonnes of fuelwood in a month. This figure represents 80 firewood consuming households from a total of 81 households (99%) that constitute the village unit. On per annum basis, the village makes use of about 389,212.3 kg or 389.2 tonnes of wood. Mean monthly gross use of firewood is approximately 374 kg/household. The mean household consumption of wood is highest at Tontro, compared with the other two settlements. A gross total of approximately 1069.3 kg of firewood is utilised in the village on a daily basis or approximately, 13.4 kg/day per household.

Comment

On a gross village total basis, Okrakwadjo makes use of the highest amount of wood per month, while Tontro uses the least total amount for any of the three villages. Such a result however reflects only the differences in population between the three settlements rather than real consumption trends which are best portrayed by use figures at the household level. For better comparability of use figures between the villages, the gross mean monthly and daily household use are found useful. Using such bases, Tontro, ranks first of the three villages with Okrakwadjo second and Teacher-Mante third, close behind Okrakwadjo (Table 18).

Sectoral

Domestic

The use of wood solely for domestic needs, take a sum of about 2559 kg/day for the three settlements together. Per household domestic consumption is approximately 7.1 kg/day (Table 18). Household uses of wood thus takes about 69.3 per cent of all uses of wood per day in the villages.

Among the three villages, domestic use of firewood is lowest at Teacher-Mante accounting for approximately 853 kg of all wood utilised per day. Each household uses about 6.7 kg of wood per day for domestic purposes, implying that, about 73 per cent of all daily uses of wood go to domestic ends. On the other hand, Tontro makes the highest use of woodfuel for daily domestic purposes. Even though the village requires a total of 614.5 kg/day of wood for domestic purposes, this is equivalent to about 7.7 kg/day per household. The proportion of daily uses of wood for domestic ends is lowest for Tontro at 57 per cent of gross wood uses. Okrakwadjo lies between the two villages in terms of mean daily household requirements of wood. In that village, a sum of 1091.7 kg/day of fuelwood is used by all households for domestic purposes, giving an average daily household use of wood of approximately 7.1 kg. On the other hand domestic use of wood account for 75 per cent of gross daily uses of wood, which is the highest among the three settlements (Table 18).

Commercial

All wood-based commercial activities in the villages depend exclusively on firewood. Specific wood-based commercial ventures and their distribution among the villages are provided as Table 19. The commercial ventures shown as Table 19 overlap in the villages of Tontro and Teacher-Mante, meaning that a single household may carry both major and minor ventures or more than one in either class. The actual commercial households in those two villages are therefore less than the absolute number of commercial ventures listed as Table 19. Tontro has the highest concentration of major commercial ventures, especially local distilleries and palm oil and palm kernel oil ventures, followed by Teacher-Mante, with Tontro in third place. In absolute terms, most minor commercial activities are found at Okrakwadjo, with the least at Tontro. Teacher-Mante however has the highest concentration of ready processed and cooked food outlets, which appear to be the most important single commercial venture by number of households in all the three settlements. The frequency of commercial operations per 28-day month in the villages is provided as Table 20.

Whether classified as major or minor (see woodfuel use types), commercial activities take place on a mean of 8.4 days/month for the three settlements together. The maximum number of operation days/month recorded anywhere among the three villages is 28 days, but by a total of only 3 households. A gross of about 31,824 kg of woodfuel is used per month by 166 commercially operating households in the three settlements together (about 45% of surveyed households). Each commercial household thus uses a mean of 191.6 kg per month or about 1.15 kg per day on a 28-day basis. On the other hand, if commercial uses of wood is assumed to account for the difference between gross and domestic uses of wood in each village

TABLE 19: WOOD-BASED COMMERCIAL ACTIVITIES BY NUMBER OF HOUSEHOLDS

ACTIVITIES	STUDY VILLAGES (BY NO. OF HOUSEHOLDS)							
	TEACHER-MANTE		TONTRO		OKRAKWADJO		ALL THREE	
MAJOR ACTIVITIES	NO.	%	NO.	%	NO.	%	NO.	%
1. Distilling (local gin)	1	0.8	7	8.6%	0	0	8	2.2
2. Brewing (local beer)	1	0.8	1	1.2	1	0.6	3	0.8
3. Palm/palm kernel oil	10	7.7	29	35.8	8	5.0	47	12.7
4. Soap	2	1.5	2	2.5	3	1.9	7	1.9
5. Medicine and Herbal	0	0	0	0	0	0	0	0
Applicable Cases	14	10.8	39	48.1)	12	7.5	65	17.6
MINOR ACTIVITIES								
1. Process/cooked food	42	32.3	15	18.5	39	24.4	96	25.9
2. Preserve/process produce	2	1.5	5	6.2	1	0.6	8	2.2
3. Palm/palm kernel oil	0	0	0	0	2	1.3	2	0.5
4. Soap	2	1.5	0	0	2	1.3	4	1.1
5. Medicine and Herbal	0	0	0	0	2	1.3	2	0.5
Applicable cases	46	35.3	20	24.7)	46	28.9	112	30.2

SOURCE- Survey Data

(Table 18), then on a daily basis, each household will be considered to use about 3.1 kg of firewood for commercial purposes. On such gross use basis, for every 1 kg of total use of firewood, 0.31 kg would go to commercial purposes. Considering however that, the actual commercial user households are 166 (Table 20) in the three villages together, who operate over a mean of 8.4 days/month, real commercial uses of fuelwood amount to about 23 kg per operation day/household.

The frequency of commercial use of wood at Teacher-Mante village is lowest among the three villages (slightly below that of Tontro). Operations occur within a mean of 6.8 days/month per household. The maximum number of operation days per month by a household is 24 days. Considered on a monthly base, the village utilises a total of about 8736.3 kg of wood for commercial purposes or 150 kg per commercial household per month. On a daily gross household woodfuel use basis, a mean of about 2.44 kg of wood go to commercial purposes by each household in the village. Thus for every 1 kg of wood used per day, 0.27 kg is used for commercial ends. On real use terms however, the 58 commercial operation households use approximately 22.1 kg per use day on 6.8 days/month.

The mean number of commercial operations at Tontro per month is approximately 7.1 days, slightly above that of Teacher-Mante. The maximum number of operation days by a household is 24. Approximately, 12734 kg of wood is used for commercial purposes by all relevant households every month. This gives a mean monthly household use of about 240.3 kg. On a 28-day/surveyed population basis, about 5.7 kg of firewood is used every day for commercial operations. In gross terms, for every 1 kg of wood used in each household, 0.42 kg go to commercial purposes. The effective amount of wood used by each of the 53 actual commercial operator-households over the mean 7.1 day/month is 34 kg. per operation day.

At Okrakwadjo, commercial operations take place within a mean of 11.2 days per month. The maximum number of operation days/month is 28 days. The highest frequency of commercial operations in a month among all households in the study villages is found here. A sum total of 10342.7 kg of wood/month is utilised for commercial operations in the village with each of the 55 commercial households using a mean of about 188.1 kg/month. On a daily basis, and with all households involved, the use of wood for commercial purposes is about 2.42 kg. On such a gross daily use basis, for every 1 kg of wood used in the village, about 0.25 kg is used for commercial purposes. Since the main commercial wood using households number only 55, and operate in mean of 11.18 days/month, the actual per household use of wood per operation is 16.28 kg (Tables 18, 19 and 20).

Per capita firewood use

Per capita use of wood applies to user households only and then for the total households covered without discrimination as to sectoral.

The firewood using surveyed population in the villages, utilise about 1.67 kg/day or 608 kg/annum of firewood per capita. In

TABLE 20: FREQUENCY OF COMMERCIAL OPERATIONS BY NUMBER OF DAYS PER MONTH

	STUDY VILLAGES							
NO. OF DAYS/MONTH	TEACHER-MANTE		TONTRO		OKRAKWADJO		All Three	
	NO.	%	NO.	%	NO.	%	NO.	%
1	7	12.1	13	24.5	9	16.1	29	17.4
2	7	12.1	7	13.2	4	7.1	18	10.8
3	1	1.7	3	5.7	1	1.8	5	3.0
4	15	25.9	7	13.2	6	3.8	28	16.8
5	0	0	1	1.9	2	3.6	3	1.8
6	3	5.2	1	1.9	0	0	4	2.4
7	1	1.7	2	3.8	0	0	3	1.8
8	10	17.2	8	15.1	5	8.9	23	13.8
9	0	0	1	1.9	0	0	1	0.6
10	2	3.4	0	0	1	1.8	3	1.8
12	7	12.1	1	1.9	10	17.9	18	10.8
16	0	0	1	1.9	1	1.8	2	1.2
18	1	1.7	0	0	0	0	1	0.6
20	3	5.2	1	1.9	8	14.3	12	7.2
22	0	0	2	3.8	1	1.8	3	1.8
24	1	1.75	5	9.4	5	8.9	11	6.6
28	0	0			3	5.4	3	1.8
MEAN NO. OF DAYS/MONTH		6.8		7.1		11.2		8.4
*TOTAL HOUSEHOLDS		58		53		56		167

- Percentages in Brackets-Expressed as number of households in applicable category against Total number of commercial households in particular spatial unit.
- Based on a Sample of 371 Households

*At Okrakwadjo, 55 households are clearly defined commercial users of firewood.

- SOURCE: Field Data

volume, this is approximately 1.02 m^3 (600 kg/m^3) to 0.87 m^3 (700 kg/m^3). When all 371 surveyed households are considered however, the per capita consumption of wood is about 1.63 kg/day or 593 kg/annum. In volume, this amounts to about 1 m^3 (600 kg) to 0.85 m^3 (700 kg).

The per capita use of firewood is lowest at Teacher-Mante, where the daily per capita use of wood for the wood using surveyed population is approximately 1.53 kg/day or 558.45 kg/annum. On the other hand, the per capita use of wood at Tontro ranks highest among the three villages with a consumption figure of 1.98 kg/day per capita or approximately 724 kg/annum. Okrakwadjo ranks second in terms of per capita use of firewood. In this village, about 1.59 kg of wood per capita/day is used by the firewood using households. This translates into 580.9 kg/annum (Table 18 gives greater detail on wood consumption in the villages).

Comment

Domestic uses of wood account for about 69 percent of all wood used in the study area. Households at Tontro use the least amount of wood (57%) for domestic ends, while those at Okrakwadjo use the highest amount (75%), followed closely by Teacher-Mante (73%). About 31 percent of all wood used in the study villages go to commercial activities. Both at the village unit and household levels, Tontro utilises the greatest amount of wood for commercial needs.

Charcoal

Details on charcoal consumption for the respective villages is provided in Table 13. Consumption values are given in both kilogrammes and cubic metre equivalent per capita per annum to represent actual users and also the surveyed population.

Gross

In all the three villages together, only 83 households (about 22%), make some use of charcoal. A total of 864 heaps of 10- Cedi equivalence or 674 kg of charcoal is used per month (refer section on woodfuel type for conversion figures). On a wood equivalent basis, approximately 3369.6 kg of wood is consumed monthly in the form of charcoal by user households only.

The village of Tontro records the lowest number of charcoal users, made up of 14 households (17% of surveyed population). About 70 heaps of 10-Cedi charcoal is used in the village every month. This is equivalent to 56.4 kg/month of charcoal giving a wood equivalence of about 282 kg/month. On the other hand, the highest number of charcoal users can be found at Okrakwadjo. In all, about 47 households (29% of surveyed population) households use charcoal at some point at that village, grossing about 591 heaps of 10-cedi charcoal per month. This is equivalent to about 461 kg on charcoal weight basis or 2305 kg/month on a wood equivalent basis.

Teacher-Mante is next to Okrakwadjo with 22 charcoal using households (17% of the surveyed population). Total amount of charcoal consumed over a month in the village is approximately 203 heaps of 10-Cedis, equivalent to about 158.34 kg of charcoal and a wood equivalent of about 792 kg/month.

Per capita charcoal

Per capita use of charcoal in wood equivalence, for user households only, is about 0.05 kg/day or 17.2 kg/annum for all the villages together. In volume per annum, this works out to a range of 0.03 m^3 (600 kg/m^3) to 0.025 m^3 (700 kg/m^3) (Table 18).

At Tontro, the daily per capita use of charcoal is approximately, 0.02 kg or 7.54 kg on annual basis. For Okrakwadjo, charcoal consumption per capita (consuming households only) is about 0.6 kg/day or 21.3 kg/capita on annual basis while charcoal users at Teacher-Mante utilises a per capita of about 0.043 kg/day or about 15.7 kg/annum (Table 18 gives details on per capita consumption figures for the surveyed population and for the respective volume equivalents).

Total- Firewood and Charcoal (Woodfuel)

In all the study settlements, the combined use of fuelwood and charcoal total about 1,388.9 tonnes of wood per annum for the surveyed population. On per capita basis, this is approximately 1.67 kg /day or 609.6 kg/annum. On a volume per annum basis, this is equivalent to 1.012 m^3 (600 kg/m^3) to 0.87 m^3 (700 kg/m^3) (Table 18).

Based on figures for the surveyed population, woodfuel consumption is extrapolated for the total population of 450 households that constitute the three study villages. Using the mean per capita consumption figure 1.67 kg per day for the surveyed population, about 1682 tonnes of wood is used by the total population per annum. On per capita basis, the consumption figure corresponds to that of the sample population of 1.67 kg/day or 1.012 m^3 (600 kg/m^3) to 0.87 m^3 (700 kg/m^3) per annum (Table 18).

Comment

Data exhibited by Table 21 shows that wood consumption vary between the villages especially, at the gross level, and over longer periods. For example, the range of wood consumption between households in the villages is about 924.4 kg per month and 36 kg per day. The degree of variation is equally great with household within individual villages. The degree of variation is however negligible at the daily domestic use level.

Summary- Utilisation

In all, about 96 per cent of households use fuelwood while 22.4 per cent make some use of charcoal. The mean per capita use of firewood amounts to approximately 1.67 kg/day or 608.2 kg/annum and 0.047 kg/day or 17.23 kg/annum for charcoal. For annual per capita volume use, the figure is 1.012 m^3-0.87 m^3 for fuelwood and 0.03 m^3 for charcoal. The only alternative fuel to wood, gas, is used at Teacher-Mante, by a single household.

Tontro records the highest per capita use of woodfuel, both for commercial and domestic purposes while Teacher Mante records the lowest . Okrakwadjo has the highest absolute number of charcoal users with Tontro, the lowest.

Households involved in specific wood-based commercial activities tend to be approximately the same in number in each village. Certain

TABLE 21: WOOD USE VARIABILITY IN KILOGRAMS (KG)

VARIABILITY PER UNIT TIME	TEACHER-MANTE	TONTRO	OKRAKWADJO	ALL THREE VILLAGES
RANGE/MONTH	906.84	871.5	888.80	924.40
VARIANCE/MONTH	18830.00	47702.50	20081.50	27812.40
STANDARD DEVIATION/MO	137.22	218.41	141 70	166.80
RANGE/DAILY GROSS	32.39	31.10	31.70	33.02
VARIANCE/DAILY GROSS	24.02	60.80	25.60	35.50
*STANDARD DEV/DAILY GR.	4.90	7.80	5.10	6.00
RANGE DOMESTIC /DAILY	12.88	8.50	13.80	13.80
VARIANCE DOM/DAILY	4.78	4.90	3.60	4.40
STAND DEV/DOM/DAILY	2.19	2.20	1.90	2.10

SOURCE: BASED ON FIELD DATA
* STANDARD DEVIATION/DAILY GROSS USE

households are however involved in more than one commercial activity.

Exploratory Findings

In referring to the objectives and associated relationships defined for this study, certain partial findings are made with regard to the data presented in the preceding sections. These findings are that;

i. there appears to a relationship between household size and amount of wood consumed. Tontro with the highest mean household size, was also the highest user of wood per household and, Teacher-Mante with relatively least numbers per household, used the least amount of wood per household;

ii. the closer a community lies to accessible wood fallowlands such as forests, the higher the expected total consumption. Households at Tontro who are located in a less degraded forest zone, tend to use more wood than those at Okrakwadjo and Teacher-Mante who are located in a more degraded wood supply environment.

iii. the higher the frequency of use of wood for major commercial activities, the higher is the expected total use. Tontro, which has the highest number of major commercial ventures also record the highest amount of mean household use of woodfuel;

iv. the greater the access to "free wood" the higher the expected uses of wood. Tontro which has the highest proportion of households with free access to wood, use the highest amount of wood per household

v. the higher the proportion of farmland ownership, the higher the expected consumption of woodfuel. Tontro, with a large proportion of land-owning households used most amount of woodfuel, while

Okrakwadjo, with the least number of land-owning households, used the least amount.

vi. the longer the distance to the source of wood, the lesser the amount of wood used. At Okrakwadjo and Teacher-Mante where most households walk far to collect wood, consumption is relatively less than at Tontro where households are generally close to their wood collection sites;

vii. the greater the use of wood for economic activities, the greater the potential for wood purchases. At both Okrakwadjo and Teacher-Mante where many households purchase wood, it mainly goes to commercial operations.

viii. The higher the non-land owning households in a village, the higher the expected household expenditure on fuels. Okrakwadjo, with a large proportion of non-land-owning households spend almost 22 per cent of household monthly budget on fuel purchases (kerosene for lighting inclusive) while Tontro with a high farmland ownership spend only about 11 per cent;

ix. the greater the non-farm population/households, the greater the potential for the use of non-wood based fuels. Teacher-Mante with a high proportion of non-farm population and ex-urbanites, record the only use of gas and kerosene.

The preceding findings, however, are based on initial data presentation and are therefore inconclusive. They are critically analysed in terms of specific variable relationships among other factors in chapter VI in an attempt to provide explanation to the pattern of wood consumption in the villages.

CHAPTER VI: ANALYSIS OF FIELD INFORMATION-
EXPLAINING WOOD CONSUMPTION PATTERNS

1. Introduction

In chapter V, broad findings on patterns of woodfuel use both between and within the study settlements were reported. These findings covered key areas of woodfuel use, namely, its demographic, use structure, and acquisition system characteristics. Generally, marked differences were noted to exist between and within the villages in terms of all the three key sectors of woodfuel use i.e. demographic, use structure, and acquisition. The degree of variation in woodfuel use between the villages is also confirmed by a statistical test of homogeneity analysis (Anova-One way). The result of this test, which yields an F ratio of 15.53 ($p=0.000$), indicated that chances that wood consumption in the study settlements is similar are less than zero per cent (0%).

The main objective of this chapter (the second analytic chapter of the study), is to provide a more detailed analysis of the findings presented in Chapter V and thereby, offer a more comprehensive explanation to the pattern of wood consumption in the villages. The hypotheses which are tested as part of the objective of this chapter are those associated with the first and second objectives of this study, spelled out in Chapter I (pp. 22 and 23).

The analysis in this chapter is undertaken in three, nested stages. The first stage, which is covered in section 2, involves univariate analysis of the variables of wood use. The univariate analysis considers the significance of variables derived from the population structure, woodfuel use type and wood acquisition patterns, which emerged as important with regard to the analysis and partial findings in Chapter V. In order to overcome possible limitations of applying univariate analysis to explain such complex issues as wood consumption in different villages, all the variables of wood consumption analysed in stage 1, are further analysed in stage 2 (section 3) as inputs to a "step-wise" multiple regression test, which is used to determine the significance of each variable among many, in explaining wood consumption both within and between the villages. In section 4 (the third stage), the whole analysis is placed into a broad ecological framework in an attempt to produce a complete picture of the sustainable functions of village fuel systems.

2. Explaining Wood Consumption- Using Variables Independently

Procedure

At this first stage of the analysis, the main objective is to assess the significance of variables independently, on wood consumption, considering the three villages as a group, and then as individual entities. Initially, variables from the field study, which were considered in Chapter V to have potential influence on overall use of wood, are tested using Pearson Correlation Coefficient (r) tests at both the gross (total) and sector levels (domestic) to help isolate significant variables of wood consumption. Variables with r values at probability levels equal to or less than 0.05 ($p \leq 0.05$) are selected for close study. The basis for the cut-off line is the relative high degree of objectivity of selection based on significance rather than on r values alone which are sometimes arbitrary (significance level is by no means a perfect index for selection of variables).

Results

Variables selected from the r tests which total 17 and are presented in Table 22, are discussed below in a sequence which refers to population structure, wood use structure and wood acquisition structure, rather than on a hierarchy of "r" and/or "p" scores.

Population Structure; made up of i) household size (Hs), which considers total number of people in a household, ii) adults, applicable to total number of members of household aged 15 and over, iii) age 10 and over, refers to total of household members from age 10 and above, iv) women, refers to all females from age 10 and over, and V) men, applies to all males from age 10 and over;

Woodfuel Use Structure; variables include; vi) wood use type (Ut), which considers the distribution of wood use whether for domestic and/or commercial purposes by number of households, vii) meals per unit time (Mt), considers the average number of meals per day by number of households, viii) multiplicity of stoves, considers the number of stoves per cooking, by number of households, ix) general commercial use (Cu), considers the total amount of of wood used for all commercial operations without classification of commercial activities, x) major commercial operation, applies to total number of households with commercial operations that require more than 40 kg of wood per operation, xi) minor commercial operation, refers to commercial operations with wood requirements of under 40kg. per operation, and xii) frequency of commercial operation (Fc), refers to the number of days of commercial operations in a month by number of households; and

Wood Acquisition System, variables include; xiii) bundles of wood collected per unit time (Bt), explained as the number of bundles collected per month, xiv) primary source of wood (Ps), refers to source (s) of wood supplying at least 75 per cent of regular wood needs, xv) occupation, combines both minor and major income earning/subsistence activities by number of households, xvi) land ownership/farm tenure, by number of households, and xvii) distance to source of wood (Ds), considered as the average distance in kilometres from a village to the usual source(s) of wood.

Whilst most of the variables identified as significant are common in their effects in all three villages, others reveal differential conditions according to specific villages. For example, household size, adults, age 10 and over, women, men, commercial operations, and bundles of wood collected per unit time, are considered significant variables in all three villages. On the other hand, farm tenure is considered significant at both gross and domestic levels at Tontro, but significant only at the domestic level at Teacher-Mante and at the gross level at Okrakwadjo. Primary source of wood is a significant variable at the gross level at both Teacher-Mante and Okrakwadjo, but significant at the domestic level, only at Tontro. Multiplicity of stoves is also significant at both the gross and domestic levels at Teacher-Mante, while it is significant at the domestic level at Okrakwadjo, and not significant at any level at Tontro (Table 22).

Table 22: Explaining Patterns of Wood Consumption-Correlation Coefficient (r) Values
(DEPENDENT VARIABLE-WOOD CONSUMPTION)

TEACHER-MANTE VILLAGE

INDEPENDENT VARIABLE	CORRELATION COEFFICIENT VALUES (R)		PROBABILITY LEVEL (1-TAILED SIGNIFICANCE	
	GROSS	SECTORAL	GROSS	SECTORAL
i. HOUSEHOLD SIZE	0.6983	0.8967	P=.000	P=.000
ii. AGE 15 AND OVER (Adults)	0.6778	0.7751	P=.000	P=.000
iii. AGE 10 AND OVER	0.6828	0.8604	P=.000	P=.000
iv. WOMEN MAJORITY HOUSEHOLDS	0.6879	0.7726	P=.000	P=.000
v. MEN MAJORITY HOUSEHOLDS	0.4155	0.6660	P=.000	P=.000
vi. FIREWOOD USE TYPE	0.7302	0.4074	P=.000	P=.000
vii. NUMBER OF MEALS/DAY	0.2560	0.5132	P=.002	P=.000
viii. MULTIPLICITY OF STOVES	0.4483	0.2583	P=.000	P=.002
ix. COMMERCIAL OPERATIONS	0.8591		P=.000	
x. MAJOR COMMERCIAL OPERATION	-0.1611	-0.5928	P=.291	P=.013
xi. MINOR COMMERCIAL OPERATION	-0.0811	0.0782	P=.294	P=.301
xii. FREQUENCY OF COMMERCIAL-OPERATION	0.5464	-0.0347	P=.000	P=.398
xiii. BUNDLES OF WOOD COLLECTED	0.5803	0.5878	P=.000	P=.000
xiv. OCCUPATION	0.3769	0.1870	P=.000	P=.017
xv. PRIMARY SOURCE OF WOOD	0.2046	-0.0975	P=.010	P=.137
xvi. FARM TENURE	-0.1053	-0.1973	P=.118	P=.013
xvii. DISTANCE TO SOURCE OF WOOD	0.0356	0.1715	P=.349	P=.030

TONTRO VILLAGE

INDEPENDENT VARIABLE	GROSS	SECTORAL	GROSS	SECTORAL
i. HOUSEHOLD SIZE	0.5534	0.8341	P=.000	P=.000
ii. AGE 15 AND OVER (Adults)	0.4729	0.7655	P=.000	P=.000
iii. AGE 10 AND OVER	0.5182	0.8333	P=.000	P=.000
iv. WOMEN MAJORITY HOUSEHOLDS	0.4667	0.7548	P=.000	P=.000
v. MEN MAJORITY HOUSEHOLDS	0.4204	0.6713	P=.000	P=.000
vi. FIREWOOD USE TYPE	0.5845	0.2160	P=.000	P=.027
vii. NUMBER OF MEALS/DAY	0.1378	0.1743	P=.111	P=.061
viii. MULTIPLICITY OF STOVES	-0.1259	-0.1537	P=.133	P=.087
ix. COMMERCIAL OPERATIONS	0.9640		P=.000	
x. MAJOR COMMERCIAL OPERATION	0.4850	0.2668	P=.385	P=.050
xi. MINOR COMMERCIAL OPERATION	0.0346	0.5110	P=.442	P=.011
xii. FREQUENCY OF COMMERCIAL-OPERATION	0.5983	-0.0024	P=.000	P=.493
xiii. BUNDLES OF WOOD COLLECTED	0.9497	0.5426	P=.000	P=.000
xiv. OCCUPATION	0.2143	0.0746	P=.028	P=.255
xv. PRIMARY SOURCE OF WOOD	-0.1205	-0.2705	P=.143	P=.008
xvi. FARM TENURE	-0.2091	-0.1286	P=.031	P=.0128
xvii. DISTANCE TO SOURCE OF WOOD	0.6130	-0.2550	P=.296	P=.412

OKRAWADJO VILLAGE

i. HOUSEHOLD SIZE	0.4400	0.8208	P=.000	P=.000
ii. AGE 15 AND OVER (Adults)	0.3735	0.7499	P=.000	P=.000
iii. AGE 10 AND OVER	0.4149	0.8439	P=.000	P=.000
iv. WOMEN MAJORITY HOUSEHOLDS	0.3660	0.7534	P=.000	P=.000
v. MEN MAJORITY HOUSEHOLDS	0.2928	0.5869	P=.000	P=.000
vi. FIREWOOD USE TYPE	0.7302	0.2632	P=.000	P=.000
vii. NUMBER OF MEALS/DAY	0.1518	0.3974	P=.031	P=.000
viii. MULTIPLICITY OF STOVES	0.0816	0.1886	P=.158	P=.010
ix. COMMERCIAL OPERATIONS	0.9382		P=.000	
x. MAJOR COMMERCIAL OPERATION	-0.2553	0.2661	P=.200	P=.190
xi. MINOR COMMERCIAL OPERATION	-0.1129	0.0866	P=.228	P=.284
xii. FREQUENCY OF COMMERCIAL-OPERATION	0.6284	-0.2391	P=.000	P=.038
xiii. BUNDLES OF WOOD COLLECTED	0.2800	0.5025	P=.000	P=.000
xiv. OCCUPATION	0.2797	0.0392	P=.000	P=.317
xv. PRIMARY SOURCE OF WOOD	0.2455	-0.0018	P=.001	P=.491
xvi. FARM TENURE	0.1640	-0.0388	P=.022	P=.318
xvii. DISTANCE TO SOURCE OF WOOD	0.1917	0.3241	P= 010	P=.000

ALL THREE VILLAGES COMBINED

i. HOUSEHOLD SIZE	0.5533	0.8528	P=.000	P=.000
ii. AGE 15 AND OVER (Adults)	0.4929	0.7535	P=.000	P=.000
iii. AGE 10 AND OVER	0.5136	0.8349	P=.000	P=.000
iv. WOMEN MAJORITY HOUSEHOLDS	0.4736	0.7435	P=.000	P=.000
v. MEN MAJORITY HOUSEHOLDS	0.3649	0.6251	P=.000	P=.000
vi. FIREWOOD USE TYPE	0.6833	0.3184	P=.000	P=.000
vii. NUMBER OF MEALS/DAY	0.2308	0.4067	P=.000	P=.000
viii. MULTIPLICITY OF STOVES	0.1229	0.1471	P=.010	P=.003
ix. COMMERCIAL OPERATIONS	0.9372		P=.000	
x. MAJOR COMMERCIAL OPERATION	-0.5920	0.1272	P=.319	P=.154
xi. MINOR COMMERCIAL OPERATION	-0.0568	0.1298	P=.275	P=.085
xii. FREQUENCY OF COMMERCIAL-OPERATION	0.5426	-0.0908	P=.000	P=.122
xiii. BUNDLES OF WOOD COLLECTED	0.7119	0.4874	P=.000	P=.000
xiv. OCCUPATION	0.2407	0.0554	P=.000	P=.148
xv. PRIMARY SOURCE OF WOOD	0.8800	-0.0922	P=.048	P=.040
xvi. FARM TENURE	-0 0459	-0 1219	P=.193	P=.010
xvii. DISTANCE TO SOURCE OF WOOD	0.0344	0.1515	P=.262	P=.002

SOURCE: BASED ON FIELD DATA

The selected variables are each discussed in detail within their categories, for their specific influence on wood consumption. A summary of salient findings is provided at the end of the overall discussion on the individual variable.

Population structure

Population structure applies to variables i to vi of Table 22 and include, household size, adults, age 10 and over, women and men. For purpose of analysis, these factors are regrouped under two main headings, household size and age-gender. The significance of each of the two analytical categories are considered, followed by a general comment on their relative importance.

Household size

The results from Table 22 indicate a high positive relationship between household size and wood consumption with the greater the number of household occupants, the higher the amount of wood used. For the combined villages, a correlation coefficient (r) of 0.55 (p= 0.000) exists between household size and gross consumption of woodfuel. For domestic uses only, the r value increases to 0.85 at the same significance level. Applying the same system of interpretation, Teacher-Mante records r values of 0.43 for gross and 0.82 for domestic uses only, Tontro r values of 0.55 for gross and 0.83 for domestic use only; and Okrakwadjo, r values of 0.44 for gross and 0.82 for domestic uses only, all with same p value (p=0.000). The high association existing between household size and amount of wood consumed is thus true for all the individual villages. This observation supports the hypothesis that as household size increases household wood consumption increases.

The interpretations for the statistical association between household size and wood use are that;

i). households within and between villages will differ in amount of wood consumed because of differences in size. On such basis of mean household size, Tontro tends to use most wood and Teacher-Mante the least (Tables 8 and 18, chapter V). Naturally, households containing many people will require greater amount of wood to cover different and many needs, compared to those with fewer occupants where needs will be relatively smaller. A large household also has the potential of people with varying energy use behaviours which can work against savings.

ii) the relationship between household numbers and amount of wood consumed, is stronger at the domestic level. This is probably so because pure subsistence uses of wood usually tend to be obligatory, uniform and repetitive over time and/or defined activities in the study villages (chapter V), resulting in general comparable use levels spatially and temporarily (Tables 18 and 23).

It appears that when and where additional members are added to a household, such as through births, migration (siblings, other relations such as for retirement or job loss), marriages, and/or paid services such as catering to others, there are changes in the normal routine of wood usage with additional needs making for additional wood requirements. On the other hand, wood requirements may change when households lose members through deaths, marriages, emigrations, and abrogation of other previous commitments requiring the use of wood, such as catering for a fee.

Comment on household size-Statistical implications

It is argued that due to the relatively lower r values for gross, compared to domestic uses, the influence of household size is not as crucial as domestic uses, in predicting wood requirements. Using Table 23 and Figure 14 (1-4) to illustrate this point, it is indicated that even though consumption levels appear to increase with larger households, on the basis of the per capita use of woodfuel in the study villages of 1.67 kg/day (Table 18), any increases observed are not proportional with size. For example, while one-member households utilise a mean gross of approximately 3.8 kg/day of wood in the study villages, households with 12 or more occupants use about 18.3 kg/day. For such increases to be proportional with size, households with $\geq$ 12 occupants require about 20.04 kg. Similarly, using the 3.76 kg/day one-member household scenario, households with 12 members or more, require about 45 kg of wood per day. In the individual villages increase in household use of wood is not proportional with increase in household size (Table 23).

A regression equation of Wc=4.388482 + 0.93438 (Hs) which explains the effects of household size on gross wood consumption for the three villages, really indicates the existence of economies of scale for large households. Leach and others (1986: pp.152-153) confirm this finding in a recent study in which they state among other things that"... in nearly every use of energy by households there are large economies of scale with respect to household size...the additional energy to cook one extra person's meal will usually be small... A [initial requirement] is usually large compared to B [additional requirement] concluding that "energy use will rise with more people in a house but not in a direct proportion". At the village of Tontro where gross consumption is highest, increases are slightly higher over increasing household size and the regression equation is Wc= 5.520326 +1.151622 (Hs). On the other hand, increases are relatively small at Teacher-Mante as indicated by the regression of Wc= 3.699223 + 0.894475 (Hs). Thus greater economies of scale are attained at Teacher-Mante than the other villages.

Even though the r value is stronger for the domestic level than the gross level, the rate of increase in domestic consumption with increased household size is actually less proportional, compared to gross uses. For example, while one-member households in the composite villages use a mean of about 3.8 kg/day, households with 12 or more members, use only about 11.1 kg (Table 23). A regression equation for the three villages of Wcd= 4.307107 + 0.468949 (Hs) where Wcd =domestic consumption of wood, indicates clearly how increases over household size tend to be smaller compared to gross level of use. Both Teacher Mante-and Okrakwadjo lie slightly below the mean equation value implying that generally, wood use in larger households in the two settlements is slightly less than expected, as opposed to being slightly higher than expected in Tontro.

From the preceding information, interpretation of high r values between household size and domestic use should be made with care. In the real sense, it appears that any such increases at the domestic level tend to be marginal with new additions or losses of use-members. A major reason for such a characteristic is probably due to the fact that, because domestic activities tend to be almost uniform over time in the study villages, relatively small amounts of wood are gained or lost with changes in household size.

A relationship between household size and wood consumption is useful in helping to predict general use levels of households as consumption units. However, as experience from the preceding analysis has shown, it does not give sufficient clues as to why for instance, households with similar size can differ in wood use or why households with relatively smaller size, in some cases, use more wood than those with bigger size. While other factors contribute to such differences and are explored later in this section, the immediate interest in this section is with the significance of population structure on wood consumption. As a result, the influence of age-gender structure of households on wood consumption is explored next.

Age-gender

Age-gender composition of households is illustrated by Figure 14 (1-4), and reveals interesting results in terms of wood use variations. Generally, households with more adults tend to use more wood. For example, households with up to 5 adult occupants, utilise an average of about 11 kg/day for the three villages, compared with 8.2 kg for households of up to 5 members without any age bias (Fig 14-1). Table 23 and Figure 14-2, also show the same trend of use for domestic purposes. On the other hand, the correlation coefficient values tend to increase when the age group is lowered. For example, the r value considering only the 15 years and over group is about

Figure 14-1: Age Category and Gross Consumption of Woodfuel

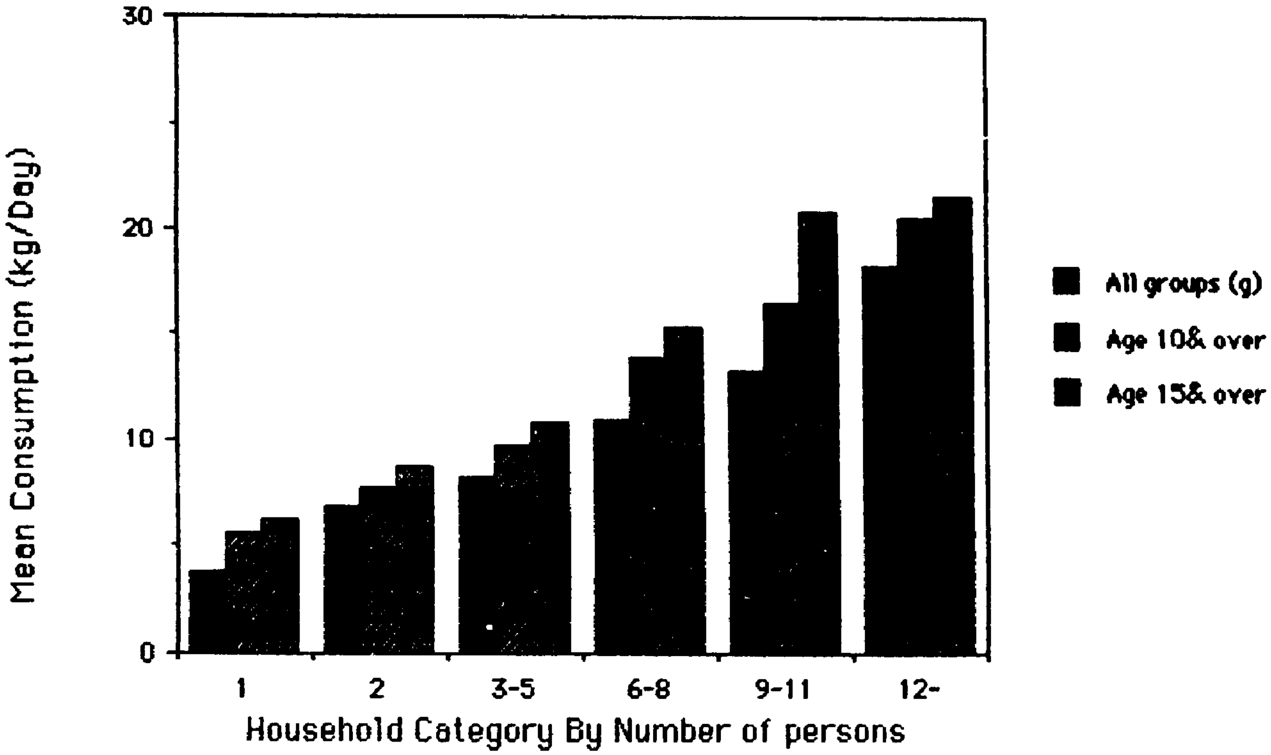


Figure 14-2: Age Category and Domestic Consumption of Woodfuel

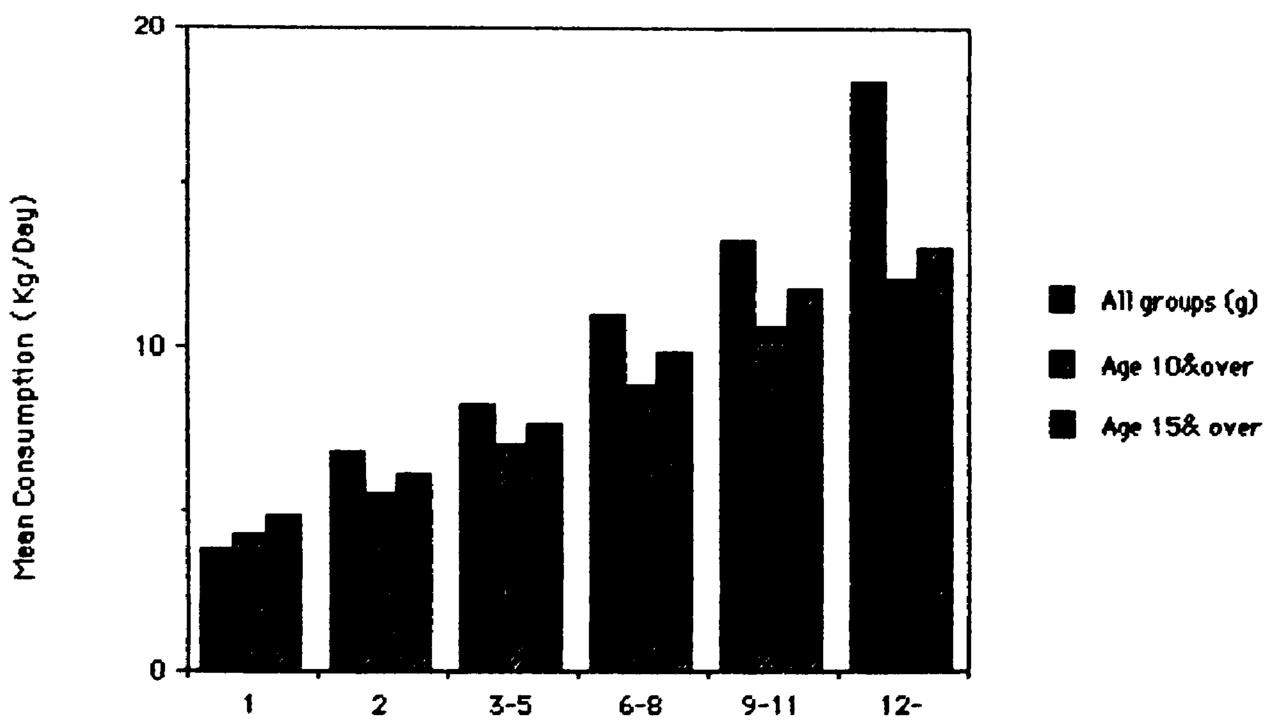


FIGURE 14-3 : AGE-GENDER AND GROSS CONSUMPTION OF WOODFUEL

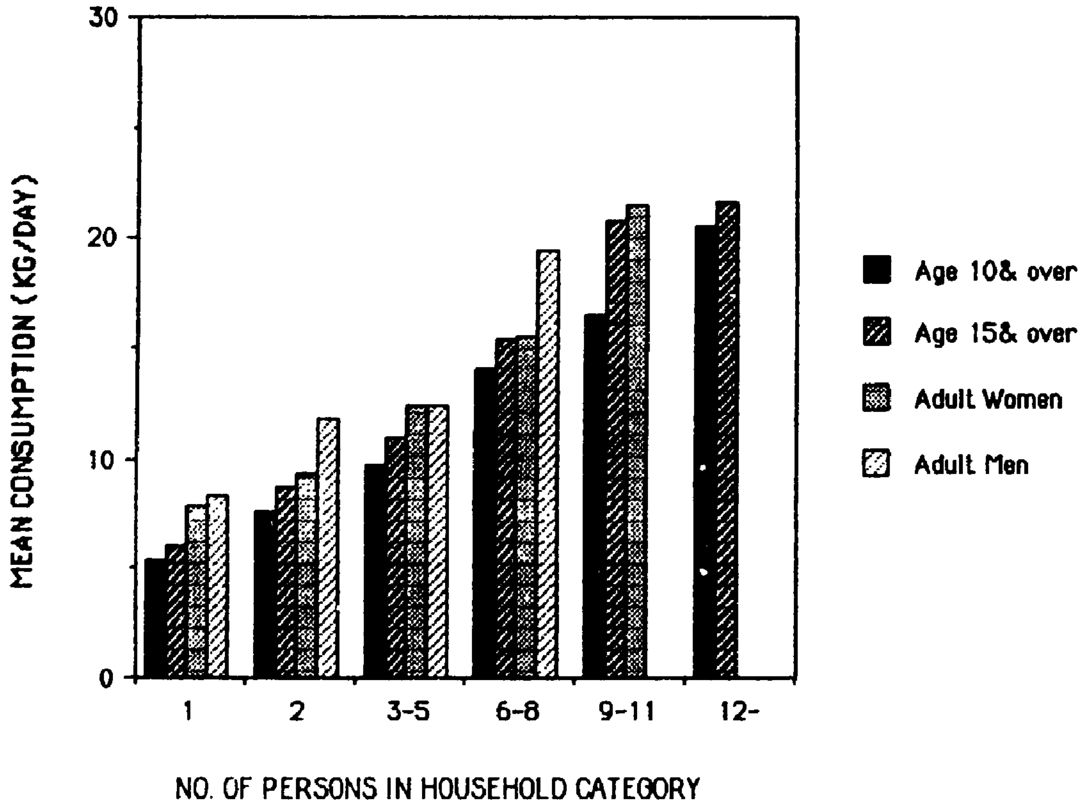


FIGURE 14-4: AGE GENDER CATEGORY AND DOMESTIC CONSUMPTION OF WOODFUEL

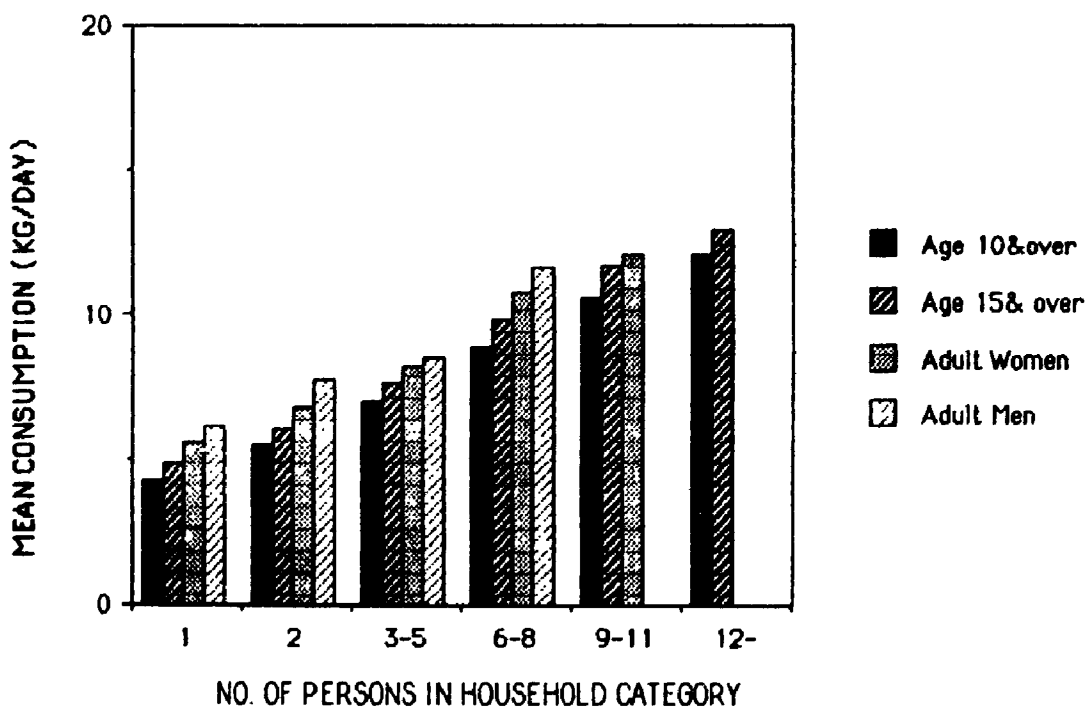


Table 23: Size-Class Distribution of Households and Firewood Consumption

Area/ Village	Size-Class (number of (People per Household)	No. of Households in Size Category		Mean Daily Gross Use (Kg)	Mean Daily Domestic Use (Kg)
All 3 Villages		All -	360	10.24	7.1
	1 Person		15	3.76	3.76
	2 People		25	6.72	4.6
	3 - 5 People		133	8.19	6.14
	6- 8 People		115	10.95	7.44
	9- 11 People		42	13.27	8.78
	12 and over		30	18.26	11.01
Teacher-Mante		All-	128	9.1	6.66
	1 Person		7	3.63	3.63
	2 People		14	5.47	4.37
	3 - 5 People		49	7.8	5.83
	6- 8 People		35	9.9	7.39
	9- 11 People		13	11.91	8.53
	12 and over		10	18.02	11.1
Tontro		All-	80	13.37	7.68
	1 Person		3	4.2	4.2
	2 People		6	9.86	4.78
	3 - 5 People		24	9.43	6.46
	6- 8 People		23	14.1	7.89
	9- 11 People		14	16.3	9.2
	12 and over		10	21.86	10.8
Okrakwadjo			152	9.55	7.14
	1 Person		5	3.67	3.67
	2 People		5	6.45	5.03
	3 - 5 People		60	8.02	6.27
	6- 8 People		57	10.35	7.29
	9- 11 People		15	11.62	8.61
	12 and over		10	14.91	11.14

Based on 360 Continously Occupied Firewood Consuming Households
SOURCE: FIELD DATA

0.49 for gross (0.75 for domestic), but increases to 0.51 (0.83 for domestic), when households with occupants from 10 years of age are considered. This difference seem to be accounted for mainly by the inclusion of households previously cut off by the age limit of 15 years and above, and where incidentally, the use of woodfuel appear rather to be more intense. This pattern of high positive relationship between age groups and wood use, is repeated in all the individual settlements, indicating that the more the adult composition of households the more will be the amount of wood used (Table 22).

The effects of age-structure on households is important because, generally, the decision to use wood for certain functions rests with the adult segment, even though wood collection involves minors as well. The age group of 10-14 also has tremendous influence on general wood use. At that age, most children, and especially girls, are expected to partake directly in all aspects of household chores, including cooking. They are mostly the users of wood for the greater part of the day when the non-school going segment is working on the farm or away from home.

Figures 14-3 and 14-4 explore the combination of gender and age influences on household consumption of wood at the gross and domestic levels, respectively. A high positive relationship exist between specific gender influence at both levels of wood use with female-majority homes generally displaying relatively high *r* values, stronger still at the domestic level (Table 22, Figure 14-3 and 4).

Possible reasons for a higher use of woodfuel by females include the fact that, i) women generally have control over domestic matters in most traditional homes, such as decisions to cook, nature, type, and manner of cooking. Girls are generally coopted to such specialised function at an early age, and ii) women and children tend to be in the house longer than males during a normal working day because of domestic related duties and/or commercial operations.

Male-majority households generally fall below female-dominant homes in terms of wood use (r values) even though differences tend to be slight. In Figure 14-3 and 14-4 for instance, it is indicated that the influence of the female factor become marked only with larger households. Among reasons why wood use in male-majority homes do not fall so low as the r values seem to portray are that, even though men are usually away from the house for most of the day, they are supplied with food from the house, especially, in new farms or other work places where foodstuffs are not available. Also, in most homes, the presence of adult working males make it obligatory for regular cooking of some quantity and quality even if the female head would have preferred otherwise.

Comment

Even though age-gender variables have significant positive effects on the nature of wood use, the manner in which this occurs is not clear-cut. For example, Teacher-Mante, which places third on the consumption scale, has the highest proportion of adults. On the other hand, Tontro which places first on the mean per household consumption scale, has the lowest proportion of adults (Tables 8, 18 and 23: also, Figures 12, 14-3 and 14-4).

Evidence from the preceding analysis shows that even though a combination of age-sex structure and household size provides a useful means of projecting woodfuel use, these factors do not help to explain sufficiently, why between homes of similar size and age-sex distribution (within same village), differences in consumption exists. Further investigation into other sources of consumption trends is necessary, particularly an examination into the nature of woodfuel use.

Woodfuel Use structure

Variables under the category of use structure are represented by numbers vi to xii in Table 22, which are grouped for the analysis in this part of the chapter, under firewood use type, meals per unit time, commercial operations and frequency of commercial operations.

Firewood use type

As introduced in the previous chapter, firewood use is distributed between domestic and non-domestic categories. The distribution of firewood use type is significant to the extent that, it provides a useful clue to differences in wood consumption between households, especially, where such differences are mostly attributed to whether certain households use wood for only domestic or commercial activities or both, in which case, variations in quantity used, will occur. Households combining commercial activities with domestic activities will generally demand more wood than those using wood for domestic purposes only.

In terms of domestic uses, it has been demonstrated elsewhere in the text that, relatively small variation exists between and within households in the villages (Tables 18 and 23). It can, on the other hand, be deduced from Tables 18 and 22 that a greater proportion of

TABLE 24: Firewood Use: Significance of meal purchase, Wood sales, Tastes and preferences
(By No. of Households)

INDICATOR QUESTIONS	VILLAGES BY APPROPRIATE NUMBER OF HOUSEHOLDS			
	TEACHER-MANTE	TONTRO	OKRAKWADJO	ALL VILLAGES
1. BUY OUTSIDE MEALS (*VALID HOUSEHOLDS ONLY)				
To conserve woodfuel	-	-	11 (6.9%)	11 (3.0%)
Food shortages	59 (45.4%)	11 (13.6%)	62 (39.0%)	132 (35.7%)
Cooking time constraints	40 (30.8%)	41 (50.6%)	39 (24.5%)	120 (32.4%)
Do not buy outside meals	31 (23.8%)	29 (35.8%)	47 (29.6%)	107 (28.9%)
2. STATUS OF WOOD FOR SALE (WOOD PURCHASING HOUSEHOLDS ONLY)				
Quality available to buy	13 (30.2%)	8 (100%)	16 (28.6%)	37 (34.6%)
Quantity available to buy	32 (74.4%)	7 (87.5%)	28 (50.0%)	67 (62.6%)
Prices too high	36 (83.7%)	2 (25.0%)	51 (91.1%)	89 (83.2%)
3. TASTES AND PREFERENCES (BY FUELWOOD USING HOUSEHOLDS)				
Some preferred species	94 (72.3%)	71 (88.8%)	96 (62.7%)	261 (72.3%)
No preferred species	34 (26.6%)	9 (11.2%)	57 (37.3%)	100 (27.7%)
4. CURRENT ACCESS TO PREFERRED SPECIES (HOUSEHOLDS WITH SOME PREFERENCE ONLY)				
DO GET	32 (34%)	42 (51.9%)	25 (25.8%)	99 ((37.8%)
DO NOT GET	62 (66%)	25 (48.1%)	72 (74.2%)	163 (62.2%)

SOURCE: FIELD DATA

* VALID HOUSEHOLDS - CONTINUOUSLY OCCUPIED HOUSEHOLDS

consumption variations can be attributed to non-domestic (commercial) uses. For example, while the r value between domestic use and total wood consumption for the villages is 0.32 (p=0.000), the r value increases to 0.68 when firewood use type applies to both domestic and non-domestic uses (gross). This relationship indicate that the more households use wood for commercial activities, the more will be the total demand for firewood.

At Tontro, slightly over 65 per cent of the households use wood for both domestic and commercial purposes, while the percentages for Teacher-Mante and Okrakwadjo are 45 and 34 per cent respectively. Because Tontro uses the most wood per household, this result appears to imply that, settlements with larger proportions of households using wood for both domestic and non- domestic purposes will use more wood compared to those who do not. Proportionally, however, Teacher Mante has more households using wood for commercial activities than those at Okrakwadjo but Teacher-Mante is third among the three villages in terms of wood consumption at all use levels.

While the above analysis shows the importance firewood use type in over-all consumption, it overlooks the importance of specific category and/or within category uses of woodfuel as crucial variables for planning purposes. In addition to this point, a general consideration of firewood use type suffers the same disadvantages noted for the preceding variables in that, as univariate factor, it fails to provide comprehensive account for all the dynamics of consumption noted in the previous chapter. Following, is a critical review of specific category use of wood, comprising, domestic food and food related (meals) and, commercial uses.

Meals per unit time-(Domestic food and related activities)

In all cases, meal and meal-related activities constitute the most common use of woodfuel in the villages. In general, it may be concluded that since every meal involves some use of woodfuel, the greater the frequency of using wood for meal preparation and/or meal-related activities per unit time, the more wood that will be required. From such a basis, households or villages with a higher frequency of cooking, will tend to use more wood than those cooking less per unit time.

For the study villages together, as many as 59.3 per cent (220 households) cook two meals a day. The median figure of two meals per day apply to each individual village as, Teacher-Mante, 61 per cent (79 households), Okrakwadjo, 60 per cent (98 households) and Tontro 55.5 per cent (45 households). Tontro records the highest percentage of households cooking three meals per day at 40 per cent, with Okrakwadjo the least, at 19 per cent. For Okrakwadjo and Teacher-Mante, it can be concluded that because relatively fewer meals are cooked per unit time, any future increases in meal preparation with woodfuel, will result in increased demands for wood.

It should be pointed out that, the preceding figures only represent average conditions. In homes with several adolescents and/or women of marriage age for example, several meals will be prepared outside the normal household meals to suit particular tastes and preferences, or cook to quality standards for a suitor/official boyfriend. In such homes, there can be as many as 6 independent cookings per day. On the other hand, in other homes most cooking is done in a group and/or purchased, rather than self-cooked.

With r values of 0.23 (p=000) for gross use, and 0.41 (p=000) for domestic uses only, a significant positive relationship exist between meals per unit time and wood consumption, indicating that as the number of meals prepared per unit time increases wood consumption increases. However, Tontro which is the highest consumer of wood per capita, records the least significant association, while Teacher-Mante, the least per household consumer, the strongest association (Table 22). The number of meals per unit time can therefore only provide a surrogate measure of wood use for domestic purposes, but not adequately for gross levels of use.

At this point it is important to introduce certain crucial factors that influence the number of cookings per unit time, as a means of i) determining future changes in such factors which tend to be dynamic, and ii) as means of determining the relationships between meals and wood use. These factors include;

Food Availability

Among the leading explanatory factors for the relationship between meals and wood use is food availability. As indicated by Table 24, as many as 71 per cent of households in the study villages purchase outside cooked meals at some point in time. Reasons for such purchases differ between villages. About 36 per cent of households cite home produced food shortages as the main reason for purchasing outside cooked meals, while 32 per cent cite time savings on cooking. The highest percentage citing food shortages are found at Teacher-Mante and Okrakwadjo (above the study villages average of 36%). It is inferred from the above information that, difficulty in obtaining raw foodstuffs, account for the fewer number of cooking per day in those two villages and for that matter, the lower amount of wood used per household, compared to Tontro (Table 24). Food shortage was actually a recurring message in most households at Okrakwadjo and Teacher-Mante during the study. It can also be asserted that if future food production improves, most households will increase the number of cooking per day to three which in turn will affect the quantity of fuel needed.

Nature of Dishes

Another important factor affecting woodfuel use is the nature of the meal (dish). In the study villages, a wide range of dishes are derived from a variety of foodstuffs. Some of the most common dishes are prepared from maize, cassava, yams, plantain, cocoyam, rice.

Generally, the property of raw foodstuff in terms of boiling time and the complexity of the dish in terms of stages of preparation and/or combination food items in the dish, will influence the amount of wood required. For some specific case examples, palm soup (soup made from boiled palm fruits- described in Ardayfio-Schandorf, 1986) can take up to 1.5 hours of fuelwood cooking time to prepare because, it involves two intensive (cooking) stages. On the other hand, light/plain soup with water as the main medium, will just take up to 45 minutes cooking time, because, it involves only one stage of cooking. Note also that, woodfuel use time expressed here applies only to the cooking process and does not refer to some ancillary preparations such as grilling and/or frying fish and meat before use in soups or boiling side vegetables such as okra for use in or with soup.

Some corn meals also take longer time to cook because, they usually involve more than one stage, including accompanying stew or soup. The most demanding in this sense is "kenkey" (prepared from fermented corn dough). It may take over 2 hours cooking time for the finishing stage but the whole process can span over 4 hours. However, kenkey is mainly a commercial product so that most users go to the market place. Meals from plainly boiled food items ("Ampesi"), such as from plantain, yam, cocoyam or cassava generally take a lesser boiling time of between 20 and 45 minutes depending upon whether the accompanying sauce/stew is ready.

It is emphasised again that, there are transition periods between stages of food preparation where one stage is switched on to another but fires are usually kept burning to wait for the next stage. Transition periods are capable of adding up to 30 minutes to effective wood use time in some cases, making for wastes. The greater the number of stages, the greater such potential losses from transition periods.

In most households, more than one earth stove (cooking stove) will be found. These are used alternatively, or use switched between indoor and open cooking facilities depending mainly on weather conditions and some special circumstances such as the location of a barn. Multiple earth stoves are used in some households to reduce or eliminate transition periods for cooking some dishes and to save time. At the village of Tontro, the relationship between earth stove and wood use is not statistically significant in terms of r values. It is, however, significant at both Teacher-Mante and Okrakwadjo (Table 22). Probably because, relatively small amount of wood is used currently at Teacher-Mante and Okrakwadjo, compared with Tontro, any future increase in the number of stoves per cooking, will lead to increased demand for woodfuel.

Considering preceding information, the use of multiple stoves appear to be related to the demands of specific meals. To this extent, the degree with which more than one stove will be used at a time, depends upon the regularity of use of particular meals. Meal specialisation between households however, has greater ethnic implications (which ultimately, reflects ecological differences of ethnic origins).

Ethnicity

While all kinds of dishes are available in all villages, traditionally, certain ethnic groups had specialised in the use of certain food items/dishes. For example, the Ewe people in the area (originally from the Volta region of the country), consume many dishes made from maize and cassava; the Gas (originally from Greater Accra) specialise with kenkey (from maize); while the Akans, mostly native to the area, use the tubers and plantain for "fufu" or "ampesi". At the village of Okrakwadjo for example, the Ewe group (about 30% of the population) use a mean of about 6.2 kg of wood per day/household for domestic purposes while the village domestic mean is 7.14 kg per day/household. The figure among the Ewes is likewise below the village average at Teacher-Mante, at approximately 6.4 kg/day/household as against 6.7 kg/day. This trend is similar at the village of Tontro The differences in wood consumption mainly come from meal specialisation. Even though households appear homogeneous in terms of meals per unit time, ethnic specialisation account for differences in wood use due to the different demands of fuel for particular dishes.

It should be stressed however, that, strict association between ethnic groups over dishes is becoming unimportant. There is a tendency towards cultural homogeneity in general, and in particular, with regard to food uses, because of such factors as intermarriages, long-term acquaintance, demonstration effects, acculturation, convenience, relative access to food, and changes in food cultivation environments. Between and within villages, the question of ethnic composition and meal types become redundant to some extent since almost all the villages have multiple ethnic groups.

Even though there is a significant relationship between frequency of meals per unit time and wood demands, such domestic uses of wood alone, fail to account for total household uses of wood, especially, when non-domestic uses have to be considered.

Commercial use of wood

Commercial use of wood has been identified as a major source of variation in gross uses. Considering total commercial consumption figures, the relationship between commercial use and gross household uses results in a high r value of 0.94 (p=000) implying that, commercial activities form a considerable proportion of total wood demands at the household level. Households with more commercial operations will thus tend to use more wood than those with little or no commercial activities. Such gross considerations of commercial uses of wood however denies information on within-sector uses, which are more crucial for planning purposes. For example, Table 19 indicates several activities under commercial uses with different potentials of wood demands. A detailed analysis of specific commercial uses will potentially provide some valuable clues to existing variations and major contributions to over-all gross uses of wood.

By definition, major commercial activities take more wood per operation so that if there is a large concentration of such operations in a village, it will lead to increased total use of wood. At a general level of observation, Tontro makes the most use of wood per household among the villages because of the presence of many major commercial operations (Table 19). Therefore, the hypothesis that a higher presence of major commercial activities will lead to higher gross use of wood, stands valid for Tontro.

<u>Statistical Significance of commercial categories</u>

The relationship between major commercial and total household use of wood gives an r of -0.059 (p.=0.32) and for minor commercial activities and total uses of wood, an r of -0.56 (p=0.27) for the villages combined. The probability values of these r figures indicate that there is no significant association between specific commercial category use type and total consumption of wood in the villages. However, at Teacher-Mante, r values for domestic uses indicate a significant negative relationship, which is interpreted to the effect that, as wood demands for major commercial activities increase, demands for domestic activities decrease. It is possible that due to relatively small number of major commercial activities here, any increase in major commercial uses of wood will reduce demands for domestic uses. On the other hand, a significant positive relationship at the domestic level at Tontro suggests that, increase in major commercial operations will probably provide more surplus wood for domestic purposes.

Comment on commercial operations

Only 66 of 371 surveyed households (17.8%) use wood for major commercial purposes thus, the influence of that commercial category type appears weak in the individual villages. However, when all 167 commercial operation households in the study villages are considered, a high positive association is seen to exist between commercial and gross uses of wood. In conclusion, since commercial activities contribute about 31 per cent of all household uses of wood (chapter V), commercial activities are important indicators of wood consumption patterns and any increase in commercial ventures will lead to more demands for wood. A missing link which will potentially offer explanation to the weak r values for category uses, may be traced to the regularity of operations per unit time.

Frequency of commercial operations per unit time

Information on the frequency of commercial operations per unit time, is capable of helping to determine the possible contributions of various commercial activity types to total uses of wood. Commercial activities in the study villages show different patterns of operation, ranging from daily to seasonal. It is expected that, the greater the frequency of operation per unit time, the greater will be the contribution to gross household uses. The field information indicate that there is a high direct relationship between operation days and consumption in all the villages, implying that as the frequency of use of wood for commercial activities increase, there is an increase in household consumption of woodfuel. The frequency of commercial operations per month is highest at Okrakwadjo, and lowest at Teacher-Mante (Table 20). An r of 0.54 (p=000) exists between operation days and gross consumption for the villages together (Table 22). This association is significant in each village for total household use, with Okrakwadjo showing the strongest positive association (0.63, p=000), followed by Tontro (0.6, p=000), and then Teacher-Mante (0.55, p=000). However, it is only at the village of Okrakwadjo that a significant inverse relationship is indicated at the domestic level, implying that as the frequency of commercial operations increase, less wood is available for the domestic sector.

Comment

With a high degree of influence of frequency of commercial operations on gross wood consumption, it is possible that changes in future commercial use of wood in the area will have tremendous impact on wood requirements. Standing as an independent variable, however, frequency of operations fails as a comprehensive explanatory factor of wood consumption in the area. For example, in the same village with households of the same commercial operation system, consumption of wood can differ for such simple reasons as differences in product type, scale of operation and pattern of operation. Other factors need to be explored to augment the search for explanation to consumption trends in the area.

Wood Supply system

The wood supply component of village fuel systems comprises factors labelled as xiii-xvii in Table 22, which are made up of bundles of wood collected per unit time, primary source of wood, occupation, farm tenure and distance to source of wood. These variables are analysed below.

Bundles of wood collected/unit time

The amount of wood collected per unit time by each household, has complex connotations, ranging from socio-economic to ecological factors. Generally, household energy use behaviours are influenced with quantity of wood available per unit time, and/or a perception of relative difficulty in obtaining wood for effective use. In most cases, households that return fewer amounts of wood per unit time because of a general problem of obtaining wood (for such reasons as distance, physical demands in preparing and transporting wood, tight family budgets, or scarcity in farmlands), tend to use wood under controlled circumstances unlike homes with unlimited access where use may be liberal.

For the study villages, a high r of 0.71 exists between bundles collected per unit time and gross consumption (Table 22). The relationship is highest at Tontro with an r value of 0.95 (p=0.000), and lowest at Okrakwadjo (r of 0.28, p=0.000). The high positive r values between wood consumption and amount of collected indicate that as more bundles of wood are collected more wood is used. To explain possible sources of such disparities, it is found that, households at Tontro return a mean of approximately 15 bundles of wood/month while at Okrakwadjo, only 6.2 bundles/month are returned (Table 13). This finding seems to be consistent with the high per capita use of wood at Tontro.

For domestic uses, r values in each of the villages are in the order of r=0.5. This fact implies that, even though a high positive association exists between wood availability and use, relative abundance as a reason, is insufficient in predicting consumption at the domestic sectoral levels, particularly with regard to those activities with similar functions. For example, Tontro's high 15 bundles/month does not really reflect its r value of 0.54 for domestic consumption. On the other hand, Teacher-Mante with only 7.3 bundles month can be said to have a much improved r at approximately 0.59 for domestic purposes (Table 15). Thus, at Teacher Mante, it is probable that more wood will go to domestic purposes if future supplies improve.

Available wood for use may be viewed in terms of demands across specialised household functions. It is possible that certain households produce more wood than others but because of demands for several competing functions, shortages occur. At Tontro for example, a greater part of available wood are used for commercial activities, so that by and large, domestic needs tend to be subsidiary. At the other extreme, most efforts at Okrakwadjo tend to be directed towards gathering enough wood for domestic uses. Commercial uses in this village depend mainly upon purchases.

Comment

Households that collect the most amount of wood, tend to use the most woodfuel. However, just as in the preceding discussions, wood collected per unit time may be a limited factor in predicting overall consumption. It erroneously assumes that there are no other means of acquiring wood except from own collection or that, there are no immediate alternatives to firewood (such as charcoal). The reality in the study villages, however, is that, few households purchase woodfuel. Those who buy, do so for commercial purposes. Users of charcoal are few (Table 12), and they regard charcoal use as temporary. Own collection provide an average of up to 90 per cent or more of household wood (Table 12), hence the importance of collecting sites in terms of wood availability to ensure adequate bundles of wood are collected. The factor of quantity of wood collected per unit time however suffers the limitations of all other independent factors in terms of lack of comprehensive explanation to the complex nature wood consumption patterns in the study villages.

Primary source of wood

A primary source of wood, for the purpose of this work, refers to any source(s) providing at least 75 per cent of regular wood needs. The source need not be directly related to vegetation, since the market place in some cases, is the primary source of wood for some households (Table 12). It is expected that villages with high proportion of households with regular, free, and abundant supply source will generally tend to consume more wood than those with supply problems in terms of availability at collecting site and/or monetary constraints.

At the combined village level, primary source of wood, as an independent variable, barely emerges as a significant factor explaining wood consumption (Table 22). In the individual villages, however, primary source of wood is a fairly significant factor at Okrakwadjo and Teacher-Mante at the gross level only, and significant at the domestic level at Tontro on an inverse basis. Okrakwadjo shows the highest r and p values, suggesting that the association is strongest there. A major reason for this is the fact that Okrakwadjo has the lowest proportion of households whose primary source of wood is their own property (Table 22). Since own property is the most significant primary source of wood in all the villages, this implies that at Okrakwadjo, primary sources are generally insecure, in terms of free access and/or ability to buy, hence the relatively small amount of bundles of wood collected per month (Table 13).

It appears that households at Tontro enjoy uniform access to wood, unlike Okrakwadjo and Teacher-Mante where greater requirements for secondary sources of wood probably mean that current primary sources are becoming unreliable. The positive relationship between bundles collected and amount consumed at Okrakwadjo and Teacher-Mante suggests that <u>it is possible for wood consumption to increase when more free (primary) sources of wood</u>

become available. Such supply improvements need not come from owned sources only because, owned sources will not guarantee adequate wood supplies if land has already been degraded. Woodfuel may also come from the market place (Table 12).

Comment

Households who control their primary source(s) of wood tend to collect and use more wood. It is noted, however, that control of primary sources will not guarantee adequate supply of wood if the source eventually become depleted of wood. The market place is also a perfect source provided costs can be met and/ or wood is available when needed. In light of preceding information, primary source of wood, as an independent variable, cannot adequately explain wood consumption trends in the study villages.

Occupation and wood use

In most cases, residents whose main occupation is farming are likely to generate more wood at no cost for use while those in non-farming occupations may have difficulty in accessing wood. Use levels are therefore expected to be greater for farmers than residents in other occupations. A reference to Table 22, however, gives mixed signals. It is shown that r values for occupation are fairly significant at both the gross and domestic levels at Teacher-Mante only. At Tontro and Okrakwadjo, it is significant only at the gross level. The relationship is strongest at Teacher-Mante and lowest at Tontro. This finding generally indicate that a high number of farming househo ls account for a high use of woodfuel.

Even though Teacher-Mante has the highest percentage of farmer-households of all the three settlements, it is the village which records the least per capita household consumption of woodfuel. Farming alone therefore cannot explain the fairly high r value for occupation and wood use at Teacher-Mante. The key to Teacher-Mante's situation, and probably that of Okrakwadjo, is that even though the farming population is high, there is a greater diversification of occupations in terms of absolute number of households, compared to Tontro for instance (Table 9). Therefore, when some members of the household are in farm, others are elsewhere pursuing other occupations, with the result that general use of wood, especially, for domestic purposes, is lower. In both settlements, it is the female component, who collect the most wood who are also engaged in secondary occupations. A reduced collection entail shortages or purchasing. Occupation seem to be least significant at Tontro, probably due to the fact that, irrespective of occupation type, the highest proportion of households collect wood for free and so wood consumption is almost equal across occupation types. Generally, occupation may not be a major determinant of access to wood/wood consumption, particularly, where wood is plentiful or where wood is depleted and the market place provides the main source.

It may be emphasised that the potential for farming households to generate cheap and plentiful wood can be impaired through depletion at collecting sites. On the other hand, households in regular wage employment (or lucrative commercial operations) may possess the financial capability to go to the market place for consistent supplies such that, future forecasts of wood consumption need not rely on occupation structure, but also influence of other related factors.

Comment

Generally, villages with a large proportion of farming households will tend to use more wood than those with more non-farming households. This finding however has limited validity since in any single household, occupation can be varied, and wood used may depend upon the nature of occupations.

In villages with relatively equal access to wood, occupation has little effect on access to wood and its use, provided that the ecosystem is able to provide adequate wood. In light of the preceding information, future forecasts of wood consumption need to consider the influence of other factors, in addition to the effects of specific village occupations.

Land ownership (Farm tenure)

If farming is recognised as an important factor of wood generation in the villages, and if people are in a position to generate abundant and free wood for use, then farm tenure type is equally important. According to Table 22, however, farm tenure is inversely related to use at the domestic level.

For individual villages, while Teacher-Mante shows a fairly significant inverse relationship at the domestic level, Tontro shows an inverse relationship at both the gross level and domestic levels. For the villages of Teacher-Mante and Tontro, it may be interpreted that as more farmers own their land, less wood will be available for use. On the other hand, Okrakwadjo's fairly significant positive association at the gross level shows that if more farmers own their land more wood will be available for use. At Tontro and Teacher-Mante, probably because a large proportion of households already control their own farm holdings and because present tenurial arrangements seem to suit adequate access to wood, as practical as possible, any future changes in farmland ownership will rather lead to decreased access and use. Evidence from the field indicated that, relatively easy arrangements can be made to obtain wood free of charge, irrespective of type of land ownership or control, especially, at Tontro.

On the other hand, at Okrakwadjo, farm tenures are of the type that leave many farmers with inadequate sources of wood. Increasingly therefore, access to wood is deteriorating in the wake of shrinking sources of farmland in that village. There is therefore a high positive association between tenurial types and consumption, suggesting that, if more households control their sources of wood, use levels will increase.

Comment

Farm tenurial types that ensure adequate access to wood, tend to lead to increased consumption of woodfuel. Such a finding will be valid only if other factors are present, especially, a practical walking distance to such farms to ensure that adequate wood can be returned to the home when required.

Distance to source of wood

It is argued that where household members have to commute over a greater distance to collect wood, both frequency and the bundles of wood returned per unit time will be lower, because of the heavy demands in time needed to collect and the effort to transport wood. In the main therefore, where principal sources of wood are closer to the settlements, more wood will be collected and used per unit time. For example, probably because Tontro lies closer to its main sources of wood, households in that village are able to collect and use the highest amount of woodfuel per unit time. On the other hand, probably the smaller amount of wood collected at Okrakwadjo per unit time, can be accounted for by the relatively longer commuting distance (Tables 13, 18 and Figure 13).

Statistically, the relationship between distance and use of wood for the combined villages is significant only at the domestic level. In the specific villages, Okrakwadjo indicates a positive relationship at all levels, Teacher-Mante, barely at the domestic level, while it not significant at all at Tontro. It must be considered that at the gross level of wood use, the pattern of wood acquisition become more diverse, especially when non-domestic uses are considered. For example increasing number of households get their commercial wood needs right in the settlements through purchases and are therefore not affected directly by the distance factor. However, since most people collect their own wood for domestic purposes, the distance factor is more important in that context.

Comment

Villages that are closer to their sources of wood tend to consume more wood than those who have to walk longer distances for wood. In villages where wood collection is not dominated by one or few major supply source (s) type(s), the distance factor will not be significant. For example, if some households purchase wood within the settlement, distance consideration is irrelevant.

Summary Findings on Univariate Analysis

The summary findings for the first stage of the analysis considers all the variables discussed independently. From the preceding analysis, the pertinent findings include the following;

i. as household size increases amount of wood used increases. Any interpretation of high positive r values between household size and use of wood should be made with care. For example, household size usually does not have direct influence on commercial uses of wood, because where much wood is used for commercial purposes, especially in large homes, and this combines with domestic uses, the impression will be given that the larger household size account for the higher use of wood. Even at the domestic level, changes in wood consumption with changes in household size have been demonstrated to be marginal, for, domestic activities tend to be uniform in wood demands and repetitive over time in the study villages, and relatively small amounts of wood are gained or lost with changes in household size.

ii. the more the adult constituents in a household, the more the amount of wood consumed. This finding will generally be stronger with domestic use of wood where age and number of adults are usually important for routine household decision making. When Commercial uses are considered, the number of adults become less important compared to the type of commercial activity.

iii. a high positive relationship exist between gender and wood use with female-majority homes generally displaying relatively high r values which are stronger at the domestic level. Information in the text and that provided in Table 22 and figures 14-3 to 14-4 indicate that such differences are not great between the sexes. For example, in households of up to 8 adult constituents, adult males show greater amount of wood consumption than household with adult women up to the same number of occupants.

iv: the greater the use of wood for both domestic and commercial activities, the more the quantity of wood demanded. It is possible however that, depending upon the intensity of wood use and/or frequency of operations, commercial activities in some households, will demand more wood than combined demands of domestic and commercial activities in other households. On the other hand, some large households will use more wood than some small households combining domestic and minor commercial use of wood.

v. the greater the number of commercial ventures, the higher the total use of woodfuel. However, when commercial activities are categorised into major and minor, their influence become less significant in total use of wood. This trend is probably because of the relatively small number of ventures under each category to make any significant impact on total consumption of wood.

vi. the greater the frequency of commercial operations per unit time, the greater is the contribution of commercial ventures to gross household uses of wood. However, due to differences in the intensity of commercial operations in terms of wood use, final product, and scale of operation, frequency of commercial operations cannot provide detailed account of wood use at the household level.

vii. the more the amount of wood collected for free the more the amount of wood consumed. There are several constraints with such finding. For example, there is no recognition for the importance of wood purchases, especially, for commercial purposes, which tend to increase the total amount of wood used in some homes. It also does not recognise the long term prospects of other fuels, including charcoal. The amount of wood collected does not necessarily help to predict the amount of wood used per unit time for, it may be less or more than actual needs.

viii. the more households control their primary source(s) of wood the more wood they will collect and use. This finding will be completely valid only if such sources are capable of supplying continuous and adequate wood. Also, provided that costs can be met, the market place is a substitute for self-collection. In most cases, primary source of wood will tend to be a significant factor at the gross level of wood use, rather than at the sectoral level.

ix. the longer the distance to wood collection sites, the less the amount of wood consumed per unit time. In villages where wood acquisition is varied and not very dependent on self-collection, the distance factor will not be significant. For example, if some households purchase wood within the settlement, the distance consideration is irrelevant. Furthermore, distance covered for wood collection will be determined by location of property (where restrictions on access to land resources exist) more than an effort to minimise time and effort needed to cover longer distances for wood.

The preceding analyses indicate that, household consumption of wood is a complex process. No one variable provides sufficient explanation for it to be used as a surrogate for, or to predict consumption trends. The aim of the next section to attempt to predict the effects of variables in explaining wood consumption on a composite basis.

3. A Multivariate Analysis of Consumption Trends

Introduction

The second stage of the analyses on woodfuel is based on multiple regression tests on woodfuel use both for the composite and individual villages. This is intended to help predict the relative influence of each independent variable among the many analysed in the preceding section, on wood consumption. This has an advantage over r estimates or bivariate linear regression equations which match only one independent variable against consumption at a time. Standing freely as independent variables, the influence of some variables are either exaggerated or depreciated because of apparent r and/or p values. It is statistically difficult to tell the relative importance of each variable under such independent treatment since the values cannot be compared. Norusis (1983, p.154) has stated that a multiple regression model "assumes that there is a normal distribution of the dependent variable for every combination of the values of the independent variables in the model". Because several of the variables identified have various levels of applicability in the settlements, their variances will differ so that, not all combinations can attain a normal distribution of the dependent variable (consumption).

A "step wise" (forward) multiple regression test is adopted for the analysis. This provides an optimal compromise by helping to detect the most significant variables of explanation to consumption. This regression model considers variables of significance for entry into the regression equation at every step. Variables that do not meet significant requirements for the equation are not accepted (Table 25). All variables used for the r tests and indicated in Table 22, were used for the "Step-Wise" multiple regression tests.

Result of the Stepwise Multiple Regression Tests

Procedure for reporting and explanation

The results of the Multiple regression tests are provided in Table 25. The result covers both the gross and domestic levels of wood consumption for the villages, together and individually. Variables that emerged as commonly significant for both gross and domestic uses and/or uniquely affecting either sector, are considered as principal composite explaining factors of wood consumption in the villages and are subjected to further discussions. The significance of variables between and within villages are assessed using both the multiple regression co-efficient (B), and the standardized values of "B" (Beta) throughout the discussions.

Table 25: Step-Wise Multiple Regression Analysis of Wood Consumption

A. DEPENDENT VARIABLE-DAILY GROSS CONSUMPTION OF WOOD-ALL 3 VILLAGES TOGETHER

VARIABLES IN THE EQUATION

*VARIABLE	B	SE B	BETA	T	SIG T
Fc	340,908.00	0.047591	0.457871	7.163	0.000
Ps	369,702.00	0.056975	0.489060	6.840	0.000
Hs	432,569.00	0.086997	0.307456	4.972	0.000
Bt	551,818.00	0.213829	0.186027	2.581	0.013
(Constant)	2.62	0.999174		2.263	0.010

Adjusted R Square=0.65686
TOTAL CASES = 371

B. DEPENDENT VARIABLE-DAILY DOMESTIC CONSUMPTION OF WOODFUEL-ALL THREE VILLAGES

VARIABLES IN THE EQUATION

VARIABLE	B	SE B	BETA	T	SIG T
Hs	0.230673	0.389700	0.430613	5.9190	0.0000
Women	0.305085	0.820460	0.264451	3.7180	0.0003
Mt	0.420085	0.129708	0.115913	3.2390	0.0015
Bt	0.295990	0.009454	0.105354	3.1310	0.0021
Fc	-0.019267	0.009333	-0.068257	-2.0650	0.0407
Age 10 and over	0.139404	0.070302	0.188490	1.9830	0.0492
(Constant)	3.337135	0.304523		10.9590	0.0000

Adjusted R Square=0.84601
TOTAL CASES = 371

C. DEPENDENT VARIABLE-DAILY GROSS CONSUMPTION OF WOODFUEL-TEACHER-MANTE VILLAGE

VARIABLES IN THE EQUATION

VARIABLE	B	SE B	BETA	T	SIG T
Hs	0.625495	0.064098	0.734129	9.758	0.000
Fc	0.330584	0.055590	0.447387	5.947	0.000
(Constant)	5.379755	0.698097		7.706	0.000

Adjusted R Square=0.76298
TOTAL CASES = 130

D. DEPENDENT VARIABLE-DAILY DOMESTIC CONSUMPTION OF WOODFUEL-TEACHER-MANTE VILLAG

VARIABLES IN THE EQUATION

VARIABLE	B	SE B	BETA	T	SIG T
Hs	0.261562	0.036209	0.480680	7.224	0.000
Women	0.479294	0.061209	0.458570	7.830	0.000
Mt	0.624776	0.186400	0.140361	3.352	0.002
Main occup.	-0.203397	0.073796	-0.092759	-2.756	0.008
(Constant)	3.043711	0.346039		8.796	0.000

Adjusted R Square=0.94044
TOTAL CASES = 130

E. DEPENDENT VARIABLE-DAILY GROSS CONSUMPTION OF WOODFUEL-TONTRO VILLAGE

VARIABLES IN THE EQUATION

*VARIABLE	B	SE B	BETA	T	SIG T
Bt	0.803651	0.053368	0.975306	15.059	0.000
Minor Commercial Act.	-3.047586	1.137594	-0.175527	-2.679	0.017
Ps	1.876761	0.717460	0.169307	2.616	0.187
(Constant)	4.545696	2.040279		2.228	0.041

Adjusted R Square=0.92291

NO. OF CASES = 81

F. DEPENDENT VARIABLE- DOMESTIC CONSUMPTION OF WOODFUEL-TONTRO VILLAGE

VARIABLES IN THE EQUATION

*VARIABLE	B	SE B	BETA	T	SIG T
Hs	0.312192	0.057670	0.559884	0.541	0.000
Fc	-0.127631	0.023816	-0.463481	-5.359	0.000
Bt	0.076783	0.019162	0.314152	4.007	0.000
Minor occup	0.245016	0.104463	0.187451	2.345	0.023
Women	0.318423	0.137856	0.223445	2.310	0.025
(Constant)	3.821316	0.352234		10.849	0.000

Adjusted R Square=0.80071

NO. OF CASES =81

G. DEPENDENT VARIABLE-DAILY GROSS CONSUMPTION OF WOODFUEL-OKRAKWADJO VILLAGE

VARIABLES IN THE EQUATION

*VARIABLE		SE B	BETA	T	SIG T
Fc	0.384316	0.075441	0.646947	5.094	0.000
Hs	0.465315	0.175877	0.335992	2.646	0.012
(Constant)	6.899299	1.929868		3.575	0.001

Adjusted R Square=0.37777

NO. OF CASES = 160

H. DEPENDENT VARIABLE-DAILY DOMESTIC CONSUMPTION OF WOODFUEL-OKRAKWADJO VILLAGE

VARIABLES IN THE EQUATION

*VARIABLE	B	SE B	BETA	T	SIG T
Age 10 and above	0.348170	0.070961	0.510744	4.906	0.000
Mt	0.651417	0.138795	0.230861	4.693	0.000
Hs	0.136947	0.053291	0.276795	2.570	0.014
Bt	0.096455	0.282100	0.225015	3.419	0.001
Freq. of wood collection	-0.049956	0.022835	-0.143406	-2.188	0.034
(Constant)	3.363526	0.330733		10.170	0.000

Adjusted R Square=0.89224

NO. OF CASES = 160

* VARIABLE- Refer Main Text for Details on Variable Codes.

SOURCE- BASED ON FIELD DATA

<u>Results for gross consumption</u> (represented as A, C, E, G in Table 25)

For the combined villages, four variables come out as the most significant. These are, frequency of commercial operations per unit time (Fc), primary source of wood (Ps), household size (Hs), and bundles of wood collected per unit time (Bt). This is represented by a regression equation of Wc=2.62 + 0.340908 (Fc) + 0.38970 (Bt) + 0.432569 (Hs) + 0.551818 (Ps).

Considering the individual villages, household size (Hs) and the frequency of commercial operations (Fc) emerge as the most significant variables explaining wood consumption at Teacher-Mante and Okrakwadjo. On the other hand, factors that emerge as most significant in predicting gross consumption at Tontro include, bundles of wood collected per unit time (Bt), minor commercial activities and primary source of wood (Ps).

<u>Comment</u>

From the preceding results, Teacher-Mante and Okrakwadjo appear to exhibit similar characteristics of wood consumption at the gross level. It is however clear by comparing the Beta values of the multiple regression coefficients for the two villages (Table 25) that, while household size emerges as the most significant variable by Beta value at Teacher-Mante, frequency of commercial operations is the most significant variable by Beta value at Okrakwadjo. This implies that the significance of the variables apply differently in the villages. Tontro emerges as unique over all the applicable significant factors.

While fewer factors explain wood consumption at the individual village level, the range of factors expand when the three villages are combined. The four most significant factors of consumption are clearly split between Teacher-Mante and Okrakwadjo on one side (Fc and Hs), and Tontro on the other (Ps and Bt).

Results for Domestic Consumption (represented as B, D, F, H, in Table 25)

Variables accepted as significant by the step-wise multiple linear equation for the combined villages are, household size, women (W10), number of meals per unit time, bundles of wood collected per unit time, frequency of commercial operations, and size of household with occupants 10 years and above (Age 10 and over-Hs10). The regression equation for domestic uses of wood (Wcd), based on Table 25, can be represented as Wcd= 3.337135 + 0.230673 (Hs) + 0.305085 (W10 +0.420085 (Mt) + 0.029599 (Bt) -0.019267 (Fc) + 0.139404 (Hs10).

In the individual villages, significant factors explaining wood consumption at Teacher-Mante include, household size, women, meals per unit time (Mt) and main occupation (Main occup . For Okrakwadjo, the significant factors include, household numbers aged 10 and over, meals per unit time, household size, bundles of wood collected, and frequency of commercial operations. For Tontro, household size, frequency of commercial operations, bundles collected, minor occupation (Minor occup), and women, emerge as the most significant factors of domestic wood use.

Comparing the individual villages, household size emerges as a significant factor in all the three villages; meals per unit time is significant at both Teacher-Mante and Okrakwadjo; women, at Teacher-Mante and Tontro, while bundles of wood collected per unit time and frequency of commercial operations are significant at Okrakwadjo and Tontro. Main occupation emerges as significant only at Teacher-Mante; age 10 years and above at Okrakwadjo and, minor occupation at Tontro.

Comment

Just as in the case for the gross level, similarity of factors between the villages appear to mask subtle differences in the magnitude of significance of variables within the villages in terms of explanation, when B and Beta values are evaluated. Generally, factors explaining domestic wood consumption are much more broad-based and show more overlaps compared to the gross level. Each village is also unique in terms of particular variables.

Evaluation of Composite Variables

This section of the the second stage of the analysis, critically considers factors that emerged as significant on the composite test of multiple regression. Since the effects of most the variables that emerged as significant have already been discussed in relation to the univariate analyses, only information regarded as prime, and not mentioned in the previous discussions is considered. According to the multiple regression test variables that most explain total use of wood in the villages include:

<u>Bundles of wood collected per unit time</u>

This is the most important explanatory variable by B value. It is in the equation for both gross and domestic uses. For the important reason that self acquisition of wood is the principal means of accessing wood in the villages, the amount of wood collected per unit time can be reasonably used to measure use.

An examination of Table 26, which compares bundles of wood collected with expected consumption, shows a surplus of up to 10 bundles in some households and a deficit of as much as 29 bundles in others. This implies that while surplus of wood exists in some homes, supply shortages exist in others. As expected, Tontro, the highest consumer of wood per household, exhibits the most surplus (with a mean gain of one bundle of wood at a time). In that settlement, amount of wood collected per unit time emerges as the most significant factor explaining wood consumption at both B and Beta values (Tables 25). Okrakwadjo carries the most deficit, of a mean of 2.4 bundles/month, while Teacher-Mante carries a deficit of 1.8 bundles/month (Table 26). Probably because of a large deficit between bundles of wood collected and that required, this variable does not enter into any of the accepted regression equations for Okrakwadjo, unlike the other two villages. At Okrakwadjo, it appears that other sources of wood compete with wood that is self collected to the extent that, the amount which is self-collected is no longer dominant (Table 14).

Table 26 Deviations Between Bundles of Wood Collected and Expected Requirements

**BUNDLES BY HOUSEHOLDS)	STUDY VILLAGES TEACHER-MANTE *	 TONTRO *	 OKRAKWADJO *	ALL THREE COMBINED *
	-13 (1)	-6 (1)	-29 (1)	-29 (1)
	-12 (2)	-5 (1)	-16 (2)	-16 (2)
	-10 (1)	-4 (1)	-14 (4)	-14 (4)
	-8 (10)	-2 (2)	-12 (3)	-13 (1)
	-7 (1)	-1 (2)	-10 (3)	-12 (5)
	-6 (5)	0 (36)	-8 (3)	-10 (4)
	-5 (1)	1 (6)	-7 (4)	-8 (13)
	-4 (12)	2 (20)	-6 (3)	-7 (5)
	-3 (4)	3 (2)	-5 (3)	-6 (9)
	-2 (13)	4 (7)	-4 (11)	-5 (5)
	-1 (5)	6 (1)	-3 (5)	-4 (24)
	0 (41)	10 (1)	-2 (14)	-3 (9)
	1 (8)		-1 (13)	-2 (29)
	2 (14)		0 (63)	-1 (20)
	3 (1)		1 (7)	0 (140)
	4 (2)		2 (4)	1 (21)
			4 (1)	2 (38)
				3 (3)
				4 (10
				6 (1)
				10 (1)
MEAN DEVIATION	-1.76	0.94	-2.42	-1.42
MINIMUM DEVIATION	-13	-6	-29	-29
MAXIMUM DEVIATION	4	10	4	10
STD DEVIATION	3.5	2.16	4.5	3.95
VALID CASES	121	80	144	345

SOURCE: SURVEY DATA

* VALUES IN BRACKET APPLY TO NUMBER OF HOUSEHOLDS

** BUNDLES REFER TO ANY AMOUNT OF WOOD OF 28 KG IRRESPECTIVE OF FORM

Comment

The significance of bundles of wood collected, as a guide to planning, can be both useful and misleading. It is useful because it provides a way of predicting expected consumption levels. It is misleading because, it leads to an erroneous impression that, wherever households are able to collect more wood, they will consume more, and/or that, certain households use less wood because they cannot collect large amounts. It also implies that all wood collected within a specified time is used up completely within that time (or that, quantity of wood collected at a particular time must exactly correspond to needs). Furthermore, bundles of wood collected as it stands, does not consider the potential of the ecosystem, in terms of wood supply. The relationship between bundles of wood collected and total consumption is not simple and must consider other factors.

Household size

By regression coefficient values (B value of 0.432569), household size is the next most important explanatory factor following bundles of wood collected per unit time (Table 25). At both Teacher- Mante and Okrakwadjo, it is the most important of two significant factors (by B value). It is significant at Tontro at the domestic level.

Due to the fact that the non-domestic sector is secondary to the domestic sector in gross consumption of wood in terms of quantity and regularity of use, variables related to household size are important in accounting for overall use variations. At Tontro, however, household size is not accepted as statistically significant in terms of total use of wood, even though it carries the largest mean household size among the three villages (Tables 7 and 8). Probable reasons for this include the greater contribution of commercial use of woodfuel at Tontro, which is almost equal to that for domestic activities, and which has little to do with household size (Tables 18 and 19).

<u>Comment</u>

Prediction of effects of household size on wood consumption can be limited under a number of conditions. It is possible for households of similar size and/or age-gender division, in the same or different villages, to vary in consumption, probably because of differences in wood use type and/or relative ease of supply. Large adult households for instance, can have several members working away from home so that fewer activities requiring wood will be undertaken in the real sense. There is also a tendency for large households to look to the market place to supplement own sources of wood, a practice which potentially provides a basis for conservation techniques to evolve because of pressures of expenditures. These reasons and many others, limit the influence of household size as the most significant factor explaining wood consumption. From its position as the second most significant factor on the B scale, household size ranks third among four significant factors by Beta Value, in explaining wood consumption at the study area level (Table 25).

Frequency of commercial operations

While the villages differ in commercial activity types, the frequency of operations can help to predict the level of wood use in a household. For example, if a minor activity utilises about 20 kg of wood per operation for a 20 day/month operation system, total amount of wood required for that period will amount 400 kg. On the other hand, a major commercial operation venture with a 5 day/month operation system and using about 80 kg of wood per operation, will also require 400 kg of wood. The difference between the two wood intensity types is made up by frequency of operations.

At both Okrakwadjo and Teacher-Mante, frequency of commercial operations emerge as one of two significant variables explaining gross consumption of wood (Table 25). It again emerges as a significant factor at Okrakwadjo at the domestic level, where field evidence showed that, wood for commercial purposes are frequently carried over for domestic purposes. In these two settlements, the large number of minor activities have to operate at higher frequencies in order to make any impacts on gross household consumption of wood. At Tontro, the frequency of commercial operations is significant in an inverse manner at the domestic level and not significant at the total use level, contrary to the high r value of about 0.55 (p=000) for total use. It is possible that at Tontro, if the frequency of commercial operations further decreases, domestic use of wood will increase.

Comment

The relationship between frequency of commercial operations per unit time and wood consumption is not direct in all cases. It is possible for households to operate fewer days per unit time, but because activities involved are intensive wood users, the effects on total wood requirements will be considerable. On the other hand, a higher frequency of minor activities per unit time will fail to register any major effects on gross uses, if wood requirements per operation are insignificant.

Primary source of wood

An interesting observation of the results of the multiple regression test is the apparent significance of primary source of wood at the composite village level. This result is somewhat unexpected because, this variable was one of the border line cases with low p values (p= 0.048 gross and p=.04 domestic), accepted for consideration in the univariate analyses. In the individual villages, it is however significant only at Tontro.

Primary source of wood cannot be ignored in village situations where large proportion of households get their wood requirements from primary sources. This factor appears insignificant at Okrakwadjo in particular, because, only 46 per cent of households fully own their farmlands, the major primary source of wood.

Generally, primary sources that are insecure will lead to varying degrees of accessibility which in turn will affect access to wood. Primary source of wood is significant at Tontro because, unlike the two other villages, primary sources provide a high percentage of wood for households. Most of such households are also likely to own their farmlands or operate them under long and flexible tenures (Tables 14 and 17). Furthermore, such farmlands are more likely to abound in firewood because of the village's location in a forest region. At Teacher-Mante and Okrakwadjo, the relationship is insignificant probably because of diversity of supply sources.

Comment

The importance of primary source of wood will not show under all situations. For example, at Tontro, households without land are assured of adequate wood at all times by other households because wood is generally available and, not strictly because of ownership of primary sources. Evidence from the field indicate that, primary sources of wood are constantly degenerating into secondary sources, because of fragmentation of original plots, rental to users, pledges, farm encroachments, and general loss of tree cover. Examples of this trend are mostly found at Okrakwadjo where several families have lost previously held land.

If current wood acquisition patterns cease to be concentrated as it is now, and wood derived proportionally from several sources, the current importance of primary source of wood will be discounted and variations in consumption will be reduced accordingly. Examining the regression model in Table 25, by Beta value, primary source of wood actually places last among the four factors that significantly explain consumption of wood in the villages. Also at Tontro, the Beta value places primary source in second position from its first position on the B scale.

Number of meals per unit time

It is stated elsewhere in the analysis that households with high frequencies of meals prepared with firewood, will tend to have high levels of wood consumption. Accordingly, meals record a high B of 0.420085 (p=000) in the regression equation for the study villages. It is considered significant at both Teacher-Mante (B=0.55) and Okrakwadjo (B=0.62). It is however, not an accepted variable at Tontro (Table 25).

At Teacher-Mante and Okrakwadjo, probably because commercial activities are less intensive, the proportion of wood that goes to the domestic sector is considerable (Tables 18 and 19). Since food related activities usually take about 80 per cent or more of daily needs of wood, an increase in the number of meals in these two villages will help increase overall wood demands. The significance of the influence of meals on domestic uses of wood appear greatest at Okrakwadjo (B and Beta values).

Comment

A reference to earlier analysis of effects of meals on wood use shows that, strictly speaking, the absolute number of meals cooked with woodfuel, is not as crucial as the specific nature of common dishes. It is possible for a one meal household. therefore, to use the same or more wood as a two or three-meal household depending on meal type. In a further consideration, supper alone account for about 70 per cent or more of daily wood requirements. Thus, a household cooking only intensive supper, is more likely to use the same amount of wood as another with a higher frequency of cooking but less demanding in wood. The Beta values actually place this factor as third in significance from its first position on the B scale for domestic purposes (Table 25).

Num' - of Women

The number of women in a household tend to influence domestic use of wood. At Tontro and Teacher-Mante, the woman factor tends to be significant. It does not however, enter the accepted equation at Okrakwadjo, contrary to r values.

Since women traditionally control cooking and other related activities, the more they are in a household, the more will be the use of woodfuel. Furthermore, most occupations labelled as minor, are female dominated. In these sense, almost all commercial uses of wood, and except for two households, trading, are considered as minor occupations. Most of these minor activities are labour and time intensive and so require a number of helpers based in or near the household. Tontro and Teacher-Mante have proportionally, the highest number of households in minor occupations on a semi-full-time basis. Apart from the effects the large involvement of women, their continuous presence in the house contribute to the use of more wood for domestic purposes. This is likely the case for Tontro and Teacher-Mante.

Comment

A large presence of females does not necessarily lead to increased domestic use of wood. Sometimes some of the ventures are so competitive and/or time demanding that, there is scarcely any resting time for other functions such as domestic uses of wood. For example, trading along the major trunk road at Teacher-Mante which involves many women, is so competitive that, sellers are on their toes constantly for any vehicle that shows up, scarcely affording any opportunity to leave the line of business without risking a slump in sales. In addition to the above observation, since several minor activities at Teacher-Mante are also related to cooked food sales, some of such food are used on the job in place of deliberate cooking, helping to save domestic wood requirements. Thus, for example, while Teacher-Mante tend to have more women in the settlement on a daily basis, the use of wood for domestic purposes is least among the three villages.

From its first position on the B values, the woman factor ranks fourth on the order of significance on the Beta scale at Tontro, and second at Teacher-Mante (see Table 19). In essence, the mere presence of a relatively large number of females does not imply an increase in wood consumption.

Summary of analysis for Multivariate Analysis

i. Considered on a composite basis, it is confirmed that four variables, namely, frequency of commercial operations, primary source of wood, household size, and bundles of wood collected per unit time, are significant in explaining wood consumption patterns in the villages. The villages are, however, affected differently by these factors both in terms of total and/or domestic uses. For example, variables that emerge as the most significant in one village, are less so in another.

ii. while the multiple regression model is helpful in identifying crucial factors of explanation, it tends to down-play the effects of all those variables that are not accepted in the equation. However, in specific and localised cases, the effects of some variables can be significant even though they will not be significant when all households in a village are considered. Because of such possible shortcomings, the model can be said to be useful only as a basis for a thorough examination of all possible factors that affect wood consumption in the area. It is satisfactory to note however that, stage one of this chapter, analysed all the significant r variables used for the multiple regression test with no discrimination.

iii. It is realised from the analyses in both section two and three of this chapter that, ecological factors possibly account for many of the variations in wood consumption in the villages, especially with regard to certain supply and use conditions. Admittedly, no comprehensive answers to the pattern of wood consumption in the study villages will be found without placing the analyses of wood use within an ecological context, which the next section attempts to do.

4. Ecological influences on wood consumption

Introduction

While many variables have been analysed to help identify and explain levels of wood consumption in the villages, a complete picture will be lost when the natural ecological set up of village woodfuel systems are not considered. The ecology of locations/areas is potentially useful in helping to determine the role of such variables as climate, soils, topography and vegetation which provide the natural setting for land use, wood availability and quality and, general wood consumption trends (Figure 6).

Considered in terms of direct woodfuel systems, vegetation represents the cumulative effects of other natural variables such as temperature, rainfall, soils, and terrain factors on village ecosystems. In reference to the the general description of the physical environment of the study region, and the villages in particular (Chapter IV), differences in location in terms of ecosystems, significantly help to explain the nature of wood consumption in the villages. For example, the ecosystem generally determines the characteristics of crucial village activities such as cropping systems, which have direct influence on wood supply and use. In specific terms, the ecosystem helps to influence supply and use of wood through such factors as wood abundance and variety of species/, the food system and the raw material basis for commercialisation which are examined in detail below.

Supply of wood

Generally, areas lying within or near non-degraded forest ecosystems and/or fallows have access to more woodfuel than those in degraded forests and derived-savanna and/or savanna environments, because of the general differences in tree cover and/or potential for tree regeneration. For example, a U.N.E.S.C.O study (1978:241), concluded that the highest annual incremental values of forests, are in regions with the most equitable moisture conditions such as at Tontro, while lowest increments occur in drier environments. According to that study, the average of 14 values found in the literature on net annual growth rates of tropical forest ecosystems is about 20 tonnes/ha ranging from 9 tonnes to 32 tonnes/ha. For practical analyses, annual incremental growth at Tontro, will be asummed to fall between 15 and 25 tonnes because of its favourable conditions, while a range of 9 to 15 tonnes per annum, will reflect the moisture deficient environments at Teacher-Mante and Okrakwadjo (This corresponds with the Ghana Forestry department's estimates of forest growth--Pluth, 1986). Households at Tontro therefore have an advantage of continuous access to wood even if removals tend to heavy and partly explains why households at Tontro (Moist Semi-deciduous) are able to collect about 15 bundles of wood per month, while those at Okrakwadjo (Semi-deciduous, inner zone-turned derived- savanna), are able to collect only 6.2 bundles. Even if farmland ownership levels at Okrakwadjo were to be the same as Tontro, and members of households were willing to collect wood for extended periods of time, differences in ecosystem will lead to fewer quantities of wood to be collected at Okrakwadjo because of general limits to supply, compared to Tontro. Within individual villages, the status of the vegetation (properties) of individual households will limit the quantity of wood that they collect per unit time. A perception of relative supply problems, real or imagined, will potentially affect the manner to which woodfuel is used at the household level.

Domestic uses of wood

In the general discussions in earlier sections of this chapter, references were made to the importance of meal types/dishes to overall uses of wood. Actually, the real factor determining meal types in a village situation where food for subsistence is mostly self-produced, is possibly micro-physical environmental conditions, which in turn determines the food cropping system and for that matter, most final meal types. The humid forest conditions of Tontro for example, allows for such prized, but moisture demanding food crops as plantain and cocoyam to be raised. Factors such as organic matter content of soils, soil moisture levels, shade and retarded erosion, favour forest environments in terms of crop productivity. In the relatively drier environments of Okrakwadjo and Teacher-Mante, plantains, cocoyams and palm trees are luxuries (palm trees can be raised in plantations) while cassava and maize are extensively raised. Since most households at Tontro have free access to those food inputs required for complex (time input) dishes such as fufu, they are likely to use more wood per unit meal compared to the other villages. Okrakwadjo and Teacher-Mante have similar meals but high costs preclude frequent indulgence in many of the households that have to buy the raw foodstuffs (especially Okrakwadjo). Tontro's access to plentiful food also makes it possible for many families to have three main cooking meals per day, affecting overall wood requirements.

Commercial uses of wood

In the previous analyses, it was confirmed that most major commercial uses of wood occur at Tontro, compared to the other two villages. This is mainly because almost all required raw inputs for commercial activities in the village are obtainable from the humid environments within the limits of the village boundary. On the other hand, similar ventures in the other two villages, have to rely on the urban markets for the same inputs at relatively high costs, and thereby limiting the number and scale of such major commercial operations. Generally therefore, the natural environment of Tontro provides opportunities for greater use of woodfuel.

Comment

The degree to which the natural ecosystem affects the direction of wood supply and use, depends upon several factors, including history of site maintenance, degree of dynamism of current land uses, income potentials (present and future), future directions in energy use mix in the area, and general development directions in the larger region (country) to which the study area belongs.

Even though the effects of the ecosystem on wood use is important, it will be an over-generalisation to associate wood abundance in households/villages with vegetation type without reference to specific site conditions. Villages need not be in forest locations in order to have access to adequate wood. These can be planted in the area and/or supplied from other locations. Current forest ecosystems are also capable of degenerating into poor bushlands and derived savanna as is the case at Okrakwadjo. On the other hand, villages can be located in wood abundant environments but few households will control the source of wood due to the land tenure system in the area- the key is accessibility. The natural ecosystem is useful in helping to predict wood consumption so much as it offers natural opportunities to complement socio-economic efforts as illustrated by the model for this study (Figure 6).

Notwithstanding the preceding comments, several socio-economic limitations, seem to place the ecosystem higher in the woodfuel

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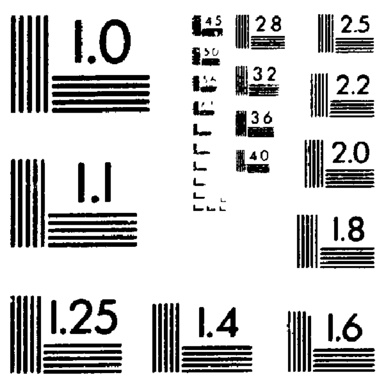


system in the villages due to the following; i) there is no deliberate planting of trees for use and/or maintenance of wood sources, even though rapid loss of tree cover is experienced, ii) the farming system, especially at Okrakwadjo and Teacher-Mante, destroy the tree cover, iii) limited incomes preclude the market place as a source of supplement/supply (and access to alternatives). iv. the external socio-economic environment offers little help in terms of fuel alternatives and/or technologies and inputs to increase production. To a greater extent, the present natural vegetation, and the potential for natural regeneration of vegetation in each village, determine all present and future access to woodfuel. Such a trend is likely to continue.

General Summary to the Chapter

Several factors, both human and physical-environmental, have been considered as significant in explaining wood consumption. It has also been proven by the preceding analyses that, dynamic linkages exist between factors affecting woodfuel use. For example, a large household will require more woodfuel to satisfy relatively large needs, which in turn will require more wood to be collected per unit time, a reality which will also affect the frequency of collection, and ultimately, depending upon the state of the collection site (ecosystem). In situations where free sources cannot support required needs, purchases have to supplement self-collected.

A general trend of low income potentials observed for the study villages, especially, at Okrakwadjo, carry the implication that few households are capable of using the market place, and/or switching to alternatives even as a limited option. In addition to limited ownership of sources of wood in many households, the possibility of negative impacts in the woodfuel system in the villages can be considerable.

Due to the fact that the modified ecosystem is still the major determinant of wood supply in the villages, it is necessary to assess the sustainability of the village woodfuel systems, so that possible ecological and related human impacts can be isolated, which in addition to pertinent findings made in this chapter, will help in suggesting planning strategies. The next chapter attempts to examine in detail, all existing and potential impacts of wood use to the natural environment and human conditions to complete the study.

CHAPTER VII: IMPACTS OF AND RESPONSES TO WOODFUEL USE

1. Introduction

The two preceding chapters have attempted to present and explain woodfuel consumption patterns in the study villages in some detail. In Chapter VI, it was established that even though socio-economic variables account for differences in wood consumption, ecological factors underlie most of the variations in wood consumption in the villages in terms of relative abundance of wood and conditions leading to increased use of wood. For example, because Tontro is located in the Moist Semi-deciduous Forest zone, which to a greater extent is, still undegraded, there is relatively easy access to wood. Tontro also lies in an ideal environment for growing foodstuffs and cash crops for both local and external domestic and commercial utilisation (Chapter IV) and, has the largest average household size among the three villages. Apart from using more wood per household, the (perennial) cropping practices at Tontro generally contribute to wood retention. On the other hand, both Okrakwadjo and Teacher-Mante lie in relatively drier Semi-deciduous Forests which have undergone intense human pressures, leading to relative difficulty in obtaining wood, and general constraints to traditional agricultural practices, and wood supply.

While a depth of information has been provided on wood consumption patterns, no attempt has so far been made to determine any significant constraints contributing to the patterns of woodfuel use in the study villages. Such information is crucial for the study, because it is a key requirement for planning in relation to woodfuel use, both present and in the future, and also, it provides a basis for assessing the degree of sustainability of woodfuel systems. To this end, the main objective of this chapter is to provide critical assessment of specific and potential impacts of woodfuel use. The rest of the chapter is set out in three main sections to meet this objective.

Due to the relative importance of the humanly modified ecosystem in the village wood supply system, the analysis of impacts begins with ecological considerations in the first section. This is followed by discussions on human (socio-economic) impacts, in the second section. The third section of the chapter concludes the analysis on impacts by considering specific household responses and adaptations to impacts identified in sections one and two, particularly, with regard to wood supply and use structures.

For general village assessment of impacts, impacts are rated on a 4-step scale, of "major", "moderate", "minor" and "negligible", as described in Chapter IV. Further to such general classification, specific impacts are reviewed in terms of their degree of applicability in each village on a sectional basis.

2. Analysis of Impacts-The Ecosystem

Introduction

Ecological impacts generally apply to physical/human processes of degradation and scarcity of supply. Targets and general causes of ecosystem degradation, are illustrated in Table 27. Degradation considers any damage, real or potential, to the general vegetation and tree species in particular. Other considerations include, soil

Table 27: Woodfuel Use- Ecosystem Impacts

IMPACTS	IMPACT TARGETS		
	COLLECTION	TRANSPORTATION	USE LEVEL
ECOSYTEM	1. Destruction of standing vegetation, saplings and seeds. Damage from Tree Felling and Processing 2. Damage to wood collection sites during the process of collection -intensification of collection-twigs, roots, barks.crop remains 3 Destruction of habitats. Imperfect Regeneration: Creation of Gaps in Vegetation including removing accessories such as strings	1. Damage to species-debranching, cutting of over-hangs along paths not well defined 2. Introduction of wastes foreign to collection sites, at rest points and along paths 3. Soil compaction and damage to vegetation at rest points 4. Damage to the General Environment - Concentrated Paths leading to rill, gully, and accelerated erosion	1. Smoke pollution -indoors - general environment 2. Thermal heat pollution 3. Destruction of micro-habitats within home system by heat and smoke

SOURCE FIELD DATA

capacity, habitat destruction, smoke pollution. Such impacts may occur at the collection site, on and/or near wood collection paths, and at the user level. Important answers sought, include, the specific nature of the relationship between woodfuel use and vegetation/species loss and, the relationship between woodfuel collection and surface/soil degradation. For purposes of analysis, smoke pollution are considered as part of human impact, and discussed under environmental health. On the other hand, Wood Scarcity Impact is measured in terms of general access to wood using quantitative procedures and indicating the relationship between scarcity and ecological damage.

i. Degradation

Loss of standing vegetation/species cover

Vegetation loss is one of the most visible measures of impacts resulting from woodfuel use. Vegetation loss which leads to surface exposure is also the basis of further degradation. Tree losses can be classified as direct and/or indirect.

Direct losses

It is assumed here that, standing live trees are not harvested or processed for woodfuel. Evidence of the use of live trees in a village will confirm a loss of vegetation cover and potential sources of wood. What happens at the collection sites-Do people cut live trees?

For the local economy, firewood collection was found to be traditional in all the villages, feeding basically on already dead wood. In most households, wood requirements are immediate and cannot wait for any prolonged processes such as felling live trees that must wait for months or years to dry. To cut large live trees for wood also requires heavy equipments other than the normal cutlass, not counting the extreme labour requirement for processing, transportation, and storage space constraints.

Live trees are, however, used for charcoal manufacturing in the area. At Okrakwadjo, for example, it is believed that charcoal making in the past, was among the fundamental causes of tree loss in the area. During the study period however, only three households were found to be involved in periodic charcoal manufacturing, located outside the village boundary and, dependent upon purchased raw wood. Almost all charcoal supplies come from outside the village. Similarly, most available charcoal at Teacher-Mante is supplied from nearby villages where trees are relatively easy to obtain. In Okrakwadjo in particular, there is complete depletion of local sources of wood for charcoal. At Tontro, the four main charcoal operators get all raw wood from within the village boundary. Production is intensive (above 6 bags of 35 kg per operation) but infrequently undertaken, due to farming activities (average of four production per year).

A real threat to the standing vegetation is the proliferation of the motorised chain-saw into the wood cutting business. At Okrakwadjo and Teacher-Mante, the threat is less significant, because the few chain saws are mostly used in new farms to help cut large overwoods to set farms clear for cropping and/or cutting and processing dead dry wood for the fuel market.

Increasing numbers of woodfuel entrepreneurs, however, are invading the village of Tontro and its surroundings. Due to the fact that the market they supply is large, specialised, and requires wood of varying moisture levels, the usual traditional system of collection is inadequate and/or inappropriate. High quality standing trees which are also usually of timber value, are selectively targeted. Depending on availability, two or more trees are cut and processed at a time by a team of chain-saw operators, and carted by trucks of up to 10-tonnes capacity to far away urban centres, chiefly to Accra and Koforidua. The damaging aspect of this new kind of wood harvests include;

Depletion of selected species

There is a concentration on few species regarded by the market as high quality. Among these are the Celtis milbraedii, Terminalia ivorensis and Triplochiton scleroxylon. On weight by weight basis, Celtis milbraedii fetch up to 100 per cent or more in monetary terms than its closest rivals such as Terminalia ivorensis and Triplochiton scleroxylon in the destined markets at Accra and Koforidua. The species, Celtis milbraedii, is now very difficult to obtain at Tontro and less than 15 per cent of households have direct access to it. For this species and all others in the wood trade, cutting rates (including timber) are such that they may be completely lost in less than a decade.

A fear of possible total depletion of some species is based on the fact that, in the forests of Ghana, as in most tropical forests, trees do not occur in pure stands. Less than 3 mature trees of particular species usually exist over an area of about 2.6 km^2. Most of the specialised species are almost completely lost in the uncleared and unprotected forests which are the first targets. Evidence shows that most fellings now occur within farms with economic plants (mostly cocoa), such as at Tontro, with all the consequences, including destruction and direct exposure of cocoa trees to desiccation. Okrakwadjo scarcely has any of the market species, while at Teacher-Mante has few, to be found further away from the settlement.

Damage from tree felling and processing

Because trees harvested are usually large, there is a great deal of damage to other trees, including economic species and farm crops. In a related study of the timber industry, Mensah (1966) documented that, in a selection felling of timber trees in a 77 ha forest compartment in Western Ghana, about 10 per cent of established trees were found to be damaged (see Hall and Swaine, 1981: pp. 66-67). The chain-saw operation, like timber extraction, is also selective and during a visit to some operational sites, damage was seen to be considerable to nearby standing vegetation. In one case, three trees of medium height in the path of the tree being felled were completely destroyed. There was also massive damage to branches on two adjacent large trees, and clearance in order to process the tree destroyed many other young trees and saplings. In addition, a large pile of debris made up of chips, wood powder, leaves, branches and other parts of the trees regarded as wastes in the fuel trade, were left as trash on the forest floor, killing or disturbing saplings. Sometimes trash is left in the dry courses of streams. During the rainy season, the natural flow of such streams are disturbed and minor diversion of courses even occur. Evidence of this was found at Tontro during the rainy season.

Imperfect regeneration after commercial cuttings

Depending on size of trees, gaps are created in the vegetation cover when trees are removed. This renders the forest floor susceptible to erosion. Some grasses and the vicious weed, Chromolaena odorata were found to have dominated certain clearings created by wood removals near Tontro, including almost all areas affected by the widespread bush fires of 1982-83. A number of cocoa trees were noted to be withering in areas that have lost shade through the removal of overwoods (either for fuel or some other purposes). Evidence found in some forest reserves to the north and south east (of the area) shows that, some of these gaps may never close, even if the forests survive.

Indirect losses of Vegetation

Under indirect losses of vegetation, losses are attributed to woodfuel in an indirect manner because households only take advantage of other land use types which directly remove the vegetation and provide the wood which is eventually used for fuel. Under this category include;

Farming

A principal process that releases wood for use in the villages is farming. At Okrakwadjo, for example, farming is becoming the greatest single supplier of wood. All wood products from new farms, charred or otherwise, are collected and piled at the edges of the farm to be transported home, when dry or as required. In more than 40 per cent of households at Okrakwadjo, new farms guarantee immediate future sources of free wood. Because of such realities, all available trees may be cut during farm clearance even when it is clear that many of such trees will not interfere with the cropping system.

Complete collection of wood products, both before and after burning or firing new farms, robs the land of natural sources of nutrients and exposes the surface to erosion and desiccation. Increased frequency of cropping is worsening the situation. At Okrakwadjo, fallows have fallen below 5 years in many instances. Farmers here report of decreasing crop outputs and/or total failures. As a result of population pressure on the land, the vegetation is rapidly changing to derived savanna, and for a distance of two-kilometre radius or more, the only tree species over 15 cm dbh is the Ceiba petandra, which regenerates only in gaps and along roadsides (Hall and Swaine, 1981). The situation at Teacher-Mante is similar, but slightly better, because most farmers here own their land, and so tend to regulate frequency of use and avoid or discourage certain damaging cropping practices such as, leaving the land bare of trees to suit some crops. At Tontro, there is no discernible effort by households to generate wood during farm clearance for later use even though left over wood may be used at some point in time, because wood is generally available. This reason also accounts for the differences in charcoal production between the villages.

Removal of branches from standing trees

Branches are removed from standing trees in farms, along paths, in settlement fringes and house-yards for firewood. A major use of such branches is animal feed. At Okrakwadjo in particular, such branches are stored for use in some households when dry. Contrary to what pertains at Okrakwadjo, branches are generally discarded after feeding animals at both Tontro and Teacher-Mante. Some households at Okrakwadjo reported that they sometimes deliberately cut overgrown branches in farms and even fence rows for specific future use as fuel.

While trees may be left intact after removing some branches, natural growth is generally retarded, and some trees will die as a result. Some specialised species also lose their habitats.

Comment on vegetation/species loss

Generally, the use of live trees is limited in the study villages probably because of availability of air-dry wood, tradition, amount of work involved, storage space, and appropriate tree species for thinning and pollarding.

ii. Soil capacity

Intensive studies to monitor soil conditions over time, will reveal probable damaging situations. Accelerated erosion occurs when removals of overwood expose the surface to erosional agents, principally, water. Postel and Heise (1988: pp. 36) have noted that in West Africa, runoff rates recorded from some cultivated and bare soils exceed those from forests by twentyfold. In another study covering several countries in Africa, Goldie (1984:145), estimated mean erosion rates under forests to be about 0.09 tonnes per hectare per year, while those under barren soils were as high as 69.1 tonnes per hectare per year (about 768 times). Within the study villages, the problem of top soil loss is potentially most alarming at Okrakwadjo because of the very sparse tree population, and usually withered vegetation and tufted grasses in the dry season. Intense and sporadic rains in the dry season potentially prove damaging to the many bare and semi-bare surfaces, particulary just before the onset of the rainy season. Agriculture and vegetation regeneration are seriously retarded at Okrakwadjo where top soils containing the most useful and available nutrients for plant growth are vulnerable to erosion. Intensive studies to monitor soil conditions over time, will reveal probable damaging situations.

Examples of compacted sites are found in all the settlements, but with particular reference to Tontro and Okrakwadjo. At Tontro, wood collection is usually site intensive. A large dead tree, naturally fallen or felled, can take days or even weeks to be processed for the home. Since most processing activities are immediately around the perimeter of the wood, there is much concentration of activities. At Tontro, some past wood collection sites were noted to carry vegetation that are poorer compared to those of the surrounding, while a few spots even remain unvegetated. At Okrakwadjo, compaction is noted in the sandy clays around heavily used bamboo groves in the valley bottoms and the swamplands. Increases in both runoff and surface standing water compared to past conditions have been noticed by inhabitants. Compaction also occurs at usual rest stops/wood piling points on paths leading to wood collection sites.

Habitats

Habitat destruction occurs in several ways, either by removing dead or live wood. For example, wood-peckers, found in most parts of the forests of southern Ghana, depend upon dead dry standing trees for their nests (holes). When these are cut, their habitats are lost. Some life forms specialising in particular species, or formations of them for their existence, such as the monkeys, also lose precious habitats, when regeneration becomes impossible or retarded, after cuttings for fuel (and/or other uses). Due to the rapid loss of habitats, wildlife is extremely scarce in all the villages, and this, in turn, means a loss of supply of "bush meat", still a major protein source in rural Ghana.

Water contamination/loss

As stressed elsewhere in the chapter, increased wood removals at the present rate, especially at Okrakwadjo and Teacher-Mante, will lead to large-scale surface destruction. This is likely to accelerate surface run-off, reduced water infiltration and, loss of ground water, while also promoting flooding and probably, high incidence of water shortage. Access to safe drinking water is currently a major problem at both Okrakwadjo and Teacher-Mante, especially during the dry season but the reasons for this is not solely due to woodfuel use.

The incidence of water contamination is also discussed in connection with direct vegetation loss. Water bodies, either in streams or lakes, are affected when woodfuel remains find their way into them, and physically choke or disturb their flow, scour, and/or add debris to contaminate their purity for drinking or general use purposes (both for humans and animals). Decomposed fuelwood also affect both the physical and chemical properties of water. In all the villages, such contamination may be found, especially, during the rainy season.

Summary Findings/Assessments of Degradation

i. On whole village basis, evidence from the field suggests that, destruction of vegetation resulting from direct woodfuel harvests is generally negligible to inapplicable because the present traditional harvesting system targets only wood that is already dead and therefore, non-contributory to standing green biomass. Even with the direct cutting of live trees associated with the chain-saw, few species are removed. Furthermore, such removal of trees is spatially and time limited for, few households have commercial trees for sale to entrepreneurs. Once targeted trees are cut, buyers and/or agents move to other locations for fresh sources;

ii. without regard to a whole village unit, and considering a long term view of wood supply dynamics, damage to standing vegetation cannot be discounted. For example, recent organised commercial inroads into the woodfuel trade, especially at Tontro, will no doubt put significant number of species under threat of destruction. Such threats are not primarily because of their potential as commercial species, but also because of damage to other trees in relation to the removal of few wanted trees. Localised destruction of this nature has already been noted to occur widely around Tontro. It is also likely that current market trees will be completely depleted in the near future and the range of species wiil expand to include previously unmarketed trees. Depending upon the scale and intensity of removal in future, this trend will affect species abundance and general vegetation and habitat destruction;

iii. new practices such as generating maximum amount of potential firewood during farm clearance at Okrakwadjo for instance, indicate that, the possibility that traditional harvesting systems will change in the near future as shortages become more acute, is high. This trend at Okrakwadjo in particular, confirms the hypothesis that as more households find it difficult to obtain adequate firewood, more standing vegetation will be destroyed. In future if households routinely cut live trees, the potential effects on the ecosystem will be more significant;

iv. because wood collection generally takes place on discrete rather than continuous stretches of land, the effects of soil damage is restricted to intensive and localised sites only. For example, erosional effects of wood collection are more noticeable in sparsely wooded and grassy sites, such as at Okrakwadjo than forested areas, such as Tontro, where any erosional products are trapped and retained within the forest environment. On a gross village basis, current damage to soils as a result of wood collection only, is negligible in the study villages. However, if future trends of wood collection succeed in exposing most collection sites to the weather elements, damage to soils may be more significant than at present.

v. a major cause of surface soil destruction at Okrakwadjo in particular, where the original forest vegetation has been destroyed and Teacher-Mante, where degradation is also high, is the large use of twigs and agricultural remains as fuel, which not only bares the surface, but also removes potential sources of soil nutrients. In both settlements, there is widespread occurrence of rills, gullies, increased run-off, low crop yields, and retarded tree growth. At Okrakwadjo especially, degeneration of vegetation is leading to wood depletion, which is also causing a change in the structure of wood use from logs and branches to largely twigs. If this trend continues a major destruction of surface cover will occur;

vi. in all the villages, the specific origin of damage to soil is generally, agricultural related. The cropping practices at Okrakwadjo and Teacher-Mante for instance, help to expose the surface to degradational agents. On some specific sites, such as new farms on the hill slopes of Okrakwadjo, and Teacher-Mante, soil damage will be classified as minor. However, since agriculture and fuel production are becoming more integrated in the villages, it is becoming unrealistic to either magnify or depreciate the effects of either of these two processes in terms of soil damage.

vii. From the preceding analysis, it can be readily inferred that wood scarcity underlies most of the ecosystem impacts identified, especially for Okrakwadjo and Teacher-Mante for now, and also involving Tontro in the near future.

3. Scarcity Impact

As a result of the dynamic consequences of accessing wood in the general environment, the state of scarcity (shortages) itself can be both regarded as an impact and an agent of impacts. Wood shortages in a general area indicate imbalance between ecosystem maintenance and resources utilisation, and is a direct measure of lack of sustainability. For example, a shortage of wood either of specific kinds and/or general, implies species loss and therefore ecosystem modification (impact). If the process of wood shortage can be accurately established, the potential for a quick identification of negative trends associated with wood use can be made and solutions suggested. The intention in the following parts, is to devise objective criteria for identifying and assessing the degree of scarcity impacts between the villages.

Measuring Scarcity-Types

A condition of wood scarcity is crucial, especially, within socio-economic systems with limited capacity for market-based fuels such as the case in the study villages where considerable pressures are placed on natural and free sources of wood. However, measuring wood scarcity is a complex task because, the concept of scarcity has both quantitative and perceptual connotations, and may vary with both time and space. Various types of scarcity situations are described below, as a means of offering a basis for the formulation of quantitative indices of scarcity to compare the villages.

i. Scarcity as Absolute Figure

Where an absolute figure is taken to represent scarcity, wood supply is measured in relation to estimated or established needs. Scarcity is assumed relative to whether needs are below or above a given supply. Hypothetically, if scarcity applies to a household, additional wood will be required for normal household tasks to be accomplished. Since wood supply and requirements must balance to enable a household to survive, the manner of making up for such a balance (or not), usually determines the direction of impacts on collection sites.

It has been suggested by certain studies that, households require a minimum energy requirement of 9-13 Gigajoules per capita/annum for all activities (Pluth, 1986 etc.). It is important to note how such optimal reference quantities of supply and need are derived. For example, if established optimal minimum demand figures are standards extrapolated from environments with different expectations and structure of [wood] fuel use, comparisons may be unrealistic and untenable. Generally, absolute figures do not represent situations of scarcity and/or abundance adequately. Even within the study villages where socio-economic and environmental conditions are somewhat similar, wood consumption may vary between households (see chapters V and VI). Notwithstanding such constraints, using absolute quantity of wood as a criteria for measuring wood shortages with regard to other factors in specific environments, will appear useful for planning considerations.

Scarcity as Quantity and Qualitative Factor

This type of wood scarcity combines quantity with qualitative assessment to consider scarcity. For example in some households in the study villages, especially at Teacher-Mante and Okrakwadjo, wood scarcity is said to exist because the absolute proportions of certain forms of wood considered high grade is less than that of wood species considered low grade even though, adequate amounts of wood exist for all household purposes.

Such a classification of scarcity is based on past experiences, preferences, and changes in land use history. An understanding of wood scarcity, within such a context may require modified planning strategies somehow different from a situation where absolute need has been confirmed.

Scarcity as Qualitative Perception

Under this type, scarcity has little to do with quantity. In some cases, wood scarcity is generally equated with vegetation loss/degradation. There is wood abundance if there are forests and old growth fallow lands, and wood deficit if there are poor woodlands and (derived) savanna, irrespective of state and/or accessibility. At Teacher-Mante for example, several households associate wood scarcity with the vegetation which is now bushland to poor secondary forest (away from the settlement) even though almost all such households are self sufficient with respect to wood in the short term.

Also, in certain households (even at Tontro), fuelwood is said to be scarce just because purchases (occasional or continuous) are made (because wood is no longer a free good). Even if it is costly in terms of time, physical efforts, and environmental destruction to generate wood free of charge, a concept of scarcity is not assumed.

Wood purchases may not necessarily represent a state of absolute scarcity. Purchases may be made as trade-offs for time and labour requirements for other activities particularly, regular wage employment and/or commercial operations. Following logically from the preceding observation, the non-farming households generally admit to wood shortages even though they may obtain wood free from other sources or get required quantity and quality from the market place. In other cases, because of such contingencies as old age, and or/sickness, wood cannot be brought from the farm. Such category of households also normally recognise a condition of scarcity. Examples are found in all the three settlements.

From the preceding discussions, the concept of wood scarcity may have to be viewed critically within a functional spatial and temporal context. Scarcity may have meaning only with reference to a particular use environment for a particular time period. Generally however, wood scarcity can be detected from the general context described in the preceding. Simple, objective and logical indices can be devised to monitor wood shortages to assist conservation and planning purposes. The next section considers the formulation of such indices of wood scarcity.

Quantitative Assessment of wood scarcity in the study Villages

A number of crucial indicators of scarcity, derived from the preceding discussion, are used to build indices of comparison (Table 28). Specific application of each indicator as a surrogate measure of scarcity is critically discussed. Each variable indicator stands separately but is comparable between villages. On the other hand, variable indicators are not comparable between them even in the same village. The interpretation is that where a village scores very low on three or more of the scarcity indicators, then the village is said to be facing wood scarcity problems. The indicators of scarcity used for the assessment include;

i. absolute quantity of available wood per capita/unit time (V)

ii. quantity of wood collected free of monetary cost and consumption (F);

iii. proportion of households in village using wood generally accepted as inferiors (I);

iv. number of households purchasing wood in a village due to absolute shortage (C);

v) number of non-wood purchasing households with primary source ofwood from sources other than own property (P)

The above conditions are examined in detail to show how they work to help identify relative abundance/scarcity of wood in an area.

Absolute Comparison of Per Capita Wood Available Per Unit Time (V)

This criteria assumes that there is a balance between consumption and available wood. For example, if a household uses 5 kg of wood per day, it is believed that it manages to get a supply of at least 5 kg a day. A formula V= (0 - C)/n where V represents deviation of per capita consumption value of individual villages from the composite value; 0/n= per capita value for the composite villages; and C/n= per

Table 28: Wood Scarcity Index

VILLAGES	*VARIABLE SCORES Real use values (V) V=0-C/n	Free access (F) F= X- k/n	Proportion of inferiors (I) I=1-Q/100	Critical need purchasers (C) C= Pl/Po
TEACHER-MANTE	-0.14	0.33	0.56	0.57
TONTRO	0.31	0.78	0.89	0.25
OKRAKWADJO	-0.08	0.11	0.43	0.73

SOURCE: FIELD DATA

* SEE MAIN TEXT FOR DETAILS ON SCORING PROCEDURE

capita value of appropriate village, is used to estimate a scarcity score. The closer the value is to one, the better the supply condition.

To begin with, the mean per capita consumption figure for the composite villages, is regarded as a minimum supply point to which every single household must aspire (Table 18). The mean per capita consumption figure for households in each village is compared with the composite standard. A village that falls below the accepted mean (composite figure) is said to have less than optimum supply. The more the figure lies below the assumed mean, the scarcer the wood supply situation and vice versa. The score for each village, is regarded as an index of potential supply. These scores are comparable between villages because varying consumption and population figures have been standardised to a per capita basis.

By the above method, Tontro scores 0.31 while Teacher-Mante and Okrakwadjo score - 0.14 and -0.08 respectively. In conclusion, there is a general wood supply problem at both Teacher-Mante and Okrakwadjo, with the problem slightly worse at Teacher-Mante. (Alternatively, the 9 Gigajoules/annum/capita minimum bench mark may be used as a reference point, to assess scarcity (with due regard to all problems associated with generalisations and spatial differences in energy use standards). Villages at or above the 9 Gigajoules mark, may be said to have satisfactory supply, while those below, unsatisfactory. With this criteria, the composite village has a satisfactory household energy supply at 9.1 gigajoules. Tontro experiences the most available energy supply at approximately 11 Gigajoules. Okrakwadjo ranks second at 8.7 Gigajoules and Teacher-

Mante last at 8.34 Gigajoules. This corresponds closely with the "V" estimations.

The above criteria may be useful for a quick identification of problem areas of wood supply. In the strictest sense, the assumed optimal supply point is only relative as it does not carry any absolute empirical acceptability in light of details in the preceding discussion to the extent that below or above that given point, wood supply may be said to be scarce or plentiful. Generally however, evidence from the field suggests that most households are self-sufficient with wood at the study area average.

Comparison Betwe n Wood Collected for Free and Consumption (F)

To further improve upon the use of optimal supply figures as a means of estimating scarcity, the difference between actual amount of non-purchased wood and the usual requirements of wood/kg/month is considered. This criterion appears useful because over 70 per cent of all households in the study area collect wood for free at all times. It is assumed that those households and/or villages with adequate supplies of wood will generally avoid the market place such that the more the excess of free wood over actual needs, the better the supply situation and vice versa.

Using the formula, $F = X - k/n$ where F represents mean deviation of freely collected wood by all households in a village over actual requirements per unit time; X=composite deviation; k=specific village deviation; and n=number of villages. To derive such scores, the absolute mean deviations of individual villages (Table 20) are compared with the composite mean balance or the optimal reference point. A score closer to one is satisfactory or is said to represent better conditions of supply while scores closer to zero represent conditions of scarcity. Tontro has the best supply score of 0.78. Teacher-Mante follows with a score of 0.33 and Okrakwadjo a score of only 0.11. The supply situation may be said to be worst at Okrakwadjo, contrary to the first test that compared only absolute figures.

Proportion of households using wood generally accepted as Inferior (I)

It is believed for the purpose of this work that, as much as possible, households will tend to collect and/or use inferior wood only if there is general difficulty in obtaining quality wood. Thus, villages indicating a high proportion of inferior use, will tend to experience some scarcity problems.

The scoring index is based on the equation $I = 1 - QI/100$: where QI proportion of inferiors in total wood demands; and I=potential quality index. A hundred per cent access to quality wood is taken as the optimum supply goal of households/villages. The scoring is built on two stages:-

1) wood classified as inferiors is expresed as a ratio of 100 per cent of all access to wood.

2) figures derived from the preceding are subtracted from 1 to yield the actual score of scarcity for comparability.

The closer the index is to 1 (100%) the better the wood supply situation and vice versa. The final results are, 0.56, for Teacher-

Mante, 0.89 for Tontro, and 0.43 for Okrakwadjo (Table 28). With the lowest score, households at Okrakwadjo are regarded as facing the most acute supply problem followed closely by those at Teacher-Mante. Tontro has a better wood supply status. This finding supports the hypothesis that the greater the proportion of inferior wood in total wood demands, the greater will be the expected wood supply problem.

In interpreting such a conclusion, much should depend upon the validity and/or accuracy of the classification of wood into "inferiors" and "quality". If a known standard is applied indiscriminately without due consideration to local circumstances, a great deal of generalisations may be made. For example, in a village such as Okrakwadjo, where the forests were lost decades ago, a new perception of quality wood species has emerged which is different from the traditional notion with regard to particular forest species such as the Celtis milbraedii. Most respondents at Okrakwadjo for instance, regard Fiscus spp. as quality species. These trees are predominant in most of the old growth bush to secondary forests especially, around and adjacent to long abandoned hamlets. Celtis spp. is not known in most households by recent generations. On the other hand, scarcely is Fiscus mentioned within the woodfuel mix at Tontro. There are also some confusing overlaps in classifying wood into Inferiors and Quality. For example, it is not easy to identify twigs of high quality species, neither is it with logs of some inferior species such as the Bussea occidentalis (Kotoprepre). In spite of short comings in using the above criteria, it may combine well with other indicators for tracking wood supply problems in the area.

Number of households purchasing wood due to critical need (C)

Using the above criteria, it is assumed that less than 50 per cent of wood requirements are obtained from own sources with purchases providing for significant proportions of daily needs. Where a greater percentage of household fuel is purchased because there is none to be taken free from own property or through other arrangements for free wood, within or from nearby settlement, such a scarcity situation may be described as absolute. A village with a large concentration of such buyers of wood will potentially face wood supply problems (Table 29).

To work out a simple index of shortages, the number of wood purchasing households due to critical need, is expressed as a ratio of the total number of wood purchasing households using the equation C=Pi/Po where pi= total number of absolute need purchasers and Po=total wood purchasing households. Each score represents an index for a particular unit of observation (village or study area). The closer the score to zero, the better the supply situation since this implies that the number of absolute need buyers are far less than the number of total purchasers. The scarcity scores for the individual villages are; Teacher-Mante, 0.57, Okrakwadjo 0.73 and Tontro, 0.25. The last position of Okrakwadjo on this scale confirms that it has a wood supply problem as seen in all previous considerations.

A complementary back-up to the above measure of scarcity may be found through the use of the number of years wood purchases began among the majority of present buyers. It may be inferred that villages that have a greater majority of households buying wood for a relatively long period back may show a higher level of scarcity.

Table 29: Major Reasons for Wood Purchases

REASONS	VILLAGES (BY HOUSEHOLDS)							
	TEACHER-MANTE		TONTRO		OKRAKWADJO		ALL VILLAGES	
	NO.	%	NO.	%	NO.	%	NO.	%
Shortage of wood in property	18	40.9	-		29	51.8	47	43.5
Lost leased farmland	2	4.5	1	12.5	4	7.1	7	6.5
Relocated, no farmland	5	3.8	1	12.5	8	14.3	14	13.0
Commercial activity	12	27.3	6	75.0	12	21.4	30	27.8
Increase in household size	-		-		-		-	
Sick/Geriatric/Leased property	5	11.4	-		2	3.6	7	6.5
Just commenced using firewood	2	4.5	-		1	1.8	3	2.8
TOTAL BUYING FIREWOOD	44	100.0	8	100.0	56	100.0	108	100.0

SOURCE: SURVEY DATA

According to Table 30, wood purchases by the majority of current buyers began about 4.3 years ago with a maximum of 20 years purchasing history. Whereas the time period wood purchases began may provide a useful tool to assess the status of relative wood abundance, any interpretations have to consider major reasons for buying wood in the specific area (Table 29), and conditions of intervening years at collection sites. In a village situation where purchases are mainly for non-domestic purposes, it may be misleading to use the time element to judge scarcity. For example at Tontro, 7 of the 8 households that buy some wood, began such purchases when commercial operations commenced and/or became intensified and is in no way connected with absolute scarcity.

It should be mentioned that the wood supply-consumption system exhibits a great deal of dynamism. For example, families may lose farms, but may acquire new ones several weeks, months or years later to help improve their wood supply conditions; new friends and/or extended families may open up previously inaccessible properties to others. Finally, fallowlands may mature with trees for fuel. Indications in most households are that, conditions of over-supply of fuelwood prevailed immediately after the devastating bushfires that gripped most parts of Ghana in 1982-83. Several years after this boom (1986), many households are currently facing scarcity situations.

Primary source of wood (P)

As confirmed in Chapter V, households derive the bulk of wood supplies from their own property. Where households have to depend

Table 30: Commencement of wood purchases (Regular and Irregular)

NO. OF YEARS	*VILLAGES			
	TEACHER-MANTE	TONTRO	OKRAKWADJO	ALL VILLAGES
1	11 (25.0%)	-	10 (17.9%)	21 (19.4%)
2	12 (27.3%)	1 (12.5%)	2 (3.6%)	15 (13.9%)
3	8 (18.2%)	1 (12.5%)	8 (14.3%)	17 (15.7%
4	7 (15.9%)	-	5 (8.9%)	12 (11.1%)
5	2 (4.5%)	1 (12.5%)	11 (19.6%)	14 (13.0%)
6	3 (6.8%)	2 (25.0%)	8 (14.3%	13 (12.0%)
7	1 (2.3%)	-	1 (1.8%)	2 (1.9%)
8	1 (2.3%)	1 (12.5%)	4 (7.1%)	5 (4.6%)
9	-	-	1 (1.8%)	1 (0.9%)
10	1 (2.3%)	1 (12.5%	3 (5.4%)	4 (3.7%)
11	-	-	-	-
12	-	1 (12.5%)	1 (1.8%)	2 (1.9%)
13			-	-
14			-	-
15			1 (1.8%)	1 (0.9%)
16			-	-
17			-	-
18			-	-
19			-	-
20			1 (1.8%)	1 (0.9%)
APPLICABLE CASES	44	8	56	108

SOURCE: SURVEY DATA

* PERCENTAGE OF APPLICABLE HOUSEHOLDS IN BRACKET

on other people/purchases for significant supplies of wood, shortages are bound to occur. Wood supply situations may be said to be satisfactory (or vice-versa) in a village with large proportion of property-derived wood.

For a simple measure of scarcity, total number of households with non-property derived primary source of wood (Ho) is expressed as a ratio of households with property-derived primary source (Hp) of wood, using the formula P=Ho/Hp. The smaller the p score the better the wood supply situation, since it implies that more households get the bulk of their wood supplies from their own property. Tontro scores lowest 0.23, followed by Teacher-Mante, 0.38 then Okrakwadjo, 0.72.

Summary

Tontro ranked excellently on all the scores. On the other hand, Okrakwadjo scored lowest on four scores and is thereby classified as the settlement with the most severe wood supply problems. Teacher-Mante equally faces problems with supply but somehow better than Okrakwadjo, according to the scores. Generally, the findings suggest wood scarcity problems in the villages with the potential of worsening conditions in the future given current trends, especially at Okrakwadjo and Teacher-Mante, where the land is already degraded.

Comment

The above measure of scarcity should be used only with attention to the limitations and deficiencies noted, including the fact that it takes a static view by looking mostly at present conditions. The measure is, however, generally useful and realistic in terms of its comparability, and the use of specific and relevant wood consumption indicators. In its entirety, the scores derived confirm most of the patterns of consumption discussed in previous chapters. Okrakwadjo comes out clearly as the most problematic settlement in terms of wood availability, mainly because of its location in the most degraded ecosystem while Tontro's favourable wood supply condition is a reflection of its location in a more favourable forest ecosystem. Generally the findings confirm potential scarcity situation in the villages.

Summary on Ecosystem Impacts- Sustainability of Village Fuel Systems

i. Information from the analysis on ecosystem impacts indicates that the wood supply environment is undergoing severe constraints. Changes in traditional wood collection patterns are occurring due to wood depletion. For example, at Okrakwadjo, a practice for getting enough woodfuel, tied with farming, is becoming institutionalised, particularly, with farmers who depend on rentals and short leases of farmland. This practice will be beneficial in an environment where forest regeneration is rapid, and where the cropping system maintains tree cover. In that case, new farmlands would release most wood requirements, without any demands on the standing vegetation. As evidenced in chapter VI, however, vegetation regrowth at Okrakwadjo is likely to be the least among the three villages. Thus the practice of tree destruction with farming, will not only deplete most future trees, but will also expose the surface to destruction since every useful woody material is collected from the new farm to be used for fuel. Similarly, limited access to wood is leading to an increase in the proportion of inferior woodfuels such as twigs, roots, stumps, barks and agricultural remains, in the total wood mix of households at Okrakwadjo and Teacher-Mante. This trend will also lead to the exposure of the surface to erosion and loss of potential soil organic matter, which in the long term, will affect natural tree regeneration and agricultural productivity, thereby increasing the wood scarcity problem.

ii. The introduction of new technology in firewood production (the chain-saw) into the villages implies a new era of direct cutting/destruction of standing trees. The chain-saw for example, is capable of cutting and processing any size and kind of tree. If the range of present market trees expand in the future and/or if more farmers have access to the chain-saw, damage to standing trees will be more significant at Tontro, where the supply of forest trees is still relatively high. Already, wood supply at Tontro, is reported to be declining compared with the past, due to devastating bushfires in the area in 1982-83. Households whose farms were affected reported mass destruction of trees and fuel, leading to booms in firewood supply in 1984-85, and downward trends since then. Cocoa farms that have not been properly rehabilitated since then will likely decline in wood production because of the rapid colonisation of the vicious weed "Achampong" which squeezes out any plant on such burnt sites.

iii. In light of i and ii above, wood fuel now contributes directly to vegetation loss and surface degradation (no matter limited the scale) in the villages, processes which used to be mainly agricultural-related.

iv. In assessing the over all sustainable nature of woodfuel use with regard to the state of village ecosystems, current wood use will be classified as unsustainable at Okrakwadjo and Teacher-Mante. The system at Tontro will be considered as sustainable in the short term, with potential problems in the near future if current use trends continue.

4. **Human impacts**

Human impacts are discussed under economic and social variables. Table 31 provides general examples of human impacts of wood use which occur through wood collection, transportation and use. In economic terms, evidence is sought to determine; i. the extent of monetary burden on households, ii. nature of labour- cost substitution for wood collection and disruption to specific income/wage earning activities and iii) lost economic opportunities due to wood collection.

In social terms, impact determination considers whether woodfuel use directly or indirectly hurt i. existing traditional practices including, tastes, preferences, and local belief systems, including gender division of labour, ii. physical health and general welfare, iii. human energy loss iv. nutrition standards v. time constraints for social development, and vi. constraints in access to common resources.

Table 31: Woodfuel Use - Human Impacts

IMPACTS	IMPACT TARGETS		
	COLLECTION	TRANSPORTATION	USE LEVEL
ECONOMIC IMPACTS	1. Damage to collection sites - -intensification of collection to involve unusual sources such as twigs, roots, barks, crop remains in order to avoid purchases -soil loss due to surface exposure -species depletion -desert-like conditions	1. Labour costs- -distances increase to collection sites, Costs passed on to consumers	1. Household/ commmunity budgets -Increased purchase of fuelwood -Increased purchase of ready foods -scarcity induced high costs of firewood -High costs of raw foodstuffs due to soil damage and weather. 2. Commercial activity -forced postponement -constraint on frequency of commercial operations -curtailment, relocation of business -Labour costs substitution

TRADITION AND CULTURE	1. Limited traditional conservation practices impaired -species destruction -species extinction -site damages due to changes in normal mode of collection	1. Labour costs/human a energy stress -distances to collection sites increase due to scarcity -Time increase for commuting	1. Cultural degeneration -inflexibility in options in tastes and preferences -adulteration of belief system -constraints on established traditional practices
PHYSICAL HEALTH AND GENERAL HUMAN WELFARE	Accidents/injuries -cuts, tree fall, injury from sharp thorns, snake bites 2. General fatigue/ Human Energy stress long walking distance more labour-hours for fuel search (Especially for women and children)	Accidents/injuries-trips and falls 2. General health/ Human Energy stress neck, back and knee pains. Cuts from stones and hidden stumps. fatigue. (Especially for women and children)	Indoor air pollution -smoke inhalation -exposure to heat and burns -eye irritations 2. General nuisance -smoke inconvenience -foul scent in clothing - dirt 3. High labour for wood processing, cleaning e.t.c.

SOURCE. FIELD DATA

i. **Economic impacts**

Household budgetary impacts (domestic and commercial)

Details of the structure of wood purchases in the study villages are analysed to determine who really purchases wood, with what frequency and/or monetary expense, and why. Without this, it is possible to regard all wood purchases as monetary drain which in some real situations may prove to be contrary.

Various reasons are provided for wood purchases in the study villages by Table 29. Generally, households are reluctant to reveal commercial uses of wood, except where this is obvious and/or when seen on the job. Further investigations revealed a wider commercial need for wood purchases. For example, according to Table 29, only 12 (27.3%) households out of a total of 44 that purchase woodfuel at Teacher-Mante ascribe commercial use as the primary reason for wood purchases. Upon a closer examination, however it was revealed that even though some of the reasons provided are tenable, 40 (91%) of the 44 households have wood-based businesses at varying frequencies of operation. Commercial motives therefore, provide the basis for most wood purchases. This is true with the two other villages. At Tontro, almost all the 8 households purchase wood to supplement freely collected sources for heavy commercial requirements; and of Okrakwadjo's 56 wood purchasing households, 45 (about 80%) do so because of additional commercial requirements. There is no doubt that the higher the commercial uses of wood, the more wood is purchased.

With lighting fuel inclusive, households require about 21 per cent of their estimated incomes for fuel purchases. Figures for individual villages are about, 21.7 per cent for Teacher-Mante, 10.7 per cent for Tontro, and 21.7 per cent for Okrakwadjo. Note that in absolute numbers, fewer households purchase wood at Teacher-Mante, compared with that at Okrakwadjo, however, intensity of buying is relatively greater at Teacher-Mante hence they attain comparable high expenditure levels.

Since most wood purchases are done by a minority of households and mainly for some income generating activities, it may be a gross over-statement to assume that all households use 21 per cent or more of available household budget/month for wood purchases. Note that for 263 (73%) other fuelwood using households, the sole expenditure on fuels is kerosene for lighting purposes, which averages approximately C110.00 per month or 3.6 per cent of monthly minimum wage. Thus, on a majority basis, there is negligible or inapplicable monetary impact on households.

There are some limitations to the preceding conclusion. On the whole, wood-based commercial operations at Tontro and Teacher-Mante tend to be competitive because of locational advantages. The ease of absorbing fuel costs as part of general production costs is greater in these two settlements.

Okrakwadjo on the other hand, suffers from a limited market due to the local nature of most of the commercial production system and unfavourable location due to the diversion of an original trunk road from the settlement. The buying power in this settlement is significantly buoyed only once a week (periodic market) with traders from all parts of the immediate districts and also with local inhabitants staying off from or delaying going to farm on the market day. For several years, the periodic market has been noticed to be attracting fewer traders. Sales on ordinary days are very low and painstakingly slow. For such businesses, which are generally small scale, wood purchases actually have direct impact on household budgets because of the practice of not separating incomes and expenditures for commercial from domestic budgets- a common practice in female-headed households (predominant in the village).

At Okrakwadjo, supplementary purchase of wood for pure domestic purposes is also on the increase. Some specific economic and social effects resulting from wood use are provided by Table 32. According to Table 32, of 67 households with household budgetary increases (because of wood purchases) in the three villages, 42 (63%) are located in Okrakwadjo alone (Table 32). Prices of wood are generally highest and also fluctuates the most, seasonal and/or short term, at Okrakwadjo.

Field evidence indicated the existence of relatively low prices of wood in the villages up to the beginning of June. This appears to reflect cumulative benefit of the immediate dry season when it is relatively easy to generate wood as well as the practice of stockpiling wood for the major rainy period. Households with excess wood to collect and appropriate dry storage space, tend to have more than adequate wood at least to the end of June, making wood purchases unnecessary and probably resulting in low prices of wood.

By late June, most stored wood has run out, and conditions for wood collection have been made uncomfortable (such as over-grown

Table 32: Some Specific Socio-Economic Effects of Woodfuel Use

EFFECTS	VILLAGES BY NO. OF AFFECTED HOUSEHOLDS			
	TEACHER-MANTE	TONTRO	OKRAKWADJO	ALL VILLAGES
1. Physical Health impacts (collection and carriage)	58 (45.3%)	52 (64.2%)	54 (34%)	164 (44.6%)
2. Curtailment of cooking for lack of woodfuel	1 (0.8%)	0 (0%)	4 (2.5%)	5 (1.3%)
*3. Increased costs for commercial operations	33 (25.4%)	6 (7.4%)	31 (19.9%)	70 (19.3%)
*4. Forced postponement commercial operations	20 (34.5%)	10 (18.9%)	30 (53.6%)	60 (35.9%)
5 Increased economic costs on household budgets	20 (15.6%)	5 (6.2%)	42 (26.4%)	67 (18.2%)
6. Limited time for social development	9 (7.0%)	21 (25.9%)	13 (8.2%)	43 (11.3%)
7. School absenteeism	1 (0.77%)	0 (0%)	3 (1.9%)	4 (1.1%)

8 Culturally Abhorrent (Taboo) species				
A. Know and use Taboo species				
Total using Taboo species	86 (100%)	42 (100%)	110 (100%)	238 (100%)
-Because of religion	42 (48.8%)	27 (64.3%)	53 (48.2%)	122 (51.3%)
-Because of wood shortages	42 (48.8%)	5 (11.9%)	46 (41.8%)	93 (39.1%)
-Relocated from area of origin	1 (1.2%)	5 (11.9%)	3 (2.7%)	9 (3.8%)
-Indifference	1 (1.2%)	5 (11.9%)	8 (7.3%)	14 (5.9%)
B. Do not Use Taboo species				
Total not using Taboo species	42 (100%)	38 (100%)	43 (100%)	123 (100%)
-Fear traditional sanctions	19 (45.2%)	10 (26.3%)	20 (46.5%)	49 (39.8%)
-Taboo species are inferiors	23 (54.8%)	28 (73.7%)	23 (53.5%)	74 (60.2%)
9. Change in distance to wood collection sites				
- Same distance	57 (47.1%)	58 (73.4%)	61 (41.8%)	176 (50.9%)
- Increased	62 (51.2%)	15 (19%)	83 (56.8%)	160 (46.2%)
- Decreased	1 (0.8%)	5 (6.3%)	2 (1.3%)	8 (2.3%)
10. General negative effects of woodfuel (Aquisition and usage)	71 (54.6%)	10 (12.3%)	118 (73.8%)	199 (53.6%)

* Percentage expressed as number of affected households against total number of commercial operating households in particular village

SOURCE: FIELD DATA

and muddy paths, marshes and swamps at collection sites, swollen rivers, and frequent drizzles). Requirements for wood are correspondingly high. Water has to be heated for bathing, people are likely to be indoors more than any other part of the year due to inclement weather and so, the tendency to use wood for other domestic activities appears high. Also, because most wood collected in the open may be wet, there is a tendency to use more pieces to set a single fire than normal, to off-set energy withdrawn for evaporation purposes.

Cooked food sales in particular do a booming business at this time of the year to take advantage of inhabitants trapped in the settlements and also making up for short-term shortage of foodstuffs which normally occurs from mid-June to late August, a transition period between the planting and harvesting seasons. The seasonal daily average of wood consumption in Table 33, indicate a slight increase in the use of wood for the period May-September (wet season) in all three settlements than in October-April. Even though the difference is not significant overall, Tontro shows the greatest fluctuation and Teacher-Mante, the least.

TABLE 33 : Seasonal Daily Mean of Wood Consumption Between the Villages (Based on survey data)

	SEASONS	
VILLAGE	WET	DRY
Teacher-Mante	9.6 kg	8.5 kg
Tontro	15.9 kg	10.8 kg
Okrakwadjo	10.15kg	9.0 kg

At Okrakwadjo, because there is little or no excess wood for build up over time, and also because most of the house structures lack adequate storage space, purchases tend to be significant (in terms of number of households involved) especially, during the wet season, when conditions for wood collection are at their worst.

Within settlements, wood supplies can vary even over a day. At Okrakwadjo for instance, most wood displayed on sale may completely sell out on a daily basis, since not much is offered for sale in the first place. It is therefore possible to pay a higher price for scarce wood in mornings and early afternoons or whenever there is a higher demand, and when incidentally, there may be little or nothing available for sale.

It may be concluded that, while generally economic impacts are inapplicable to negligible at the composite level, within the settlement of Okrakwadjo in particular, impacts may range from minor to moderate.

Labour cost substitution-Monetary

In a system where most wood requirements are collected free of any monetary payments, potential monetary impacts may be assessed through disguised earnings of labour time-costs for wood collection. Labour-hours for wood collection are estimated and expressed into real Cedis, against the government stipulated minimum wage. Data for mean wood purchases per unit time are compared with the disguised earning-hours to determine which of the two systems of wood acquisition- free collection or purchase- is actually favourable to the area. If potential wage loss is more than savings on self collection, then there are impacts and vice versa.

Using the accepted minimum wage potential of C3000.00, the typical average weekly pay is about C750.00 or C18.75/hour. With approximately 5.18 hours expended on wood collection per week in the combined villages, this amounts to C97.13/week in wage equivalent. The mean monthly expenditure on wood is approximately C387.38 or about C97.00/week (Chapter V), meaning that wood prices and disguised wage-labour for wood collection per unit time, are the same.

At Teacher-Mante, the 4.6 hours/week for wood collection amounts to C86.80 in disguised wage labour. Average wood purchases per week approximate C110.29. Self collection of wood is therefore cheaper than the market place. Tontro's 5.68 hours may earn a disguised income of C106.5/week. Since wood purchases amount to a mean of C55.03/week, labour costs are higher than wood prices. Also at Okrakwadjo, wood collection per week involves 5.18 hours, and disguised earning of C97.13/week. Wood purchases amount to a mean of C92.23 indicating that labour costs are higher than prices of woodfuel.

It is apparent that woodfuel prices are still cheap, and most households with steady income will be better off buying wood from the market place rather than expending relatively costly labour time for collection. It may again be demonstrated that, if households who can afford the market place really do so, a number of socio-economic and environmental impacts may be avoided. Note however that, the illustration made so far is hypothetical to the extent that, majority of households really do not have any alternative opportunities to earn wages while domiciled in the settlement, apart from current meagre earnings mainly from farming. Self collection in this instance, represents real savings on hard earned incomes instead of assumed monetary costs. Again, unless purchases deter wood use, the market place is not likely to change current downward trends in supply in a significant way. Generally therefore, labour cost impacts in monetary terms may be said to be inapplicable to negligible.

Economic opportunities lost through wood collection

According to Table 34, the period for wood collection typically falls within prime time for economic activities. Taking time off to collect wood for the next day's operation or/and for domestic needs amounts to a time-money loss in sales or operations, especially, where business is not wood related.

At Okrakwadjo, most food sellers maintain that they have to tailor output to an optimum quantity that can be sold quickly enough to enable farm activity and wood collection to take place. Several of such commercial operators mention that they potentially loose as much as 60 per cent of sales by leaving the line of business each time, they look for wood and/or go to work in the farm.

Actual impacts in this case, are difficult to assess. Taking food sales in the villages as an example, the market is strongest in the morning when there is a rush for breakfast before a day's routine begins. Most sales therefore end in the morning after which most potential buyers are away in the farms or various work places. Operators who leave for farms and/or for firewood later in the day mostly accomplish business tasks before doing so and, may not be

Table 34: Typical Time-Activity Type of Households (Normal Farm Working Days)

ACTIVITY	TIME (LOCAL)
1. Housework/Preparation for work (including, water supply, cleaning, bathing and general personal health care, child care, breakfast, assemblage or/and sharpening of tools)	5.30 am. - 8.00 am
2. Economic and/or obligatory work (including especially, farm work, wage employment, and other activities such as commercial	8.00 am.- 4.00 pm.
3. Housework/hobbies/part-time earnings (home chores such as child care, cooking, cleaning, water supply, minor repairs and and construction, crafts, petty business, such as dress making/ tailoring, shoe mending and hair dyeing)	4.00 pm.- 6.30 pm.
4. Social time (church, benefit groups, singing and dancing groups, visits)	7.00 pm. - 9.00 pm
5. Retiring time (week-ends inclusive- applicable to about 80% of residents or more, especially, during major farming season)	9.00 pm. - 9.30 pm.
*6 Sleeping time	9.30 pm. - 5.30 am.

* Women wake up earliest to begin cleaning and child care chores.
SOURCE: FIELD DATA

hurt financially. It is also common for such operators to leave their wares with other people when they find it absolutely necessary to be elsewhere.

Furthermore, households with access to money generating ventures are not deterred by lack of time for wood collection because, they make enough money to use the market place as an alternative source. This is confirmed by the high incidence of wood purchase among business operators and regular wage earners in the area. From experience, it is only when wood collection is perceived to be profitable than a competing money generating activity that the latter may be sacrificed.

For isolated cases, economic impacts may be negligible to minor but for the greater majority of people, such impacts are inapplicable to negligible

Summary-Economic Impacts

In most cases, economic impacts resulting from woodfuel use are serious only in households that depend upon the market place as a primary source of wood and/or as an intensive supplementary source of wood for domestic purposes. For the whole study villages, since purchase as a primary source involves only 38 households (10.3%), economic impacts from wood fuel use will be said to be negligible.

For specific villages, the current trend of purchase at Okrakwadjo is relatively high while the supply situation points to serious problems in the very near future. Teacher-Mante follows closely on the heels of Okrakwadjo. Generally, economic impacts are classified as minor to moderate at Okrakwadjo because of the increased domestic use of purchased wood. Impact on commercial operations at both Okrakwadjo and Teacher-Mante tend to be minor. In terms of business operations, woodfuel use leaves no applicable impacts in the real sense. There is also no significant cost of labour in terms of disguised wages. Most households capable of buying wood potentially provide socio-economic and environmental gains.

Social Impacts

i. Tradition and culture

Village life is generally built around a system of folk beliefs, practices and controls which, in turn, are closely linked with local resources, occupation, house, and time-history. For example, [because it has historically been the most readily available fuel resource within the immediate environment] firewood is regarded in most households as ancestral fuel to be maintained. It forms part of most rituals to the gods and ancestral spirits, dwelling places are built to suit its use, and its use is the spiritual centre of home activity. Specific effects of wood shortages on such socio-cultural practices in the study area are considered to include;

Tastes and preferences

Most households in the individual villages have preference for certain tree species (Chapter V). In prime woodfuel environments, such as forests under minimal pressure, traditionally preferred species are selectively harvested first, from a number of wood species, before all others. As they become difficult to obtain, other species in order of preference are utilised until scarcity rules out any such choices (and/or until time when a generation of villagers forget completely about traditional tastes for selected species altogether). In a village where most households have lost such traditional taste-preference opportunities due to persistent scarcity, socio-cultural impacts may be said to exist.

Of 96 households at Okrakwadjo (63%) who seek to have access to certain preferred species, only 25 households (26%) actually get them and this is because they buy wood from sellers outside the settlement. Tontro's supply of preferred species appear somewhat more favourable because as many as 52 per cent of households with preferred species (89 per cent of households) continue to get them, while at Teacher-Mante only 34 per cent get them (Table 24; also, Table 32).

Compared with the other villages, it seems that at Okrakwadjo, most households are completely forgetting about the existence of any previously held premium fuelwood species, because of probable absence from the fuel mix for some time past. In terms of making choices with regard to taste and preferences, socio-cultural impacts will be classified as major for the three villages. Impacts at Teacher-Mante will be classified as moderate to major, while impacts at Tontro, impacts will be classified as minor to moderate.

Belief system

Among most households, it is commonly known by custom and tradition that, certain species, parts of trees, and or agricultural remains are not expected to be used for cooking purposes. A common example is the Ceiba petandra (onyina), and/or dry cassava sticks. Routinely, roots, barks and leaves of trees are also discarded in most homes. Of households who still do not use such taboo trees, majority believe they are inferiors. Those who fear traditional sanctions for not using them, (even in the face of shortages), are in the minority (Table 32). Wood shortages and modern religious beliefs are the two most important factors that have contributed to undermine the traditional system of preserving some species/biomass under general guise of inferiority.

To all the villages, and on a gross basis, belief systems are being negatively influenced in a major way. This finding validates the hypothesis that the scarcer the supplies of wood the more will be the use of non-traditional and taboo species. As an exception, among the Ewes, there is a strong attachment to tradition. To them, most taboo species are still not used, even though they tend to face the most severe wood supply problems as a group because they mostly depend upon rental and lease tenures.

Traditional fuel acquisition practices

Wood collection in the villages takes place within 95 days in a year or approximately 1 out of every 4 days. This ranges from Okrakwadjo, 104 days/year to Tontro, 87 days/year. Thus, labour requirements for wood tend to be high in all the villages but higher in villages with general difficulty in accessing wood. Such high demand of labour notwithstanding, women collect most of the available fuelwood in all the villages, supported by children (Chapter V). Most men still believe that traditionally, responsible adult males should not publicly perform tasks such as carrying loads of firewood, because of possible depreciation of social standing and prestige.

Even though wood collection has a major negative effect on women, such impacts originate more from the degree of difficulty in getting and transporting wood than the absolute number of days for collection. For example, homes that record the highest number of days for wood collection include those with plentiful supply of wood, but who bring just enough wood to last a day or two, after each farming day. Again, households that spend the most time per wood collection (about 3.5 hours) are found at Tontro where wood is relatively abundant. There is no doubt that other domestic activities are equally demanding on female labour-time (Chapter V; also, Table 14), which when considered together with wood collection, potentially place undue stress on their physical health and socio-economic development. Intensification of wood collection due to shortages has not radically changed the existing traditionally set division of labour.

ii. Physical Health and general Welfare

The health implication of woodfuel use may be considerable. Most of such health effects are common to general wood use with few specific cases relating to scarcity situations. Health effects include all circumstances of use of wood that will result in undue physical and mental stress. These include;

Environmental Health-Indoor smoke-related problems

The serious environmental health implications of smoke pollution is outlined by Smith (1986), in which he states among other things that "...in small-scale combustion [of woodfuel], the emission factors of carbon monoxide, particulates and hydrocarbons-three of the five major categories (the other two are oxides of sulfur and nitrogen) of combustion derived air pollutants can exceed those of coal, the dirtiest of the fossilised fuels..." It is possible that smoke from the heavy use of firewood in the area may succeed in polluting the otherwise non-industrial environment of villages.

Impacts from wood fuel smoke will be major indoors more than in the free atmosphere because even though cooking is done both indoors and outdoors, for the majority of households, a great deal of cooking is done in enclosed areas (kitchens), especially, during the rainy season. Usually, there are no windows or chimneys in such enclosed kitchens to carry smoke outside. The result is smoke concentration in the kitchen environment itself, as well as in bed-rooms through open ceilings and cracks in walls. Potentially, smoke is inhaled in vast quantities both within the kitchen and in bed-rooms. A major study on indoor smoke pollution in the study villages is required to establish actual health implications. In a parallel situation, cookers are exposed to intense heat during the cooking process, a potential health hazard.

Eye irritation from smoke, is a common problem during cooking, especially, in confined kitchens. A number of users complain of eye problems derived from wood smoke, such as involuntary tears from the eyes with close proximity to fires. For example, a lady at Teacher-Mante has been specially advised by a physician to switch over from firewood to charcoal in order to avoid developing serious eye problems. Blowing fires manually to assist combustion instead of fanning leads to involuntary smoke inhalations. Coughs usually follow such inhalations Smith's (1986) account on health implications of smoke pollution elsewhere in the text, draw a parallel between smoke inhalation and heavy cigarettes use.

Transport (distance) and health

In all the three villages, about 46 per cent of households report of increase in distance to wood collection sites, compared with the situation in the past 10 years while about 51 per cent cover the same distance. Okrakwadjo reports the highest increase in distance, affecting about 57 per cent of households, followed by Teacher-Mante with 5i per cent of households. Tontro experiences the least increase in distance, applying to only 19 per cent of households (Table 32). Almost all households reporting health effects mention neck, head, back and knee pains, as a result of carrying heavy loads of wood over relatively long distances. Complaints are greater in households with increased frequency of wood collection, to cater for non-domestic uses. On several occasions during the rainy season of 1986, wet and slippery roads are alleged to have led to trips and falls resulting in some injuries related to the knee and the hip. In one case, a load of firewood fell on a youngster who was bed-ridden for almost two weeks. In geriatric homes in particular, bringing adequate wood for one-time use is really a major problem due to the general incapability of carrying heavy loads.

At Okrakwadjo and Teacher-Mante, the degree of impact due to change in distance to wood collection sites can be described as minor. Reports about increase in distance for wood collection and its general effects must be received with care. In the study villages, it was revealed that from time past, wood could be collected from several sites irrespective of distance but mostly dependent upon location of property, changes in wood abundance with respect to time and area of intensive farm work. There is a shuffling between collection sites either regulary or periodically and both distant and near sites are exploited at the same time. This also implies that, increase in distance to wood collection sites will occur even though no shortages in the real sense are experienced. In other cases, certain households mainly depend upon others for their wood needs and depending upon who the benefactor is at a particular time, collection sites will be closer or further away from the settlement. Location of property is a key determinant to the spatial distribution of wood collection sites. For people with large properties which run close from the village to distances away, chances are that, resources from near sites will be used and exhausted first and with time, such resources will be available mostly in distant locations. It is in such a sense that distances to collection sites, may increase with wood shortages.

Collection -Accidents/ health

During the process of wood collection, serious cuts from misplaced cutlasses and axes are common. Branches from falling trees (deliberately felled for firewood) commonly fall on firewood gatherers. Such accidents happened on six occasions during the study, and victims required some medical attention. Most accidents occur in villages where relatively big branches and logs predominate in the supply mix, such as at Tontro. There is intensive ancillary activity in this case, to process the wood at the site, and accidents commonly happen. A great deal of fatigue is also reported by those households that have access mainly to large wood forms

Summary

In the strictest sense, the preceding health problems are generally inferred because of the effects of other related factors. On such an inferred basis only, indoor smoke pollution will be classified as a major problem in all the villages. All the other problems range from negligible to moderate. There is no doubt that as it becomes more difficult to collect wood physical impacts will increase dramatically.

iii Human labour cost-Energy

It is possible to assess the effects of wood collection on human welfare, by comparing the amount of human energy expended on wood collection with the amount of energy derived from fuel uses per unit time.

Based on Brown and Lemay (1985: 116), the daily energy requirement for a person doing average work is estimated to range between 2500 and 3000 kcal. In all the three villages since an average of about 8.6 bundles of wood is collected per 28-day month by each household, on a daily basis, about 0.31 bundles (of 28 kg/bundle) or approximately 8,700 grams of wood is collected by each household (Table 13). According to Table 1 (chapter I), air dry wood has a calorific content of about 3.5 kcal/gram. Therefore, the amount of energy derived from wood collected on a daily basis is 30,450 kcal. Assuming that each person collects wood, this amounts to 5075 kcal per capita of energy. This figure is far and above the suggested daily energy requirements for average work of between 2500 and 3000 kcal. At Okrakwadjo where the amount of wood collected per day, is lowest-0.22 bundles or 21560 grams- the amount of energy from wood per capita, is about 3511 kcal/day. At Tontro, energy from wood per person per day is about 7706 kcal, while at Teacher-Mante, the figure is about 4275 kcal per person per day. Considering that wood collection is specialised over household labour in all the villages and takes place within a mean of only about 7.3 days in a month and approximately 3 hours per each collection day (Tables 14-16), the amount of energy made available through wood supply is considerable. In such gross terms, the effects of wood collection on human energy loss may be said to be inapplicable.

There are several observations to be made in connection with the preceding assessment:

i. making available such gross amount of energy from wood does not imply that this amount of energy is made available to the human body through food nutrition which is the ultimate source of energy to the human body for all work. When Ghana is considered as a whole, the daily Calorie supply per capita in 1985 was 1747 (World Bank, 1987: 260), far below the suggested minimum levels for the amount of physical work done, especially, in the rural areas. The calorie supply situation has not changed dramatically particularly, with the villages of Okrakwadjo and Teacher-Mante, where seasonal food supply problems still exist. Thus in real terms, gross Calories from woodfuel is useful only when it is translated into food energy and as such, human labour will suffer even though energy supplied from woodfuel will be more than needed per unit time.

ii. the assessment made does not consider energy losses not only through usage, but also through storage.

iii. energy requirement of the human body is variable and depends on such factors as body weight, age, and muscular activity (Brown and Lemay 1985 for details).

The comparison between energy for wood collection and energy derived from wood is a complex one since there are many variables to consider. In operational terms, relative abundance of foodstuffs will provide a key criteria for determining whether impacts will exist or not. From such a basis, Labour costs in human energy terms will be classified as negligible to minor at Okrakwadjo, negligible at Teacher-Mante and negligible to inapplicable at Tontro.

iv. Nutritional Impacts

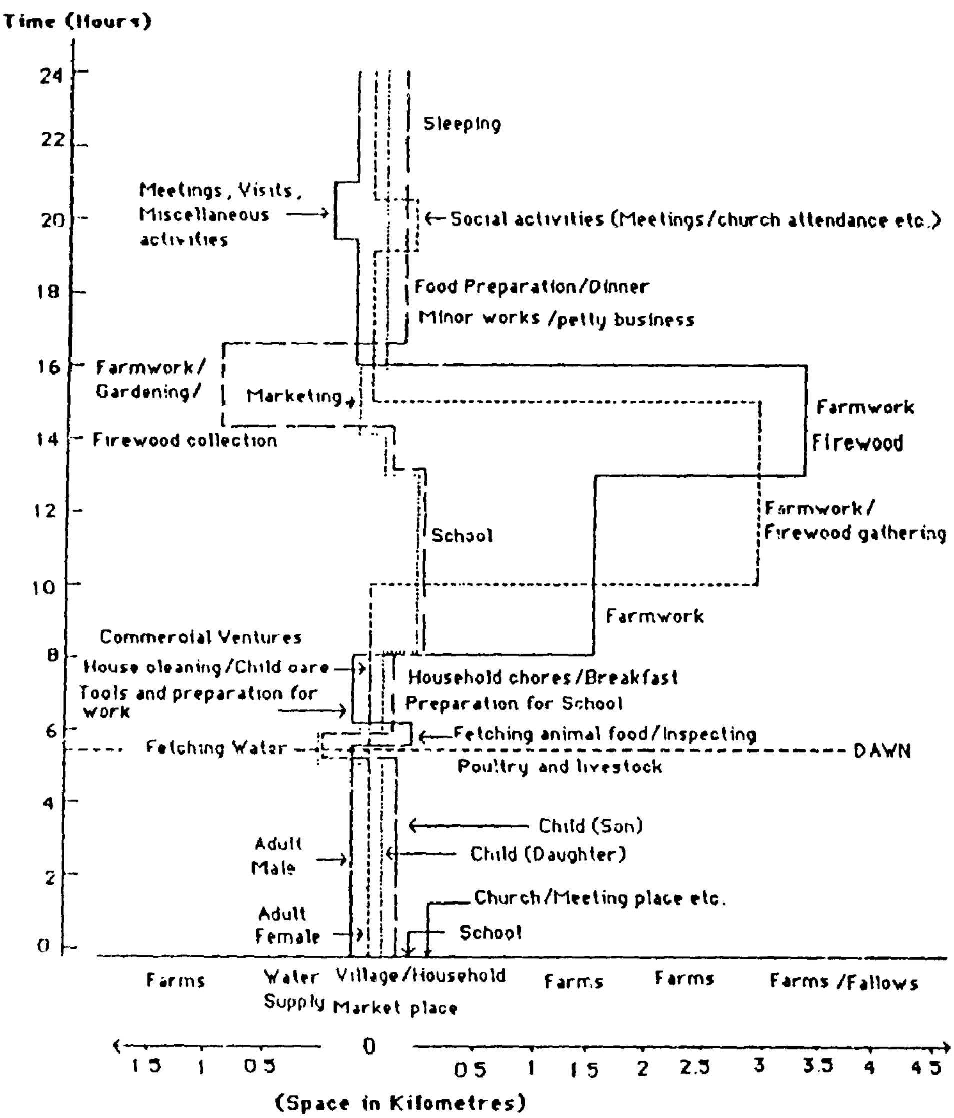
In the composite area, only 5 households (1.3%) believe they sometimes cook less food because of wood shortages. Four of such cases are found at Okrakwadjo alone (Table 32). Several of the cases however involve single-occupant geriatric households who depend mainly on charity for wood. Most households rather cite shortage of foodstuffs as a major nutritional problem in the area, especially at Okrakwadjo and Teacher-Mante (Table 32). They maintain that once foodstuffs are obtained, every means is sought to get fuel for cooking, including borrowing and the use of inferiors. Nutritional effects from wood shortages is not applicable because there is always an alternative on the ready food market, however, low income opportunities in the villages make it difficult for many households to buy food on a regular basis.

v. Time- Distance constraints for social development

As discussed in Chapter III, time is an important resource in societies where most activities are directed towards self-sufficiency. Time then becomes a surrogate substitute for both social and economic costs and its use must be balanced over a range of activities. When an activity takes a disproportionate share (according to normal time share) of available waking time, other activities suffer and this will tend to affect the very existence of such societies. Details of a typical Time-Activity pattern of a farming household in the study area (excluding Sundays) is given as Table 34 while Figure 15 represents both Time and Activity Space for a normal week day of a typical 4-member farming household in any of the study villages.

According to Table 34 (also Figure 15), wood collection mainly takes place within an 8-hour block of time between 8 am. and 4 pm. Note that this typical time block applies to majority of wood collectors only. In some cases, collection is done early in the morning or late in the evening, as appropriate. The same Table 34 also indicates that most social activities, apart from education, take place in the evenings, so that in the main, there is little or no conflict between woodfuel collection and social development. Actually, within

Figure 15 : A general Time-Space Activity Pattern of a typical 4-member Household.



NOTE: Travel distance is covered by walking. Since walking is generally slower than any type of motorised transport, time covered for distance to and fro, must be subtracted from general time indicated for particular space activity type. (Average speed of movement depending upon local terrain and delays associated with group activities, is about 4.3 km/hr. Maximum distance to wood collection and other landuse sites is about 6.4 km (see Text).

SOURCE: FIELD DATA

the whole study villages, only 43 households (11.3%) have noticed any negative social development implications of wood use within the recent past (Table 32). They go on to classify such implications as avoidable. At Tontro however, due to the general intensity of wood collection, many households are unable to fulfill certain social obligations because by night fall, when most of these activities take place, they may be fatigued and therefore cannot attend. Almost half of all cases negative influence of wood collection on social activities were reported at Tontro (Table 32).

While Table 34 reveals the possible effects of wood collection in relation to other activities on household time-budgets, Figure 15 shows how the limitation of movement to and fro land use sites, including for wood collection, will take a great deal of effective time for actual work. Since most households in the study villages cover about 3 kilometres on foot to collect wood, a walking time of about 45 minutes is required to the source(s), and an equal time for the return trip (Fig. 15). Generally, trips for wood collection are slower, especially, when women and children go in groups. Wood collection then provides a break from boring household chores, and provide opportunities for meeting friends and kins. In such cases, delays may be considerable, and wood collection may actually serve a positive social function. Whatever the nature of wood collection trips, almost all activities, including those that are home-bound, may be under the constraint of time.

In connection with school attendance, permission was sought to obtain information on school absentees between June and August, and between September and middle November. A follow up was made to contact such pupils to find out main reasons for such absenteeism. Only 4 pupils in the whole villages missed classes because they were solely required to help get wood to the house. Wood collection therefore does not cause any disruption to school development in the area.

Over all, social impacts resulting from wood use is negligible in the study area. At Tontro, such impacts range from negligible to minor.

vi. Constraint of access to common resources

It is commonly asserted in the area that, just some few several years back, wood was collected free from any property without formal permission. Evidence in the field confirmed that with increased loss of tree cover as farms expand, woodfuel begins to be scarce. Furthermore, with increase in size and population of the settlement, pressures begin to mount on available wood resources and as a result, most land owners begin to express concern over their own security of (adequate) supply. Restrictions on general entry begin at such a point.

In all the study villages, even though wood may be derived from other people free, contrary to previous practice, there is no occasion that wood may be removed from a property without prior permission. To that extent, woodfuel is no longer a common resource in the study area.

5. Responses to Impacts

Responses to wood use impacts can be classified as both traditional and modern. Traditional responses involve cultural and all use adaptations involving little or no modern technological and scientific managerial applications. Modern responses centre on In..itutional arrangements to make for alternative energy sources, scientific management and technology to contain, mitigate or correct impacts. Only traditional responses are examined in this section.

Traditional Responses: User level

Traditional responses are the most significant in the study villages. Responses range from the use level to collection sites. At the household use level, responses include, "recycling" or "re-use", wood-mix balancing, cooking rationalisation and, quantity rationing and stricter use control.

"Recycling" or "re-use"

The rationale is to lengthen the duration of available wood, thus cutting down on the frequency of additional supplies. Mechanisms employed include putting out fires on all unfinished pieces of wood after cooking and, storing them for re-use. Similarly, embers are quenched, and stored for use as "charcoal". Such charcoal may be used to heat soup, prepare stew (sauce) and beverages, and several other light cooking. If embers are not saved for re-use, they may burn out into ashes with all energy use potential lost.

Traditionally, it is said that a real home is where the fire place is always alive. It has therefore been a tradition in the past to leave domestic fires unquenched after use. In the study villages, fires are now kept alive for periods of less than 6 hours during the day in most households. At Okrakwadjo, most fireplaces are kept alive only during the cooking process. Despite deliberate measures to save wood by putting out fires immediately after use, much wood forms currently in use in that village are so inferior that, embers die out naturally soon after use. Effective domestic fire-use-hours for all households average 4.5 hours. At Tontro, several households still maintain the traditional two-logs, set end to end, and kept live on a continuing basis. Tontro records the highest mean effective fire-use-hours (8 hours). In all the villages, households agree that such effective use-hours have decreased more than 50 per cent in the recent past.

Putting out fires for re-use generally avoid wastes. However, there are several socio-economic trade-offs including those mentioned elsewhere. For example, because there are no fires to help set lamps and new fires, matches and kerosene must be available at all times. Increased use of these items which must be purchased, put extra strain on limited household budgets. Prolonged low heat and smoke which help to dry and preserve foods and house structures are also lost when fires are put out immediately after use

Wood mix balancing

Under this strategy, a conscious effort is made to mix purchased or/and hard collected wood, regarded as premium, with inferior types, instead of pure use of either. Such a use type ensures quality burning, helps lengthen use, and minimise buying or trips to scarce collection sites.

Cooking rationalisation

The trend in most traditional households with unlimited supplies of foodstuffs has been no controls on number of cooking per unit time. As woodfuel become scarce and/or expensive, cooking activities allegedly become increasingly streamlined and/or centralised. At Okrakwadjo, the pattern is two major wood use times- mornings and evenings. All users must take advantage of continuously burning fires during these time blocks. Cooking is also planned to benefit whole households as much as possible, to discourage individual cookings.

Heating of water for bathing purposes is restricted in most homes to very young children, the sick and the very old. In some households, there is no attempt to attain self-sufficiency in dish types. Finished food items that are relatively cheap at the market place are purchased rather than self-prepared in order to save wood, among other considerations. Multiple cooking, such as combining food for fufu and raw palm nuts to be used later for soup simultaneously is also another practice to cut down use.

It should be noticed that, in most households, and especially at Okrakwadjo and Teacher-Mante, notwithstanding the fact that limited fuel sources may give cause to cooking rationalisation, the fundamental reason for controlled cooking as evident in the field is food shortages.

Quantity rationing and strict use control

In households with appropriate facilities, firewood is put under lock and key, especially, when adult members are away from home. In other households, an adult or the lady head, gives out required quantities to be used for each activity. Permission is required for any additions. Such responses are mainly noted in firewood purchasing households.

There is also strict separation of commercial from domestic fuel to avoid possible "misuse" of purchased commercial fuel for domestic purposes. Examples of such strict controls are noted in most households at Okrakwadjo, and to some extent, at Teacher-Mante. Disbursement of wood fuel is generally more relaxed at Tontro.

Traditional Responses: Site level

Limited conservation

A current common practice among many farmers is to leave as many young trees as possible during farm clearance. These trees which are nurtured over several years, are primarily earmarked for consumptive purposes mostly firewood and possibly farm use and for some home construction work.

Two major processes undermine tree preservation, especially at Okrakwadjo and Teacher-Mante. The most serious single threat come from farmers on short lease or rentals. The other equally crucial factor is attributable to indiscriminate tree hunting.

Short leases and rentals

Farmers on short lease and rentals appear not bound by any moral or legal obligations to ensure a healthy state of the land on which they work, including tree preservation. At Okrakwadjo such farmers, growing mainly corn, cassava and tomatoes, believe trees interfere with the cropping system, through unnecessary shade, competition, root damage, and pest infestations and diseases. In addition, the same piece of land is used several times within the period of the lease, leaving very little or no fallow periods for natural re-establishment of soil fertility and healthy plant growth.

Another practice associated with the preceding farming system that undermines tree growth is the use of the hoe. Hoeing, in most cases, is analogous to ploughing. The land must be free of obstacles-growing trees, saplings, stumps and anything that may interfere with the smooth use of the hoe. While helping to expose the land surface to degradational agents, it removes all potential trees, and also disturbs the top soil, making it more susceptible to erosion (the cutlass rarely scratches the soil surface and erosion hazards are least).

Several land owners are responding to dangers associated with short leases. The response in most cases is a complete abrogation of leases and rentals in their current form, especially at Teacher-Mante and Okrakwadjo. In place of this, "share cropping" is becoming predominant. Share cropping allows property owners a say in the way their properties are put to use. They benefit directly from any increased productivity, and so ensure that the land is put to good use. Tenant farmers are usually requested to preserve trees no matter the cropping system. Some property owners also disallow cultivation systems, such as the use of the hoe. The owner may terminate all arrangements without any penalties, when agreements are flouted. For the part of the renter, there is no extra motivation to over-use a piece of land, since any added benefits must be shared with the owner.

If such traditional land use controls persist, it is possible that negative land use practices that tend to destroy or degenerate the land resources, may be contained. This practice however may not be carried to the extent where on-site non-land-owning farmers will be unduly victimised, to worsen the current state of land hunger in the area.

<u>Controlling wood hunting</u>

Because it is generally difficult to obtain wood, especially for construction purposes (a result of the general depletion of trees), tree piracy is common, even with deliberately preserved trees.

The most significant culprits, according to households, are school children, frequently requested by school authorities to supply poles for fencing and other minor school and associated church constructions. Apart from school children, some adult individuals are also involved in such tree thefts.

School authorities are being requested by farmers to ensure that pupils bring poles from their homes. On the other hand, adult individuals caught "stealing" poles are seriously reprimanded and in a few cases prosecuted.

Summary

The traditional response system appears to be self-motivated and self- imposed within realities of local environments over time. It has a potential of high success but, it is also realised that, responses have limited objectives, are uncoordinated, non-binding, unscientific and time-dependent. Few households will decide to control wood use just because of severe supply problems. As soon as conditions become better, such controls are relaxed. Such a phenomena was visible during the study, when some households were prudent with wood use during the rainy season when it was difficult to obtain wood, but liberal during the dry season.

General Summary of the Chapter

i. Information from the analysis indicate that at Okrakwadjo and Teacher-Mante where the original forests have been degraded, wood supply is limited. On the other hand, supply is still high at Tontro where the forest environment is relatively undegraded.

ii As a result of wood depletion, the usual traditional wood collection patterns are changing. At Okrakwadjo, wood is now being cut during farming not basically to facilitate crop productivity but to gather enough wood for future use as fuel. Also, there is an increase in the proportion of inferior woodfuels such as twigs, roots, stumps, barks and agricultural remains, in the total wood mix of households at Okrakwadjo and Teacher-Mante, where access to wood is severely constrained by forest loss.

Due to relatively nutrient poor and arid soils, tree regeneration in the villages, especially at Okrakwadjo, is relatively slow compared with Tontro, and this process of mass cutting of trees and use of potential soil organic materials for fuel, will accelerate the existing rate of vegetation degradation from forests to bushland and to derived savanna.

iii. The introduction of the chain-saw will lead to a rapid destruction of trees, especially at Tontro, if many households get access to it, and/or if the present traditional system of wood collection fails to yield enough wood and/or if the range of current market species (currently less than 2 per cent of available tree species) are expanded to include those previously unused.

iv The presence of the vicious weed, "Achampong" (which displaces all competing plants) in all the villages, provide a major challenge to future forest growth, especially, when present forest sites are significantly disturbed in the future, such as through forest fires of the magnitude of those of 1982-83..When this happens, even the relatively moist forest conditions at Tontro will not guarantee a smooth forest succession without intensive and costly control of Achampong.

v. with regard to present supply conditions of village ecosystems, the use of woodfuel at Okrakwadjo and Teacher-Mante is no longer self sustaining. Tontro enjoys a more sustainable system at present, mainly a benefit to the forest environment which has not udergone serious damage in relation to the land use types in the village. However, Tontro is exposed to negative characteristics which will eventually lead to the degradation of the forests and stress in the wood supply system in the near future.

vi. In terms all households in the combined villages, economic impacts of woodfuel use is generally negligible. In the individual villages, however, households at Okrakwadjo face minor to moderate budgetary impacts. More disruption to commercial operations is also likely to occur at Okrakwadjo where about 50 per cent of households do not get enough wood to buy when needed. Also, at Teacher-Mante, over 25 per cent of households report of increased in commercial operation costs due to wood purchases. Already, 84 and 91 percent of households at Teacher-Mante and Okrakwadjo respectively, maintain that current wood prices are too high. It is possible that several commercial ventures will cease if prices of wood continue to rise relative to profits.

vii. In most cases, economic impacts resulting from woodfuel use are serious only in households that depend upon the market place as a primary source of wood and/or as intensive supplementary source of wood for domestic purposes.

viii. Currently, there is no significant cost of labour in terms of disguised wages for wood collection because, both the cost of wood and labour seem to be equal and, there seems to be no economic advantage either to buy wood or to collect wood. This assertion however falters when the generally low income potentials of the villages are taken into consideration. At present, because incomes are low, wood collection actually implies economic savings. If future wage levels increase relative to woodfuel, the amount of time devoted to wood collection at present will actually amount to labour-dollar (Cedi) loss.

ix. Most wood collectors are home-maker/farmers who are not regularly employed. Wood collection is generally timed to avoid conflict with other money making ventures. Therefore, loss of economic opportunities through wood collection is generally <u>negligible</u>.

x. Traditional options and preferences for particular fuel species are suffering because of wood depletion. Only 63 per cent of households at Okrakwadjo indicate some preference for some species, and out of this, only 26 per cent still get them, mainly through the market place. Access to preferred species is closing in all the villages. Similarly, trees that were previously regarded as taboo, are now increasingly used. Logs are almost absent in many households, especially. at Okrakwadjo and Teacher-Mante. Fires are now kept alive only when needed, contrary to previous practices in relation to traditional beliefs. General negative socio-cultural effects of wood shortages is moderate to major in all the villages, with Okrakwadjo, indicating the most significant negative impact.

xi. In spite of increasing labour requirements for wood as shortages occur, female labour still dominates wood collection. This fact seems to relate to the traditional division of labour and the traditional mode of production which gives women preserve over activities related to domestic affairs. In this sense, labour requirement for wood collection is not worse than other domestic activities, such as cooking and/or food harvests and, any resolution of impacts should take a wider view of intra-household job sharing. Furthermore, in some specific cases, wood collection was seen to provide therapeutics and social functions by offering opportunity to women to leave the back-breaking domestic chores within the confines of households, and meeting and socialising with kins and friends. There is no doubt that woman-labour will have to be complemented by male-labour because of the increasing difficulty in accessing wood and the intensity of work it entails.

xii. Indoor air pollution appears to be a major health problem with woodfuel use in all the villages, because smoke from woodfuel circulates freely within homes since the enclosed kitchen places are not equipped with chimneys to carry smoke outside.

xiii. Distance to source of wood in the villages has increased. This increase is resulting in more reports of physical body stress, because wood collectors have to carry their load over longer distances and involving longer time. Increase in distance to source of wood is greatest at Okrakwadjo, where wood supply problems are the most acute, and lowest at Tontro where wood supply is currently adequate. Evidence from the field showed that increase in distance to source of wood is not always related to shortages. Crucial factors accounting for change in distance include location of property, wood abundance and area of intensive farm work. These are all dynamic processes which change with time.

xiv. When the amount of energy for wood collection in labour effort per unit time, expressed in kcal, is compared with gross energy available from wood collected per the same time, there is a net gain of energy from woodfuel. However, the excess energy from wood will be useful only if it can be translated to human energy for the work involved in wood collection. At Okrakwadjo and Teacher-Mante where seasonal food shortages exist, a net loss of human energy actually occurs in some households where the effort made to collect wood is not matched by energy derived from converting wood energy to human energy through adequate/food (quantity and quality).

xv. Nutritional problems due directly to wood shortages are not applicable in any of the villages, because there is always an alternative on the food market provided money is available. The practice of mutual wood borrowing from kins and friends, also ensures that no household goes hungry because of firewood. Nutritional problems generally relate to food shortages and/or lack of money for the food market.

xvi. Even though wood can still be derived from other people free, access to all wood collection sites is no longer open to general use. Generally, woodfuel is no longer a common resource in the study villages. It is becoming more of a commercial commodity;

xvii. Traditional response to wood scarcity problems is minor and uncoordinated.

With regard to the preceding summary and details provided by the model for this study (Figure 6, Chapter III), the woodfuel system, both in the short and long-term, is not sustainable at Okrakwadjo and Teacher-Mante. In these two villages, both the ecosystem and human welfare is under great stress. Conditions at Tontro show a better self-supporting system but this will likely change if there is no intervention in current use trends.

CHAPTER VIII: **CONCLUSION**

The primary objectives of this study have been to collect information on the actual amount of wood used as fuel, at the household and village level, to investigate the variable relationships surrounding acquisition and use of wood for fuel, and impacts of woodfuel use, economic, socio-cultural, and ecological. Furthermore, it was stated in Chapter 1 that the development and application of methods of study for collecting accurate and consistent woodfuel information at the field level which will benefit planning and/or conservation, was an integral part of the study. Insofar as a systematic and replicable system was developed and has been applied to the village and household levels, then it is asserted that the major methodological objective has been met. The comprehensive and consistent nature of the information collected in the field which are analysed in Chapters V to VII, has provided comprehensive information on woodfuel use in Ghana through detailed investigation of the three selected study villages and the conditions under which woodfuel is utilised. The results of this application represent the most complete, detailed study at the actual level of use in Ghana and, as a model for village level energy planning.

In this concluding chapter, key findings from the study are summarised and evaluated in terms of the relationships hypothesised for the study in Chapter I. In addition to the evaluation of the study findings, projection of future supply and demand trends and, the implication to the ecosystem and human welfare is undertaken. Finally, a framework for appropriate conservation and/or planning responses to problems in woodfuel systems are described.

Summary Findings

Significant findings of the study are summarised under wood use and wood use impacts. Significant issues concerning wood use in the villages are identified and evaluated with regard to corresponding relationships postulated in Chapter 1.

Wood use

The Summary findings on wood use are based initially on field data presented in Chapter V of the study. Information from Chapter VI, which analysed partial findings made in Chapter V, is utilised to help evaluate significant relationships in village wood consumption trends. The summary is based on significant issues raised in the study, in the sequence followed.

i. Village Fuel variety: The study overwhelmingly confirmed the importance of woodfuel at the village level. Of the 371 surveyed households, only two used alternative fuels, gas and kerosene, respectively. There was no evidence to suggest that the use of the two alternative fuels, in two households at Teacher-Mante, marked a potential trend towards the adoption of alternative fuels in general. When charcoal, a form of woodfuel, is regarded separately, the study found that it is usually used by regularly employed non-farm working households, mostly migrants, living in rented premises with limited kitchen facilities for firewood and/or have limited access to firewood. Except in a single case where medical reasons were cited, the few major charcoal users indicated they intend to switch over to firewood, which is cheaper, as soon as conditions for firewood use became conducive. Residents using charcoal are usually those with experience of urban life. In this case, charcoal use may be perceived as a reflection of "high class life". Except in a few cases, all charcoal use is regarded as temporary and/or as supplementary to firewood use. From the preceding information, it appears the hypothesis that the incidence of use of alternative fuels will increase with increase in the non-farm population /incomes in the villages, is not validated.

ii. Consumption The daily per capita use of firewood for the three villages is about 1.67 kg or a volume per capita per annum of 1.02 m^3-0.87 m^3 (and 0.03-0.025 m^3 per capita/annum of charcoal). The average firewood consumption figure is equivalent to that estimated by F.A.O. (1981), for Ghana. Charcoal consumption in the villages is below that estimated by F.A.O> for Ghana.

iii. Household size: As postulated in Chapter 1, the study established that the larger the household size, the more the demand for woodfuel. For example, Tontro, the village with the highest mean household size records the highest total use of woodfuel per household at about 13.4 kg/day, while Teacher-Mante which has the least mean household size, recorded the least daily use of wood of 9.1 kg/day/household It was, however, found that direct relationships between household size and total use of wood usually do not provide sufficient reasons for explaining/predicting wood consumption because of the influence of other variables such as age-gender composition of households and woodfuel use types between households and villages. For example, in two households of the same size, the household with more adults will tend to use more woodfuel than the one with relatively younger members. In the same way, households using wood for more intensive and frequent commercial operations, will tend to use more woodfuel than those using wood for domestic purposes only.

iv. Commercial use of wood: Commercial activities account for about 31 per cent of total combined use of wood in the three villages. Due to the high number of major commercial activities at Tontro, compared to the other two villages, and due to the fact that average household consumption of wood is greatest at Tontro than in all the villages, one will take to be valid, the hypothesis that, higher frequencies of use of wood for major commercial activities leads to higher total consumption of wood. However, the relationship between major commercial activities and total uses of wood was found to be statistically insignificant in the villages. The study established statistically that, the greater the frequency of commercial operations per unit time, the greater is the total household consumption of woodfuel. This factor emerged as statistically significant in all the villages, but especially, at Okrakwadjo and Teacher-Mante, where a higher frequency of use is required for dominantly minor wood using ventures to have an influence on total use of wood per unit time.

Even though statistical tests confirmed the significance of frequency of commercial operations on wood use, due to differences in intensity of wood requirements, final products, and scales of operation, the validity of this finding is not absolute, considering wood consumption realities in the specific villages. For example, even though the frequency of commercial operations (7 days/month) is not the highest among the three villages, households at Tontro are the highest commercial users of wood, at about 42 per cent of all uses of wood. Tontro is also the highest total user of wood per household. On the other hand, Okrakwadjo with the highest frequency of commercial operations (11 days/month) has the lowest proportion of commercial wood demands, at only 28 per cent of total uses of wood, and is also not the highest user of wood per household. It appears that the nature of the commercial venture in terms of wood demands, the total number of commercial ventures, and the frequency of operations together determine the influence of the commercial factor in wood consumption.

v. Proximity to undegraded forests/fallowlands: Tontro which lies in a relatively undegraded moist forest environment is the village with the highest per capita use of firewood at about 1.98 kg/day and a volume of 1.21 m^3 -1.03 m^3 per capita/annum while at Teacher-Mante where access to wood is relatively difficult due to vegetation degradation, the least per capita consumption of about 1.53 kg/day or a per capita volume of 0.93 to 0.8 per annum is recorded. This finding validates the hypothesis that the closer a village lies to accessible fallowlands, especially forests, the more the amount of wood used. The validity of this finding is however constrained when Okrakwadjo is considered. Even though all analyses in Chapters V-VII show that Okrakwadjo is the village with the most degraded environment, and where access to farmland is most difficult, it is not the least in terms of household use of woodfuel. The implication is that location near fallowlands, even though important for villagers who scarcely buy wood, is not a causal factor of wood use. Location near fallowlands can only promote liberal use of wood and not cause it if the conditions for demand, such as increased average household size and commercial activities are not in operation. On the other hand, even though it may be difficult to obtain wood at a place, conditions such as demands of commercial activities and regular means of making income, will rather ensure that a regular supply of wood to the household from the market place will be maintained.

vi. Free sources of wood: In the villages where the highest proportion of households collect most wood for free, the total amount of wood used is high. This finding tends to send mixed signals with regard to the hypothesis postulated that, households that collect the most wood for free, tend to use the most woodfuel per unit time. The hypothesis is valid for Tontro where the highest number of bundles of wood is collected and also where the highest amount of wood is used per household. On the other hand, while households at Teacher-Mante collect more bundles of wood than those at Okrakwadjo, households at Okrakwadjo use more wood than those at Teacher-Mante. The relationship between wood collected and wood used is also not very significant when considering sectoral levels of use. For example, while a daily difference of about 4.3 kg exists between households for total use of wood, the difference is only 1.02 when domestic uses are compared between the villages.

The preceding situation, can be variously explained. For example, wood purchases usually supplement wood collected for free, thus a household which actually collects small amount of wood may end up using more wood; the amount of wood available for use depends upon the distribution of available wood between activities in terms of priority areas. In this sense, commercial activities usually use more household fuel compared with domestic needs, in proportional terms. Such factors make it difficult to predict the effect of wood collected and final use for, the amount collected can be less or more than actual needs.

vii. Occupation: The study found that villages with large proportions of farming households tend to use more woodfuel, thus validating the postulated positive relationship between farm population and wood use (Chapter 1). The real effects of this relationship is difficult to isolate because, about 77 per cent of households in all the villages are farmers, and there is no significant differenc between the villages statistically, in terms of farmer-population. Moreover, Teacher-Mante, which has proportionally the highest farming population, is the lowest consumer of woodfuel per capita. Limitations to the occupational factor stem from reasons such as, i). availability of woodfuel: even if the proportion of farmers in a village is very high but the land is degraded, constraints on supply and use will occur; ii). low prices of woodfuel relative to other fuels: In rational economic terms, most rural dwellers will use wood because the wood resource is cheap, and involves little or no initial investments for use, compared to most alternative fuels; iii). lack of alternative fuels in the villages (except kerosene for lighting): This reality implies that even if some households can afford alternative fuels, they are not physically available to be used; iv). relative ease of accessing wood: In all the villages, wood can be obtained for free, provided it is available, and no matter the occupation; v). the association of woodfuel with rural life: this singular fact succeeds in drawing even ex-urbanites to woodfuel use and, vi). the near uniformity of standard of living in the villages: Without regard to occupation and income, access to certain basic goods and services are cut off to most rural dwellers. This implies that conditions of living generally reflect local resources and circumstances, with little variations between occupations.

viii. Distance: The mean distance covered for wood collection in the villages is 2.8 km, ranging from 2.2 km (shortest) at Tontro to about 3 km (furthest) at Okrakwadjo. The result generally confirms the hypothesis that the longer the distance to wood collection sites, the less the amount of wood consumed per unit time. There is, however, an anomalous situation between Teacher-Mante and Okrakwadjo. In relative terms, distance to sources of wood are closer at Teacher-Mante than at Okrakwadjo, but households at Teacher-Mante use less wood per household, than at Okrakwadjo.

The discrepancy between distance and wood consumption can be explained by several factors. For example, distance will be considered significant if all households collect all their wood needs. The location of property is also crucial in villages where access to resources is no longer universal. Some household members will always walk longer because of the location of their property. Changes in farm locations also have effects on changes in distance to sources of wood. There is no doubt, however, that in villages where resources near the settlements are over-utilised, people will have to commute longer for the usual quantity and quality of wood.

ix. Primary source of wood: The study found that the more households controlled their primary source(s) of wood, the more they collected and used wood. At Tontro where most households controlled their primary sources of wood, consumption is highest among the three villages. This finding is valid where sources of wood are undegraded and labour is available to collect adequate wood when required. In villages with diverse wood acquisition systems, no single source usually emerges as most significant, and sources need not be controlled for adequate woodfuel to be acquired. For example, while proportionally more households at Teacher-Mante control their primary sources of wood compared to Okrakwadjo, households at Okrakwadjo, who are less likely to control their sources of wood, use more wood than those at Teacher-Mante.

x. Land tenurial types: Statistically, the study found no significant relationship between existing land tenure systems and total amount of wood used. For example, Teacher-Mante which has the highest proportion of its households fully owning their farmlands, used the least amount of wood, compared with the other two villages. The tenurial factor will normally be considered important in village situations in terms of the degree of access to land resources, particularly woodfuel, provided farmland remained undegraded. The tenurial factor is rendered less significant in the study villages probably because of the existence of mutual arrangements for free wood from friends and relations when shortages do occur, and irrespective of land holding type. The market place also removes some of the importance of land holding.

Comment: The use of woodfuel is heavy and overwhelming in all the villages. Even though many factors emerge as significant in explaining levels of wood consumption, no single explanatory factor appears comprehensive enough. With regard to specific conditions in the villages, household size, with respect to age and gender differences, presence of commercial activities, considering, total, intensity and frequency of operations, primary source of wood, subject to wood status, and bundles of wood collected per unit time, which is also related to occupation, access to land, vegetation status, and labour for collection, collectively influence the nature of wood consumption in the villages. In terms of planning implications, there is basic need to know the actual amount of woodfuel used, the state of the vegetation from where wood is collected, and locally critical variables which affect the woodfuel system.

Impacts

Impacts of woodfuel use are summarised under ecological, economic cultural, physical health and general social welfare and summary on impacts is mainly based on Chapter VII of the study.

Ecological Impacts

The issues involved relate to whether wood use leads to vegetation loss and general surface degradation in the villages. The summary examines;

i Vegetation/species loss: Primarily, the study found that current use of woodfuel does not directly cause vegetation loss in the villages, because, the majority of households collect dead wood rather than cut live trees. Since the wood form mostly used is not directly related to live, standing vegetation, it is unrealistic to transform the amount of wood consumed to an equivalence in vegetation loss. However, increased wood depletion, indirect tree-cutting for farming, and commercial demands from the urban centres will potentially change the usual traditional pattern of wood collection. For example, live trees are now being cut in large quantities by some farmers at Okrakwadjo during initial farmland clearance so that adequate wood can be generated for future use as fuel, as the usual sources of wood are almost depleted. The chain-saw has also been introduced into the woodfuel market because of increased and specialised urban commercial needs. If these new trends are increasingly adopted, there will be large scale depletion of species.

ii. Agricultural land use: Local agricultural practices are the immediate causes of tree depletion. For example, the bush-fallow system, which is the common agricultural practice in all the villages, is wasteful in terms of tree loss. There is more threat to the ecosystem as fallow periods reduce considerably due to increased pressures on available land. At Orakwadjo and Teacher-Mante, fallow periods are now below 7 years, meaning that natural plant succession is not allowed adequate time to its climax, or even half way through it. This results in both poor agricultural soils and restricted tree regeneration. Furthermore, at Okrakwadjo, where maize, cassava and vegetables (tomatoes, pepper and egg-plants) are the chief crops, the extent of tree loss is greater. because such crops are generally shade-intolerant and are also heavy users of available natural sources of nitrogen in the soil. Thus, while more trees are removed to grow the crops, the soil is again impoverished, reducing the general potential of plant productivity in the village. This situation may be compared with Tontro, where the dominant crop is cocoa which is perennial, and with which trees are deliberately left standing and/or nurtured to provide shade to the growing cocoa crop. In this situation, the ecological situation is satisfactory.

iii. Use of inferior forms of woodfuel: As wood scarcity increases, wood collection is intensified to involve non-traditional sources of wood. For example, the proportion of inferior woodfuels has increased dramatically in the total wood mix of households at Okrakwadjo and Teacher-Mante where the ecosystems are more degraded. At Okrakwadjo for instance, as much as 57 per cent of total wood used is accounted for by inferior woodfuel. On the other hand, at Tontro where woodfuel is still relatively plentiful, 90 per cent of all wood used is classified as quality wood. The increased use of inferiors implies that twigs, roots, stumps, barks of trees and agricultural remains which normally offer surface protection and organic matter for the soils, are being removed to the potential detriment of agricultural productivity and future vegetation regeneration.

iv. Degradation and species transformation/loss: As the land surface becomes more degraded, the more is the invasion of persistent weeds, such as the "Achampong" which displaces all competing plants including young trees. The problem is potentially alarming in all the villages, but most acute at Okrakwadjo, where both agricultural productivity and vegetation growth has been affected. If current trends continue, tree growth in the village will be completely retarded in the near future, and massive labour and other inputs to production will be required to ensure crop growth.

Comment: Generally, the nature of the village ecosystem influences the rate and extent of damage/degradation. At Okrakwadjo and Teacher-Mante, where the original forests were relatively Dry-semi Deciduous by nature, degradation has been rapid because, tree regeneration is slower under the relatively drier environments, and the soils are also relatively dry and impoverished (relatively, low humic content) for farming. Thus, while any increased cutting of trees are relatively slower to replace by natural means, farmers have to change and/or extend their crop lands to new areas frequently, to ensure increased production. These processes are damaging to both the vegetation and surface protection. The general difficulty in accessing wood at Okrakwadjo and Teacher-Mante, therefore, is a reflection of their location in relatively drier and over-used ecosystems. On the other hand, at Tontro, the Moist Semi-Deciduous ecosystem ensures rapid plant growth, and relatively humus rich agricultural soils due to the constant supply of vegetative matter and rapid rate of decomposition under the moist and humid conditions. Both perennial cropping and agricultural productivity are therefore high, and this is favourable to wood retention. For planning and/or management considerations, there is need for efficient maintenance of vegetation cover in relation to human demands, using agriculture to improve the wood supply system; and improving and diversifying fuel sources.

Economic

Economic impacts determine the extent to which woodfuel use financially affect households, directly and indirectly, with regard to the general limited opportunities of making incomes in the villages. The major economic issues include;

i. Wood purchases: The study found that the non-farm and the non-land owning population(s) are not significant sources of increased wood purchases in the villages, contrary to the hypothesis that the greater the number of non-farm households in a village, the higher will be the incidence of wood purchases. Rather, most wood purchasing in the villages is commercially motivated. For example, the village of Teacher-Mante which has the highest number of households operating commercial ventures, purchase the most firewood, even though Okrakwadjo has the highest number of non-farm and non-land owning households. Even where commercial needs give cause for buying wood, households do so only when it is difficult to get it free, both in terms of availability and the labour for collection. For example, notwithstanding the fact that households at Tontro use the most amount of wood for commercial purposes, a total of only 8 households (10%) purchase wood in that settlement because it is relatively easy to get free wood, while as many as many as 56 households (35%) purchase wood at Okrakwadjo, because of scarcity.

In many cases, the economic impacts resulting from woodfuel use are mostly experienced in households that depend upon the market place as a primary source of wood and/or as intensive supplementary source of wood for domestic purposes. Generally households do not buy wood as a matter of routine even in the face of scarcity. However, at Okrakwadjo where some wood purchases also service the domestic sector, budgetary impacts are becoming significant in relation to the restricted means of deriving income in that settlement.

ii. Price changes relative to ability to buy: At Okrakwadjo and Teacher-Mante where wood is growing scarcer, the majority of wood purchasing households maintain that current wood prices are increasing compared to the past. Commercial operations are likely to be disrupted as it becomes difficult to obtain adequate wood due to shortages and increased costs of wood. However, when price changes for firewood over time are compared with general changes in manufactured commodity prices, price increases for woodfuel is seen to be lagging far behind. This situation is however immaterial to village dwellers who historically have regarded firewood as a free good, and also, whose means of income are very low. Hence, any slight increases in prices of woodfuel are regarded as significant.

ii. Economic importance of woodfuel: Even though wood can still be derived from other people free, access to all wood collection sites is no longer open to general use. Wood is becoming more of a commercial commodity. However, because wood prices are still cheap, relative to wages, there is no significant cost of labour in terms of disguised earnings for wood collection at present. If opportunities for making incomes improve in the future while wood scarcity continues, the cost of collecting wood, in disguised earnings, will be significant.

iv. Conflict with economic opportunities: At present, most wood collectors are home-maker/farmers who are not otherwise employed. Wood collection is thus generally timed to avoid conflict with other household money making ventures. Therefore, loss of economic opportunities under the present system through wood collection is generally negligible.

Culture and tradition

Generally, cultural impacts of wood use relate directly to species loss, and changes in the structure of household distribution of labour for wood collection. Significant impacts include:

i. Restrictions in choice, taste and preference: As more species are lost due to vegetation loss, most households no longer have options to select wood species for fuel, compared to the past when wood was plentiful and when traditional options and preferences dictated types of wood utilised. In many cases, species that were previously regarded as taboo to local beliefs, and/or inferior to social standing, are now liberally used, and are even difficult to obtain. At Okrakwadjo for instance, relatively few households still have access to their preferred species and they mostly obtain these from the market place. In many households, because there has not been any free choice to the kind of woodfuel used for some years past, the idea of preference is becoming foreign. According to the study findings, the hypothesis that the higher the wood supply problem in a village, the higher the probability of use of non-traditional and taboo species, is valid. Socio-cultural effects of wood shortages are becoming significant in all the villages, especially at Okrakwadjo and Teacher-Mante.

ii. Changes in labour for wood collection: In spite of increasing labour requirements for wood as shortages occur, female labour still dominates wood collection. This finding is contrary to the hypothesis that as the wood supply problem becomes more acute, more disruptions in the traditionally set household division of labour will occur. The domination of female labour appears to be a reflection of the maintenance of existing traditional family relations and the existing traditional mode of production, more than any negative power relations between genders. For example, in most traditional homes, domestic activities, to which wood collection forms an integral part, is usually female controlled. At the same time, because most households strive to be self-sufficient, especially, with regard to subsistence, each member contributes significant amount of labour to make this possible. Depending upon the ecology of the local area and dominating occupations, specialisation of intra-household functions do emerge, usually based upon perceived relative difficulty of performing tasks. In the forest areas of Ghana for instance, men are generally supposed to clear, fell trees and fire new farmlands because these are perceived to be difficult and dangerous tasks, while women generally help in planting, tending crops, harvesting and transporting produce (considered moderate and less dangerous tasks). With the problem of wood shortages becoming more acute, men are becoming more involved at the cutting and processing end, particularly with logs and bigger branches. A modest beginning is also being made at the carrying level (most despised by men).

Physical Health and General Welfare

Physical Health and General welfare considers all health implications of wood use with regard to physical and mental stress, and denied opportunities for social/self development. Significant issues include;

.. Pollution: Indoor air pollution appears to be a major potential health problem in all the villages because, cooking is mainly done in enclosed kitchens with no chimney facilities to carry smoke outside. Smoke from woodfuel circulates freely within homes and rooms.

ii. Frequency of wood collection and physical health implications: Wood collection in the villages takes place within 95 days in a year ranging from 104 days/year at Okrakwadjo to 87 days year at Tontro. This finding shows that the more difficult it is to obtain wood, the more frequently wood is collected, and the more the stress on physical health. Some qualifications to this finding are necessary. In some farming households, the routine has been to collect just enough wood for each use day, therefore, wood collection takes place in more days in a year than average. Households falling under this category are among those with abundant supply of wood. Furthermore, households using wood for commercial activities require to collect more wood at frequent intervals to meet constant demands and this will not necessarily reflect shortages. Again considering that wood collection at Tontro actually involves more time than any of the villages, the longer time dimension for each collection day compensates for the least number of days in a year for wood collection, and any effects on physical health will be equally significant. However, this finding does not negate the reality that as wood becomes scarce the number of days for collection increases, and this will increase the incidence of stress on the general body.

iii. Time-Distance implications: There are reports that as distance to sources of wood and time for wood collection increase, labour-efforts for collecting and transporting wood is intensified and this has direct effects on physical health, mainly because, wood collection is generally non-mechanised. Under such conditions, physical health effects are expected to be high in villages where wood supply is a chronic problem, such as at Okrakwadjo and Teacher-Mante.

A general impression given by majority of households about the distance and time effort required for wood collection is that it is a no more difficult task than other household chores. Thus, the amount of time involved for wood collection does not necessarily reflect amount of labour expended. There is no doubt, however, that wood collection has tremendous effects on physical body stress, particularly, women who are the major collectors of wood.

iv. Nutrition: Nutritional problems due to wood shortages are not directly applicable in any of the villages. The practice of mutual wood borrowing and help from kins and friends, ensure that no household goes hungry because of firewood shortage. Nutritional problems generally relate to food shortages and/or lack of money for the food market.

vi. Conflict between wood collection and social opportunities: Considering the time involved in wood collection, it will appear that most women will be denied opportunities for their social development. Usually, households at Okrakwadjo who face the most acute wood supply problem should indicate constraints in social welfare due to wood collection. On the contrary, however, reports on limited time for social development is highest at Tontro where, ironically, average distance to sources of wood are the shortest and where woodfuel is relatively plentiful. Compared to the other villages, most households at Tontro still use logs and relatively bigger branches for firewood. Processing and transporting wood is therefore more labour-intensive and time consuming. Each wood collection day potentially results in a great deal of fatigue and, women are unable to attend to activities outside the household. At Okrakwadjo for instance, twigs dominate the wood mix, and this requires relatively less effort to harvest than logs. Actually, most time involved in wood collection at Okrakwadjo is taken up by wandering over larger wood collection space to gather enough wood, more than the harvesting process itself and thus intensity of labour is relatively light.

Comment: As the wood supply situation deteriorates, there will major socio-economic impacts. However, efforts to maintain the woodfuel system now, to avert very critical situations in the future, are non-existent. Many questions with regard to planning considerations come forward. For example, is there a need to intensify manufacturing or change the village economy? Does wood dependence retard development? Is the traditional system of specialisation of duties, and the existing mode of production a hindrance to change? How best can wood be accessed to avoid the excessive labour demands on women? How can the wood consumption environment be made safer for users? What are the appropriate responses to cultural needs as wood scarcity increases?.

Wood use and the model for the study

This section of the work attempts to compositely evaluate the sustainability of village woodfuel systems using key conditions suggested by Figure 6, which explains the sustainability of village woodfuel systems in humanly modified ecosystems. The utility of the model (Figure 6), with regard to specific field findings is also assessed as an attempt at improving the model itself for any future studies. The evaluation of the sustainable nature of woodfuel use, and the efficiency of the model with regard to the study, are described below.

i. Balance between wood supply and demand: According to stage 1 of the model of the study, a sustainable woodfuel system must have a balance between wood supply and demand. According to the summary findings to the study, such a balance does not exist, at Okrakwadjo and Teacher-Mante. Tontro is well supplied with wood currently, but this advantage is likely to be lost in the near future if no intervention in the present system of wood consumption occurs.

ii. Relationships between vegetation and population dynamics/land use: Stage 2 of the model shows the interrelated effects of vegetation, population, and village land use on woodfuel. The study found that size, quality and species diversity of the vegetation in the villages have deteriorated significantly. There are increased demands for wood and other land resources such as food and fibre, as the human population increases, resulting in reduced carrying capacities of village ecosystems. This is affecting wood supplies significantly. Once shortages occur, previous traditions and restraints that helped to bring a balance between ecosystem dynamics and human population dynamics which is fundamental to sustainable woodfuel systems, no longer operates. This implies that the process of ecosystem destruction and the erosion of human welfare will become uncontrollable, circular, and cumulative processes. Generally, the relationship between agriculture and the vegetation system is negative. The system of farming is generally depletive of the vegetation cover, while productivity is very low. Both processes directly and significantly degrade local ecosystems and reduce potential supplies of woodfuel.

iii. Time-Space efficiency: Generally, distance and time were found to be less significant in relation to the use of the ecosystem for wood supplies. As land become increasingly privatised, and wood becomes a commercial commodity, there are restrictions on entry to properties. Thus, no matter how close a property lies to a village, and no matter the abundance of woodfuel in that property, the owner of the property has the sole right to woodfuel in it. Factors that really determines distance and time covered for wood collection, include, the location of property (ies), vegetation status, changes in locations of farms, tenurial systems, size of holdings, economic potentials, and ease of access to wood from kins and friends.

iv. Internal socio-economic characteristics. This is represented in stage 2 of the model. Existing internal socio-economic characteristics are both negative and positive to village woodfuel systems. Some negative trends are attributed to existing land tenure systems which generally do not promote efficient use of the land resources. Existing tenurial systems also usually lead to small size of holdings and landlessness. In addition, most villagers have limited incomes to the extent that the ecosystem becomes the immediate source of most needs, even if these can be obtained from the market place cheaply. Low incomes also imply that, access to inputs to promote productivity in agriculture, for instance, which will in turn reduce pressures on village lands, is difficult. Aspects of village social relationships which work to reduce pressures on resources such as woodfuel, is the existence of mutual help between residents. Landlessness, size of holdings and economic potential is overcome through mutual help from residents with excess supply of land resources, such as woodfuel. In terms of wood use, such positive

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trends have limited contributions to long term efficiency of woodfuel systems, because they tend to distribute the depletive nature of woodfuel use to a wider sphere.

v. <u>Alternative opportunities:</u> According to stage 3 of the model, the village is linked with the external environment through the flow of goods, services, ideas and skills. Generally, while the villages service the external environment with food and inputs for development, very little in the sense of goods and services reach the villages. The absence of alternative opportunities and innovations from the external regional and national environment increases the dependence of the village population on the ecosystem, for basic needs.

<u>Comment</u>: According to stage 4 of the model, woodfuel use is not sustainable activity in the study villages. Okrakwadjo and Teacher-Mante exhibit the most negative trends of woodfuel use as a result of the much degraded ecosystems, conditions which are further worsened by their location in drier environments and relatively high population numbers. Species depletion is high and conditions are being created for rapid vegetation loss and surface destruction. Even Tontro, where the forest environment is less degraded will not escape serious modifications in the ecosystem if present wood use trends continue. Serious socio-economic consequences are also faced due to wood shortages and degraded village ecosystems.

The erosion of the ecological and socio-economic viability of villages will have major consequences not only for the local inhabitants but also for the country as a whole since the villages are the major providers of food and raw materials for national development. How will future wood supply and demand situations affect the ecosystem and human welfare looking at present circumstances?

The Utility of the Model: The model for the study is effective because it highlights the complex nature of village fuel systems and show key elements and relationships that are vital to woodfuel systems, and which any field level investigation cannot ignore. On the other hand, due to structural changes in access to land in the villages, the effects of time-space implications on village fuel systems/land use systems, is somehow exaggerated (in the model) while the relationship between agricultural land use and fuel production will require more attention (in the model), in future studies. With regard to the poor performance of national economies of most developing countries, including Ghana, in terms of responding effectively to problems such as village energy systems, stage 2 of the model, which considers critical variables within villages, such as population, vegetation and land use situations, should be given the most attention in a model for future studies.

Projections for the future

Based on empirical information on current wood supply and demand situations in the villages, projection of future wood demands can be made to assist planning and conservation strategies. Proper projections of woodfuel use based on detailed and consistent information will help to detail the appropriate inputs, techniques and manpower for efficient planning in the rural energy sector vis-a -vis the national economy.

Procedure for projection

Projections on wood use can be done in several ways but the commonest and regularly used procedure with regard to firewood consumption is the use of population growth rate and/or growth of an economy as a surrogate for rate of increase in demand (see Pluth, 1986). Also, annual biomass increment/area is used as a basis for comparing the balance between growth in demand and wood availability/supply. To project for future wood consumption in the villages, the following steps are followed; i). a time dimension and reference year are first assumed; ii). wood consumption figures for the base year must be known; iii). a rate of growth in consumption must be determined, either through existing standards, or estimated upon criteria related to wood use such as population and/or economic growth. Once the annual rate of increase has been determined, consumption can be project based upon the rate in increase and the difference in years. Wood consumption can be compared with natural wood increments estimated as the net forest increment in tonnes/volume per unit area/year (chapters IV and VI). This figure represents potential wood available for use without cutting into the stock of the standing vegetation. When wood demand levels are lower than annual wood increments, the demand situation is described as normal. However, the closer the proportion is to one (100%), the the scarcer the wood situation.

In projecting the state of future wood demand and supply in the villages, a time frame of 10 years is assumed, in jumps of 5 years, representing 1986, 1991, and 1996. Wood consumption projection is based on 1986 figures, when the study was undertaken. An annual increase in wood demand of 2.8 per cent is assumed, to correspond with the annual increase in population growth in the area. On the other hand, annual demand growth rates of 2.5 per cent per annum is used by the Forestry department of Ghana (Pluth, 1986). Projected wood consumption in each village for each selected year, is compared with the total wood increment per annum, determined by the total annual wood increment on land available to the village (Table 35).

As stated in chapter IV, the total land area for Tontro is approximately, 35 km^2. An annual forest increment of 15 tonnes/hectare gives the village a total annual wood growth of 52,500 tonnes. Both Teacher-Mante and Okrakwadjo are given an annual wood increment of 10 tonnes/ha, to reflect the relatively drier environments (Chapter VI). Based on this figure, Teacher-Mante's land area of 38.5 km2 gives a total annual wood increment of 38,500 tonnes, whilst Okrakwadjo's 32.7 km^2 yields about 32,700 tonnes of additional wood each year.

Results: According to Table 35, the current annual consumption of wood at Tontro, is less than 1 per cent of present forest increments. By 1996, the percentage of consumption against wood increment will be just around 1 per cent. At Teacher-Mante, current wood consumption is about 1.1 per cent of annual wood increment. By 1996, the percentage will be about 1.4 of total annual wood increment. For Okrakwadjo, current wood collection is estimated to

TABLE 35: PROJECTION OF WOOD USE IN THE STUDY VILLAGES BY 1996 (TONNES)

Village and Annual *Rate of Increase	CONSUMPTION BY PROJECTED YEAR 1986 (Base year)	1991	1996
TEACHER-MANTE			
2.5% Annual Increase	426.09	479.35	539.27
2.8% Annual increase		485.75	553.75
TONTRO			
2.5% Annual Increase	389.94	438.69	493.52
2.8% Annual increase		444.54	506.77
OKRAKWADJO			
2.5% Annual Increase	561.8	632.02	711.08
2.8% Annual increase		640.45	730.12

*2.5% Annual consumption Increment is used by the Forestry department of Ghana (Pluth, 1986)
*2.8% Annual Increment Based on Annual Population Growth Rate

Estimated wood Increment Per Annum (see Text)
Teacher-Mante: 38,500 Tonnes
Tontro: 52,500 Tonnes
Okrakwadjo: 32,700 Tonnes
SOURCE: FIELD DATA

take about 1.7 per cent of annual vegetation increment. By 1996, the percentage is estimated to increase to 2.2. According to the preceding information, wood consumption in all the villages is well below annual rates of vegetation growth.The general conclusion is that wood consumption is safe with regard to available supply potentials.

Limitations of the procedure:

Notwithstanding the reported net gains in wood increments over projected demands for all the villages, there are several limitations with using the preceding procedure for assessing future wood use balance. Among such limitations include;

Population growth rates as a meaure of demand: By using the rate of population growth to estimate future wood demands, it is assumed that current standards of use will be maintained. However, demands can increase dramatically when for example, industrial use become intensified. On the other hand, demand may be curtailed when alternative fuels become available. Population growth rates do not adequately account for dynamic processes that occur between the intervening years of projection. Again, demand levels based on population growth rates erroneously assume uniform distribution of use. Differences in population structure and fuel use types, for example, will lead to either shortfalls or exaggerations in projection.

Gross considerations of growing plant stocks of an area: All types of plants in the villages are supposedly included in estimating forest growth, including growing agricultural crops and all other plants without regard to their suitability for wood production, and assuming that every kind of vegetation matter is used as fuel. This is however not the case in the villages because, cultural preferences and traditional sanctions place constraints on the kinds of species utilised as fuel.

Accessibility/land ownership: Except where land is perfectly communally held, projections that grossly consider whole spatial units such as villages, may be unrealistic, because they do not take accessibility of users into account.

Regularity and/or Reliability of Forest Mensuration: Estimates of forest growth/volumes are scarcely undertaken due to reasons such as costs, equipments and manpower. In Ghana for example, if the forests are enumerated at all, they mostly apply to economic trees, in a few forest reserves. Costs will further preclude any frequent forest mensurations so that figures which are usually quoted are out of date (assuming that they are correct). For example, even though the vegetation at Okrakwadjo is supposed to be forest, the forests have long been degraded, but figures applied for vegetation growth will still classify Okrakwadjo as a forest zone

Due to the limitations discussed, caution needs to be exercised in applying information based on projections. It is, however, to be noted that projections of woodfuel use are useful planning tools and may complement other kinds of information. Without greater reliance on the projected wood supply situation, but mainly considering present field situations as analysed in the first part of this chapter and elsewhere in this work, wood supply at Okrakwadjo and Teacher-Mante will reach critical conditions by the next decade. Tontro will rapidly decline as a major wood supply locale s, especially, when the cocoa farms are destroyed. The implications for the ecosystem and human welfare will be challenging.

Appropriate Conservation/Planning Responses

This final stage considers the significant findings made from the study in relation to conservation and/or planning responses to the energy situation described. Such responses are envisaged to involve strategies which may help lead to sustainable woodfuel systems. To make for sustainable use of woodfuel, strategies have to consider such conditions as, increasing the supply of fuel for human development, maintenance and protection of the fuel supply environment, efficiency of use of fuel, and aviodance of risks with woodfuel use. Operational consideration of the preceding conditions range from the wood supply environment to the consumer, and within the spatial framework of the village boundary, to the regional/national and the international systems need to be designed. All strategies will have to be guided by evolved policies and institutional arrangements to make them operational and effective.

Providing a general framework for application, rather than a comprehensive evaluation of strategies, the next section discusses specific and appropriate conservation and/or planning responses to the wood energy situation. The discussion is are categorised as; i) supply and site management ii. Demand management and, iii. education and policy/institutional framework for i and ii. Specific examples are provided to illustrative purposes.

Supply and Site Management

Specific strategies under supply and site management include; strategies for increasing and maintaining tree stands and wood supply, considering the demands of different ecological differences and, increasing wood supply from the present system (agricultural related and wood wastes and/or surplus wood from less pressured environments).

i. Increasing the supply of wood-Forest Planting and Maintenance

The most fundamental basis for increasing wood supply to overcome shortages and related impacts is to maintain a high tree population through increased planting and maintenance of growing trees. In Ghana for example, the Central Forestry Department has been involved in forest planting programmes for decades. Like other developing countries, the emphasis however, is on government controlled forests which are mostly in reservations. Strategies include enrichment plantings at various scales, including the conversion of an area of 57,000 ha of local "unproductive" hardwood forests of the Subri Forest Reserve in South-Western Ghana, to fast growing exotic species, suitable for pulp and fuelwood, under a F.A.O. project in the 1970s (F.A.O., 1985). The forestry department also has some planting programmes to benefit fuelwood outside the official reserves. The department controls access to all official forest reserves to prevent unauthorised tree cutting, prevents the spread of uncontrolled fires, especially, along the forest-savanna boundary, and ravaging browsing animals such as goats from destroying saplings. The Forestry department also promotes natural regeneration through the removal of overwoods, removal of competition to growing saplings and all other obstacles that inhibit efficient tree growth.

Generally, government planting programmes have the advantage of finance, qualified personnel and appropriate inputs. However, the planting programmes have failed to make any impact as far as village wood supply is concerned, not only because afforestation has failed to keep pace with wood loss, but mainly because the location and objectives of the planting programmes do not benefit village fuel provision. There is no link whatsoever, of such programmes with the village level, in terms of species utilised, and local inputs and participation. The intended objective of most plantings is to increase the supply of economic trees for timber or charcoal production for industrial and urban needs. Villages will only benefit if they are considered as integral parts of planting schemes and have inputs in the design and the formulation of projects.

Increasing Supply through the Present System

Agricultural related:

Studies have indicated that with appropriate management practices, adequate wood can be generated from agriculture. For example, a world Bank project in the Sudan has projected that if wood is cut rather than burned during farming, up to 50 m^3/ha of firewood can be generated from each cleared farmland (Postel and Heise, 1988).

With respect to Ghana, and the study villages in particular, most farmers do not have access to yield-enhancement inputs such as chemical fertilisers, so that ashes from burnt organic matter, including wood, provide most needed nutrients for plant growth. Thus, if most wood on farms can be saved for fuel uses, alternative means of improving soil fertility have to be found. Chemical fertilisers seem to be the proven alternative but, domestic manure and cropping practices that restore soil fertility can also be utilised to increase soil/crop productivity. Again, in applying the strategy of maximum use of wood with farming, caution must be exercised, especially, in wood scarcity areas and areas with low plant productivity, to ensure that mass cutting of standing trees will not follow this practice. There is no doubt that the sustenance of the wood energy sector in the villages hinges on agricultural productivity and increased farm incomes. Much attention is thus required to support village agriculture and society.

Wood Wastes and Surplus Wood

The Subri forest project in Ghana in the 1970s (F.A.O, 1985) for example, provided wood wastes associated with the mass clearing of the natural forests for conversion into fast growing exotic trees for charcoal manufacturing. Charcoal conversion from logging wastes in Uganda is also alleged to have resulted in an increase in charcoal production from 200 tons to 63,700 (short) tons (Postel and Heise, 1988; also, World Bank, 1986).

Another way of improving wood supply which logically comes out from the preceding is the improvement in woodfuel distribution. It is realised that wood surplus exists in many locations, including logging and industrial wastes, but because of the effects of distance (transportation), scarcity intensifies in areas of high demand. If an efficient distribution system could be established to tap wood resources from areas of over-production to centres of demand, pressures will be reduced in local ecosystems that are unable to support demands.

Demand Management

Managing energy demand includes all strategies that are intended to reduce the amount of wood that is directly removed from the ecosystem. Strategies under demand management include, use efficiency, reduction of services requiring the use of woodfuel, inter-fuel substitution, economic mechanisms, and education.

Use efficiency

Efficient use of woodfuel at the household level is mainly related to the technical medium for using wood such as stoves and utensils for cooking. For example, wood energy losses of up to 90 per cent have been reported with the use of traditional cooking stoves (Foley et al., 1984, Postel and Heise, 1988 etc.) In many rural areas, especially the study villages in Ghana, most cooking utensils in use now, are aluminium made and are therefore thermally efficient. Major sources of wastes can be traced to the traditional stoves which range from simple three-stones/tyre rims to horse-shoed earth built stoves. In most of the stoves, burning cannot be controlled and depending upon the height of the base of the cooking pot and the fire in the stove, heat escape can be considerable.

To increase energy efficiency improved stoves are required. Foley et. al. (1984: 9). have reported study findings of energy savings of 20-35 per cent compared to open fires. And according to a recent report, the introduction of an improved charcoal stove 'Dodoma stove' or 'jiko la Dodama, which is made of local materials, has led to savings in charcoal of up to 25 kg/month in Tanzania, which if consistent will help save many trees (A.A.I, 1986:68)

There is no doubt that improved stoves can reduce the level of demands of woodfuel. However, as some other studies have indicated, some of the stoves that have been designed have actually showed little or no savings. Sometimes, too, reports of savings may be psychological rather than performance of equipments. For example, Foley et. al. (1984:9), have documented an observation by an expert in the field that two weeks of daily measurements of wood in Burkina Faso, without the use of stoves was sufficient to reduce consumption of wood by 25 per cent. The concept of wood use efficiency, as applied by most researchers and planners to village situations is unrealistic. There is no wastage as far as rural wood use is concerned. In other words, efficiency of use is 100 per cent, considering the fact that cooking is not the only function a fire is to serve. If heat escapes, it dries produce, protects roofing, provides warmth and other services crucial to the maintenance of households.

For conservation and planning considerations, it should be realised that the existence of stoves alone will not guarantee savings if such stoves are not used efficiently, or left to deteriorate. Stoves also cannot save trees in environments where fundamental causes of tree loss are not woodfuel originated.

Reduction of services requiring woodfuel

By reducing the amount and/or services requiring woodfuel, savings can be made. Since cooking and related activities take over 70 per cent of all daily uses of wood, savings have to begin from that level. For example, if all cooking is centralised at the household, this will reduce the number of times for using wood and will provide effective checks to reckless use. Bulk food should be prepared where possible so that meals can be used over several days, to cut down on cooking. Heating of bathing water for instance, should be restricted to the very young and old, or the sun can be used to increase the temperature of water before boiling so that effective boiling time can be reduced. Furthermore, cooking activities that require several stages should be bridged by combining compatible stages.

Most of the preceding suggestions may be considered only when households perceive real shortages of wood. Some of the mechanisms mentioned will also require good storage facilities for food, such as home refrigerators, which are ironically depended on energy.

Cutting down on services requiring woodfuel, as a means of controlling demand, will be possible only when alternative supplies exists, in order not to compromise general quality of life. Certain basic necessaries, such as power and storage facilities will also be required.

Alternative Fuels

The provision of alternative fuels is a major long-term solution to help ease the pressures on village wood supply sources. For example, if electricity is available, it will help for lighting purposes, and will provide services for storage and cooking, even if only for a minority of the households. Electricity may also provide the basis for agro-based industries, and possibly, may attract other industries in the long term. Employment outside farming in the villages, will help provide incomes for marginal farmers and the landless. In the long term people can afford certain basic necessaries which hitherto was provided directly from the forests.

Over-all, availability of alternative fuels will reduce demands on wood supply, but villagers will adopt such fuels only if costs are reasonable both in relation to wood supplies, and income levels. At present, most villagers cannot afford the initial costs of investment in a cooking stove or a refrigerator.

Education and Policy Formulation

Several conditions can also be created from the external environment to maintain the wood energy system. Among these include;

Education: In most villages, the perception of wood depletion is absent so long as no food goes uncooked for lack of firewood and, once wood can be obtained for free, no matter the difficulty in obtaining it. Educating the rural population to identify imminent dangers of wood loss to, agriculture, surface cover, the local and external economy, and the general environment, can instil good land stewardship and controlled use of woodfuel. Government leadership will be required in this direction to be supplemented by local resources.

Policy/Institutional framework Strategies suggested for containing the wood energy sector require formalised policies and appropriate structures/institutions to make them operational. The existence of appropriate institutions to oversee the energy sector for instance, is a foremost requirement for problem identification, proper selection of alternative choice of actions to meet problems in the energy sector, efficient and consistent formulation of policies and, efficient execution and monitoring of policies. Proper institutional arrangements will also ensure that appropriate resources will always be assembled to meet rising problems, which are vigorously and consistently studied. In most developing countries, including Ghana, even though policies and institutions exist to manage the energy sector, most of such institutions are recent, and are preoccupied with the modern energy sector to the disadvantage of the rural energy sector. A greater policy and institutional attention will be required to make the wood energy sector sustainable.

Summary Remarks

The study has demonstrated how effective methods can be developed to collect woodfuel information at the use level. Woodfuel as currently used in the villages is damaging to the ecosystem, especially, in relatively dry environments, where tree regeneration is constrained by moisture deficiency. As populations increase, wood demand levels will increase, a situation which will further worsen the state of the ecosystem. Even though current population levels in the villages are high, the immediate source of pressure on land producing woodfuel is the low productivity associated with the local farming systems. Such low productivity is characterised by rapid expansion of cultivation to all available lands to ensure increased yields, and thus, leading to widespread destruction of vegetation. Increased trends of private land holdings, and perennial cropping, also reduce accessibility to unused land, especially, for food cropping, and this has contributed to the trend of increased frequency of use of plots, even where population numbers are relatively low. Intensive and continuous studies are required to establish all implications associated with the dynamic relationships between village agriculture and wood use. Continuous and comprehensive field level investigations are necessary to provide effective and consistent answers for making village woodfuel systems sustainable.

APPENDIX 1: SAMPLE QUESTIONNAIRE- HOUSEHOLD CONSUMPTION OF WOODFUEL IN GHANA

Locality code .... Household code ....

1) Total males 0-9 years of age...

2) Total males 10-14 years of age..

3) Total males 15 years and over..

4) Total females 0-9 years..

5) Total females 10-14 years ....

6) Total females 15 years and over...

7) Total number of people in household.......................................

8) Educational status of head of household................................

9) Main adult occupations? 1) Farming...........
2) Trading products......3) Trading agricultural products.....
4) cooked food sales........ 5) Government employee...............
6) Artisan.............7) Other\wage labour...............

10) Other\minor occupation? 1) Farming...............
2) Trading manufactured products.............
3) Trading agricultural products.........
4) Cooked food sales.......... .5) Government employee...........
6)Self-employed artisan......... 7) Other wage labour...............

11) Farmland tenure: 1) Full ownership.............
2) Own part, rent part..........
3) Lease rent\rent all...........4) Share cropping....... 5) Gift................
6) No farmland.........

12) What is the main fuel for the household? 1) Firewood..............

2) Charcoal...............3) Kerosene.............4) Electricity..........................

5) Gas............

13) What is the secondary fuel? 1) Firewood................2)
Charcoal................

3) Kerosene............ ...4) Electricity.................5) Gas.................

14) How do you use firewood? 1) Household purposes only..............
2) Commercial purposes only...........) Do not use wood......................

15) No. of meals prepared in a day using firewood.

16) Do you set separate fires for cooking and other household activities?
1) Set.............2) Partly set..........3) no, same fire.........
0) Do not use firewood..

17) How many bundles of wood do you burn per week? ....

18) Do you use charcoal? 1) Yes...............0) No...........

19) Do you buy charcoal? 1) Yes...............0) No ....

20) How much charcoal do you buy in a month? 1) Very small (1-5 heaps of 10 cedis)...........2) Small (6-12 heaps)............... 3) Fairly large (12-24 heaps-up to 1 small bag).............4) Large (over 25-50) heaps-up to 1 maxi bag)........5) Very large (Over 50 heaps) ....

0) Do not buy...........

21) What major commercial activities do you use wood for?
1)Distilling alcohol..............2) Brewing\pito.........3) Palm and palm kernel oil............. 4) Other............0) No commercial activities

22) What other commercial activities do you use wood for? 1) Processing raw foodstuffs and\or ready cooked food for sale...............2)Preservation and processing of agricultural produce........c) none..........

23) How many times do you operate in a month? ....

24) What is the general trend of your operation? 1) Year round.......... 2)seasonal...............3) intermittent....................

25) How many bundles of wood do you burn per operational month?.........

26) What cooking devices do you use for firewood? 1) Fixed earth stove...........2) Metal wood stove.. 3) 3-stone open...........4) Tyre rim, blocks, etc.................0) None

27) How many earth stoves do you use at a time?..................

28) How do you acquire wood for household purposes? 1) Self-collection...... 2) Purchase................3) Part collection, part purchase............. 4) gift....................5) Part collection, part gift................6) Do not use wood..............0) None

29) How do you acquire wood for commercial purposes? 1) Self collection.................2) Purchase...........3) Part collection, part purchase...............4) Gift.............5) Part collection, part gift............6) Do not use wood............

30) State your primary source of wood. 1) Own property..........2) Property of extended family........... 3) Communal property.............. 4) Friends.........5) Do not collect wood........

31) State your secondary source of wood. 1) Own property........................

2) Property of extended family............3) Communal property...............

4) Friends............5) Do not use wood....................

32) What is the normal distance you travel for wood? ....

33) Has there been any changes in collection distance?

1) Increased.............2) decreased.........3) Same\do not know..........

34) How many times do you go out for wood per average month? Give number of collecting days...........

35) Has there been any changes in the number of times for wood collection? 1) Increased because of shortages...... ....2) Decreased because of s shortages .... 3) Decreased because of distance.............. 4) Increased because of additional commercial needs........... 5) Increased because household size increased..........6) Decreased because household size decreased..............0) Has remained the same\no opinion.........

36) Approximately what time do you allot per average fuel collection day? Give specific time in hours.

37) How many bundles do you bring home per month?

38) State nature of fuelwood collection. 1) Independent of agricultural activities.................2) With agricultural activities.............0) Do not collect wood.........

39) According to 38, is it both independent and with agricultural activities? 1) Yes....................0) No...............

40) Who collects wood for the household? 1)Woman\women.............2) Women and children................3) Children.............4) Women and adult males............5) Adult males...................6) Children and adult males.............0) No wood is collected.........

41) Do you perceive a shortage of woodfuel in the settlement? 1) Yes..... 2) No..

42) If yes to 41, why? 1) None in own property................2) Get wood only in farming season.............3) Wood fast running out in own property as in others...........4) Buy wood.............5) No property in the settlement but use wood............

43) If no to 41, why? 1) Have big property................2) Wood is fairly plentiful in own property.............3) Have a small family\ live by myself so do not need much wood.............

44) In the face of shortages, do you use inferiors (of mainly twigs, bamboo, agricultural, industrial and domestic wood wastes)?1) Yes.......0) No.......

45) Do you have preference for some species of trees for fuel?..........1) Yes ....2) No..........

46) Do you get all preferred species? 1) Yes............0) No..........

47) If no to 46, is it because they are mostly forest species, and the forests are gone due to agricultural practices? 1) Yes...............0) No............

48) No to 45. because mainly forest species, but the forests have been destroyed by bushfires? 1) Yes...............0) No...........

49) No to 46 because of overuse for fuel? 1) Yes.........0) No.......

50) No to 46 because have to wait for mortality? 1) Yes..........0) No........

51) No to 46 because have restricted property? 1) Yes..........0) No...........

52) If yes to 46, is it because you buy wood? 1) Yes..........0) No......

53) Yes to 46 because you have a forest fallow? 1) Yes.........0) No.........

54) Yes to 46 because you farm near a forested area? 1) Yes..........0) No.....

55) Yes to 46 because you get in area outside village boundary? 1) Yes........ 0) No.........

56) Yes to 46 because you depend upon others who ha· · large areas in fallow? 1) Yes ....0) No............

57) You know of trees with taboos on them but still use them , why? 1) Christian, do not care about taboos.............2) Because of shortages..........3) Have relocated from place of origin so do not care taboos...........0) Do not know......

58) You do not use identified taboo species, why? 1) Fear consequences of use despite shortages...........2) They are mostly inferiors, plentiful good wood around.............

59) when did you start purchasing wood? No. of year,\months, etc..........O) no response................

60) Why did you begin to buy wood from then? 1) Wood in own property ran out\running out...........2) Lost leased farmland.................3) Relocated to this settlement where no farmland is owned..............4) Commercial activity ....5) Took on a large household...........

61) Are prices of the woodfuel you buy too high? 1) Yes...........0) No..........

62) Do you always get the required quantity to buy? 1) Yes........0) No........

63) Do you think you always get the quality you want? 1) Yes.......0) No........

64) How much do you spend on woodfuel per month? Give specific amount.

65) How much do you spend on other fuels?

66) Is your household affected by increased shortages of firewood? .
1). Yes............0) No............

67) Are costs increasing for commercial purposes? 1) Yes............0) No..........

68) Are there increasing household expenditures for woodfuel?
1) Yes ....0) No...........

69) Do you spend money on outside cooked food primarily? 1) To conserve wood? ....2) Because of pressing time for other activities? ....0) Do not buy food..........

70) Do you cook less and\or serve less food because of scarcity of woodfuel? 1) Yes..............0) No ....

71) Do you think because of fuelwood collection there is lesser time for other socio-economic activities? 1) Yes............2) No.........

72) Do you think woodfuel gathering and transportation have effects on you physically? 1) Yes.............0) No

RANKING(Assumption-Equal accessibility and unit costs).

73) Firewood 1 2 3 4 5

74) Charcoal 1 2 3 4 5

75) Kerosene 1 2 3 4 5

76) Electricity 1 2 3 4 5

77) Gas 1 2 3 4 5

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