BIBLIOGRAPHIC DATA SHEET

1. CONTROL NUMBER	2. SUBJECT CLASSIFICATION (695)
PN-AAH-451	AK00-3000-0000

3. TITLE AND SUBTITLE (240)

Traditional fuels: present data, past experience and possible strategies

4. PERSONAL AUTHORS (100)

Knowland, William; Ulinski, C. A.

5. CORPORATE AUTHORS (101)

6. DOCUMENT DATE (110)	7. NUMBER OF PAGES (120)	8. ARC NUMBER (170)
1979	87p.	333.7.K73

9 REFERENCE ORGANIZATION (180)

Ulinski

10 SUPPLEMENTARY NOTES (500)

11. ABSTRACT (350)

12. DESCRIPTORS (920)

Fuelwood	Renewable resources
Firewood	Fuel
Energy	Deforestation
Forest management	Natural resources

13. PROJECT NUMBER (150)

14. CONTRACT NO.(140)	15. CONTRACT TYPE (140)
AID/OTR-147-79-59	

16. TYPE OF DOCUMENT (160)

AID 590-7 (10-79)

PN-AAH-451

3.33.7
K13

TRADITIONAL FUELS:
PRESENT DATA, PAST EXPERIENCE AND POSSIBLE STRATEGIES

Prepared for the
Agency for International Development

Bill Knowland
Carol Ulinski

September, 1979

PREFACE

In February 1979 the principal author submitted an unsolicited proposal to the Office of Evaluation, Bureau for Program and Policy Coordination of the Agency for International Development to undertake a study on the traditional fuels problem. This report is the product of that effort, and is submitted in fulfillment of contract no. AID/OTR-147-79-59.

The intent of this issues paper is to (1) provide an overview of the present state of data and theory on problems associated with firewood and other traditional fuels, (2) assess the significance of traditional fuels problems in the context of AID's mandate, (3) suggest some priorities for an AID traditional fuels program and (4) draw together a preliminary bibliography on the topic. Previous thinking about the traditional fuels problem has been oriented from either the viewpoint of rural energy use or from the viewpoint of forestry. This paper attempts to integrate these two perspectives.

Time constraints have prohibited more than a "broad brush" treatment of any of these subjects, but it is hoped by the authors that this paper may provide some preliminary policy guidance and stimulate much more detailed assessments of all aspects of the topic.

The research for this report was undertaken in Washington, D.C. during the spring and early summer of 1979. It is based upon a review of available literature on the subject. The bulk of the paper was drafted by William Knowland, with the exception of Section IV, which was written by Carol Ulinski, who also edited the final report. James Tarrant of the Overseas Development Council compiled the statistical appendices. Annotations in the bibliography are taken from David French's "Firewood in Africa", with his kind permission. This report was typed by Lisa Whiton.

The authors are grateful to Stephen Klein, Energy Policy Advisor to the Bureau for Program and Policy Coordination, who encouraged the proposal leading to this study. Appreciation is also owed to Alan Poole and to a number of other individuals who generously, and benevolently, offered comments on a preliminary draft of the paper or made substantial suggestions about its content: Michael Benge, Bruce Currey, Erik Eckholm, Lawrence Ervin, Peter Freeman, Patrick Fleuret, Lincoln Gordon, James Howe, Bill McGrath, Richard Morse, Walter Parham, Sally Patton, Anthony Pryor, and James Tarrant.

Special gratitude is owed to the East-West Center's Resource Systems Institute, for providing a haven in which much of the drafting was accomplished.

TABLE OF CONTENTS

		Page
I.	Introduction	1
II.	The Nature and Extent of the Firewood Crisis and its Implications for Development	5
	The Data Base	5
	National Reliance on Traditional Fuel	6
	Consumption and Production	8
	Consumption	8
	Production	11
	Patterns of Use	12
	Domestic Use	12
	Industrial Use	12
	Symptoms and Effects of Traditional Fuels Stress	13
	Socioeconomic Effects	14
	Environmental Effects	15
	Positive Notes	16
III.	Solutions	17
	Increasing Supplies of Wood Fuels	17
	Improved Stoves and Kilns	19
	New and Renewable Energy Options	21
	Conventional Energy Options	21
	Research and Data Gathering	22
	Opportunities for AID	23
IV.	Past and Present Efforts	25
	India	25
	South Korea	27
	The Sahel	29
	Foreign Assistance Activities	35
	AID's Past Involvement	36

Page

V. Recommendations for an AID Traditional Fuels Program 38

Rationale for an AID Traditional Fuels Program 38

Recommendations 38

Appendices

1. Woodfuel Consumption, National Data, 1976

2. Charcoal Trade in Developing Countries (1966 and 1976)

Tables

1. Approximate National Reliance on Traditional Fuels 9-10

2. Trend of Firewood Consumption in Sahel West Africa: 1975-2000 30

3. Sahel West Africa: Impact of First Generation Projects on Urban Demand for Wood Fuel to the Year 2000 33

4. AID-Supported Forestry Projects with Fuelwood Components, Sahel West Africa 37

Figures

1. Inanimate Sources of Energy in Developing Countries, 1976 7

Bibliography

I. INTRODUCTION

Firewood and charcoal, or wood fuels, together with dried dung from cattle and other livestock, and crop residues such as millet straw, rice husks, bagasse, and cotton sticks, are the world's traditional fuels.* This year, the people of the developing countries** will burn as fuel an amount of wood that, stacked together, would stand at least 20 feet high and 20 feet tall and extend completely around the Equator, plus a 400 million ton mountain of dung and a similar mass of crop residues. In oil equivalent, this would equal about 2.7 billion barrels, worth at least $55 billion at present prices.[1/]

Nevertheless, traditional fuels have been almost totally neglected by foresters, energy specialists, and development authorities. In large part, this was by design. It has been generally assumed that as countries develop economically, they must make a transition from traditional fuels to petroleum, natural gas, coal and hydro and nuclear electric power--the conventional energy of the industrialized world. The conventional energy sources are far more "productive" and versatile than the traditional sources, and insofar as material progress is based on the ability to effectively harness increasing amounts of energy for productive purposes, the conventional sources have been essential to modern economic development.

But this official neglect has also been in part due to the difficulty and frustration of measuring or assessing the amounts and patterns of traditional energy usage. In contrast to conventional, or "commercial" energy, there are no accounting offices at the edge of woodlots to record cubic meters of wood production and there are no meters in the kitchens of third world households recording BTUs or kilowatt hours of firewood consumed. Mostly unrecorded and untaxed, the traditional, or "noncommercial" fuels have been neglected largely out of ignorance and uncertainty about their significance.

---

* In some areas, modest quantities of vegetable oils are burned for light. For the purpose of this paper, they will be ignored.

** In this paper, the developing countries, or the third world, does not include China and other centrally planned economies of Asia. Data for these countries, when available, is included in the statistical appendices.

The role of traditional fuels in the daily lives of the world's poor is pervasive. Four out of five families in the third world--roughly half of the world's people--rely on traditional fuels. The basic cooking and heating needs of some 1.5 billion people are met primarily or totally by wood fuels, and--largely because they lack wood--nearly half a billion more meet their needs mainly with dung and crop residues.*[2] Traditional fuels are virtually the only fuels utilized by perhaps 90 percent of all the people living in rural villages and small towns of the developing countries.[3]

However, in many areas, local supplies of wood are being consumed faster than they can grow. Consumption of wood fuels may be increasing at roughly 1.5-2.0 percent annually in the developing countries as a group.[4] But even though most developing countries still have sufficient forested lands that their total annual wood production, or natural growth, considerably exceeds the total wood fuel needs of their people, local shortages can be severe. Because firewood is bulky and decays rapidly in warm, humid climates, it is seldom transported far from where it is grown. Trees and forests are essentially capital stocks that produce an annual return of wood. Once a community begins to exceed the regrowth capacity of its local tree resources, or begins to live off of tree capital rather than tree income, a rapid and exponentially accelerating cycle of depletion begins.

But unless people can afford alternative commercial fuels, and unless such fuels are available, they must turn to other traditional fuels--dung and crop residues--or they must devote more time and income to purchasing wood fuels brought in from ever greater distances from their community. In some cases, even this is insufficient, and in some wood-short regions, families are cutting back from two cooked meals a day to one. As a result, the general welfare of the community declines. But because they are already most dependent on traditional fuels, and because they can less afford to switch to other fuels, the poorest people in the community are usually the most seriously affected.

Perhaps the most insidious effect of this process is that the removal of trees and forest cover and the switch to dung and crop residues interrupts the natural ecological cycles of water storage and soil protection and replenishment. The result is that the future ability of the community to produce food as well as fuel is seriously impaired. In other words, the community is "undeveloping."[5]

Overuse of wood fuels and the ensuing ecological and socioeconomic problems have come to be known as the "firewood crisis." In several countries, notably Nepal, Haiti, several of the Sahelian countries, and in parts of India and Indonesia (Java), the term "crisis" barely conveys the severity of the problem. Most developing countries are victims of firewood or wood fuels stress to some degree, however, and the Nepals and Haitis are simply in an extremely advanced stage.

*According to the season, fuel sources may be predominantly grain stalks, wood or dung.

The June, 1978 U.S. Strategy Conference on Tropical Deforestation, sponsored jointly by the State Department and AID, and the simultaneous Workshop on Firewood in Africa sponsored by the Africa Bureau, clearly identified both traditional fuels and tropical deforestation as issues of considerable U.S. concern. Only a year before, AID had begun to increase its activities in rural energy development assistance, and the U.S. Congress in 1977 had added an amendment on rural energy programs to the Foreign Assistance Act.

In follow-up to the Strategy Conference on Tropical Deforestation, AID has joined with other government agencies in establishing an interagency task force to define a U.S. policy position on tropical deforestation. The U.S. public, through a number of interested NGOs, is closely monitoring and contributing to this process. Several members of Congress have also expressed particular concern about this area, and an amendment to the Foreign Assistance Act giving AID a clear mandate in community forestry has just been passed.* And finally, in August 1979, the President personally instructed the Administrator of AID and the Director of Action/Peace Corps to give high priority to forestry programs, to include projects for increased production and conservation of firewood. Thus it appears that AID is embarking on a new facet of development assistance: community forestry and traditional fuels.

The purpose of this paper is to review the state of knowledge of the "firewood crisis" for the purpose of facilitating AID planning and programming. In Section II available data on the use of traditional fuels has been compiled and analyzed. Difficulties in data-gathering are summarized, and gaps in data have been identified. The enormity of the firewood crisis, and its implications

---

*The International Development Cooperation Act of 1979 states the following: "The Congress recognizes that the accelerating loss of forests and tree cover in developing countries undermines and offsets efforts to improve agricultural production and nutrition and otherwise to meet the basic human needs of the poor. Deforestation results in increased flooding, reduction in water supply for agricultural capacity, loss of firewood and needed wood products, and loss of valuable plants and animals. In order to maintain and increase forest resources, the President is authorized to provide assistance under this section for forestry projects which are essential to fulfill the fundamental purposes of this section. Emphasis shall be given to community woodlots, agroforestry, reforestation, protection of watershed forests, and more effective forest management."

for development, are clearly stated. A range of solutions for addressing this problem are outlined in Section III. Illustrative national and regional programs addressing the fuelwood crisis are summarized in Section IV, and the efforts of donor agencies, including AID, are briefly summarized. Section V provides the rationale for a more extensive AID role in seeking solutions to the firewood crisis, and offers recommendations for the development of a traditional fuels policy and program.

II. THE NATURE AND EXTENT OF THE FIREWOOD CRISIS AND ITS IMPLICATIONS FOR DEVELOPMENT

That there is a severe, and worsening, scarcity of firewood and related traditional fuels in parts of the third world is obvious enough. But the precise nature and extent of the problem eludes easy definition.

The Data Base

National statistics on traditional fuels, where they are available at all, are notoriously "soft", and there are still only a handful of detailed studies at the household or community level of demand, supply, and distribution patterns of traditional fuels.

Traditional fuels simply do not lend themselves to ready quantification. Almost by definition, they are unmeasured, at least by central statistical authorities. Firewood and charcoal are increasingly important items of commerce in cities and towns, but most wood fuels, and virtually all dung and crop residues used in rural areas are used by the family that gathers them. No money is exchanged, and the fuels are valued only in the numbers of loads carried or hours and days spent in gathering them.

On the supply side, estimation of the productive capacity of a forest or woodlot (for wood fuels) or of an agricultural field (for crop residues) or even numbers of livestock (for dung) is itself difficult. The areas, let alone the yield rates, for most forest and agricultural lands are seldom known with precision. Even where forest statistics are fairly accurate and up to date, unless they include non-forest trees, such as those standing in private yards and alongside roads and fields, they still miss perhaps the major source of firewood supplies. Depending on local growing conditions, yield rates for a particular tree species or for a given crop can vary dramatically. For example, short-stemmed, high-yielding varieties of rice may yield less than a quarter of the straw that indigenous varieties produce. And in the Sahel, estimates of average annual yields in a given zone vary by a factor of two.

After the basic resource base and gross production have been estimated, the amount of useable production should then be calculated. Since this involves questions of accessibility and alternative uses, estimations of traditional fuels supplies becomes largely an economic problem.

Calculations of the amount of useable production are also difficult to estimate. The practical measures of consumption of wood fuels are in arm or head loads, stacks, cartloads, or sacks (for charcoal). But these are gross measures at best, since wood varies

considerably according to species, moisture content, size and shape of branches or logs, and proportion of twigs and leaves included. To determine the energy content of local fuels requires at least a modest engineering laboratory. The energy values of a given quantity of wood or other fuel may vary considerably from area to area, and very few measurements have ever actually been made. Finally, the efficiency--both under laboratory and kitchen conditions--with which the fuel is consumed or burned should be estimated. Again, this has almost never been done; the efficiencies of most traditional cooking devices have never been tested.

However, in comparison to other traditional fuels, firewood is perhaps the most uniform and easiest to quantify. The variations in mass and energy content of dung and crop residues are generally even worse than for wood.

Wood fuel consumption estimates for Bangladesh, where a number of estimates of regional or national consumption have been made, vary by a factor of ten.[1/] This is probably the normal case. Most "field surveys" conducted to date have relied on one-time interviews with wood gatherers or heads of households. They are therefore based on the recollections and estimates of the interviewee rather than on actual physical measurement. Sometimes very dubious assumptions are made in these surveys. For example, one day's consumption may be assumed to be one 365th of yearly consumption, or the amount purchased by those at a wood fuels market may be extrapolated to all households.

For the reasons cited above, it is impossible to precisely quantify the amount of traditional fuels being produced and consumed in developing countries. However, sufficient data are available for generally estimating the extent to which these countries rely on traditional fuels to meet their energy needs.

National Reliance on Traditional Fuel

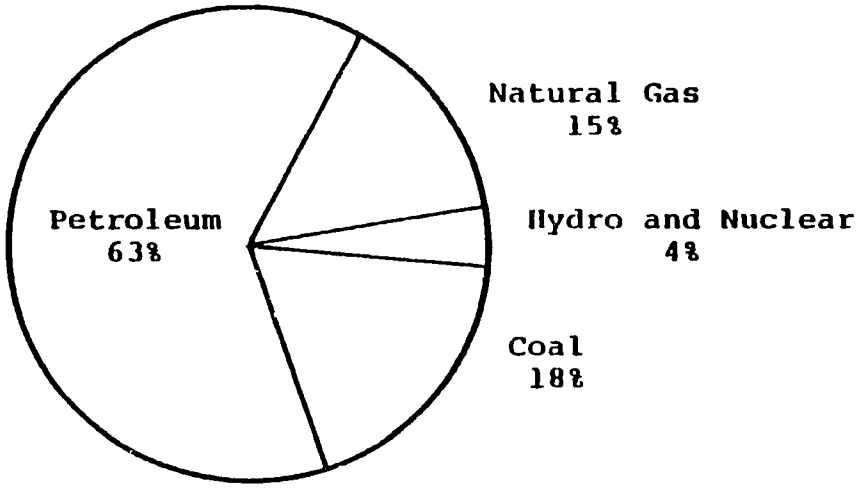
Governments, foreign donors and energy experts have "conventionally" viewed energy in the developing countries to be as pictured in Figure 1A. But there are a small number of more or less detailed surveys of traditional fuels use within specific communities of several countries. By conservatively extrapolating from these studies, and from the best available national estimates of consumption of wood and other traditional fuels, it is reasonable to assume that the picture of energy fuels sources in the developing countries more nearly resembles Figure IB. By conservative estimate, then, traditional fuels account for approximately one-third of all the fuels used in the developing countries as a group.*

*Animal draft power and human labor, animate energy or the traditional power sources, are virtually never included in energy analyses. For most public policy decisions, they can be safely ignored. But in Third World agriculture they are important sources, providing up to 90% of all energy used in traditional agricultural systems. Measuring and accounting for animate energy is problematic, but estimates for India and Thailand suggest that animate sources account for nearl a third of all energy used in developing countries. This paper addresses only inanimate, traditional fuels. The whole area of traditional power sources merits study as well.

Figure 1

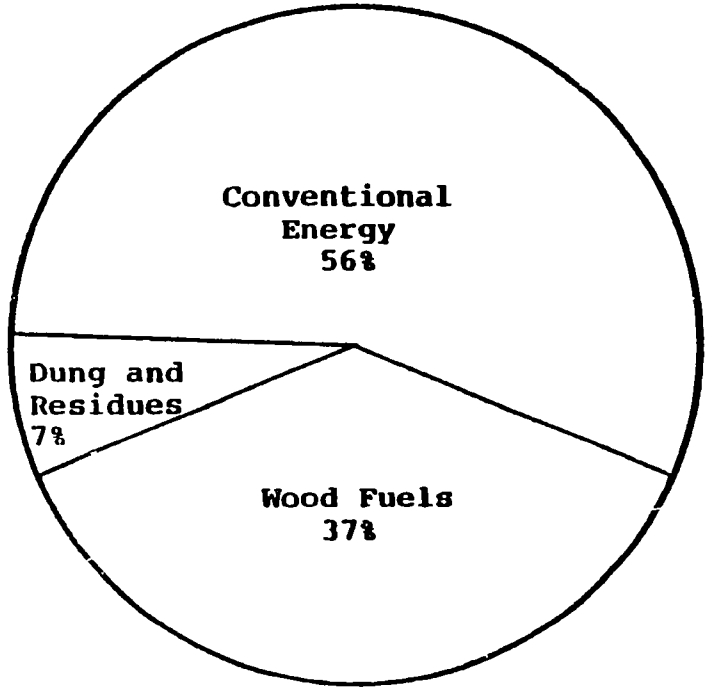
Inanimate Sources of Energy in Developing Countries, 1976

A. Conventional Energy



Total: 846 x 10^6 Metric Tons of Coal Equivalent

B. Conventional Energy Plus Traditional Fuels



Total: 1517 x 10^6 Metric Tons of Coal Equivalent

Source: Conventional energy data from U.N., World Energy Supplies, Series J. Traditional fuels data from Arnold, 1978; Spears, 1978; and FAO, Yearbook of Forest Products, 1977.

From AID's perspective, however, this may considerably understate the significance of traditional fuels. In the first place, the bulk of the third world's conventional fuel consumption occurs in the better-off developing countries, many of which are outside of AID's purview. These countries also account for relatively small shares of the third world's total consumption of traditional fuels. Therefore, many developing countries, especially the poorest, are proportionally much more reliant on traditional fuels. Roughly 65 countries derive half or more of their fuel from traditional sources. Of these, nearly 45 are at least 75 percent reliant on traditional fuels, and traditional fuels provide at least 90 percent of all fuels in nearly 30 of the world's poorest countries. (See Table 1.)

Furthermore, while considerable amounts of wood fuels are used in some modern industries such as steel smelting, and wood fuels and crop residues are widely used throughout the third world in small commercial and industrial enterprises, the vast bulk of traditional fuels are consumed by households. Therefore the well-being of most people in the developing countries is directly related to price and availability of traditional fuels.

Consumption and Production

Consumption

The official estimate of annual wood fuels consumption in the developing countries is about 1300 million cubic meters.[2] This estimate is based largely on figures collected from national governments by the FAO, and some critics consider that this figure underestimates actual consumption by nearly half.[3] In any event, FAO experts agree that the primary reason that wood fuel consumption in many areas, including much of India, is not considerably greater, is that the wood supplies simply are not available there. Therefore, cow dung and crop residues must be burned instead.

Estimates of dung and crop residue consumption are even far less certain than for wood fuels. For example, in one African country, it was recently found that large numbers of rural people consume millet straw. They do so by choice, largely because after harvest it can readily be gathered from fields adjacent to their homes. But the forestry officials in the capital city were unaware that their people consumed anything but firewood.[4]

Table 1

Approximate National Reliance on Traditional Fuels

Expressed as Share of Total Commercial Energy Plus Traditional Fuels

- all data are from 1976
- derived from Appendix A and author's estimates
- figures in parentheses are the percentage of officially reported wood fuel consumption as a share of combined wood fuel and commercial energy
- listed, within categories, roughly in order of ascending GNP per capita

Modest Reliance	Medium Reliance	Heavy Reliance
Less than half	approximately one-half to three-quarters	three-quarters or more .* = nine-tenths or more
Pakistan (22)	Togo (67)	*Benin (86)
Mauritius (2)	India (28)	*Burundi (89)
Morocco (22)	Indonesia (62)	*Cameroon (82)
Rhodesia (36)	Sri Lanka (55)	*Cape Verde (NA)
China (9)	Vietnam (55)	*Central African Empire (91)
N. Korea (0.3)	Gabon (44)	*Chad (94)
S. Korea (8)	Liberia (53)	*Ethiopia (93)
Philippines (.41)	Mauritania (63)	Gambia (73)
Ecuador (20)	Senegal (63)	Guinea (74)
Albania (24)	Zambia (45)	*Guinea Bissau (87)
Algeria (4)	Thailand (34)	Kenya (74)
Tunisia (25)	Bolivia (45)	Lesotho (NA)
Iran (1.3)	Colombia (37)	Madagascar (80)
Lebanon (1.6)	El Salvador (53)	*Malawi (82)
Argentina (3)	Guatemala (60)	*Mali (97)
Chile (14)	Honduras (64)	Mozambique (74)
Cuba (5)	Malaysia (25)	*Niger (87)
Dominican Republic (19)	Mongolia (25)	*Rwanda (96)
Guadalupe (19)	Brazil (38)	Sierra Leone (76)
Mexico (4)	Costa Rica (50)	*Somalia (90)
Panama (29)	Nicaragua (47)	Sudan (81)
Peru (20)		*Tanzania (94)
Uruguay (13)	(21 countries)	*Uganda (91)
Fiji (2)		*Upper Volta (94)
Cyprus (NA)		Zaire (76)
Malta (NA)		Afghanistan (76)
Portugal (3)		Bangladesh (63)
Romania (2)		Bhutan (NA)
Turkey (18)		*Burma (85)
Yugoslavia (4)		*Cambodia (93)
		*Laos (87)
		*Nepal (96)

Table 1, continued

Modest Reliance	Medium Reliance	Heavy Reliance
Less than half	approximately one-half to three-quarters	three-quarters or more.* = nine-tenths or more
Libya (5) Hong Kong (NA) Israel (NA) Singapore (NA) Bahamas (NA) Venezuela (8) (36 countries)		*Yemen (NA) *Yemen (NA) *Haiti (92) Angola (74) *Botswana (NA) Congo (80) *Eq. Guinea (86) Ghana (74) Nigeria (82) *Swaziland (NA) Paraguay (74) Papua New Guinea (66) (44 countries) *26 countries

Unclassified: Egypt, Iraq, Syria, Bahrain, Brunei, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates.

Production

The data on potential traditional fuels supplies are more tenuous even than those for consumption. Estimates of forest land in the third world vary considerably, and do not include trees in yards or along roads or fieldsides that comprise a major source of domestically-consumed firewood. Several estimates of the potentially available quantities of crop residues and animal manures have been attempted.[5] But their authors freely admit that these should be considered very rough estimates of the outer limits of resource availability. Even where such residues are an important component of fuel supplies, generally less than a quarter of the materials are gathered and used for fuel.[6]

In any event, at the macro level, accurate supply figures may be essentially irrelevant, or at least not very useful. For practical purposes, it can usually be assumed that supplies equal consumption. Analytically, the only way to say that supplies are inadequate is to establish a "minimum" fuel need and compare it with available supplies. But defining a minimum fuel requirement is fraught with even more difficulties than, say, setting a minimum nutritional requirement. Not only do people's energy "needs" vary according to climatic and cultural and other factors, but a given quantity of fuel may be used either inefficiently or very efficiently depending on what kind of kiln, stove, or other conversion device is used.

At the micro level, traditional fuel supplies can generally be assumed to be "adequate" if (1) people are using wood or charcoal rather than other fuels, and (2) the cost, either in monetary price or time devoted to gathering fuel, is low and stable. Equilibrium involving use of dung or crop residues have been reached in many areas that either are naturally treeless or have been deforested for a number of years. It should also be emphasized that fuel is not the only product that trees produce. Fruit and nut trees are often important sources of food and individual trees or groves may have religious significance. People will try to preserve these trees even when local fuel trees have been exhausted.

Patterns of Use

Domestic Use

Quantities and types of traditional fuels usage vary markedly from country to country, and even between adjacent villages. Therefore it is extremely difficult to generalize about traditional fuels usage, except to say that firewood and charcoal generally seem to be preferred over other traditional fuels. This is unsurprising, since wood fuels are relatively more concentrated (have a high heat value per unit of volume or weight), are easier to transport and store, and generally are cleaner burning than dung or residues.

Beyond that, it is possible to identify at least ten factors that seem to influence the amounts and composition of traditional fuels use by individual consumers (i.e. families):

- availability of fuel
- relative price of fuel
- income level of consumer
- size of family (larger families appear to use less fuel *per capita*)
- food and cooking style preferences
- other cultural practices or inhibitions
- climate, and seasonal changes in climate
- educational level of consumer
- urbanization
- personal preferences

Urban use of traditional fuels is likely to be primarily of charcoal, because of its relative convenience and cleanliness, and because it is easier to transport and store.

Industrial Consumption

Perhaps 15 percent of all wood fuels are consumed by industries, either small local enterprises, such as pottery, brickmaking, and blacksmithing, or in large-scale steel and other metallurgical processing. 1/ Charcoal is generally the equal of good quality coal for metallurgical industries, and a number of developing countries,

such as Brazil, which do not have major domestic coal reserves, rely heavily on charcoal for their steel production. This seems likely to increase. Fuelwood and bagasse can also readily be used to generate electric power, and AID is already involved in such a project in the Philippines. In Senegal, peanut shells are now being used to power peanut oil plants.[8]

Charcoal is also increasingly valuable as an item in export trade. Several oil-rich but wood-short countries of the Persian Gulf, where charcoal is a preferred cooking fuel, are willing to pay high prices for shipment from East Africa. In recent years the industrialized countries have also rapidly increased their use of activated charcoal, which can remove pollutants and wastes in a number of industrial processes. The international charcoal trade deserves analysis. India, Sri Lanka, Indonesia, and a number of African countries seem to be substantial charcoal exporters, supplying charcoal to Japan and Western Europe as well as to the oil states of the Middle East. The official statistics (FAO) on international charcoal trade are included as Appendix 2 to this paper.

Symptoms and Effects of Traditional Fuels Stress

Reliance on traditional fuels has contributed to deforestation problems ever since humans first began to concentrate in settlements large enough that their domestic firewood needs, or fuel demands for specialized purposes such as smithing and smelting, exceeded the sustainable capacity of adjacent woodlands. The traditional responses to such situations appear to have been to move to a new area where wood was more plentiful or to convert to alternative fuel sources, such as dung and crop residues. A few hundred years ago, of course, some people, notably in Western Europe, began to make what might be termed the conventional response to such shortages, i.e. the use of coal and other fossil fuels.

Localized overuse of firewood has a long history. However, the present set of environmental and socioeconomic problems surrounding overuse of traditional fuels results from two conditions which are fundamentally new in human history. First, rapid rates of population growth, urbanization, and settlement of nomadic peoples are all working to raise fuel demands in individual communities. But also because of population pressures, unsettled frontier lands are now scarce. Therefore few people can still make the traditional response of moving to an area where firewood is more plentiful. Second, the wealthier people in a community, and the wealthier communities within regions, generally do have access to alternative energy supplies. These alternatives, conventional fuels such as kerosene, bottled gas, or coal, are inherently more powerful or economically productive than traditional fuels. Frequently they

are actually less expensive than traditional fuels. As a result, the wealthier are able to further increase their productivity and wealth, while their poorer neighbors, "stuck" with dwindling supplies of traditional fuels, grow both absolutely and relatively poorer.

Socioeconomic Effects

The firewood crisis is a classic "tragedy of the commons", but severely exacerbated by poverty. While the population of a community is small or stable, it probably consumes less firewood than the surrounding woodlands regenerate each year. Even if population or per capita consumption increases to the point that annual regrowth is consumed, there will be no perceptible effect. But once consumption exceeds annual regrowth, the standing forest, or tree capital, is reduced. If the trend continues for even a few years, the result is a precipitous and accelerating decline in availability of wood resources. Even once this trend becomes obvious, the "tragedy" is that it is in the interest--or need--of all to continue cutting and gathering fuel, but in the interest of none to replenish this resource - in many countries, those who plant trees have no guarantee to the harvest.

The effects are similar, however the trees may "disappear." For instance, land cleared for agriculture no longer produces wood for fuel. Or land that has traditionally been open may be made private; even if it still contains trees, they may no longer be a legally available source of fuel.

The trend tends to develop its own impetus; as a landowner realizes that wood fuel is becoming scarce or of commercial value, for the first time he may "close" access to the wood fuel collection on his land, perhaps reserving it for his own use or perhaps selling the fuel in a market. As a result, the pressure on the woodlands that remain accessible is increased, and the cost of firewood and charcoal rises.

In many areas during this decade, prices for commercial firewood and charcoal have risen as fast or faster than the price of kerosene or other petroleum-based fuels. And in areas as diverse as Nepal and East Africa, the gathering of firewood that a decade ago was an hour's chore near one's home now may involve a 10 kilometer walk or ride and families commonly must devote 200-250 person days each year simply to maintaining a minimum firewood supply. 9/

In general, this inflated work burden seems to fall most heavily on women who, along with children, have been the traditional firewood gatherers in most cultures. But in some cases, the additional distance and difficulty of fuel gathering is

making it a man's job. Whether gathered by men or women, the constant need for firewood supplies reduces the time available for agriculture or cottage industries and other productive activities. (There are also a few reports of children dropping out of school in order to assist their families to meet their fuel needs.[10] Some observers attribute the increasing labor intensity of fuel gathering to be a factor in a couple's decision to have large families.[11])

Purchase of firewood or charcoal has been estimated to require a quarter to a third of the average laborer's income in several Sahelian cities.[12] The burden of high fuel costs--whether measured in earned income or hours devoted to gathering--falls heaviest on the poor. Unable to afford substitutes, they have little choice but to pay more or to decrease their consumption. In some areas, people appear to have been reduced from two to only one cooked meal a day, and in some areas there has been a shift to planting crops that require less cooking.[13] No detailed study is available, but it seems likely that this reduces the nutritional level of the people involved.

People in some areas have become openly defiant of government laws prohibiting fuel collection from state-owned woodlands. Since forestry departments are usually responsible for protection of such forests, rural people in a number of countries have come to identify the forest ranger as a government policeman, to be outwitted if possible, and to be fought if necessary.[14]

The most insidious social effect of firewood stress appears then to be that the poor, who already use their energy with the least utility, must devote more and more of their limited income, time, and labor to simply maintaining their present fuel consumption. This further disenfranchises them from the development mainstream, and may contribute to their distrust of government authorities. In arid areas, especially where they can observe the loss of accessible trees or woodlands within just a few years, the impact is a clear manifestation of their lack of control over their lives and future betterment.

Environmental Effects

The most deleterious environmental effect of firewood stress is the diversion of dung and crop residues from crop lands, thereby preventing the return of organic matter to agricultural soils.[15] This short-circuiting of the natural soil cycle has serious effects on soil fertility, erosion, and water retention.

Firewood overconsumption is clearly a serious factor in desertification--the human-induced degradation of arid lands into unproductive deserts. Firewood consumption itself is probably not a

major cause of deforestation in most areas with humid climates. However, even in humid regions, use of wood, twigs, and leaves may occur at levels that impair soil quality, at least over the long-term, and on mountain slopes the loss of organic matter may quickly lead to serious erosion problems.

Burning of traditional fuels, with the general exception of charcoal, poses health problems and fire hazards. Respiratory problems and eye disorders are far more common among those (women) frequently exposed to the smoke from household use of traditional fuels. Burning of traditional fuels also has undetermined effects on ambient air quality. Burns and loss of property due to fires from traditional fuels usage have received little attention, but should be considered.

In general, the environmental consequences of burning wood fuels appear to be less serious than the burning of other fuels. Therefore, from a societal view, wood is generally the traditional fuel of choice. Because of health impacts and convenience of use, individual consumers also generally consider wood to be the preferred of traditional fuels. 16/

Positive Notes

A recent study for the Congressional Office of Technology Assessment offers a very encouraging conclusion. After reviewing the potential resource availability and the existing or likely-to-be-developed technologies, the researchers found it "credible" that it is possible to "provide enough energy from locally accessible biomass to meet all requirements for cooking, space heating, lighting, and, where applicable, for tube well irrigation in the rural areas in all developing countries." 17/
(emphasis added)

With a concerted effort, the international scientific and forestry community should be able to develop more efficient stoves, improved tree varieties, and agroforestry systems that will ultimately boost the productive capacity of most developing countries and that will offer sustainable employment in rural areas that otherwise might have stagnated economically and ecologically and been given up as wastelands.

A range of solutions for addressing the fuelwood crisis is the subject of the next section.

III. SOLUTIONS

Technologically, the firewood crisis is an energy problem. There are a range of solutions for addressing this crisis. Some of these involve forestry-type interventions, such as establishing fuelwood plantations or village woodlots for the purpose of increasing supply. Another approach is to promote conservation, through the introduction of more efficient cookstoves and improved charcoal making techniques. And thirdly, reliance on fuelwood could be reduced by substituting alternative fuels, such as biogas or petroleum. These possibilities, including their potentials and constraints, will be discussed in greater detail in this section. The need for a more complete data base upon which to base policy and programming decisions is emphasized. This section concludes that in some countries, only a national effort will address the problem, and urges AID to provide assistance in this endeavor.

Increasing Supplies of Wood Fuels

The most obvious solution to wood scarcity is to plant more trees, either in large commercial plantations, in village woodlots, or in private yards and along the edges of fields and roadsides. The planting may also be aimed at counteracting desertification, protecting watersheds, and increasing forage and building supplies or other forest products. As public works projects, reforestation and afforestation projects can provide labor and are attractive projects in "food for work" programs, particularly in the rainy or "off" seasons, when other public works projects such as road construction come to a halt.

Private or public fuel plantations near urban markets appear to be attractive investment opportunities, and could greatly relieve the pressure that urban wood fuel needs place on rural wood supplies. Since a profit motivation and well-organized commercial wood fuel markets usually are already established, these commercial plantations will probably be relatively easy projects to support.

Village woodlot programs will generally be much more problematic, even though they are on a smaller scale. Scarce or private land may be needed for tree growing. And insuring that the poorer inhabitants of a village, who may be most in need of the firewood, have equal access to the wood produced can be very difficult.*

*Examples of how these problems have been met in programs in India and South Korea are discussed in Section IV.

Although trees have long played an important role in providin human material goods and services, in contrast to most food plants they have barely been domesticated or improved for human purposes. There is increasing, and well-justified interest in agroforestry--the interaction of tree crops with traditional cultural crops or livestock production and the development of cultural tree crops.

Agroforestry holds tremendous promise for producing fuelwood while also improving the productivity of both conventional agricultural lands and more marginal land areas--such as hilly or mountainous, and wet climates and, to a lesser extent, arid regions. But the present state of the art is still in its infancy, and even with advanced scientific research techniques, genetic selection and enhancement of specific tree crops face the problem of trees' slower life cycles than of most food crops. While most agricultural crops are ready for harvest and produce seed within a single growing season, trees usually require at least several years, sometimes even several decades, to complete a generation.

A number of tree species are already known to be distinctly attractive as fast-growing fuel varieties, however. Their rate of growth may be several times that of most trees. Varieties of eucalyptus, Gmelina, and Leuceana, for example, are already fairly well known, and these types could be beneficially planted in many areas. These and other species merit continued testing and improvement.

Fast-growing varieties may be the best way to meet a wood shortage. Over the longer term, however, or in areas where wood fuel supplies are not so tight, trees that are raised for fruit and nuts or for other products may be a more attractive option. Fuel can be produced, at a less intensive rate, from the trimmings and deadwood of these trees. For example, in Malaysia, firewood is scarcely a problem in rural areas because, throughout the country, prunings from rubber plantations are readily available.

Applied research and technical know-how are only two elements of a community forestry project. With a minimum of effort and care, tree planting can be done by anyone. Since trees can produce food, forage, building materials, fiber, shade, and since they are widely recognized to have beneficial effects in reducing erosion and loss of surface water, it would seem that virtually everyone would have an interest in reforestation and afforestation. But the fundamental problems of poverty, inequity, and lack of infrastructures in many developing countries greatly hinder such a simple solution.

In order to plant trees, people need to have a stake in some of the benefits. They need assurance that they or their children will have access to the wood and other products that the tree may

ultimately produce. Existing land distribution and property rights frequently fail to offer such assurances.* Furthermore, the relatively long lead times, several years at least, before most trees begin giving any return on the planting investment, make tree planting and nurturing a low priority in the lives of poor people with concerns about supplying today's food, fuel, and other material needs. Finally, even where people might be willing and able to plant trees, seeds or nursery stock are frequently not available, nor are the fertilizers or irrigation water supply that may be necessary.

Because traditional fuels problems are largely manifestations of the socioeconomic complexities (poverty and inequality) that underly all development problems, technological projects can be successful only to the extent that they are supported by government commitment and the active participation of the local community.

There have been a number of rather disastrous attempts to force reforestation projects on rural communities. But there are also some instances where reforestation efforts have made progress that is little short of astounding. These include South Korea and parts of India. In all these cases, the government authorities have demonstrated strong support for rural betterment, and have provided some basic technical assistance and nursery stock; and the people have been given control over the design of the planting scheme and have shared in the benefits.

Improved Stoves and Kilns

Most stoves or fireplaces in third world homes probably deliver between 2-10 percent, and at most 20 percent, of the fuel's energy content to the food being cooked. In contrast, a typical American household's gas stove's efficiency is closer to 70 percent.

Traditional cooking technologies have evolved over the centuries in accordance with cultural and environmental opportunities and constraints. But it seems reasonable to expect that appropriate, improved stove designs are possible which could double or triple average heat transfer efficiencies--effectively doubling and tripling the local supplies of traditional fuels.

---

*In Asia, the percentage of landless and near landless families in rural areas ranges from 53% in India to 85% in Java, Indonesia. These figures are also high for Latin America, ranging from a low of 55% in Costa Rica to 85% in Guatemala and Bolivia. Although data are not available for Africa, evidence indicates that the inequities caused by land ownership patterns are considerable. See Milton Esman, "Landlessness and Near-Landlessness in Developing Countries (Ithaca, New York: Cornell University, August 1978.)

The evidence on the small number of improved stove types that have been developed in recent years is mixed. In some instances a given design appears to significantly reduce fuel consumption. In other homes using the same stove, no saving is apparent. A great deal seems to depend on how well the individual stove is constructed, and on the cooking practices of the cook.

The most promising new stove design is the Lorena stove, developed in Guatemala.[1/] Carefully constructed of a mixture of certain types of clay and sand, with metal baffle and a chimney, the stove, when constructed properly, appears to perform very well. It seems to be gaining steady acceptance in rural Guatemala and Mexico, and it is now being introduced in Java as well.

The basic thermodynamics of small combustion chambers such as in small stoves and fireplaces has never been rigorously studied. VITA, ITDG, and other technology development groups are now arranging to conduct this basic research. They deserve full support from AID. After the basic heat transfer processes are better understood, there should be opportunities for studying and adapting traditional stove designs.

Clay stoves or chulas have attracted the attention of local engineers in a number of countries, and local universities will undoubtedly have a strong role to play in the analysis and improvement of traditional stove designs in their countries.

Traditional technologies for charcoal production can also be greatly improved. Traditional charcoal kilns may be very crude; the charcoal may simply be produced in pits covered with earth. As a result, a good deal of wood is wasted. It may take up to twelve units of wood to produce a unit of charcoal. But with modern kilns or pyrolysis units, this recovery rate can be improved.

The primary barrier to much greater use of more efficient kilns is probably their cost. But charcoal is a well-commercialized business in most developing countries, and the rate of return on an efficient charcoal kiln should usually be fairly good. The problem then is one of initial investment cost, and a shortage of capital available to small charcoal producers. With modest funds channeled through local lending agencies, AID might thereby be able to have a significant impact on consumption of wood for charcoal.

The importance of improved stoves and kilns is hard to overstress. They make an immediate and permanent reduction in the per family consumption of wood or other traditional fuels.

New and Renewable Energy Options

There is great hope for the new renewable energy sources in rural areas of developing countries. Solar power systems, windmills and generators, small hydro units, and biogas generators all hold a great deal of promise. But all of these, except biogas units, are producers of mechancial or electrical power, not fuels. Efforts to introduce solar cookers to India and Africa have been made for over a century, so far without success. Attempts to develop appropriate solar cookers should certainly be continued. Solar water heaters already hold a great deal of promise for replacing wood fuels in small commercial establishments, such as restaurants and canteens, and perhaps in private homes as well.

For rural fuels, biogas is perhaps the most promising of the new technologies. Biogas makes use of crop residues and animal dung more efficiently than if they are burned in traditional fires, and it preserves their residues as a high quality fertilizer. It also makes it possible to utilize human wastes and the wastes of animals such as pigs and poultry that have not traditionally been used as fuel. But ironically, biogas use can seriously worsen the fuel situation of traditional energy users. In India, for example, at least 3-4 cattle are necessary to provide sufficient dung for the biogas digestors being used. But only relatively wealthy farmers have that many cattle, so only they can benefit from the improved technology. Traditionally, the people who use cow dung are often not the people who own the cattle--again, a reflection of relative wealth, since the farmer who can afford cattle can also afford to purchase wood or kerosene. Therefore, when a wealthy farmer begins using biogas, the poor and landless who have traditionally been allowed to collect the droppings of cattle are suddenly denied access to the cow dung, losing what may be their only source of fuel. This effect might be mitigated by establishment of community biodigestors, as is the practice in China. But in most situations such community systems may be difficult to put into practice.

Biogas should be widely encouraged, because it does reduce pressures on alternative fuels and increases overall efficiency or productivity of fuels use in a community. But due consideration should be given to the equity problems that introduction of biogas technology can raise.

Conventional Energy Options

Conventional energy solutions to traditional fuels shortages, i.e., substitutions of fossil fuels, generally will not be applicable. There may be instances where a small or low grade coal deposit can be developed to provide fuel for a community or region, and a few countries rich in oil or natural gas may be able to afford to invest in the infrastructure needed for those fuels to meet a significant share of domestic needs. But conventional fuels will be too valuable for industry and as fertilizer or petrochemical feedstocks, or as foreign exchange earners, to be allocated

to rural domestic fuel needs. Even "emergency" allocation and subsidy of petroleum fuels for domestic markets to offset local wood fuel shortages seems to hold little promise. Kerosene stoves, for instance, would also have to be provided, and people would have to perceive that these new conventional fuels were desirable and that supplies could be counted on.

Although the introduction of electricity through central grids has occasionally been touted as a means of substituting for traditional fuels, this option also seems likely to have very little impact. Rural electrification programs are extremely costly, and they are only slowly penetrating rural areas. Even in "electrified areas" usually only the wealthiest can afford to purchase the (subsidized) electricity--or the appliances necessary to use it. Hot plates and electric stoves are comparatively expensive and alien devices for most rural people.

Research and Data Gathering

As already emphasized, data on traditional fuels usage are sparse. But relatively little statistical data are necessary to establish some initial priorities and develop a first generation program. Detailed studies of a community's particular supply, demand, and distribution patterns must be conducted at the project planning level because usage patterns differ markedly between and within regions. Much of the relevant data--such as the choice of tree species or stove design, or the best technique for introducing these technologies in a given community--can only be derived from actual project experience.

There is need, however, for governmental capacity to assess the general levels and patterns of traditional fuels consumption in order to design overall energy and other public policies. This suggests the need for traditional fuels offices or officers within governments. Ideally, these might be located within the government ministry responsible for energy, with very close ties to the ministry responsible for forestry, agriculture, and land use.

As an increasing amount of experience is gained in traditional fuels projects, and as information about new stoves and kilns and improved tree varieties accumulates, it will be increasingly important for governments to have a capacity to examine and review this information, so that it may be adapted to local needs and situations. This suggests both a need to establish effective mechanisms of international information exchange and a need for careful review of projects as they are conducted. Foreign donor agencies such as AID share these interests, and AID might play a useful role by supporting case studies and project reviews.

There is need for basic research and development (R&D) on a number of topics related to traditional fuels:

- basic sociological, economic, and ecological studies of traditional fuels usage;
- thermodynamics of conversion technologies--both basic engineering studies and adaptive work on traditional stoves and charcoal kilns;
- agronomy and silviculture;
- yields of traditional fuel crops;
- traditional agronomy or cultivation techniques;
- improved cultivation techniques and genetic improvement of fuel crops.

Information exchange will be vital. Researchers, project managers, and policy makers all need to be kept abreast of the latest developments in community forestry and traditional fuels. Cross-fertilization of research and project ideas between third world experts should be facilitated. Exchange of high-quality seeds and other propagating materials will be important. Case studies and how-to manuals will be important to project managers. And careful, perhaps creative, economic analyses of traditional fuels and forestry projects will be of particular interest to public policymakers.

Opportunities for AID

Traditional fuels problems are essentially local problems which must be dealt with at the local level. But there are at least a few countries where these local problems have multiplied to the point where they are pervasive problems at the national scale. In areas such as Nepal, Haiti, and the Sahel, probably nothing less than major national or regional programs will have sufficient impact to make much difference on the situation. Such programs are under development, with at least some participation by AID, in Nepal and the Sahel. It has also been proposed that AID should organize such a national program in Haiti.[2/]

But the general thrust of AID community forestry and traditional fuels assistance activities should probably be in integrating forestry components into comprehensive rural development programs. This is the basic strategy of the World Bank.[3/]

In addition, AID should be open to opportunities for addressing traditional fuel needs of urban areas. Urban traditional fuels problems should be well within even a strict interpretation of AID's mandate to focus on the "poorest of the poor" for several

reasons. In the first place, it is lower income urban dwellers who are most dependent on wood fuels and cannot afford to convert to conventional alternatives. And secondly, the concentrated, large-scale consumption needs of urban areas are a steady drain, penetrating every farther into surrounding rural areas. This drain literally saps the present and future productivity of rural areas, and increases the incentives for migration to urban areas.

Several countries, notably Korea and India, are addressing their fuelwood problems with a concerted national program. In the Sahel, a regional reforestation effort is underway to arrest desertification and restore an ecological balance. AID has played an active role in the formulation and implementation of this program. These efforts will be discussed in greater detail in the following section.

IV. PAST AND PRESENT EFFORTS

In recent years, several countries have perceived the pressures of firewood stress and have mobilized programs which have effectively reduced their problems.* In India such efforts have been underway since the early 1950s, with varying degrees of success. South Korea may have made the most remarkable comeback to date, in the space of less than a decade.** The countries of the Sahelian region, faced with severe environmental degradation, have recently launched a program to address these problems through their regional development cooperation group, the CILSS. AID has participated in this program, and is funding several fuelwood projects.

In this chapter, these experiences will be reviewed and the past efforts of AID and other donors will be briefly summarized.***

India

Political support for community forestry in India dates back to the early 1950s. The newly independent government's first Five-Year Plan established community forestry as a high priority, and the revised National Forest Policy gave state forestry departments the mandate to encourage and support these activities. Vanamahotsava, or the annual Festival of Trees, was inaugurated to raise public consciousness to the importance of trees. However, in spite of strong government commitment, community forests have not "clicked."[1/]

The general failure of "social forestry", as it is now being called, can in large part be attributed to strong local distrust of the national and state forestry departments, which have traditionally been responsible for managing and protecting forest tracts for timber production. Forestry agents are viewed by the rural poor as enforcement officers unconcerned with the needs of the local populace for wood products.

---

* The forestry program of the People's Republic of China has reportedly been overwhelmingly successful. Lack of information, however, has precluded a review of this effort.

** Reviews of the Indian and Korean experiences are based upon the work of Eckholm, Shah, Argal and Bong Won Ahn.

*** A detailed review of past and present fuelwood projects supported by AID and other donors was not within the scope of this study. Several efforts are currently underway to compile this information. First, the Bureau for Program and Policy Coordination and the Development Support Bureau in AID are in the process of making an inventory of all AID forestry projects. Second, the U.S. Forest Service has a participating agency service agreement (PASA) with AID to inventory all forestry activities supported by other donors. And third, the Peace Corps will soon be undertaking an evaluation of ten case studies of forestry/natural resource projects to identify factors contributing to project success or failure.

In an attempt to reverse this past trend of failure, the State of Gujarat created a forestry extension service in 1969 and embarked upon a program geared to the needs of the rural poor. One of the first activities was to plant trees on government-owned land along roads and canals. In exchange for protecting the seedlings, neighborhood communities were given the right to cut the grass from beneath the trees and share the proceeds from the harvests. This effort has demonstrated to local people that trees can in fact grow, and quickly, in their communities with beneficial returns. Local impressions of the forest department have also become more favorable. As for more concrete accomplishments, trees have been planted along 6,000 km, or 35% of all state roads and canals.[2/]

The next step was to promote a village plantation scheme. Extension agents visited villages to encourage local leaders to set aside four hectares for a community woodlot. Each participating village receives seedlings, and the government also provides the wages for laborers who plant and maintain the woodlots. In return, villagers are responsible for protecting the trees from premature cutting and hungry livestock. The village harvests all minor forest products, and the tree harvests are shared by the village and the Forestry service. To date, 3,000 of Gujarat's 18,000 villages have established woodlots under this program.[3/]

The department is now encouraging private individuals to plant trees on their own land, and is offering free seedlings and advice. It is also considering the possibility of providing subsidies to poor farmers, who cannot afford to make the long-term investment required without some outside help. And, as a way to combat pilfering of forest tracts, plans are underway to implement a "Social Security Program" whereby landless farmers will be paid by the government to plant, care for and protect small parcels of forest land in exchange for annual wages and a share of the proceeds when the trees are harvested.

Spontaneous community involvement and initiative in forestry programs in Gujarat still is an idea of the future: the current effort remains a government program. However, impressive gains have been made over the past half decade. Trees have been planted on land which was, until recently, sterile. The extension service is slowly earning the trust of the local populace as it works with them to meet local needs for wood products. Community forestry may have a future in Gujarat if the extension service continues to provide the enlightened leadership and assistance of the past few years.

In addition to promoting reforestation activities, the government of India is also supporting efforts to conserve firewood and minimize the losses associated with the burning of dung. The Hyderabad Engineering Research Lab has designed a smokeless mud "chula" or stove that can be fabricated with earth, clay, or bricks, and saves from 20-40% on fuel.[4] The Central Arid Zone Research Institute in Jodhpur has designed a solar cooker which can be used to cook all kinds of food. And as early as 1939 the Indian Agricultural Research Institute designed a biogas digestor or "Gobar-Gas-Plant" which produces a gas for cooking and a sludge fertilizer. By 1974, about 7,000 plants had been installed throughout India, with plans to distribute an additional 36,000 plants by the year 1979. The problem with all the above mentioned inventions is one of cost: many families cannot afford to purchase a biogas digestor or a solar cooker without some financial assistance. And in the case of the smokeless "chula", people still must be convinced that the extra effort required to build the stove will pay off.[5]

Efforts are also underway to improve the efficiency of crematoriums, reducing wood use from 400-500 kilograms to 160 kilograms. This could result in substantial savings in a country where everyone is cremated.[6]

South Korea

A large percentage of Korea's domestic energy is used to heat the home during the cold winters, when a family can burn as much as four tons of organic material to keep warm. Also, in a country where ancestor worship is still an important part of daily life, families reserve some forest land for burying their dead. On the supply side, all forest land was public until 1910, when private ownership was legalized. However, peasants still view this land as a public good and collect forest products freely. As a result, there has been little incentive for owners to replant and maintain this land.[7] As wood becomes more scarce, people are turning to agricultural residues, grasses and forest litter as sources of fuel. As elsewhere, removal of ground cover is causing erosion on hillsides, downstream flooding and declines in soil fertility.

Village Forest Associations (VFAs) have sprung up spontaneously throughout Korea since the 14th Century[8] and were formally recognized by the government in 1931. One decade later the Forest Law was enacted which provided a legal basis for VFAs, recognizing them as cooperatives responsible for implementing forestry activities. Then in 1973 the government launched the Ten Year Forestry Development Plan, and undertook a number of measures to boost the country's reforestation program. These efforts were consistent with the Saemaul or "New Community" movement, inaugurated in 1971 to slow down rural-urban migration by decentralizing economic development and enhancing the standard of life in the countryside. The forest service was reinforced; laws were passed, and are being enforced, which prohibit tampering with forests, as well as requiring forestation of all steep lands; and, an extensive public education campaign was started. Perhaps most significantly, VFAs have been established in almost every village in the country to execute forestry activities.

VFA membership, which is mandatory, includes forest landowners and representatives from each household. Every VFA is part of the national, nongovernmental network, the Korean National Federation of Forestry Associations, based in Seoul. This union acts as a liaison between the individual VFAs and the government forestry service, the latter providing policy guidance, and financial and technical assistance.

During the initial phase of the program, surveys were made in each village to calculate local needs for forestry products and identify lands suitable for reforestation. Trees are planted by the villagers on a volunteer basis. If the land to be planted is privately owned, the landowner has the choice of doing it himself or turning it over to the association. The harvests are distributed among all households. Marketable surpluses are sold, and the proceeds are deposited into the village cooperative fund for use at some future time. The VFAs also patrol the national forests in their vicinity, protecting them against illegal exploitation and forest fires. In return, they are free to harvest forest products and fuelwood.

The accomplishments of the program are impressive. Korea appears to be well on its way to solving its fuelwood problem. By 1977, about 643,000 ha. of fuelwood plantations had been established.[9] According to Bong Won Ahn, an official of the national federation: "The fuelwood component of our forestry program is essentially finished. We calculated the needs and set planting targets, and now these have been met. By the early eighties, when increasing amounts of wood will be harvested from the new plantations, our rural fuel problems will be largely solved."[10]

---

*About 177,000 ha. of the total were financed with a loan from the World Bank.

Trademarks of the Korean program include strong government commitment to and support for a national and community forestry program, and active village participation. It should be noted, however, that participation is mandatory, although the work and the benefits are equally shared by all.

The Sahel

The Sahel, a semi-arid zone in West Africa, sandwiched between the Sahara desert to the north and the tropical rain forests to the south, is a marginal area characterized by variable rainfall and periodic drought. During the past decade, prolonged drought, coupled with overuse of the region's resources, have created a situation of extreme environmental degradation. According to a recent study, a large part of the Sahel will be desert by the year 2000 unless a massive, concerted reforestation effort is undertaken immediately. 11/

The process of desertification has in part been caused by the widescale removal of trees and other vegetation by local populations, who use it for fuel. In the Sahel, wood is the major source of energy, providing 84% of the region's total energy needs. Ninety-nine percent of domestic energy is supplied by a combination of wood, charcoal and agricultural wastes.

However, the rate of natural regeneration and reforestation has not kept pace with demand, and in some areas in the Sahel there are already severe shortages. Large belts of desert, in some cases as great as a 100 km. radius, have already been created around many towns and cities in the Sahel. These population centers are placing increasingly greater pressures on land further and further away. Dakar, the capital of Senegal, imports all of its fuelwood requirements from other parts of the country, and consumes 89% and 36% of total national marketed supplies of charcoal and firewood, respectively. About 85% of the city's residents use firewood exclusively for heating, cooking and other domestic tasks, with the remaining 15% using it at least in part. 12/

By the year 2000, it has been estimated that annual consumption for the entire region will be about 33.5 million cubic meters. (See Table 2.) To meet this projected demand, 3-6 million hectares must be reforested by the year 2000, or 150,000-300,000 hectares annually. The current level of effort, averaging about 30,000 hectares per year, is clearly inadequate. The situation is further aggravated by the slow growth rate of trees in this water-scarce area.

Table 2

Trend of Firewood Consumption in Sahel West Africa 1975-2000

Countries	Million m^3/year					
	1975			2000		
	Urban	Rural	Total	Urban	Rural	Total
Chad	470	1,600	2,000	1,700	3,600	5,300
Niger	340	2,500	2,800	1,200	4,600	5,800
Upper Volta	400	3,300	3,700	1,400	5,800	7,200
Mali	610	2,900	3,500	1,900	5,200	7,100
Mauritania	120	700	800	600	1,100	1,700
Senegal	1,000	1,900	2,900	2,900	3,000	5,900
The Gambia	50	250	300	120	430	550
Cape Verde Is.	NA	NA	NA	NA	NA	NA
TOTAL	3,000	13,000	16,000	9,800	23,700	33,500

Source: CILSS/Club du Sahel, Energy in the Development Strategy of the Sahel: Situation - Perspectives - Recommendations, October 1978.

In 1973, the seven countries most severely affected by the drought formed the Permanent Interstate Committee to Fight the Drought in the Sahel (CILSS).* The purpose of this regional organization is to mobilize international financial and technical assistance for achieving the regional objectives of food self sufficiency and restoring an ecological balance. Working in close coordination with the national Ministries for Water and Forests of each member country, the CILSS has sought support from the development community for forestry-related projects.

In 1976, as part of an effort to raise awareness to the problems caused by deforestation, the CILSS, with the U.N. Sahelian Office and the FAO, convened a conference in Dakar to examine the role of forestry in the rehabilitation of the Sahel. At that time, the shortage of firewood was identified as a major problem. Participants formulated a Plan of Action, which included the following elements:

- Production of wood to meet local needs for fuel and construction;
- Management of range (pasture) resources:
- Conservation efforts to enhance agricultural productivity;
- Protection and mangement of wildlife.

Later that same year, an informal international consortium, the Club of the Sahel, was formed to undertake long-term planning and programming for achieving the regional objectives of food self-sufficiency and environmental stabilization. As part of this effort, the Forestry and Ecology working team was created to draft a long-term forestry program for the Sahel. Team members include representatives from the Water and Forest Service of all the CILSS-member countries, interested donors, and the international development organizations.** A permanent, full-time staff is based at the CILSS Secretariat in Ouagadougou, and is reponsible for implementing the team's decisions.

Within the context of the Forestry and Ecology working team, problems are identified, priorities established, solutions proposed and a program approved. This program is regional in the sense that it addresses problems common to all the member countries. However, with the exception of a handful of regional activities, the majority of the proposed solutions will be funded on a bilateral basis and implemented by the forest services in each country. The

---

* The seven original members of the CILSS are: Mauritania; Senegal; Mali; Niger; Chad; Upper Volta; and the Gambia. The Republic of Cape Verde was granted membership in 1976.

** Donor countries and international organizations involved in planning and implementation of the Forestry/Ecology first generation program include: U.S.A.; Germany; France; Norway; the Netherlands; Switzerland; Belgium; FAO; World Bank; European Economic Community; and, the European Development Fund.

ermanent staff in Ouagadougou plays an active role in mobilizing financial and technical assistance for the program and coordinating donor efforts.

Planning for the first phase of a long-term program was completed in June 1977. Admittedly, it only begins to address the needs identified by the Sahelians the year before. For example, the projects for wood production, in the aggregate, will yield a total of 236,000 m^3 annually by the year 2000. This is a far cry from projected urban demand for the same year, projected to reach about 10 million m^3. See Table 3. However, the work of the team is dynamic and ongoing. It recently met in Niger (June 1979) to review the progress of the first generation program, and develop guidelines for the next phase.

Several proposals for conservation and training are now being considered by the CILSS countries, and if approved, would possibly merit support from AID. These are briefly described below:

--Introduction of more efficient wood-burning stoves. According to a recent study, an intensive effort to encourage the use of improved cookstoves could, in 5 years, produce a savings of several million m^3 for the entire Sahel. 13/ This project would include an inventory of current cooking practices; construction and testing of various prototypes; and the dissemination of the most promising cookstoves on a large scale. This effort would be undertaken in close cooperation with local women's organizations, manufacturers, and research institutes.

--Short-term training in forestry techniques. A major constraint to a massive reforestation effort in the Sahel is the shortage of qualified forestry personnel to manage and implement projects. In 1977, there were only 500 forestry technicians in the entire region, whereas in 1980 an estimated 4,370 agents will be needed to implement the proposed forestry effort. This shortfall in trained personnel is due in large part to inadequate training facilities in the region.

Short-term, on-site, hands-on training is viewed as one way to quickly increase the numbers of skilled personnel. One proposal under consideration is to sponsor intensive, one month training courses in forestry techniques for rural extension agents, high school students, and forestry technicians. 14/ It is estimated that 140-160 people could be trained annually in this way, and that each graduate could supervise tree planting activities on 20 hectares each year. By the year 2000, approximately 3,000 people could be trained, and assist in reforesting a total of 630,000 hectares. This represents about one-tenth of projected needs.

Table 3

Sahel West Africa: Impact of First Generation Projects (for which funding has been obtained) on Urban Demand for Wood Fuel to the Year 2000 (in 1000 m^3/year)

Country	Projected Urban Demand in the Year 2000	Expected Production From First Generation Projects (already financed)	Difference
Chad	1,700	8	- 1,692
Niger	1,200	40	- 1,160
Upper Volta	1,400	98	- 1,302
Mali	1,900	33	- 1,867
Mauritania	600	10	- 590
Senegal	2,900	45	- 2,855
Gambia	120	2	- 118
Cape Verde	NA	NA	NA
TOTAL	9,820	236	- 9,584

Source: J.D. Keita, Elements de Strategie Pour la Satisfaction des Besoins en Combustibles Ligneux du Sahel , D'ici L'an 2000, May 1979.

One major constraint to the implementation of a forestry program in the Sahel is the apparent lack of commitment by the national governments of the CILSS member countries. The representatives of the Forest Services are only too aware of the seriousness and magnitude of deforestation in their respective countries, and have been trying to obtain the support of their own governments in attacking this problem. However, the major effort to date has been concentrated on meeting more immediate needs for food and water, and forestry has been accorded a lower priority. As a result, the Water and Forest Service receives only a small share of the national budget, and in Niger, less than 1%. This places severe limits on planning, programming and project implementation. Because it has no funds, the Niger Water and Forest Service is constantly struggling "to maintain its credibility within the government and vis-a-vis its client public."15/ A related constraint is the lack of forestry personnel at all levels. In the Gambia, for example, the Conservator of Forests is a Britisher who is on loan from the British Overseas Development Ministry, and there is only one Gambian with an advanced forest degree. And in Niger, there are few top level managers and a poorly trained field staff. Some of these constraints can partially be addressed by donor-supported projects. However, the meager operational budgets do raise some questions about the ability of the countries to assume recurrent costs and support projects after the donor spigot has been turned off.

During these past few years, the major emphasis has been on designing projects and identifying funding sources, almost to the exclusion of long-term planning. In light of the desperateness of the situation, it has been important to immediately start activities which begin to address the problem. However, a greater level of effort is now needed for obtaining more precise information on the extent of deforestation and desertification in the Sahel. No calculations have yet been made to determine the total area needing restorative interventions. One approach for obtaining this information is to include data collection and analysis in project planning and implementation.

Since the establishment of the international Forestry and Ecology Team, the CILSS has been relatively more successful in attracting donor support for forestry activities.
As of June 1979, funding for 39% of the $175 million, first generation program had been secured, and an additional 41% promised. The ongoing work of the team has helped to raise the consciousness of Sahelians and donors alike to the enormity of the problems associated with deforestation, and their implications for achieving other development goals such as food self-sufficiency. The team has also provided a forum for cooperation between Sahelians and donors to identify problems, establish priorities, seek solutions, and develop long-range plans and programs for addressing the problems. Regular meetings, both at the technical and policy level, ensure an

ongoing, continuing effort to address a problem which might otherwise slip by the wayside as so often in the past. The fulltime staff, which includes a forester and ecologist, backstops and implements the conclusions and recommendations of the working team, and plays a key role in mobilizing the necessary financing for proposed activities.

Foreign Assistance Activities

The global experience in community forestry is very limited. Over the years, AID and other donors have been involved with occasional industrial forestry projects or with soil conservation or watershed protection projects which include forestry components. It has only been since the mid-1970s, however, that the importance of the energy and environmental aspects of forestry have been widely recognized. The World Bank's Forestry Sector Policy Paper issued in 1978 was the first clear policy declaration on the subject from a major donor agency. The Bank is now supporting a number of community forestry activities, and estimates that 250,000 hectares will be reforested with Bank support by 1980.[18] More recently, the FAO has adopted a similar policy, which is described in a recent publication entitled "Forestry for Local Community Development." Several national donors, most notably Canada, have also begun to support traditional fuels and community forestry projects in a number of countries.

Canada, through the International Development Research Centre, also took the lead in establishing the International Council on Research in Agroforestry. This agency, headquartered in Nairobi by former Director of FAO forestry programs Kenneth King, holds considerable promise for facilitating information flow and research on improved tree varieties and cropping techniques.

The world's professional foresters also have only recently come to widely perceive traditional fuels problems and the need for community forestry. Until the early 1970s foresters had been almost exclusively concerned with productive forestry--industrial materials and watershed protection or wildlife conservation. The World Forestry Congress of 1978, held in a developing country, Indonesia, with the theme "Forests for People" has clearly established wood fuels and community forestry and agroforestry as important forestry concerns, however.

Similarly, until the mid-1970s, energy experts have been almost entirely preoccupied with conventional energy sources. It is only with the wane of cheap and plentiful oil supplies that their attention has been seriously directed towards new and renewable energy possibilities and then, finally, to traditional energy sources.

AID's Past Involvement

The U.S. has not been a leader in the area of traditional fuels or community forestry. Over the years, some small-scale efforts have been undertaken by Peace Corps and private voluntary organizations (PVOs). Forestry volunteers have been working in the Sahel since 1962 on a wide range of activities, including nursery management, establishment of village woodlots, planting *Acacia albida* in farm fields, and forest management. And several PVOs, notably CARE, Catholic Relief Service, Church World Service and Africare have implemented forestry-related projects. More recently, AID has approved several forestry projects in the Sahel which include firewood components. See Table 4. The focus is on large-scale plantations to meet urban needs, village woodlots, and improved management of existing natural forest reserves. Some conservation efforts, such as the introduction of more efficient woodstoves and improved charcoal-making techniques, are being proposed within the context of AID-supported renewable energy projects. In the aggregate, these efforts only make a small dent in addressing the problem at hand, and clearly a greater commitment is required.

Recommendations for strengthening and expanding AID's policy and program in traditional fuels will be presented in the next section.

Table 4

AID Supported Forestry Projects with Fuelwood Components
Sahel West Africa*

Project	Outputs
Chad Reforestation (CARE)	• 52,500 trees for windbreaks and woodlots • 350,000 *Acacia albida* trees on 3,500 hectares
Senegal Fuelwood Production	• 3,000 hectares fuelwood plantations
Gambia Forestry	• 1,300 hectares fuelwood plantations • 50 hectares village woodlots
Upper Volta Forestry Education and Development	• management and rational exploitation of existing national forest reserves
Sequenega Integrated Rural Development (Africare)	• 150 hectares village woodlots

*Table only includes information on fuelwood components.

V. RECOMMENDATIONS FOR AN AID TRADITIONAL FUELS PROGRAM

Rationale for an AID Traditional Fuels Program

Although AID has very limited experience in traditional fuels problems, or the community/agroforestry expertise needed to cope with them, there are several reasons for AID to make a serious program commitment to the subject. First, increasing scarcity or actual shortages of traditional fuels are reducing the productivity, health, and welfare of millions of people--especially the poorest--in many developing countries. This exacerbates existing inequities in distribution of wealth and power within communities and between rural and urban areas. Second, overconsumption of traditional fuels is stressing the environment of many communities, reducing the quality and quantity of the soil and water resources on which the present and future well-being of development depend. Third, with the elimination of petroleum fuels as an option for most rural people in the third world, there is an urgent need to develop alternative fuels with which they can increase their productivity in a sustainable manner in the future. Biomass fuels hold particular promise, and there is a logical evolutionary path from the reestablishment or improved management of traditional wood fuel or fuel crop resources to the more advanced biomass fuel systems of the future.

Both in the U.S. and the Third World, there is increasing concern about rural energy shortages and tropical deforestation. If AID is to effectively respond to these problems, it will be necessary to strengthen and expand current programs in forestry and energy. The following recommendations are offered as a balanced set of steps for strengthening AID's traditional fuels program.

Recommendations

- Establish traditional fuels as a priority program area. A long-term commitment should be made by AID to the problem. Support for traditional fuels projects should be included as a major component of a new AID commitment to community forestry. It should also be defined in the context of AID's incipient energy program.

- Develop American expertise in problems of tropical deforestation. Presently, the U.S. has very little expertise, experience, or capacity to design and implement traditional energy and community forestry projects. Returned Peace Corps volunteers represent the major source of U. S. talent in tropical forestry. Many of these volunteers may have desired to continue with forestry assistance activities, but until recently there were no opportunities for doing so. AID should work with Peace Corps to locate these former volunteers and perhaps survey them for their subsequent experience and interest in future project activities.

With the exception of the Peace Corps, there are few possibilities for young American foresters to gain significant overseas field experience without jeopardizing their career prospects in this country. As a result, there are only a handful of American foresters familiar with tropical forestry conditions and possessing foreign language skills available to provide technical assistance. Since the demand for tropical forestry expertise already seems to exceed supply, and will grow in the future, there is an immediate need for young professionals to receive language training and to be given opportunities to work on projects in the field. This can be done in several ways: by encouraging and supporting graduate and post-graduate field research on traditional fuels and community forestry issues; and by participating in FAO's associate expert program. The FAO program offers young professionals the chance to work with tropical forestry experts in developing countries.

- Seek opportunities to cooperate with other international donors in the community forestry and traditional fuels areas. This could include increased U.S. support for relevant programs of the World Bank and UNDP, as well as the International Council on Research in Agroforestry (ICRAF).

- Review of all past activities related to forestry or traditional fuels, for the purpose of drawing upon the lessons of past efforts and identifying project participants (expertise).

- Strengthen communication and flow of information between AID/W and the field on the subject of traditional fuels and community forestry. Although the missions are already heavily burdened by existing mandates, traditional fuels and community forestry are increasingly recognized as a priority by AID field missions and their host governments. AID/W presently has very little capacity to respond to field requests for technical information or absorb and utilize data from the field. As a preliminary step, information packets, including several publications such as Eckholm's Planting for the Future and the World Bank Forestry Sector Paper might be sent out to all missions.

- Include traditional fuels components in agriculture, energy, and rural development projects, wherever applicable. For the first several years, while experience is being gained and U.S. support capabilities are being developed, AID should concentrate on relatively modest projects. These would involve comprehensive approaches, but on a relatively small scale, limited to a few villages or a single region of a country. Successful projects can then be replicated or revised and adapted for use on a broader scale.

- Consider providing support for major national or regional projects on traditional fuels. Haiti has frequently been cited as a country in which the firewood crisis is already so severe that nothing short of a major comprehensive assault on the problem will be successful. In the Sahel, CILSS has outlined a major integrated program on firewood scarcity which clearly deserves full U.S. support.

- Support efforts by the Peace Corps and private voluntary organizations (PVOs) in the traditional fuels and community forestry program area. A number of key community forestry and traditional fuels activities can be accomplished only on a small scale. For example, the introduction of improved wood stoves to a region may best be conducted by only one or two persons working with little fanfare with local people over a period of several years. These are the kinds of skills that Peace Corps and PVOs specialize in.

- Develop a set of initial guidelines for analysis of traditional fuels and community forestry projects. Because of the relatively long timespan between project initiation and results, and because of the high proportion of non-market and social costs and benefits in these kinds of projects, a clear set of project assessment criteria would be useful to project designers. This initial set of guidelines would merit review within a few years, to be modified as experience is gained.

- Provide easy access to data and information generated by project identification and review documents. Although PIDs and other project documents are usually available to scholars, experts and the general public in theory, in practice they are not.

- Strengthen project evaluation. Important lessons can be learned from the successes and failures of traditional fuels and forestry projects, and can be applied to future project planning. A special effort should be made to insure full evaluation of all AID-supported projects, and widespread dissemination of the results.

- Expand the Peace Corps village energy surveys, which AID is already supporting, to include participation by graduate student and professional social scientists conducting field work in rural or urban communities.

- Examine trends in international charcoal trade with attention to the impacts of charcoal exports on domestic fuel supplies for traditional fuel users.

Much of the "knowledge gap" can be filled only through actual project activities. Action and data gathering should be integrated. But this is no excuse for delaying project activities. Traditional fuels problems are local problems; their nature and severity may vary markedly within a single country. Until there are much more data, analysis, and project experience available, only the broadest generalizations can be made in the diagnosis of these particular problems in prescribing strategies and tactics to apply to specific communities or sets of communities.

During the 1970s, the oil-energy crisis of the rich has been mirrored by the firewood-energy crisis of the poor. Oil and firewood problems both are likely to worsen considerably during the next several decades, and it is clear that if present trends in use of both oil and woodfuels continue, increasing numbers of people will face greater economic distress and personal hardship. For both energy crises, the next decade or so will be crucial. The problems must be more clearly defined, tactics and strategies for solutions must be tested, and the institutional capacity and political will to enact solutions must be established.

Footnotes

I. Introduction

1. This was derived by taking the square root of the FAO's wood fuels consumption estimate of nearly 1300 million cubic meters (A), divided by the equatorial circumference of about 40,000 km (B):

$$\frac{A}{B} = 18.5 \text{ ft.}$$

Dung and residues estimates are from John Spears, 1978.

Oil equivalent calculated at 2.3 m^3/metric ton of coal equivalent (TCE) and 4.9 barrels of oil (bbl)/TCE. Oil value calculated at $20/bbl.

2. Arnold, 1978. Spears, 1978.

3. Openshaw, 1978.

4. Openshaw, 1978.

5. French, 1978.

II. The Nature and Extent of the Firewood Crisis and its Implications for Development

1. Tyers, 1976.

2. Arnold, 1978; Arnold and Jongma, 1978.

3. Openshaw, 1978.

4. Ernst, 1978.

5. For example, see T.B. Taylor Associates, 1978 or ODC/META, 1978.

6. Makhijani and Poole, 1975.

7. Openshaw, 1978.

8. Steedman et al, 1979.

9. For example, see Eckholm, 1975.

10. Reddy and Prasad, 1977 and UNEP, "The Other Energy Crisis" (film) 1977.

11. Reddy and Prasad, 1977.

12. See Eckholm, 1978; CILSS, 1978; Floor, 1977.

13. Arnold, 1978; Spears, 1978.

14. Eckholm, 1978.

15. Eckholm, 1975 and 1978.

16. Openshaw, 1978.

17. T.B. Taylor Associates, 1978.

III. Solutions

1. Evans, 1979; and Joseph, forthcoming.

2. Benge, 1978.

3. Forestry Sector Paper, 1978; Spears, 1978.

IV. Past and Present Efforts

1. Shah, 1978.

2. Eckholm, 1979.

3. Eckholm, 1979.

4. Argal, 1979.

5. Argal, 1979.

6. Eckholm, 1979.

7. Bong Won Ahn, 1979.

8. Bong Won Ahn, 1979.

9. Eckholm, 1979 and Bong Won Ahn, 1979.

10. Eckholm, 1979.

11. Club du Sahel/CILSS. Energy in the Development Strategy of the Sahel, 1978.

12. AID, Senegal Fuelwood Production, 1979.

13. Ki-Zerbo and de Lepeleire, 1979.

14. Ben Salem, 1979.

15. AID, Niger Forestry and Land-Use Planning Project, 1979.

16. Stebler, 1979.

17. Spears, 1978.

APPENDIX 1 WOODFUEL CONSUMPTION, NATIONAL DATA, 1976

Country Low-Income (45) (p/c GNP < $300)	Population Mid-1976 (millions)	Per Capita GNP 1976 ($) 166	1976 Commercial Energy Consumption per capita (kg of CE)	1976 Official Woodfuel Consumption Estimate (1000 cub. mtrs)	Woodfuel Consumption Other Estimates (cub. mtrs.)	1976 Woodfuel Consumption per capita Quantities (cub. mtrs.)	1976 Woodfuel Consumption per capita Energy Value (kg of CE)	1976 Woodfuel as % of Total Energy (incl. comm. energy - %)
Africa (28)		191						
•†Benin	3.2	130	49	2212		0.69	300	86
•†Burundi	3.9	120	12	869		0.22	95	89
†Cameroon, Unit. Rep.	6.5	290	98	6523		1.00	434	82
†Cape Verde	0.3	260	12	7.2		--	--	na
•†Central African Emp.	1.8	230	41	1829		1.01	439	91
•†Chad	4.1	120	23	3286		0.80	347	94
Comoros	0.3	180	59	na		--	--	na
†Egypt	38.1	280	473	115		0.003	1.3	neg.
•†Ethiopia	28.6	100	27	23203		0.81	352	93
•†Gambia	0.5	180	84	244		0.48	208	73
•†Guinea	4.5	150	93	2716		0.60	260	74
†Guinea-Bissau	0.5	140	58	430		0.86	373	87
†Kenya	13.8	240	152	13701		0.99	430	74
•†Lesotho*	1.1	170	na	na		--	--	na
†Madagascar	7.7	200	66	5068		0.66	286	80
†Malawi	5.1	140	56	3036		0.60	260	82
•†Mali	1.3	100	27	2863		2.20	956	97
†Mozambique	9.3	170	133	8240		0.88	382	74
•†Niger	4.7	160	35	2595		0.55	239	87
•†Rwanda	4.4	110	17	3870		0.88	382	96
†Sierra Leone	3.1	200	112	2500		0.81	352	76
•†Somalia	3.2	110	47	3258		1.02	443	90
•†Sudan	18.2	290	143	25245		1.39	601	81
•†Tanzania, Unit. Rep.	15.6	180	68	36675		2.35	1021	94
Togo	2.3	260	85	924		0.40	173	67
•†Uganda	11.9	240	48	13600		1.14	496	91
•†Upper Volta	6.2	110	18	3920		0.63	274	94
Zaire	25.6	140	62	11800		0.46	200	76

continued

Country Low-Income (45) (p/c GNP < $300)	Population Mid-1976 (millions)	Per Capita GNP 1976 ($)	1976 Commercial Energy Consumption per capita (kg of CE)	1976 Official Woodfuel Consumption Estimate (1000 cub. mtrs.)	Woodfuel Consumption Other Estimates (cub. mtrs.)	1976 Woodfuel Consumption per capita Quantities (cub. mtrs.)	1976 Woodfuel Consumption per capita Energy Value (kg of CE)	1976 Woodfuel as % of Total Energy (incl. comm. energy - %)
Asia (15)		160						
•+Afghanistan	19.5	160	41	5939		0.30	130	76
•+Bangladesh	76.1	110	33	10045		0.13	56	63
•Bhutan	1.2	70	na	na		--	--	na
+Burma	31.2	120	49	19611		0.63	273	85
+India	620.7	150	218	118179		0.19	83	28
□ Indonesia	134.7	240	218	111700		0.83	360	62
+Kampuchea (Cambodia)	8.3	70	16	4055		0.48	208	93
•+Lao People's Dem. Rep.	3.4	90	61	3043		0.90	--	87
•Maldives	0.1	110	na	na		--	--	na
•+Nepal	12.9	120	11	8700		0.67	291	96
+Pakistan	72.5	170	181	8743		0.12	52	22
+Sri Lanka	14.0	200	106	4177		0.30	130	55
Vietnam, Soc. Rep.	46.4	160	124	16300		0.35	152	55
•+Yemen, Arab. Rep	6.9	250	41	na		--	--	na
•+Yemen, People's Rep.	1.7	280	324	na		--	--	na
Latin America (1)		200						
•+Haiti	4.6	200	28	1436		0.75	326	92
Oceania (1)		250						
Solomon Is.		250	290	191		--	--	na

continued

Country Lower-Middle Income (p/c GNP $300-$699)	Population Mid-1976 (millions)	Per Capita GNP 1976 ($) 429	1976 Commercial Energy Consumption per capita (kg of CE)	1976 Official Woodfuel Consumption Estimate (1000 cub. mtrs.)	Woodfuel Consumption Other Estimates (cub. mtrs.)	1976 Woodfuel Consumption per capita Quantities (cub. mtrs.)	1976 Woodfuel Consumption per capita Energy Value (kg of CE)	1976 Woodfuel as % of Total Energy (incl. comm. energy - %)
Africa (17)		444						
Angola	6.4	330	166	6766		1.06	461	74
Botswana*	0.7	410	na	709		1.01	439	na
Congo, People's Rep.	1.4	520	142	1822		1.30	565	80
Equatorial Guinea	0.3	330	94	392		1.31	570	86
+Ghana	10.1	580	157	10579		1.04	452	74
+Ivory Coast	6.8	610	380	5014		0.74	322	46
Liberia	1.6	450	410	1750		1.09	474	53
+Mauritania	1.3	340	102	526		0.40	174	63
Mauritius	0.9	680	405	22		0.02	8	2
Morocco	17.9	540	273	2706		0.15	65	19
Nigeria	64.7	380	94	64265		0.99	430	82
Rhodesia	6.5	550	634	5400		0.83	360	36
Sao Tome & Principe	0.1	490	139	na		--	--	na
+Senegal	4.5	390	156	2759		0.61	265	63
Seychelles		580	570	na		--	--	na
Swaziland*	0.5	470	na	450		0.90	391	na
Zambia	5.1	440	540	5181		1.02	443	45

continued

Country	Population Mid-1976 (millions)	Per Capita GNP 1976 ($)	1976 Commercial Energy Consumption per capita (kg of CE)	1976 Official Woodfuel Consumption Estimate (1000 cub. mtrs.)	Woodfuel Consumption Other Estimates (cub. mtrs.)	1976 Woodfuel Consumption per capita Quantities (cub. mtrs.)	1976 Woodfuel Consumption per capita Energy Value (kg of CE)	1976 Woodfuel as % of Total Energy (incl. comm. energy - %)
Lower-Middle Income (p/c GNP $300-$699)		429						
Asia (6)		419						
China, People's Rep.	836.8	410	706	142000		0.17	73	0.4
Jordan	2.8	610	527	3		neg	neg.	neg.
Korea, People's Rep.	16.3	470	1072	4640		0.28	121	0.3
Korea, Rep.	34.8	670	1020	7350		0.21	91	8
Philippines	44.0	410	129	22960		0.52	226	.11
Thailand	43.3	380	308	16091		0.37	160	14
Latin America (14)		586						
Belize		670	603	73				
Bolivia	5.8	390	118	3550		0.60	260	45
Colombia	23.0	630	685	21379		0.93	404	37
Ecuador	6.9	640	455	1940		0.28	121	20
El Salvador	4.2	490	260	2856		0.68	295	53
Grenada	0.1	420	211	na		--	--	na
Guatemala	5.7	630	257	5130		0.90	391	60
Guyana	0.8	540	1072	16		0.02	8	neg.
Honduras	2.8	390	264	1000		1.07	466	64
Paraguay	2.6	640	189	3181		1.22	530	74
St. Lucia	0.1	580	166	na		--	--	na
Oceania (3)		479						
Papua New Guinea	2.8	490	989	4870		1.74	756	66
Tonga	0.1	410	190	64		--	--	na
Western Samoa	0.2	350	160	60		0.3	130	45
Europe (1)		540						
Albania	2.5	540	867	1608		0.64	278	24

continued

Country	Population Mid-1976 (millions)	Per Capita GNP 1976 ($)	1976 Commercial Energy Consumption per capita (kg of CE)	1976 Official Woodfuel Consumption Estimate (1000 cub. mtrs.)	Woodfuel Consumption Other Estimates (cub. mtrs.)	1976 Woodfuel Consumption per capita Quantities (cub. mtrs.)	1976 Woodfuel Consumption per capita Energy Value (kg of CE)	1976 Woodfuel as % of Total Energy (incl. comm. energy - %)
Upper Middle-Income (38) (p/c GNP $700-$1,999)		1215						
Africa (6)		1163						
Algeria	17.3	990	729	1278		0.07	30	4
Djibouti		1940	727	na		--	--	na
Namibia *		980	na	na		--	--	na
Reunion	0.5	1920	674	31		0.06	26	4
South Africa*	25.6	1340	2985	1000		0.39	170	5
Tunisia	5.9	840	456	1768		0.30	130	22
Asia (8)		1390						
Iran	34.1	1930	1490	1997		0.05	21	1.3
Iraq	11.4	1390	727	15		neg.	neg.	neg.
Lebanon	2.7	1070	533	60		0.02	9	1.6
Macao	0.3	780	381	na		--	--	na
Malaysia	12.4	860	578**	5613		0.45	195	25
Mongolia	1.5	860	1166	1350		0.90	391	25
Syrian Arab Rep.	7.6	780	744	50		0.01	4	neg.
Taiwan (ROC)	16.3	1070	na	na		--	--	na
Latin America (16)		1126						
Argentina	25.7	1550	1804	1427		0.13	56	3
Barbados	0.2	1550	974	na		--	--	na
Brazil	110.2	1140	731	112890		1.02	443	38
Chile	10.8	1050	987	3500		0.32	139	14
Costa Rica	2.0	1040	488	2254		1.13	491	50
Cuba	9.4	860	1225	1500		0.16	69	5
Dominican Rep.	4.8	780	683	1737		0.36	156	19
Guadeloupe	0.4	1500	685	15		0.38	165	19

continued

Country	Population Mid-1976 (millions)	Per Capita GNP 1976 ($)	1976 Commercial Energy Consumption per capita (kg of CE)	1976 Official Woodfuel Consumption Estimate (1000 cub. mtrs.)	Woodfuel Consumption Other Estimates (cub. mtrs.)	1976 Woodfuel Consumption per capita Quantities (cub. mtrs.)	1976 Woodfuel Consumption per capita Energy Value (kg of CE)	1976 Woodfuel as % of Total Energy (incl. com. energy - %)
High Income (18) (p/c GNP ≥ $2,000)	1,101.8	4976						
Africa (2)	1.0	5746						
◻ Gabon	0.5	2590	1279	1166		2.33	1011	44
◻ Libya	2.5	6310	1589	504		0.20	86	5
Asia (11)	19.2							
Bahrain	0.2	2410	11998	na		--	--	na
Brunei	0.2	6100	14209	75		--	--	na
Hong Kong	4.4	2110	1113	na		--	--	na
Israel	3.5	1920	2541	11		neg.	neg.	neg.
◻ Kuwait	1.1	15480	9198	na		--	--	na
Oman	0.8	2680	696	na		--	--	na
◻ Qatar	0.1	11400	25236	na		--	--	na
◻ Saudi Arabia	6.4	4480	1901	na		--	--	na
Singapore	2.1	2700	2262	na		--	--	na
United Arab Emirates	0.2	13990	13322	na		--	--	na
Latin America (5)	17.1	2528						
Bahamas	0.2	3310	7286	na		--	--	na
Martinique	0.3	2350	984	10		0.03	13	1
Trinidad & Tobago	1.1	2240	4272	10		0.01	4	neg.
◻ Venezuela	12.1	2570	2038	7545		0.58	252	8

Legend

† Considered by the U.N. to be one of the 45 countries "most seriously affected" by recent adverse economic conditions.

● Considered by the U.N. to be one of the 28 "least developed countries."

◻ Member of the Organization of Petroleum Exporting Countries.

Appendix 1

Notes

* Botswana, Lesotho, Namibia and Swaziland are members of the Customs Union of South Africa. No data is available for these individual countries. The data for South Africa represents the total figure for all five countries.

**Peninsular Malaysia only.

Sources

Population, 1976, from John W. Sewell and the Staff of the Overseas Development Council, The United States and World Development, Agenda 1977, New York, 1977, Annex A-1

Per capita GNP, 1976, from Martin M. McLaughlin and the Staff of the Overseas Development Council, The United States and World Development, Agenda 1979, New York, 1979, Annex A-4.

Commercial energy consumption, per capita, 1976, from United Nations, ECOSOC, Statistical Office, World Energy Supplies, 1972-1976, Series J, No. 21, New York, 1978, Table 2.

Woodfuel consumption estimate from, United Nations, FAO, 1977 Yearbook of Forest Products, 1966-1976, FAO Forestry Statistics Series, Rome, 1979, "Production of Fuelwood and Charcoal". Note: Woodfuel production is assumed to approximate consumption in these statistics.

Woodfuel consumption per capita by energy value calculated on the basis of: 2.3 cubic meters equal 1 metric ton of coal equivalent.

APPENDIX 2: CHARCOAL TRADE IN DEVELOPING COUNTRIES

1966 and 1976

Low-Income (45) (p/c GNP < $300)	IMPORTS 1000 cub. mtrs.		EXPORTS 1000 cub. mtrs.		EXPORTS 1000 $		NET EXPORTS 1000 cub. mtrs.		NET EXPORTS 1000 $	
Country	1966	1976	1966	1976	1966	1976	1966	1976	1966	1976
Africa (28)										
●+Benin	-	-	-	-	-	-	-	-	-	-
●+Burundi	-	-	-	-	-	-	-	-	-	-
+Cameroon, Unit. Rep.	-	-	-	-	-	-	-	-	-	-
+Cape Verde	-	-	-	-	-	-	-	-	-	-
●+Central African Emp.	-	-	-	-	-	-	-	-	-	-
●+Chad	-	-	-	-	-	-	-	-	-	-
Comoros	-	-	-	-	-	-	-	-	-	-
+Egypt	1	-	1	-	17	-	-	-	na	-
●+Ethiopia	-	-	-	-	-	-	-	-	-	-
●+Gambia	-	-	-	-	-	-	-	-	-	-
●+Guinea	-	-	-	-	-	-	-	-	-	-
+Guinea-Bissau	-	-	-	-	-	-	-	-	-	-
+Kenya	-	-	19	-	375	-	19	-	375	-
●+Lesotho	-	-	-	-	-	-	-	-	-	-
+Madagascar	-	-	-	-	-	-	-	-	-	-
●Malawi	-	-	-	-	-	-	-	-	-	-
●+Mali	-	-	-	-	-	-	-	-	-	-
+Mozambique	-	-	-	-	-	-	-	-	-	-
●+Niger	-	-	-	-	-	-	-	-	-	-
●+Rwanda	-	-	-	-	-	-	-	-	-	-
+Sierra Leone	-	-	-	-	-	-	-	-	-	-
●+Somalia	-	-	19	-	688	-	19	-	688	-
●+Sudan	-	-	-	-	-	-	-	-	-	-
●+Tanzania, Unit. Rep.	-	-	-	1	-	6	-	1	-	6
Togo	-	-	-	-	-	-	-	-	-	-
●+Uganda	15	-	-	-	-	-	-	-	-	-
●+Upper Volta	-	-	-	-	-	-	-	-	-	-
Zaire	-	-	-	-	-	-	-	-	-	-
Asia (15)										
●+Afghanistan	-	-	-	-	-	-	-	-	-	-
●+Bangladesh	-	-	-	-	-	-	-	-	-	-
Bhutan	-	-	-	-	-	-	-	-	-	-
+Burma	-	-	-	-	-	-	-	-	-	-
+India	-	-	-	1	-	-	-	-	-	-
Indonesia	-	-	-	49	-	1660	-	49	-	1660
+Kampuchea (Cambodia)	-	-	-	-	-	-	-	-	-	-
●+Lao People's Dem. Rep.	-	-	-	-	-	-	-	-	-	-
● Maldives	-	-	-	-	-	-	-	-	-	-
●+Nepal	-	-	-	-	-	-	-	-	-	-
+Pakistan	-	-	-	-	-	-	-	-	-	-
+Sri Lanka	-	-	13	-	678	-	13	-	678	-
Vietnam, Soc. Rep.	-	-	-	-	-	-	-	-	-	-
●+Yemen, Arab. Rep.	-	-	-	-	-	-	-	-	-	-
●+Yemen, People's Rep.	-	-	-	na	-	69	na	-	69	

continued

1966 and 1976

	IMPORTS		EXPORTS				NET EXPORTS			
Low-Income (45) (p/c GNP $300)	1000 cub. mtrs.		1000 cub. mtrs.		1000 $		1000 cub. mtrs.		1000 $	
Country	1966	1976	1966	1976	1966	1976	1966	1976	1966	1976
Latin America (1)										
++Haiti	-	-	-	-	-	-	-	-	-	-
Oceania (1)										
Solomon Is.	-	-	-	-	-	-	-	-	-	-
Lower Middle-Income 38 (p/c GNP $300-699)										
Africa (17)										
Angola	-	-	-	-	-	-	-	-	-	-
•Botswana	-	-	-	-	-	-	-	-	-	-
Congo, People's Rep.	-	-	-	-	-	-	-	-	-	-
Equatorial Guinea	-	-	-	-	-	-	-	-	-	-
+Ghana	-	-	-	-	-	-	-	-	-	-
+Ivory Coast	-	-	-	-	-	-	-	-	-	-
Liberia	-	-	-	-	-	-	-	-	-	-
+Mauritania	-	-	-	-	-	-	-	-	-	-
Mauritius	-	-	-	-	-	-	-	-	-	-
Morocco	-	-	-	-	-	-	-	-	-	-
] Nigeria	-	-	-	-	-	-	-	-	-	-
Rhodesia	-	-	na	na	22	22	na	na	22	22
Sao Tome & Principe	-	-	-	-	-	-	-	-	-	-
+Senegal	-	-	-	-	-	-	-	-	-	-
Seychelles	-	-	-	-	-	-	-	-	-	-
Swaziland	-	-	-	-	-	-	-	-	-	-
Zambia	-	-	-	-	-	-	-	-	-	-
Asia (6)										
China, People's Rep.	-	-	-	-	-	-	-	-	-	-
Jordan	3	-	-	-	-	-	-	-	-	-
Korea, People's Rep.	-	-	-	-	-	-	-	-	-	-
Korea, Rep.	-	-	-	-	-	-	-	-	-	-
Philippines	-	-	-	17	-	-	-	17	-	-
Thailand	-	-	40	34	459	1049	40	34	459	1049

continued

1966 and 1976

Country	IMPORTS 1000 cub. mtrs. 1966	IMPORTS 1000 cub. mtrs. 1976	EXPORTS 1000 cub. mtrs. 1966	EXPORTS 1000 cub. mtrs. 1976	EXPORTS 1000 $ 1966	EXPORTS 1000 $ 1976	NET EXPORTS 1000 cub. mtrs. 1966	NET EXPORTS 1000 cub. mtrs. 1976	NET EXPORTS 1000 $ 1966	NET EXPORTS 1000 $ 1976
Upper Middle-Income, continued										
Asia (8)										
Iran	3	2	3	-	10	-	-	-	na	-
Iraq	18	6	-	-	-	-	-	-	-	-
Lebanon	2	-	9	-	-	-	7	-	na	-
Macao	15	2	-	-	-	-	-	-	-	-
Malaysia	23	42	4	6	114	197	-	-	-	-
Mongolia	-	-	-	-	-	-	-	-	-	-
Syrian Arab Rep.	-	-	-	1	7	70	0	3	-	70
Taiwan (ROC)	-	-	-	-	-	-	-	-	-	-
Latin America (16)										
Argentina	-	-	-	-	-	-	-	-	-	-
Barbados	-	-	-	-	-	-	-	-	-	-
Brazil	-	-	-	-	-	-	-	-	-	-
Chile	1	3	-	-	-	-	-	-	-	-
Costa Rica	-	-	1	-	11	-	1	-	11	-
Cuba	-	-	-	-	-	-	-	-	-	-
Dominican Rep.	-	-	-	-	-	-	-	-	-	-
Guadeloupe	-	-	-	-	-	-	-	-	-	-
Jamaica	-	-	-	-	-	36	-	-	-	36
Mexico	-	-	2	2	57	257	2	2	57	257
Netherlands Antilles	-	-	-	-	-	-	-	-	-	-
Nicaragua	-	-	-	-	-	-	-	-	-	-
Panama	-	-	-	-	-	-	-	-	-	-
Peru	-	-	-	-	-	-	-	-	-	-
Suriman	-	-	-	-	-	-	-	-	-	-
Uruguay	-	-	-	-	-	-	-	-	-	-
Oceania (2)										
Fiji	-	-	-	-	-	-	-	-	-	-
Pacific Is. Trust Terr.	-	-	-	-	-	-	-	-	-	-
Europe (6)										
Cyprus	-	-	-	-	-	-	-	-	-	-
Malta	-	-	-	-	-	-	-	-	-	-
Portugal	-	-	-	3	-	347	-	3	-	347
Romania	-	-	20	17	900	1300	20	17	900	1300
Turkey	-	-	-	-	-	-	-	-	-	-
Yugoslavia	1	10	9	18	543	3567	8	8	na	na

continued

1966 and 1976

Country	IMPORTS 1000 cub. mtrs. 1966	IMPORTS 1000 cub. mtrs. 1976	EXPORTS 1000 cub. mtrs. 1966	EXPORTS 1000 cub. mtrs. 1976	EXPORTS 1000 $ 1966	EXPORTS 1000 $ 1976	NET EXPORTS 1000 cub. mtrs. 1966	NET EXPORTS 1000 cub. mtrs. 1976	NET EXPORTS 1000 $ 1966	NET EXPORTS 1000 $ 1976
Lower Middle-Income, continued										
Latin America (11)										
Belize	-	-	-	-	-	-	-	-	-	-
Bolivia	-	-	-	-	-	-	-	-	-	-
Colombia	-	-	-	-	-	-	-	-	-	-
Ecuador	-	-	-	-	-	-	-	-	-	-
+El Salvador	-	-	-	-	-	-	-	-	-	-
Grenada	-	-	-	-	-	-	-	-	-	-
+Guatemala	-	-	-	-	-	-	-	-	-	-
+Guyana	-	-	1	-	39	-	1	-	39	-
+Honduras	-	-	-	-	-	-	-	-	-	-
Paraguay	-	-	-	-	-	-	-	-	-	-
St. Lucia	-	-	-	-	-	-	-	-	-	-
Oceania (3)										
Papua New Guinea	-	-	-	-	-	-	-	-	-	-
Tonga	-	-	-	-	-	-	-	-	-	-
-Western Samoa	-	-	-	-	-	-	-	-	-	-
Europe (1)										
Albania	-	-	-	-	-	-	-	-	-	-
Upper Middle-Income 38 (p/c GNP $700-1,999)										
Africa (6)										
Algeria	-	3	-	-	-	175	-	-	-	-
Djibouti	-	-	-	-	-	-	-	-	-	-
Namibia	-	-	-	-	-	-	-	-	-	-
Reunion	-	-	-	-	-	-	-	-	-	-
South Africa	-	-	1	1	36	48	1	1	36	48
Tunisia	-	-	2	-	124	-	2	-	124	-

continued

1966 and 1976

High-Income (48) (p/c GNP - $2,000	IMPORTS 1000 cub. mtrs.		EXPORTS 1000 cub. mtrs.		EXPORTS 1000 $		NET EXPORTS 1000 cub. mtrs.		NET EXPORTS 1000 $	
Country	1966	1976	1966	1976	1966	1976	1966	1976	1966	1976
Africa (2)										
◻ Gabon	-	-	-	-	-	-	-	-	-	-
◻ Libya	2	-	-	-	-	-	-	-	-	-
Asia (10)										
Bahrain	-	3	-	-	-	-	-	-	-	-
Brunei	-	-	-	-	3	-	-	-	3	-
Hong Kong	28	16	-	2	5	135	0	0	na	na
Israel	-	-	-	-	-	-	-	-	-	-
◻ Kuwait	13	14	2	2	120	287	0	0	na	na
Oman	-	-	-	-	-	-	-	-	-	-
◻ Qatar	-	2	-	-	-	-	-	-	-	-
◻ Saudi Arabia	-	2	-	-	-	-	-	-	-	-
Singapore	16	9	2	6	56	405	0	0	na	na
United Arab Emirates	-	-	-	-	-	-	-	-	-	-
Latin America (5)										
Bahamas	-	-	-	-	-	-	-	-	-	-
Martinique	-	-	-	-	-	-	-	-	-	-
Trinidad & Tobago	-	-	-	-	-	-	-	-	-	-
Venezuela	-	-	-	-	-	-	-	-	-	-

Legend

+ Considered by the U.N. to be one of the 45 countries "most seriously affected" by recent adverse economic conditions.

• Considered by the U.N. to be one of the 28 "least developed countries".

◻ Member of the Organization of Petroleum Exporting Countries.

Note: Net Exports derived from import and export data in Appendix 2.

Source: United Nations, FAO, 1977 Yearbook of Forestry Products, 1966-1976, FAO Forestry Statistics, Rome 1979, "Imports of Charcoal", Exports of Charcoal", by quantity and value, pp. 102-3.

BIBLIOGRAPHY

(Note: The annotated portions of this bibliography are reproduced in entirety from the 86 citation annotated bibliography prepared by and with the permission of David French, and contained in "Firewood in Africa", Discussion Paper for the Africa Bureau Firewood Workshop, June 12-14, 1978. Washington, D.C.: AID.)

Bibliography Outline

A. Energy Needs (General)

B. Energy Sectors of Specific Countries

1. Analyses

2. Surveys

C. Traditional Energy Sector Issues

1. The Environment

2. Forestry in Developing Countries

3. Forests and Woodfuels (General)

4. Forests and Woodfuels (Regional Studies)

a. Sahel

b. Other Regions

5. Forests and Woodfuels (Country Studies)

D. Energy Solutions: Improved Traditional Fuels

1. Improved Traditional Conversion Devices

2. Charcoal (General)

3. Charcoal (Country Studies)

E. Energy Solutions: Modern Renewable Alternatives to Traditional Fuels

1. Renewable Energy (General)

2. Bioconversion

3. Biogas

4. Solar

A. Energy Needs (General)

Bhatia, Ramesh. 1976. "Energy Requirements of Different Farm Systems." In Indian Journal of Agricultural Economics, July-September.

Bild, Ralph W. 1978. "Rural Energy Requirements in the Developing World." In International Energy Issues, May 4.

Donovan, Hamester & Rattien, Inc. 1977. Review of Literature, Conferences and Programs Concerning Energy Assistance to Less Developed Countries. Report to Brookhaven National Laboratories. Washington, D.C.: Donovan, Hamester & Rattien. Annotated bibliography.

Hayes, Denis. 1977. Energy for Development: Third World Options. Worldwatch Paper No. 15. Washington, D.C.: Worldwatch Institute. December.

Howe, James W. and staff. 1977. Energy for the Villages of Africa. Washington, D.C.: Overseas Development Council.

Kerr, Warwick E. "Problemas Energeticos em Comunidades Pequenas, un Possivel Solucao." Paper presented at a symposium on Energy and Development in the Americas. Sao Paolo, Brazil, March 12-17, 1978.

Makhijani, Arjun. 1976. Energy Policy for the Rural Third World. London and Washington, D.C.: International Institute for Environment and Development. September.

Notes that improved stoves and utensils could economize on firewood and proposes extensive research to develop such equipment.

Palmedo, Philip F., Robert Nathans, Edward Beardsworth, and Samuel Hale, Jr. 1978. Energy Needs, Uses and Resources in Developing Countries. Report to U.S. AID, Upton, N.Y.: Brookhaven National Laboratory. March.

Parikh, J. 1975. Energy and Development. PUN 43. Washington, D.C.: World Bank.

"Reports and Recommendations of Workshops Symposium on Energy and Development in the Americas, March 12-17, 1978." In Interciencia, Vol. 3, No. 3, 1978, pp. 182-190.

Revelle, Roger. 1975. "Energy and Rural Development." In Georgia Institute of Technology, Economic Development Laboratory, Discussion Papers on the Problems of Science and Technology. Atlanta: Georgia Institute of Technology. December.

Energy use in developing countries is already considerable, but conversion processes are quite inefficient. In the short run, improved stoves can conserve firewood for cooking or water heating. Over the longer term, there may be promise in rapidly growing tree species, along with the use of biogas or solar technologies.

United Nations Environment Program, Regional Office for Asia and the Pacific. 1978. UNEP - Asia Report 1977. Bangkok, Thailand.

United Nations, Food and Agriculture Organization. 1976. "Energy for Agriculture in Developing Countries." In FAO Monthly Bulletin of Agriculture, Economics and Statistics, Vol. 25, No. 2.

B. Energy Sectors of Specific Countries

B.1 Analyses

Club du Sahel/CILSS. 1978. Energy in the Development Strategy of the Sahel: Situation, Perspectives, Recommendations. Comite Permanent Interetats de Lutte Contre la Secheresse dans le Sahel. October.

Energy Research and Development Group, Nepal. 1976. The Energy Sector. Kathmandu, Nepal: Tribhuvan University.

Floor, W.M. 1977. The Energy Sector of the Sahelian Countries. The Netherlands: Ministry of Foreign Affairs.

Fundacao Instituto Brasileiro de Geografia e Estatistica, Superintendencia de Estatisticas Primarias. 1974. Excerpts from Estudo Nacional da Despesa das Familias. Sao Paolo, Brazil: Fundacao Instituto Brasileiro de Geografia e Estatistica.

Goldemberg, Jose. 1978. "Brazil: Energy Options and Current Outlook." In Science, Vol. 200, No. 4338, pp. 158-163.

Goldemberg, Jose. Coordinator. 1976. Energio No Brasil. Sao Paolo, Brasil: Academia de Ciencias do Estado.

Henderson, P.D. 1975. India: The Energy Sector. Washington, D.C.: World Bank.

Kashkari, Chaman. 1975. Energy: Resources, Demand and Conservation with Special Reference to India. New Delhi: Tata McGraw-Hill.

Makhijani, Arjun. 1977. "Energy Policy for Rural India." In Economic and Political Weekly, Vol. XII, nos. 33 and 34, pp. 1451-1469.

Revelle, Roger. 1976. "Energy Use in Rural India." In Science, Vol. 192, pp. 969-975.

Sankar, T.L. 1977. "Alternative Development Strategies with a Low-Energy Profile for a Low GNP Per Capita Energy-Poor Country: The Case of India." in Leon Lindberg, ed., The Energy Syndrome. Lexington, Ma.: Lexington Books.

B.2 Surveys

C. Lotti and Associates, Meta Systems, Montreal Engineering Company and Snamprogetti. 1976. Bangladesh Energy Study. Administered by Asian Development Bank under U.N. Development Program.

Digernes, Turi Hammer. 1978. "The Energy Situation of a Town in Semi-Arid Sudan." Discussion Paper for United Nations University's Workshop on Firewood, Ife, Nigeria, August 9-12, 1978.

Donovan, Hamester and Rattien, Inc. 1977. World Trends in Energy Supply and the Role of Inexhaustible Energy Resources in Lesser Developed Countries, and the Implications for U.S. R&D. Report to the Brookhaven National Laboratory. Washington, D.C.: Donovan, Hamester and Rattien, Inc.

Food and Agriculture Organization. 1976b. Yearbook of Forest Products 1963-1974. Rome: FAO.

Includes estimates by country of annual production of fuelwood and charcoal.

Government of India. 1965. Energy Survey of India Committee Report. New Delhi: Government of India.

Government of India. 1974. Fuel Policy Committee Report. New Delhi: Government of India.

McGranahan, Gordon and Manuel Taylor. 1977. Urban Energy Use Patterns in Developing Countries: A Preliminary Study of Mexico City. New York: State University of New York, Stony Brook Institute for Energy Research.

National Council of Applied Economic Research. 1965. Domestic Fuels in Rural India. New Delhi: National Council of Applied Economic Research.

Sherman, Michael M. 1978. Household Use of Energy in Pakistan. Islamabad: USAID. May.

T.B. Taylor Associates. 1978. "Survey of Biomass Energy Programs and Use in the Developing Countries." Prepared for the Office of Technology Assessment. Washington, D.C. December 23.

Tyers, R. 1976. Energy in Rural Bangladesh. Cambridge : Harvard Center for Population Studies. Mimeograph.

Von Oppen, M. 1979. "A Note on Recent Developments in the Prices of Fuel for Domestic Use in India." Prepared for the International Seminar on Energy, Hyderabad, India, January 4-7, 1979.

C. Traditional Energy Sector Issues

C.1 The Environment

Adeyoju, S. Kolade and E. N. Enabor. 1973. A Survey of Drought Affected Areas of Northern Nigeria. Ibadan: University of Ibadan, Department of Forestry. November.

Comite Permanent Interetats de Lutte Contre la Secheresse dans le Sahel. 1977. Bibliographie du Programme Propose Pour L'Equipe Ecologie et Environnement au Sahel. Ouagadougou, Upper Volta: Comite Permanent Interetats de Lutte Contre la Secheresse dans le Sahel. Mimeograph.

Council on Environmental Quality. The Global 2000 Report to the President: Entering the Twenty-First Century. Washington, D.C.: Government Printing Office. Forthcoming.

Dale, T. and V. Carter. 1974. Topsoil and Civilization. Rev. ed. Norman University of Oklahoma Press. Originally published 1955.

Du Bois, Victor D. 1974. The Drought in West Africa. American Universities Field Staff. West African Series, Vol. XV, No. 1.

Eckholm, Erik P. 1976. Losing Ground: Environmental Stress and World Food Prospects. New York: W. W. Norton & Co.

Includes chapters and extensive references on "A History of Deforestation" and " The Other Energy Crisis: Firewood."

Food and Agriculture Organization, Forest Resources Division. 1975. Environmental Objectives in Forest Land Management. Rome: FAO. July.

Forests help provide pure air and water, more beautiful surroundings, and protection for wildlife. Unfortunately, these benefits are difficult to quantify, and we must often use "intuitive economics" to determine their value. To take adequate account of environmental aspects of forest activities, we should rely more on multidisciplinary planning teams, environmental impact analyses, and greater public involvement in the project design process.

Frimigacci, M. Bucket. 1977. "Ecologie et Environnement au Sahel." Ouagadougou, Upper Volta: Comite Permanent Interetats de Lutte Contre La Secheresse Dans le Sahel.

Glantz, Michael H. (ed.). 1977. Desertification: Environmental Degradation In and Around Desert Lands. Boulder, Colorado: Westview Press.

Haiti: A Study in Environmental Destruction. Conservation Foundation Letter. Washington, D. C., November 1977.

National Academy of Sciences. 1977b. Resource Sensing From Space: Prospects for Developing Countries. Washington, D. C.: NAS.

Describes available and projected systems for remote sensing of crop yields, erosion, alterations in land use, and other environmental changes. Outlines uses already made of satellite data for studying earth resources.

Rapp, Anders. 1974. A Review of Desertization in Africa - Water, Vegetation, and Man. SIES Report No. 1. Stockholm: Secretariat for International Ecology.

Stanford, Geoffrey. 1979. "World Hunger." Comments prepared for the Presidential Commission on World Hunger. Cedar Hill, Texas: The Greenhills Foundation. February 19.

Thompson, James Z. 1977. "Ecological Deterioration: Local-Level Rule-Making and Enforcement Problems in Niger," in Desertification:Environmental Degradation In and Around Desert Lands. Boulder, Colorado: Westview Press.

United States, Agency for International Development. 1979. Environmental and Natural Resource Management in Developing Countries. A Report to Congress. Washington, D.C.: Agency for International Development. February.

C.2 Forestry in Developing Countries

Adeyoju, S. Kolade. 1976. "Land Use and Tenure in the Tropics." In Unasylva, Vol. 28, Nos. 112-113.

As forest activities in Africa grow beyond the traditional preoccupation with timber production, new approaches to ownership and use of land will be required. Problems inevitably will arise in trying to reconcile traditional forms of land tenure with national economic objectives. The technical background of most foresters is of little help in dealing with such issues. Forestry services need better communication with local groups in order both to explain new policies and to understand existing land use patterns.

Adeyoju, S. Kolade. 1975. "Where Forest Reserves Improve Agriculture." In Unasylva, Vol. 27, No. 110.

Creation of forest reserves is often assumed to conflict with interests of local farmers and herders. By allowing for multiple uses of forest land, these difficulties can be minimized. The Nigerian forest service, for example, is experimenting with a taungya (intercropping) system; and land in savanna reserves has been set aside for grazing. Even where farmers are made to settle outside forest areas, their need to use available land more effectively may lead to improved agricultural practices.

Auchter, Richard J. 1976. AID Annual Report. PASA TA(AG)03-75. Madison, Wisconsin: U.S. Forest Products Laboratory. January.

Bene, J. G., H. W. Beall, and A. Cote. 1977. Trees, Food and People: Land Management in the Tropics. Ottawa: International Development Research Centre.

Benge, M. D. and H. Curran. 1976. BAYANI (Giant Ipil-ipil, Leucaena leucocephala): A Source of Fertilizer, Feed and Energy for the Philippines. USAID Agriculture Development Series. Manila: United States Agency for International Development.

Notes that in proper soil and climate, Bayani can grow as much as 20 meters in six years. Bayani can be used for food, alcohol, lumber and fertilizer as well as fuel.

Catinot, R. 1974. "Contribution du forestier a la lutte contre la desertification en zones seches." In Bois et Forets des Tropiques. May-June.

Chudnoff, Martin. 1973. Development of the Tropical Wood Resources. Washington, D.C.: AID Office of Science and Technology. November.

Reviews available literature on tropical flora, primary tree species, roundwood removals, and other information relevant to commercial use of forest resources in such countries as Nigeria and Gabon. Of particular concern is the absence of data which might lead to greater exploitation of secondary species.

Cliff, Edward P. 1973. Utilization of Tropical Forests: Review of the Forestry Literature in the AID Reference Center. Washington, D.C.: AID Technical Assistance Bureau. November.

Reviews 135 publications covering forestry issues in 43 countries. The dominant concern is to accelerate commercial use of trees, especially secondary species for which only limited markets now exist. Emphasis is on improved research, policies and practices on the part of central governments and major private concerns. Only nine reports deal with such issues as "extension and public education, including assistance to farm forestry and small owners." Firewood is not mentioned.

Donaldson, Graham. 1978. Forestry: Sector Policy Paper. Washington, D.C.: World Bank. February.

Douglas, J. Sholto and Robert A. de J. Hart. 1976. Forest Farming. London: Watkins.

A general introduction to forest farming, including farm design, planting and cropping, choice of trees, and promising geographical areas for expansion. "First and foremost," tree farming offers possibilities for food production: nuts, fruits, oils, livestock fodder. Production of timber and environmental considerations are also important. Firewood is not mentioned.

Draper, S. A. et al. 1976. Forestry Sub-Sector Report. Washington, D. C.: World Bank.

Draper, S. A. 1977. Wood Processing and Utilization at Village Level. Third FAO/SIDA Expert Consultation on Forestry for Local Community Development.

Eckholm, Erik P. 1979. Planting for the Future: Forestry for Human Needs. Worldwatch Paper 26. Washington, D.C.: Worldwatch Institute.

Felker, Peter. 1978. State of the Art: Acacia albida as a Complementary Permanent Intercrop with Annual Crops. Prepared under contract for USAID. Riverside, California: Department of Soil and Environmental Sciences, University of California, Riverside. April.

Fox, Gordon D. 1972. Forestry in Developing Countries: Potentials, Constraints and Opportunities (Preliminary Survey). Washington, D. C. AID Technical Assistance Bureau.

Concentrates on commercial uses of timber. Major sections cover problems and solutions with respect to institutional and legal issues, transportation, information and research, and forest industries.

Fox, Gordon D. 1973. Technological Opportunities for Tropical Forestry Development. Washington, D.C.: AID Office of Science and Technology.

To promote industrial exploitation of wood products, reviews the potential of such technologies as aerial spraying, computerized sawing of logs, kraft pulping, radio communications, and portable lasers for cadastral surveys.

Freas, Alan D. et al. 1973. Factors Influencing the Utilization of Tropical Wood Species. Washington, D.C.: AID Office of Science and Technology. November.

Considers factors inhibiting use of secondary tree species for industrial purposes.

Mackie, Cynthia (ed.). 1978. NRDC Tropical Moist Forests Conservation Bulletin (Number 1). Washington, D.C.: Natural Resources Defense Council. May.

Describes major institutions and programs working on protection and use of tropical moist forests. Includes both public and private groups, in the U.S. and abroad.

McComb, A. L. and J. K. Jackson. 1969. "The Role of Tree Plantations in Savanna Development." In Unasylva, Vol. 23(3), No. 94.

Concentrates on technical and economic aspects of tree plantations in Nigeria. Since trees grown in this way could be used for industrial purposes, most fuelwood would continue to be supplied from existing savanna woodlands.

National Academy of Sciences. 1977a. Leucaena: Promising Forage and Tree Crop for the Tropics. Washington, D.C.: NAS.

Leucaena grows well in semi-arid and savanna regions, as well as in more humid lowlands. It coppices readily and can be harvested for firewood in cycles as short as 3-10 years. In addition, leucaena can be used for timber, fertilizer, and forage.

National Academy of Sciences. 1979. Tropical Legumes: Resources for the Future. Washington, D.C.: NAS.

Persson, R. 1974. Forest Resources of Africa. Stockholm: Royal College of Forestry.

Persson, R. 1974. World Forest Resources. Stockholm: Royal College of Forestry.

Sartorius, Peter and Hans Henle. 1968. Forestry and Economic Development. New York: Praeger.

Sivaraman, B. 1977. "Forestry for Community Development (Village Forestry)." Paper prepared for the Second FAO/SIDA Expert Consultation on Forestry for Community Development, Rome, June 21-22, 1977.

Sommer, A. 1976. "Attempt at an Assessment of the World's Tropical Forests." In Unasylva, Vol. 28, Nos. 112-113, pp. 5-25.

Spears, John S. 1978. "The Changing Emphasis in World Bank Forestry Lending. A Summary of Recent Experiences and Problem Areas of Relevance to the Eighth World Forestry Congress Sessions Concerned with "Forestry for Rural Communities." Presented at the Eighth World Forestry Congress, Jakarta, Indonesia. October.

United Nations, Education, Scientific and Cultural Organization. 1978. Tropical Forest Ecosystems: A State of Knowledge Report. Natural Resources Research XIV. Paris: UNESCO/UNEP/FAO.

United Nations, Food and Agriculture Organization. 1978. Forestry for Local Community Development. Forestry Paper No. 7. Rome: FAO.

United Nations, Food and Agriculture Organization. "Wood: World Trends and Prospects." In Unasylva, Vol. 20.

Vietmeyer, Noel. 1978. "Tree Legumes: Shock Troops for the War on Deforestation." September 8.

Westoby, J. C. 1963. "The Role of Forest Industries in the Attack on Economic Underdevelopment." In Unasylva, Vol. 16, pp. 168-201.

C.3 Forests and Wood Fuels (General)

Arnold, J.E.M. 1978. "Wood Energy and Rural Communities." Paper presented at the Eighth World Forestry Congress. Jakarta, Indonesia, October 16-28, 1978.

Arnold, J.E.M. 1976. "Wood for Energy." Rome: FAO. Mimeographed.

Arnold, J. and J. Jongma. 1977. Wood as a Source of Energy in Developing Countries (preprint). Rome: FAO.

Bethel, J.S. 1977. Wood for Fuel in a Tropical Forest Utilization System. Research Reports Contribution No. 29. Seattle: University of Washington, Institute of Forest Products. October.

Earl, Derek E. 1975b. "A Renewable Source of Fuel." In Unasylva, Vol. 27, No. 110.

An average hectare of tropical forest can be converted to 85 tons of fuelwood or 10-20 tons of charcoal. Systematic management of only 10 percent of their tropical forestry could produce enough fuel for African countries to sustain 5 percent annual growth in total energy consumption for more than 20 years. In addition, forest programs provide income and a sense of self-reliance in needy rural areas. A major barrier to such programs has been the attitude that use of fuelwood is "primitive" and to be discouraged, but this attitude is changing as other energy sources become scarce.

Earl, Derek E. 1975a. Forest Energy and Economic Development. Oxford: Clarendon Press.

Growing populations in developing countries will use greater amounts of fuelwood for cooking and heating. With urbanization, more of this wood will first be converted to charcoal, further increasing the pressure on forests. In addition, charcoal or methyl alcohol from wood will find a wider range of industrial applications as fossil fuels grow scarce. Fortunately, "the forests of the world are physically capable of sustaining supplies of fuel well above the basic energy needs of man," although expansion and sound use of these supplies will require governments to develop active forest energy polices. Notes the difficulty

of using official statistics for policy-making, since these systematically understate forest use and do not reflect the wide variations in fuelwood consumption that often prevail in different regions or villages. In evaluating use of fuelwood vs. fossil fuels, the introduction of social ("shadow") prices for labor and foreign exchange will tend to increase the relative attractiveness of fuelwood projects.

Eckholm, Erik P. 1978. "Firewood: The Poor Man's Burden." In International Wildlife. May-June.

Notes the success of rural forestry schemes in China and South Korea. In both countries, strong local institutions have allowed extensive popular participation in project planning and implementation.

Eckholm, Erik P. 1975. The Other Energy Crisis: Firewood. Worldwatch Paper 1. Washington, D.C.: Worldwatch Institute. September.

Firewood supplies are being rapidly depleted in much of the Third World. This is a direct threat to the poor, since nine-tenths of the people in most of these countries depend on firewood for fuel. In addition, the accelerating degradation of woodlands leads to soil erosion, flooding, desertification, and declining soil fertility. These problems are futher accentuated as people turn from wood to dung for fuel, robbing farmlands of the nutrients that dung has traditionally supplied. Massive tree-planting projects are called for, along with research into alternative energy sources such as solar cookers or biogas plants.

Food and Agriculture Organization. 1976a. Wood for Energy. Rome: FAO.

Openshaw, Keith. 1976. Woodfuel--A Time for Reassessment. (Stencil No. 300.) Morogoro, Tanzania: University of Dar-es-Salaam. September.

Higher petroleum prices may contribute to increased use of fuelwood and charcoal. For household uses alone, demand for wood in developing countries may grow by 1.5-2.0 percent annually. In order for governments to plan the fuelwood plantations and village woodlots required to meet rising demand, wood consumption and resource surveys are needed. With respect to charcoal production, Openshaw notes that both overall costs and wood requirements per ton can be reduced by as much as 50 percent by using manufactured kilns in place of traditional conversion methods

Openshaw, Keith. 1977. "Woodfuel - A Time for Reassessment." In East African Journal. January.

Openshaw, Keith. 1978. "Woodfuel - A Time for Reassessment." In Natural Resources Forum.

Openshaw, Keith. 1974. "Wood Fuels the Developing World." In New Scientist. January 31.

Sanger, Clyde. 1977. Trees for People: An Account of the Forestry Research Programs Supported by the International Development Research Centre. Ottawa: International Development Research Center.

Discusses a series of IDRC fuelwood projects, including establishment of village woodlots in Niger, species and yield trials for irrigated forest plantations in Mali, and afforestation of marginal lands in Kenya. The IDRC is also supporting a three-member forestry team, based in Nairobi, to serve a number of African countries. Among other tasks, this team will supervise preparation of state-of-the-art papers covering forestry research in Africa.

Spears, John S. 1978. "Wood as an Energy Source: The Situation in the Developing World." Presented at the 103rd Annual Meeting of the American Forestry Association. Washington, D.C.: World Bank. October.

United Nations. Economic Commission on Asia and the Pacific. 1976. "Wood as a Source of Energy." Second Africa Meeting on Energy. March 1, 1976.

C.4 Forests and Wood Fuels (Regional Studies)

a. Sahel

Canadian International Development Agency. 1974. "Study Mission on Forest Energy in the Sahel and West Africa." October 2 - December 17, 1974.

Club du Sahel. 1977. Summary Record of Club du Sahel/CILSS Meeting on Ecology and Reforestation Paris, 12-13 October, 1977. November.

As of October 1977, the proposed CILSS reforestation program included 77 national and seven regional projects, calling for $146 million in external assistance for such activities as dune stabilization, village plantation, land use planning, tree nurseries, research and training. In line with the program's overall objectives, a number of these projects made specific provision for fuelwood production. Specific commitments and potential activities of various donors are reviewed.

Comite Permanent Interetats de Lutte Contre la Secheresse dans le Sahel. 1976. CILSS/UNSO/FAO Consultation on the Role of Forestry in a Rehabilitation Programme for the Sahel. Final Report. Ouagadougou: Comite Permanent Interetats de Lutte Contre la Secheresse dans le Sahel.

Comite Permanent Interetats de Lutte Contre la Secheresse dans le Sahel. Equipe Ecologie et Environnement. 1977. Note de Synthese sur la Strategie Forestiere au Sahel. April.

Comite Permanent Interetats de Lutte Contre la Secheresse dans le Sahel. Equipe Ecologie-Forets. 1979. Bilan Analytique des Resultats des Efforts de Recherche de Financement Entrepris dans le Cadre du Programme de Premiere Generation et Consequences a en Tirer pour le Nouveau Programme. Prepared for the meeting of the Ecology-Forestry Working Team, Niamey, June 25-29, 1979.

Delwaulle, J.C. 1973. "Desertification de l'Afrique au Sud du Sahara." In Bois et Forets des Tropiques. May-June.

Delwaulle, J.C. 1976. Le Role de la Forestiere dans la Lutte Contre la Desertification. CILSS Consultation, Ouagadougou. April.

Keita, J.D. 1979. Elements de Strategie Pour la Satisfaction des Besoins en Combustibles Ligneux du Sahel d'Ici l'An 2000. Comite Permanent Interetats de Lutte Contre la Secheresse dans le Sahel. May.

Ki-Zerbo, Jacqueline and Guido de Lepeleire. 1979. L'Amelioration des Foyers Pour L'Utilisation Domestique du Bois de Feu: Ses Possibilites et Son Impact au Sahel. Prepared at the request of the Comite Permanent Interetats de Lutte Contre la Secheresse dans le Sahel. May.

Ulinski, Carol. 1978. U.S. Forestry and Ecology Program in the Sahel. Prepared under contract for USAID. Washington, D.C. October 31.

United Nations. Environment Program. 1976. Consultancy on Firewood and Substitutes in the Sahelian Zone and North Africa. Report. Nairobi: UNEP.

Weber, Fred R. 1977b. Economic and Ecologic Criteria: Proposed Club des Amis du Sahel Forestry/Anti-Desertification Program. Report for AID/AFR/SFWA. May.

Background material for considering forestry programs in the Sahel, including areas of greatest fuelwood need, local prices for wood and charcoal, costs of forest plantations, specific problems of various climate zones, and

criteria for project evaluation. Notes that tree projects normally cost $565-725 per hectare for planting and maintenance through the first year. When care in later years is included, along with cutting and stacking of wood, the total cost of firewood from these projects is about $10 per ton versus average current prices "at source" of about $6 per ton. While such plantations are of high priority in southern areas of the Sahel, northern zones have greater need for projects to protect existing vegetative cover. Unfortunately for all these efforts, no Sahelian country yet has an effective forest management program. In defining and mobilizing support for forestry programs, a first need is for good communication among managers, technicians, and bureaucrats (Sahelian and foreign), as well as local farmers and herders.

Weber, Fred R. 1977a. Reforestation in Arid Lands. Mt. Ranier, Maryland (VITA) and Washington, D.C. (ACTION/Peace Corps).

Practical guidance for carrying out local reforestation projects, with emphasis on conditions in West Africa. Covers general issues in project planning, as well as specifics of selecting tree species (in line with environmental constraints, purposes of the project, and human factors); choosing among planting techniques (direct seedings, cuttings, nurseries); managing nurseries; preparing and using the planting site. Appendixes provide information on tree species, climate, and soils in West Africa.

Weber, Fred R. 1976. The Role of Forests in Sahelian Rehabilitation Efforts. Report on CILSS/UNSO/FAO conference, Dakar, 26 April - 1 May, 1976 .

Summarizes technical papers by outside experts and country reports by forestry officials from Cape Verde, Gambia, Mali, Niger, Upper Volta, Senegal, Chad, and Mauritania. Concludes that urgent forestry needs in the Sahel require action particularly in the areas of administration (forest services should be strengthened and given a greater voice in development planning), education (for forest service personnel as well as farmers and herders), and research.

Weber, Fred R. 1977c. Sahel Peace Corps Director Workshop Report. Report to Peace Corps. December 28.

Only 31 of 500 Peace Corps Volunteers in the Sahel are working on forestry activities, although CILSS and the Club du Sahel have declared this a priority area. Given proper administrative arrangements and adequate funding, large numbers of additional PCVs could usefully be put to work on such projects as vegetation surveys, forest reserve management plans, village woodlots, regional nurseries, and training of local technicians.

b. Other Regions

French, David. 1978. "Firewood in Africa." Discussion Paper for the Africa Bureau Firewood Workshop, June 12-14, 1978. Washington, D.C.: AID.

French, David. 1978. "Energy for Africa's Future." In Africa Report, May-June.

Notes that in many African countries, more than four-fifths of all energy comes from noncommercial sources, especially firewood and charcoal. The pool of such material is becoming smaller, however, as deforestation proceeds at a rate that could leave Senegal bare of trees in 30 years, Ethiopia in 20, and Burundi in seven. Even considering other possibilities (oil, solar, etc.), reforestation will long remain the primary means for making energy available to Africa's scattered and largely rural population.

Laurie, M.V. 1974. Tree Planting Practices in African Savannas. FAO Forestry Development Paper No. 19. Rome: FAO.

Practical guidance for afforestation of savanna areas.

Openshaw, Keith. 1971. La Foret Amazonienne--Source d'Energie. Paris: Centre Technique Forestiere Tropical.

United Nations, Food and Agriculture Organization. 1976. Development and Forest Resources in Asia and the Far East: Trends and Perspectives, 1961-91. Rome: FAO.

United Nations, Food and Agriculture Organization. Forestry and Forest Products Division. 1967. Timber Trends and Prospects in Africa. Rome: FAO.

Includes a review of past fuelwood consumption, although major emphasis is on industrial uses of wood.

C.5 Forests and Wood Fuels (Country Studies)

Argal, P. 1978. "Role of Wood Energy in the Rural Economy of India." Paper FRC/3-8. Presented at the Eighth World Forestry Congress, Jakarta, Indonesia, October 1978.

Arnold, J. 1967. Malawi--Investigating Wood Requirements: Repo to the Government. Rome: FAO.

Concentrates on forest industries, although estimates are included of future fuelwood requirements.

Battelle Memorial Institute. 1969. Liberian Forest Policy. Washington, D.C.: AID.

Calls for rapid exploitation of forests, with secondary species left to protect the land after more valuable trees are removed.

Bong Won Ahn. 1978. "Village Forestry in Korea." Paper FRC/1-5. Presented at the Eighth World Forestry Congress, Jakarta, Indonesia, October 1978.

Brokenshaw, David and Bernard Riley. 1978. Forest, Foraging, Fences and Fuel in a Marginal Area of Kenya. USAID Africa, Bureau Firewood Workshop. Washington, D.C., June 12-14, 1978.

Centre Technique Forestier Tropical. 1975. Possibilities de Production de Certaines Forets du Tchad en Bois de Feu, Charbon de Bois et Autres Produits. Report for FAO and UNDP.

Clark, W.F. 1970. "Timber Supply and Demand for 1970-1990." Nepal Project Report. No. 1. Rome: FAO.

Development and Resources Corporation. 1965. The Development of Southeast Liberia: A Report to the U.S. Agency for International Development. New York: Development and Resources Corporation. December.

With respect to forest resources, recommends "aggressive and thorough exploitation by private operators" in order to increase timber production.

Development and Resources Corporation. 1967. Forest Resources of the Southwest Region, Ivory Coast. Washington, D.C.: AID.

Recommends technical and market research to expand export and commercial use of trees.

Digernes, Turi Hammer. 1977. Wood for Fuel--Energy Crisis Implying Desertification: The Case of Bara, the Sudan. Bergen: Universitetet i Bergen, Geografisk Institutt.

In fragile ecological areas, population pressures and poor land management can combine with shortages of rainfall to produce rapid desertification. Patterns of fuel use during this process pass through four stages: (I: People gather their own wood from local fields and forests. II: As the immediate area becomes desertified, wood and charcoal are supplied commercially from surrounding land. III: As the desertified area extends outward, wood and charcoal come from land around smaller villages nearby; kerosene and other imported fuels are used. IV: Desertification spreads to nearby villages, leading to increasing dependence on imported fuels.) In Bara, which is now in Stage III of this process, annual per capita expenditures for fuel include £6.25 for charcoal, £ 3.24 for wood and £ 6.60 for kerosene (used for lighting and cooking). Daily per capita consumption amounts to 1.98 kg of wood and 1.11 kg of charcoal. To avoid the worst consequences of Stage IV desertification, attention should be given to more efficient collection, processing, and use of wood and charcoal; creation of forest reserves; and introduction of windmills or solar energy devices. Since breakfast in Bara is eaten at 10:00 a.m. and dinner around 4:00 p.m. solar cookers might be feasible.

Ernst, Elizabeth. 1977. Fuel Consumption Among Rural Families in Upper Volta, West Africa. Ouagadougou: Peace Corps. July 5.

Results of a survey in two villages in Upper Volta. Millet stalks serve as the principal fuel for six months following the harvest. Wood is gathered for fuel during the remainder of the year, a process to which village women devote more than four hours each day. In the area surveyed, the morning meal is prepared before sunrise and the evening meal after sunset.

Fleuret, Patrick and Anne Fleuret. 1978. "Fuelwood Use in a Peasant Community." In Journal of Developing Areas, Vol. 12, No. 3, April.

Results of a survey in one village in the Usambara Mountains of Tanzania. An average family of five uses 22.4 kg of wood each day for cooking and heating. This requires most village women to spend 6-12 hours per week making trips to the nearest forest reserve, in addition to time spent collecting twigs and branches nearby. During part of the year, charcoal may also be used for warmth during the night. Total wood consumption by the 200 people of the village is equivalent to 1,360 acacia trees each year. Most cooking is done before 8:00 a.m. or after 5:00 p.m.

Gambia Land Resources Development Project. 1973. The Gambia: A Wood Consumption Survey and Timber Trend Study, 1973-2000. Report to the Overseas Development Administration, United Kingdom. London: Gambia Land Resources Development Project.

Horvath, Ronald J. 1968. "Addis Ababa's Eucalyptus Forest." In Journal of Ethiopian Studies. January.

James, Corland L. 1964. Forestry Projects in Liberia. End of Tour Report, Project 669-11-170-002. Monrovia: USAID/Liberia. December 31.

Describes the status of an AID project in continuous existence since 1951. Specific activites include an inventory of forest resources, demarcation of protected national forests, strengthening of Liberia's Bureau of Forest and Wildlife Conservation, and promotion of forest products industries. Exclusive interest is in the timber potential of forest areas.

Kio, P.R. 1972. "Shifting Cultivation and Multiple Use of Forest Land in Nigeria." In Commonwealth Forestry Review. June.

Koeppen, Robert C. and S. Blair Hutchinson. 1973. The Problem of Unbalanced Species Utilization in the Forests of Ghana and Nigeria as it Relates to the Need for Assistance in Determining the Properties of Lesser-Used and Unused Species. Madison, Wisconsin: Forest Products Laboratory. November.

Lanly, J.P. 1969. "Regression de la Foret Dense en Cote d'Ivoire." In Bois et Forets des Tropiques. September-October.

"Le Deboisement en Haute-Volte: Les Besoins en Bois de Chauffe de Ouagadougou." In Le Developpement Voltaique, No. 40. Ouagadougou, Upper Volta: Societe Africaine d'Etude et de Developpement. August.

Lerche, C. and A.S. Khan. 1970. An Estimate of Timber Trends in West Pakistan. Rome: FAO.

Martin, Luann Habegger. "The Ecology and Economics of Cooking Fuels in Ghana." Submitted to the Faculty of the School of International Service of The American University. Washington, D.C.

Moeller, Roger D. Renewable Resource System for Use of the Haitian Forests. A Working Paper. Prepared for AID Office of Science and Technology. Washington, D.C.

Openshaw, Keith. 1971. Present Consumption and Future Requirements of Wood in Tanzania. Technical Report No. 3, Document FO SF/Tan 15. Rome: FAO.

Pearson, Scott R. 1974. Concession, Royalty and Tax Policies for Ghanaian Timber. Stanford, California: Food Research Institute. April.

Prepared for USAID/Ghana, this report investigates policies through which the Ghanaian Government could capture the "economic rent" associated with exploitation of timber resources by private companies.

Rocha, A.A. 1978. "Carvoes Brasilieros: Reservas e Utilizacao." Paper presented at a symposium on Energy and Development in the Americas, Sao Paolo, Brazil, March 12-17, 1978.

Roche, Laurence. 1974. Major Trends and Issues in Forestry Education in Africa: A View from Ibadan. Bulletin 4, Department of Forest Resources Management. Ibadan: University of Ibadan.

Shah, S.A. 1978. "People's Participation in Forestry for Community Development in India." Paper FRC/1-14. Presented at the Eighth World Forestry Congress, Jakarta, Indonesia, October 1978.

Skold, P. 1970. Present and Future Wood Demand and Supply - Kenya. Rome: FAO.

A general survey, including estimates of domestic fuelwood consumption.

United Nations, Food and Agriculture Organization. 1971. Forest Industries Development Planning, Tanzania: Present Consumption and Future Requirements of Wood in Tanzania. Based on the work of K. Openshaw. Technical Report 3, Document FO SF/TAN 15. Rome: FAO.

United Nations, Food and Agriculture Organization. 1972. Nigeria: The Market for Firewood, Poles and Sawnwood in the Major Towns and Cities in the Savanna Region. Technical Report No. 6, Document SF/NIR 16. Rome: FAO.

United Nations, Food and Agriculture Organization. 1970. Savanna Forestry Research Station, Nigeria: Wood Requirements in the Savanna Region of Nigeria. Based on the work of S. Thulin. Technical Report 1, Document FOR:SF/NIR 16. Rome: FAO.

In Nigeria's savanna region, annual firewood consumption per capita is about 22 cubic feet, accountinf for more than 90 percent of all wood consumed. Cornstalks and dung are also used for fuel. Total consumption of firewood in this area should increase from 785 million cubic feet in 1965 to between 865 and 1230 million cubic feet in 2000, or about 85 percent of all wood used.

United Nations, Food and Agriculture Organization. 1964. Sudan: Present Wood Consumption and Future Requirements. Document T.A. No. 1820. Rome: FAO.

United Nations, Food and Agriculture Organization. 1964. Tanzania: Present Consumption and Future Requirements of Wood in Tanzania. Technical Report No. 3, Document SF/TAN 15 and project working document. Rome: FAO.

United Nations, Food and Agriculture Organization. 1972. Thailand: Present and Future Forest Policy Goals, A Timber Trend Study 1970-2000. Document T.A. 3156 and project working document. Rome: FAO.

United States, Agency for International Development. 1979. Gambia Forestry. Project Paper No. 635-0205. Washington, D.C.: AID.

United States, Agency for International Development. 1979. Niger Forestry and Land-Use Planning. Project Paper No. 683-0230. Washington, D.C.: AID.

United States, Agency for International Development. 1979. Senegal Fuelwood Production. Project Paper No. 685-0219. Washington, D.C.: AID.

United States, Agency for International Development. 1979. Upper Volta Forestry Education and Development. Project Paper No. 686-0235. Washington, D.C.: AID.

Weber, Fred and Maryanne Dulansey. 1978. Chad Reforestation Project. Midpoint Evaluation. Prepared for CARE, Inc. Washington, D.C.: Consultants in Development. April.

Wellwood, R.W. 1966. Report to the Government of Nigeria on Forest Industries. Rome: FAO.

Concludes that use of secondary species is essential if timber is to contribute adequately to Nigeria's development.

D. Energy Solutions: Improved Traditional Fuels

D.1 Improved Traditional Conversion Devices

Delwaulle, J.C. and Roederer. 1973. "Le Bois de Feu a Niamey." In Bois et Forets des Tropiques, No. 152. November-December.

Dutt, G.S. "Improved Wood-Burning Cooking Stoves for LDCs." Princeton, New Jersey: Princeton University, Center for Environmental Studies. Undated.

Dutt, G.S. 1978. "Reduced Cooking Energy Use in Rural India." Princeton, New Jersey: Princeton University, Center for Environmental Studies. Report PU/CES 74. November.

Evans, Ianto. 1979. Lorena Owner-Built Stoves. Stanford, California: Volunteers in Asia, Inc.

Garberson, Whitney. 1979. "Preliminary Testing of Wood Consumption in Four 'Smokeless Cooker' Models and the Traditional Three-Stone Fire." Ouagadougou, Upper Volta: Peace Corps. January 26.

Gupta, J.N. Sen. "Fuelwood Plantations in India." An information paper prepared for the Asia-Pacific Forestry Commission. Rome: FAO.

Josephs, Stephen . A Design Guide to Wood-Conserving Stoves. Mt. Ranier: Volunteers in Technical Assistance and the Intermediate Technology Development Group. Forthcoming.

Openshaw, Keith. "A Comparison of Metal and Clay Charcoal Cooking Stoves." Morogoro: University of Dar es Salaam.

Raju, S.P. 1966. "Smokeless Kitchens for the Millions." Park Town, Madras: The Christian Literature Society.

Walton, J.D., Jr., A.H. Roy, and S.H. Bomar, Jr. 1978. A State-of-the-Art Survey of Solar-Powered Irrigation Pumps, Solar Cookers, and Wood-Burning Stoves for Use in Sub-Sahara Africa. Atlanta: Georgia Institute of Technology, Engineering Experiment Station. January.

With respect to wood stoves, provides references to about ten miscellaneous publications. Of these, only a report by the Brace Research Institute includes a prototype for use in developing countries, and this has not yet been field-tested. Concludes with a proposal by the authors for experimentation with a stove of their own design, to be constructed from a five-gallon paint can for less than $5.

D.2 Charcoal (General)

Benge, Michael D. 1978. Renewable Energy and Charcoal Production. Washington, D.C.: Agency for International Development. October.

Earl, Derek E. 1974. A Report on Charcoal. Rome: FAO.

A viable charcoal industry is seen as a means of increasing the profitability of forestry. Emphasis is on industrial uses of charcoal. Experiments with a Mark V portable steel kiln in Uganda are reviewed, and suggestions are made for further research.

Earl, D.E. 1973. Charcoal and Forest Management. Department of Forestry: University of Oxford, Limited Circulation.

Little, E.C.S. 1972. "A Kiln for Charcoal-Making in the Field." In Tropical Science, Vol XIV, No. 3.

Describes a portable metal kiln able to convert scrub to charcoal in a 24-hour cycle. Field tests of the kiln were carried out in Kenya as part of an FAO/UNDP project.

Mihalyi, L.J. 1972. "Charcoal from the Zambian Forests." In The Geographical Magazine, Vol. XLV, No. 3. December.

Tatom, John W. 1976. Clean Fuels from Agricultural and Forestry Wastes. Atlanta: Georgia Institute of Technology, Engineering Experiment Station. October.

United Nations, International Labor Organization. 1975. Charcoal-Making for Small-Scale Enterprises: An Illustrated Training Manual. Geneva: ILO.

United States, Department of Agriculture, U.S. Forest Service. 1961. Charcoal, Production, Marketing and Use. Forest Products Laboratory Report, No. 2213. July.

D.3 Charcoal (Country Studies)

Chiang, Tze, I., et al. 1976. Pyrolytic Conversion of Agricultural and Forestry Wastes in Ghana: A Feasibility Study. Report for AID Office of Science and Technology. Atlanta: Georgia Institute of Technology. July.

Proposes testing in of a system able to convert up to six tons of sawdust per day into charcoal and pyrolytic oils. Estimates that such a system would be profitable if operated 2-3 shifts each day.

Earl, Derek F. 1972. Ivory Coast: The Place of Charcoal in the Economy. Geneva: ILO.

Earl, Derek E. 1971. Madagascar: The Potential for Charcoal. Document FO:SF/MAG 8. Rome: FAO.

Earl, Derek E. 1973. Nepal--The Charcoal Industry and Its Potential Contributions to the Economy of Nepal. Technical Report NEP/69/513 . Rome: FAO.

Georgia Institute of Technology with the Development Technology Center of Bandung Institute of Technology and the University of Padjadaran. 1977. Pyrolitic Conversion of Agricultural and Forestry Wastes to Alternate Energy Sources in Indonesia--A Feasibility Study. Report to USAID. (Project A-1914, AID/ASIA-C-1203). February.

Kabagambe, Dennis M. 1976. "Aspects of Resource Conservation and Utilization: The Role of Charcoal Industry in the Kenya Economy." Working Paper No. 271. Kenya: Institute for Development Studies, University of Nairobi. June. Mimeograph.

Kokwaro, J.O. 1974. "Workshop on Advantages and Disadvantages of Charcoal Burning in Kenya." Paper presented at the Workshop on Environment and Rural Development in Africa, Kenya, November 11-30, 1974.

Powell, John W. 1978. "Wood Waste as an Energy Source in Ghana." In Norman L. Brown ed., Renewable Energy Resources and Rural Applications in the Developing World (AAAS Selected Symposium 6). Boulder, Colorado: Westview Press.

The potential power output of Ghana's wood wastes is greater than current national power consumption. Full use of wastes produced in forests by logging and land clearing will be economically feasible only when the cost of firewood rises substantially. Of greater value now may be the estimated 25,500 tons of sawdust produced annually by Ghana's sawmills, more than half of which are concentrated in the Kumasi area. A pyrolytic converter to make charcoal from sawdust is being tested in Kumasi by the Georgia Institute of Technology. Ghana's Department of Forestry has also tested a number of kilns for converting wood to charcoal. Although the best of these (the Tranchant kiln) is 2-3 times as efficient as traditional methods, its relative complexity and high cost have kept it from being widely adopted.

Tatom, John W. 1977. Demonstration of Alternative Fuel Production Through Pyrolysis of Agricultural Wastes at the UNEP Rural Energy Center in Senegal. November.

Describes technologies for pyrolytic conversions of agricultural wastes (rice, straw, peanut hulls, bagasse, cotton gin trash, etc.) to charcoal, oil and gas. Assuming that suitable stoves are available to use the pyrolytic

oil, these systems can increase by about 2.5 times the amount of useful energy from a given amount of biomass. Proposes a converter to process one ton of peanut hulls per day as part of UNEP rural energy center in Senegal.

Uhart, Edmond. 1976a. Charcoal Industry in the Sudan. Addis Ababa: U.N. Economic Commission for Africa. January.

An earlier survey estimated per capita fuelwood consumption in the Sudan to be 1.6 m^3 in 1960. This seems too high, and a new survey should be carried out. To help meet charcoal needs in major towns, 60,000 ha should be planted with fast-growing tree species on irrigated land in Gezira and Blue Nile Provinces, at a total cost of about $6 million. Several types of fixed masonry kilns could be built nearby: Katugo (about $1,000 each); Missouri ($2,000); or Beehive ($1,000-2,000). Between 50,000 and 60,000 tons of charcoal could be produced annually through such a project.

Uhart, Edmond. 1975. Charcoal in the Sahelian Zone. Addis Ababa: U.N. Economic Commission for Africa. July.

Estimates that half of the Sahel's urban population uses charcoal, at a per capita rate of 15 kg per month. In Upper Volta, a family of five now spends about $156 annually for charcoal. To maintain an adequate charcoal supply, eucalyptus plantations should be planted within 50-80 km of urban centers; existing kilns should be encouraged; and new charcoal production should be considered in heavily forested areas up to 200 km from major markets. For the Sahel (Chad, Upper Volta, Mali, Mauritania, Niger and Senegal), the cost of an adequate firewood plantation program alone would be about $27 million annually, or enough to plant 390,000 hectares over a 10-year period.

Uhart, Edmond. 1976. Charcoal Problem in Somalia. Addis Ababa: United Nations, Economic Commission for Africa.

Uhart, Edmond. 1976. Le Charbon de Bois a Madagascar. Addis Ababa: United Nations, Economic Commission for Africa

E. Energy Solutions: Modern Renewable Alternatives to Traditional Fuels

E.1 Renewable Energy (General)

Brace Research Institute. 1976. A Study of the Feasibility of Establishing a Rural Energy Centre for Demonstration Purposes in Senegal. Report to the U.N. Environmental Program. Quebec: McGill University.

Canadian Hunger Foundation and Brace Research Institute. 1976. A Handbook on Appropriate Technology. Ottawa: Canadian Hunger Foundation. April.

Includes instructions for making a smokeless wood stove, based on a design from Ghana's Department of Social Welfare and Community Development. Summary sections of the Handbook give considerable attention to methods of transferring such technologies. A key role is that of "appropriate technology catalysts," who are cautioned to gain a thorough knowledge of the communities in which they work and to involve community members throughout the process of articulating needs, exploring solutions, and introducing new techniques.

Darrow, Ken and Rick Pam. 1976. Appropriate Technology Sourcebook (second edition). Stanford, California: Volunteers in Asia. November.

Includes a brief chapter on wood, sawdust and rice hull stoves. The book's introduction emphasizes that effective use of such devices is a function less of gadgetry than of the process through which new technologies are found and applied. This process must be community-based and participatory, leaving room for outsiders primarily as catalysts and as sources of limited, short-term technical support.

French, David. 1977. Appropriate Technology in Social Context: An Annotated Bibliography. Mt. Ranier, Maryland: Volunteers in Technical Assistance.

An introductory section notes that people for decades have been trying to transfer appropriate technologies in rural areas, as often as not unsuccessfully. Least successful have been attempts to introduce technology "softwares," or new ways of doing things. In general, failure has resulted from inattention to social context. To do better, aid donors or "changing agents" will need to collaborate closely over time with people at the local level. Ultimately, success will depend on the existence of village institutions able to make technology choices and carry out technology activities.

French, David. 1977. Economic and Social Analysis of Renewable Energy Projects: The State of the Art. Report to USAID. November 22. Annotated bibliography.

French, David. 1979. "The Economics of Renewable Energy Systems for Developing Countries." Washington, D.C. January.

Howe, James, James Bever and James Tarrant. 1978. "Prospects for the Use of Small-Scale Renewable Energy Technologies for the Developing World." A Background Paper for the Energy, Water, and Telecommunications Department of the World Bank, in Preparation for the World Development Report II.

Lawand, T.A. 1978. "The Potential of Renwable Energies in Planning the Development of Rural Areas." Report to the International Solar Energy Society." Quebec: Brace Research Institute.

Meta Systems, et al. 1979. Thailand Renewable Non-conventional Energy Project, Annexes to Project Paper. Project No. 493-0304. Bangkok: USAID. May. Draft.

National Academy of Sciences and Tanzanian National Scientific Reserach Council. 1978. Workshop on Solar Energy for the Villages of Tanzania, Dar es Salaam, August 11-19, 1977. Washington, D.C.: NAS.

Pak, Simon J., and Charles R.H. Taylor. 1976. "Critical Factors in Economic Evaluation of Small Decentralized Energy Projects." In Science and Technology Report, No. 25. Washington, D.C.: World Bank. November.

Reddy, A.K.N. and Krishna Prasad. 1977. "Technological Alternatives and the Indian Energy Crises." In Economic and Political Weekly, Tribandrum, India, August, pp. 14[illegible]-1502.

Smil, Vaclav. 1977. "Intermediate Energy Technology in China." In Bulletin of Atomic Scientists, Vol. 33, No. 2, pp. 25-31.

Steedman, Charles. 1979. "Working Papers for a Renewable Energy Project in Senegal." University of Michigan, Center for Research on Economic Development. March. Mimeograph.

E.2 Bioconversion

Acioli, Jose de Lima. 1978. "Alcool Como Combustivel--Desenvovimentos Recentes." Paper presented at the Symposium on Energy and Development in the Americas, Sao Paolo, Brazil, March 12-17, 1978.

Hammond, Allen. 1978. "Biomass Conversion--A Rediscovered Source of Fuels." Paper presented at the Symposium on Energy and Development in the Americas, Sao Paolo, Brazil, March 12-17, 1978.

Moisan, Francois and Daniel Thery. 1977. "Towards a New Industrial Vegetal Civilization--Principal Solar Programs in Brazil and Australia." In Ecodevelopment News, No. 3, October, pp. 29-34.

Poole, Alan. 1977. Energy from Biomass: A Conceptual Overview. Study prepared for ERDA/APAE. Washington, D.C.: Institute for Energy Analysis/Oak Ridge Associated Universities. September 30.

Includes a major section on "Bioenergy in Underdeveloped Countries." Such countries have great need for bioenergy (most notably for firewood) along with great potential for supplying this (due to high yields of biomass systems in tropical and subtropical regions). Biomass is also attractive for LDC's since its production is relatively labor-intensive.

E.3 Biogas

Barnett, Andrew, Leo Pyle and S.K. Subramanian. 1978. Biogas Technology in the Third World: A Multidisciplinary Review. Ottawa: International Development Research Centre.

Appropriate Technology Development Organization. 1978. Gobar Gas: An Alternate Way of Handling the Village Fuel Problem, Fertilizer and Fuel. Islamabad: Government of Pakistan.

Bhatia, Ramesh. "Economic Appraisal of Bio-Gas Units in India: Framework for Social Benefit Cost Analysis." In Economic and Political Weekly, Vol. XII, Nos. 33-34, pp. 1503-1518.

McGarry, Michael G. and Jill Stainforth. 1978. Compost, Fertilizer, and Biogas Production for Human and Farm Wastes in the People's Republic of China. Ottawa: International Development Research Centre.

Moulik, T.K. and U.K. Srivastava. 1975. Bio-gas Plants at the Village Level: Problems and Prospects in Gujarat. Ahmedabad: India Institute of Management.

National Academy of Sciences. 1977. Methane Generation From Human, Animal and Agricultural Wastes. Washington, D.C.: NAS.

Odend' hal, Stewart. 1972. "Energetics of Indian Cattle in Their Environment." In Human Ecology.

Prasad, C.R., K.K. Prasad, and A.K.N. Reddy. 1974. "Biogas Plants: Prospects, Problems and Tasks." In Economic and Political Weekly, special issue, August, pp. 1347-1364.

Solly, R.K. 1977. "A Study of Methane Digesters in the South Pacific Region." In Appropriate Technology, Vol. 3, No. 4.

Thery, Daniel. 1977. "Biogas: A Program for Sahelian Countries." In Ecodevelopment News, No. 3, October.

E.4 Solar

Florida Institute of Technology. 1975. Center for Energy Alternatives. Solar Cockers for Haiti: A Feasibility Study. November.

Langerhorst, J., G. Prast and T. Thalhammer. 1977. Solar Energy: Report on a Study of the Difficulties Involved in Applying Solar Energy in Developing Countries. Eindhoven: Netherlands Minister for Development Cooperation. February.