THE TRADITIONAL OR HOUSEHOLD ENERGY SECTOR
A REVIEW AND POLICY RECOMMENDATIONS

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THE TRADITIONAL ENERGY SECTOR

EXECUTIVE SUMMARY

In the mid 1970s events such as the Sahelian drought and the sudden escalation of petroleum prices caused development planners and environmentalists to become concerned about whether traditional fuel resources were adequate to supply the energy needs of the rapidly expanding populations of third world nations. The traditional fuel sector had received little attention and was one in which there was very little hard data. Nonetheless, in response to a felt need, development assistance agencies began to undertake projects designed to ameliorate the perceived shortages, actual or upcoming, of traditional fuels.

Studies and responses in this sector were often restricted to fuelwood because of a widespread perception that wood was, or ought to be, the primary fuel for the traditional energy sector. Reinforcing this perception was a common presumption that the third world's deforestation problems derived in significant measure from fuelwood gathering. As noted, casual observations were the bases for action in this sector where, at the time, there was neither project experience nor significant field data.

There is now a significant amount of field experience with projects addressing one or more aspects of traditional energy fuels. In addition, surveys and studies have been undertaken in several countries in an effort to generate a better understanding of this complex field. Concepts and approaches are changing as a more complete understanding develops. This paper results from an effort to consolidate and extend existing knowledge and experience from the surveys, studies and projects.

The evidence presented here is distilled from the thoughts of many specialists in and out of AID. Clearly some of the thinking which has gone into this paper is also incorporated in the just published AID Energy Policy Paper. On the other hand, in important ways the findings from this work suggest the strong need to further revise that policy paper, as well as the Agency's general view of this important sector. The altered view of the energy sector which emerges from this research can be stated in a few sentences as follows:

A. Household, or traditional fuels, are expensive and in scarce supply. Their purchase or gathering impose a significant burden on many households in the developing world. However, it appears that in most environments there is no crisis of availability. The scarcity situation has been long present and it is a situation to which the people have adapted. Rising populations will increase demand for the scarce fuels.

1. The price rises of woodfuel in urban areas which took place in the 70s probably reflect at least as much a petroleum price pull as a price rise caused by decreasing supplies of

traditional fuels.

2. Generalizations must be treated with caution in this field because variations in availability and price, particularly for woodfuels, are large apparently depending on climatic conditions among other factors. It appears that the traditional fuel situation is manageable in most humid and in rural semi-arid areas. In urban semi-arid and throughout the more arid environments localized, sometimes severe, fuel shortages are not uncommon.

B. The traditional energy sector is very complex, with a wide variety of fuels in use and with well developed private supply channels established to meet existing demand. Dozens of biomass substances are used for household energy. Overall for the third world it is unlikely that split wood supplies more than 25% of energy demand. However, the range is from close to 100% in some areas to not more than 10% in others. Rice straw, jute and cotton stalks, coconut husks, animal wastes, etc. supply about half of traditional energy needs in the third world. It is very likely that, in many cases, wood cannot, and should not, be substituted for these fuels. In general, the rural poor rely on fuel sources other than wood to a greater than is the case for other economic classes.

1. In many areas there is little marginal land for trees. In such areas crops planted on available land must be high valued and multi-purpose. For example, in Egypt and Bangladesh, crop and animal wastes provide most household energy.

2. In some climatic conditions, in areas of low rainfall or in high mountains for example, farmed wood is very expensive and is not likely to be a viable fuel for the poor. Examples of such conditions are parts of India, Lesotho, parts of the Sahel, parts of Pakistan and the high Andes.

3. In other areas it would appear that trees are the desirable fuel source, such as in the humid tropics where there is marginal land or low population densities.

C. There is no clear, across the board, association between deforestation and fuelwood gathering. Again we are faced with a lack of data in a field which is very complex. There does appear to be an increasingly widespread view among professionals in this field that fuelwood gathering is seldom a major cause of deforestation.

1. There are few reliable field data as to the actual causes of deforestation. Some of the estimates which have been taken as authoritative can be shown to have important errors.

2. Desk deduction and non-systematic field observations tend to support the conclusion that forest destruction comes from land clearing for agriculture, burning and overgrazing of young regrowth and lumbering far more often than from fuelwood gathering. This conclusion seems to be born out from satellite data.

3. Exceptions to this seem most likely in low rainfall climates where commercial fuelwood gathering for urban centers

takes place and where mature trees are relatively small and easy to harvest with small tools.

D. The most important finding from this review is that it is not feasible to disassociate fuel use of biomass from its other uses such as food, feed, fertilizer, construction materials and so forth. Frequently there are competing uses for the same plant, even the same plant parts. Similarly there is competition for use of biomass production resources. Any resource--e.g. land or water--used for one purpose, potentially reduces the potential for producing biomass to meet other needs.

1. Crops in the third world are typically multipurpose. In a Bangladesh village rice grain is used for food, rice straw is a feed, a fuel, a fertilizer, sometimes a construction material, rice husk is a fuel and a feed, etc. In the Andes animals provide food, fuel, clothing, fertilizer and exports.

2. Total biomass production potential is limited and in some villages is being, more or less, totally utilized. Fuel production occurs only at the expense of something else as in the Bangladesh village referred to above. Or, conversely, use of biomass for feed may conflict with it use as fuel. Dung supply seems to limit the system in parts of the Andes.

E. The final suggested modification to the view of the traditional energy sector is a more problematic one. There has been a more or less common presumption that the use of crop residues and animal wastes as fuels is undesirable. This view holds that these products should be used as fertilizer for food production and wood substituted-as-a fuel. The interaction of biomass production with soil fertility and the environment is complex. There are production systems, some apparently dating back thousands of years, in which crop and animal wastes are used to meet both fuel and fertilizer needs. These systems appear to provide the greatest human good in the given environment. There simply appears to be no real possibility for substituting wood in some of these cases. The suggested revision to the past view is modest enough. The possibility of designing systems for meeting fuel needs from crop residues and/or animal dung should be investigated in certain environments.

1. Non-wood fuels are most likely to be preferred where there is one or more of the following conditions present, high elevations where trees grow poorly, arid climates where trees also grow poorly, areas with little marginal land or where land rents are high, areas where population density is very high and income levels are very low.

2. Fuel use from trees can have as destructive an environmental effect as can using other biomass products for fuel. Trees consume biomass production assets, they extract minerals from the soil and the burning of their stalks reduces the organic matter returned to the soil.

F. These views evolve from thinking already underway in the Agency and extend that thinking to new frontiers. All the views expressed are considered as sufficiently likely and to have significant enough program and policy implications to justify their consideration. Some are grounded in rather good evidence, others seem the best interpretations of weak data and may later be disproven given the development of better data. For this reason, one recommendation which is made is for further study. The acceptance of the statements made above leads to a series of policy recommendations designed to adapt Agency programs and concepts to the new information.

POLICY RECOMMENDATIONS FROM THIS REVIEW

I General--A priority area for attention is that of traditional fuel needs. In traditional villages more biomass, by weight, is likely to be used for fuel than for any other need. Current AID policy gives attention to the traditional fuel sector; however, there is an undue emphasis on fuelwood.

Specific--

a. Models should be developed for appropriate fuel sources for different climatic conditions, terrains, income levels and so forth. These models should be developed based on current experience and should consider wood, crop residues and dung as possible valid sources of household energy.

b. Current and planned fuelwood projects should be reviewed to determine if they will truly address the fuel needs of the rural sector, particularly the poor. Frequently, wood is not the fuel of the poor and in some countries it is very expensive to produce.

c. More data need to be collected on current fuel mixes in different areas, these data should differentiate fuel mix by social class.

d. The tradeoffs involved in the use of dung and crop residues as fuels rather than fertilizers need to be examined.

II General--There is a need for a holistic view of biomass production and use when planning projects relating to food crops, commercial crops and fuel crops. Currently, there is a tendency to address each basic need independently when planning assistance projects.

Specific--

a. During the development of agriculture and fuel projects there should be a review of the effect of any proposed crop change on total biomass available to meet the various needs of villagers.

b. More data should be developed on current biomass production/needs balances in a set of "representative" environments.

c. Some prototypical holistic biomass projects need to be developed.

d. Consideration should be given to developing a biomass team approach to project development in AID regional and central bureaus as well as in the field.

III General--The Agency's response to needs in the traditional fuel sector is still technologically driven by tree(fuelwood) technology. There is a need for consideration of the economically preferable fuels, be they wood or otherwise.

Specific--

a. Studies need to be undertaken to determine the most cost effective "fuel" projects in environments where wood is expensive or difficult to grow.

b. Fuelwood research is needed, but should be focused on those areas where wood is a most plausible fuel for the traditional market.

c. More attention should be given to fuelwood research for the commercial market.

IV General--There is a need for a modified Agency "View" of the traditional fuel/biomass production sector. Agency wide, many officers view the traditional energy sector from a frame of reference influenced by the papers of some years ago. Second, there is little understanding of the actual fuels used in the traditional energy sector and of the multiple competing uses for biomass which exist in subsistence villages.

Specific--

a. A general concepts paper should be prepared for Agency wide circulation. That concepts paper should broaden the view of possible traditional fuels beyond just fuelwood, express the holistic view of biomass production and contain data on current mix of traditional fuels as related to climate, land value, social class and so forth.

b. Brief seminars(1 to 2 hours) should be held for mid-level staff in DP, PD and TR offices, summarizing the data underlying the concepts paper.

c. A video tape of these seminar materials should be prepared for distribution to the field.

V General--There is a need to codify and make available to staff the expanding, but still sparse, body of data on traditional energy balances/fuel use.

Specific--

a. A planning factor or "Fact" book should be developed collating existing knowledge.

b. As results from the studies recommended under I and II become available, the fact book should be updated.

PROJECT OVERVIEW AND BACKGROUND

The original intent in this review of the traditional cooking energy sector was to determine if AID project experiences in the sector suggested a need for changes and adaptations. As the review of projects progressed, it became clear that many of the operating assumptions underlying the projects did not appear to be supportable. At the same time, there was a true paucity of hard data on the real situation in the traditional energy sector. Supposedly authoritative sources such as the World Bank and the FAO, as well as AID documents, often contained assertions which did not seem to match with reality. Scattered anecdotal references were used as if they were broadly applicable.

As these realization developed, the study expanded in scope and in time. Obscure references were tracked down and gradually a reasonably well supported pattern began to emerge. This evolving pattern required major revisions of early views of the traditional energy sector. As is common, other professionals were also busily engaged in redefining the shape of the energy wheel. Gradually, these other views were uncovered and it was found some officers within the Agency were evolving similar perspectives. This review goes somewhat further than the current position taken as authoritative within the Agency. Two appendices analysing recent AID positions--one on the current AID Energy Policy Paper and the other on a Bangladesh fuelwood project PID--are attached to this paper to try to make concrete where the views are different. Similar conclusions would be made on other documents such as the S&T fuelwood research initiative, or the Africa Forestry Strategy draft.

Because some of the views expressed here are still not fully accepted this paper discusses at some length the sources and bases of conclusions. It also contains a lengthy bibliography with limited annotations. A reference file of these reports has been established.

The findings seem to fall rather neatly into five major categories. These are:

1. Current availability of traditional fuels.
2. Current traditional fuel mix.
3. A Holistic View of Biomass Production in the Third World.
4. Deforestation and Fuelwood Gathering.
5. Trees, Dung and Ecology.

The report is organized under these five headings. In each case a summary of data and conclusions are presented. Reference numbers are inserted in the text where appropriate to guide the reader to the source of material. In each of the sections there is an evaluation of the confidence level with which the conclusions are made. Where there are particular needs for better understanding suggestions for more study are made. The report closes with an annotated bibliography of most of the reports consulted during this study.

I. AVAILABILITY OF HOUSEHOLD FUELS

A. Introduction

Many development professionals have expressed concern about the adequacy of supplies of traditional fuels. Following the oil price rises of the 70s, it was often said that a corresponding crisis of traditional fuel availability and price could be expected, or even was already present. Most of the discussion of the subject relied on anecdotal evidence in the absence of firmer data. Some new information has come to light on the question of traditional fuel availability. This section summarizes that data and makes an interpretation of its probable implications.

Household energy use in much of the Third World is primarily for cooking. For this study cooking and household energy will be treated as synonymous. The vast majority of cooking in the rural areas of the Third World is done with biomass fuel--wood, shrubs, leaves, crop residues and animal wastes. This study examines only the biomass fuels (traditional fuels) used for household energy generation. Some consideration is given to the urban sector, but the emphasis is on the rural sector.

It is not feasible with the quality of information available to provide a definitive conclusion as to how severe the problem of obtaining cooking fuels is for typical Third World households. Clearly fuels are scarce. The limited hard data available supports the situation of scarcity. Just as clearly the situation varies from country to country and within countries, by region. The limited hard data available can be treated in one of three categories--user perceptions of availability, price data on traditional fuels, and amount of time spent in collecting cooking fuels. Each category tells us something about fuel availability in various countries. From a review of these scattered bits of evidence, it is possible to make some supportable conclusions about the overall situation.

B. User Perceptions of Fuel Availability

How do rural families see their fuel situation? The obvious way to start a study of this subject is to ask the people involved. There are few published results of such questioning, however.

By far the most meaningful of the available data of this type are from a survey of 13,000 households conducted in India in 1979. This survey was done for a national random sample and appears to have been well done. When asked, 95% of the respondents indicated that fuel availability was not much of a problem for them. On a question about whether they had more or less of a problem in obtaining cooking fuel than was the case five years earlier, 90% indicated no change with the remaining 10% evenly divided between better and worse. (119)

India is one country in which the cooking energy should be relatively scarce. Nonetheless, it appears that the rural population does not perceive a worsening situation in fuel supplies for household use.

A small survey is available for a province in the northern Philippines, in an area where population density is high and where it is said that a firewood deficit exists. The results of this survey provide no conclusive evidence that the cooking fuel situation has worsened in recent years. A variety of tree wastes were used as fuel and most people said the fuel situation was unchanged in recent years, a minority indicated a modest worsening of the situation. In contrast, in this wood dependent region a significant majority of respondents said their town had more trees now than a few years ago. (113,115,118)

For some very limited data from Mali the results are similarly ambiguous. Observations in four regions indicate that in the highest rainfall area, 1200mm, wood was the primary fuel and was perceived as readily available. In a lower rainfall area, 800-900mm, wood again was the fuel, but some problems of scarcity were perceived. In two more arid regions wood is not an important cooking fuel and wood availability is cited as a problem. There were no references in the study on the degree to which the commonly used fuels, crop residue and dung apparently, were difficult or expensive to obtain. (125, 126)

As noted the hard data are sparse. More than two hundred fifty documents were read in the process of this review and conversations were held with over fifty people in concerned with this field. I do not believe there are significant hard data available which indicate that household fuel is perceived as critically scarce by rural dwellers. This does not say that critical scarcities do not exist, only that good quality field data documenting perceptions of extreme scarcity do not show up in the literature reviewed.

C. Price as an Indicator of Scarcity

Prices of traditional fuels have not been extensively documented. There are frequent citations of prices or price trends in the literature. But, the use of the numbers cited is restricted by such considerations as general trends in inflation, the limited quantity of traditional fuels that are traded and the oil induced energy sector specific inflation. Few of the data on prices account in any satisfactory way for these factors. Consequently it is not possible to be confident that the data provide useful indicators of fuel scarcity trends.

Rather than burdening this discussion with a modestly large number of references to very limited bits of data, I will present only a synthesis. For the reader wishing to have more detail, there is a bibliography appended to this report. Price references may be found in documents numbers 47, 69, 90, 112, 117, 119, 124, 132, 135, 151, 152, 156, 173, 175, 184, 194.

1. For urban Sahelian African conditions there are at least two countries for which data, of ambiguous quality, suggest that purchase of cooking fuel consumes from 20 to 30% of income for the poor. This conclusion is included, despite the uncertainty of its basis, because the assertion is made in so many separate documents.

2. Fuelwood prices have increased considerably over the years since 1973, there is no consistent evidence that this increase has been at a rate above that of price increases for other energy products. It may be that the price increase is one which is mainly oil price induced, rather than one reflecting a decreasing supply of traditional fuels, as is often suggested.

3. Where traded, twigs and dung are cheaper on a weight basis than is wood. It is not clear that on a per unit of useful energy basis that these fuel are cheaper than wood. Agricultural wastes are not traded to any degree and almost no data on prices could be found.

4. Urban wood prices have gone up considerably more steeply than is the case for rural settings, although most rural fuels used are not traded.

5. On a usable heat basis, available data suggest that, in the more arid and urban areas of the world, energy from wood fuels approach, and may even exceed, the cost of energy from oil valued at international prices. A theoretical analysis of the cost of producing wood in such environments confirm the probable high cost of wood in arid area(see Appendix A).

6. The poor purchase less of their fuel and use lower quality fuels such as twigs, leaves and crop wastes.

7. The best study available on woodfuel price trends is by the World Bank for Addis Ababa(175). This study shows an average real annual increase of 9% a year in fuelwood prices, with most of the increase occurring in 1974 to 1978. These are the years in which petroleum prices were increasing most rapdily. Whether or not wood price increases in Addis exceeded overall energy sector inflation cannot be determined from the published data.

In summary, such data as are available suggest that traditional fuels in urban areas are relatively expensive. The purchase of fuels for cooking does impose a significant burden on the poor, urban household's limited budget. There is a lack of data on whether wood fuel prices have increased at rates above, or below, overall energy sector prices. Much of the fuel used is not traded making the development of price data rather difficult.

D. Time Required for Fuel Gathering

As in the prior two sections the data are sparse and occasionally contradictory. Again I am reluctant to use materials which appear to be anecdotal in nature. The situation is a little better in that a few surveys of time/task relationships for rural families have been accomplished which indirectly give some indication of the difficulty of gathering fuel.

Some standards for comparison may be established by examining overall person time available.

A rural family with 6 to 7 members has, perhaps, 50 to 60 person hours per day for productive activities. This allows for 12-14 hours of potential work time, the loss of 1.5 persons as non-productive because of age, and for about two non-productive hours per person during the day.

The survey data available show three household activities as heavy time consumers, these are food processing and cooking, water collection and fuel gathering.

The following data have been found on time spent on cooking and water collecting.

1. For seven villages in India:
Cooking: low-1.5 hrs, hi-6.4 hrs, avg-3.9 hrs.
water: 1.2 hrs. (135)
2. For eight villages in Nepal
cooking: low-1.9 hrs, hi-4.5 hrs, avg-3.8 hrs
water: low-0.3hrs, hi-1.2hrs. avg-0.6 hrs. (1,59, 135)
3. For five villages in Mali:
cooking: 5.2 hrs.
water: no data
4. Unspecified samples in
Nepal: Cooking-3.1 hrs, water-0.7 hrs.
Bangladesh: cooking-9.0 hrs. water-0.5 hrs.
Pakistan: cooking-5.3 hrs, water-0.5 hrs.
Java: cooking-2.8 hrs.
Upper Volta: cooking-2.7 hrs. (59)

The typical time spent on food preparation, cooking and water gathering is on the order of 4 to 6 hrs. per day or about 10% of the person power available to a family. In terms of a standard, if fuel gathering consumes less than this time per day, it is fair to say that it probably does not represent an intolerable burden on the family.

The available data on time spent in gathering wood shows large variation. I suspect that the variation represents both real variation and variation induced by poor quality data. There is little that can be done to separate the two effects. The available data are:

a. Seven villages in India:
lo-0.66 hrs. hi-5.2 hrs. avg-2.4 hrs. (135)
b. Seven villages in Nepal:
adults 0.67 hrs.
children 1.1 hrs. (1,59,135)
c. Bangladesh: 0.25 hrs. (59)
d. Nepal: 0.65 hrs. (59)
e. Two villages in India:
Adults, medium land holder-0.56 hrs.
children, medium landholder -0.2 hrs.
Adults, landless-0.95 hrs.
Children, landless-0.5 hrs.
f. Java: 0.8 hrs. (59)
g. Upper Volta: 0.6 hrs. (59)

These surveys indicate that rural families spend from 0.5 to

3 hours per day on fuel collection. Numbers in the range of from 0.5 hours to 1.5 hours seem to be most common. These data appear consistent with observations from long time observors that fuel collection is often undertaken incidental to many other activities, such as walking to market or to the field or to crop gathering. The time spent on fuelwood gathering is about equal to that needed to bring water and is generally less than one half the time required for food preparation/cooking.

Available evidence suggests that a rural family must allocate from 2 to 4% of available person hours to fuel gathering. These data cover a moderately large range of environments. This does not suggest that fuel is a major problem for the rural poor, but also suggests that fuel gathering requires an important expenditure of available resources. More time is normally spent on food preparation, with similar amounts of time devoted to water gathering. As with water, oftentimes much of the burden of fuel gathering falls on children.

E. Conclusions on the Availability of Household Fuels

The evidence available do not support a conclusion that the household energy situation is perceived to have worsened in recent years. Fuel acquisition is shown to be expensive in money or in time; it rates as one of the important burdens on family resources, probably after food and water. For the urban poor there are some very limited indications, mainly from Sahelian countries, that fuel purchases reresent a major expenditure class.

Before we undertake projects to ameliorate fuel shortages, we need to know more about the character of the current fuel supply situation for the specific area where the project is planned. We need to know the types of fuels and their availability, differentiated by social class. Probably studies of the allocation of time spent in acquiring fuels would be most useful in the rural areas since most fuels are collected not purchased. In the urban sector price data can be useful. It may be that simple surveys of perception of supply can be useful, but I would suggest these must be used cautiously.

II. MIX OF FUELS USED FOR HOUSEHOLD ENERGY NEEDS

The previous section generally supports the view that household energy costs are high. Thus, projects addressing the supply or conservation of traditional fuels may be appropriate given supporting analysis of the local situation. Increasing populations will cause these already tight supplies to become more so.

This section presents data on the mix of fuels which are now used for household energy purposes. There has been considerable attention given to fuelwood. Other common fuels have been largely ignored. Yet, a major share, if not a majority, of cooking energy is supplied from fuels other than wood.

Again, some definitions need to be developed before the discussion is presented.

1. Various tree products are used for fuel. Some of these products, such as twigs, leaves and dead branches, do not involve the destructive harvesting of the tree. These fuels, which might be called tree wastes, are more commonly the fuels of the poor, while the better off are more likely to use split wood. Both for the ecological considerations, non-destructive harvesting, and for social class information, tree product fuels are separated into two categories whenever data permit.

Wood--any tree part obtained by destructive harvesting, this category is usually best approximated as split wood.

Twigs--tree parts such as pruned branches, leaves, and dead parts which can be harvested without killing the tree.

Generally wood is a higher quality fuel than twigs.

2. Many types of crop residue are used for fuels, These include items such as rice, millet, jute and cotton stalks. In addition, residue from tree crops are also burned for cooking. These include coconut husks and fronds, palm oil waste products, over aged rubber trees and probably many others. Normally when parts of a plant, grown for other purpose, are used for fuel, those parts are treated as crop residues. The exceptions to this are wastes from trees grown for wood products such as poles and lumber. These products, when information is available, are classified under twigs.

3. Animal wastes are a good fuel in arid and semi-arid areas and possibly in more humid climates during the drier times of the year. Dung will be used to categorize any animal excrement used in its solid state as fuel.

4. There are other fuels used in varying degrees. These include biogas, grasses and of course petroleum products. This paper addresses only biomass fuels. Very little information exists on biomass fuels other than the main categories listed above.

A. Data on Current Mix of Household Fuels

This paper focuses on the rural sector insofar as data available can be disaggregated to cover only the rural areas. The fuel mix in the cities is different with wood and twigs representing a much larger proportion of the traditional fuels. The urban fuel sector is also different in that it is primarily commercial, while in the rural sector most fuels are not traded. For these reasons, what is said in this paper cannot be readily applied to the urban fuel situation of the developing world.

Household energy use has become a subject of increasing interest in the past few years. Consequently there is an increasing base of field data on the types of fuels used, on the quantities used and on who uses what types of fuels. The quality of these data are satisfactory for some purposes. From them we can obtain a general indication of the prevalence of different types of fuels worldwide and by region. We can derive probable relationships between, climate, population density and income level and type of fuels most likely to be used for cooking. The data will not, in general, be adequate for specifying the specific situation for a particular region of a country.

The following data, which appear to be based on reasonable field surveys, are available on fuel mix. The data sets are divided by the general level of aridity for the country for which the data apply. This is only an approximation since rainfall varies greatly within many countries. Despite its limitations, this separation of the data provides some useful information.

1. Arid Areas or areas with semi-arid montane environments

a. Data from a survey of 148 households in one village in Lesotho showed:

Fuel	Percent of Energy Supplied
Wood and Twigs	2
Dung	52
Crop Residue	4

Another category, shrubs provided some 42% of energy. (43, 44)

b. For two villages in Mali a non-systematic survey showed that in the most arid area, rainfall under 300mm, dung was the primary fuel. Wood was scarce and some residue from palm trees was burned. In the other village, rainfall probably in the 400+mm range, wood is preferred but hard to get. Other fuels such as straw, dung and other agricultural residues are used to supplement wood. Relative quantities could not be determined. (125, 126)

c. Again for some detailed observations in Upper Volta, it is shown that wood is used in the wet season and millet stalks employed during the dry season. Millet stalks provide at least half the energy used for cooking. (76)

d. Extensive data from Ethiopia show a heavy dependence on agricultural residues and dung. In the more arid regions of the country wood is seldom used as a fuel. The following table is for national aggregates. (175)

Fuel	Percent of Energy Supplied
Wood and Twigs	40
Dung	34
Crop Residue	24

e. A detailed Analysis of dung as fuel or fertilizer in a small region of the altiplano in Peru provided good information on fuel sources. The results are: (132, 171).

Fuel	Percent of Energy Supplied
Wood and Twigs	est. at under 10%
Dung	est. at over 90%
Crop Residue	apparently rarely used

2. Semi-Arid Areas

a. For two villages in Mali with rainfall above 900mm and located on year round rivers, it was found that wood is the predominant fuel. In the village with high rainfall, 1200mm, wood is plentiful, while in the second, which is in the 900mm regime, wood is considered scarce. (125,126)

b. The survey referred to previously for India provides the best information on fuel use. (119)

Fuel	Percent of Energy Supplied
Wood	21
Twigs	37
Dung	24
Crop Residue	18

The table is for the rural sector only.

c. There are a number of other village level surveys from India which generally confirm the nationwide survey, but which also offer additional information. (109, 135, 151, 152)

Fuel	Percent of Energy Supplied
Wood	5 to 30%
Twigs	5 to 50%
Dung	15 to 60%
Crop Residue	5 to 35%

Green plants are also mentioned as fuels in some areas, with up to 25% of energy supplied. These surveys provide some indication of the differences in fuels by economic class. In one village the landless rely heavily on twigs while the farmers with viable sized farm units burn wood and dung.

d. Aggregate data are available for Turkey. (162)

Fuel	Percent of Energy Supplied
Wood	22
Twigs	22
Dung	34
Crop Residue	22

e. Egypt is treated as semi-arid for this analysis. Data available are limited, but it is clear that wood is seldom used for cooking in the countryside. It appears that dung and crop residues are both important fuels. (194)

f. In Botswana, a survey of a single village shows that wood is the most commonly used fuel and dung and crop residues are also important sources of household energy. (41)

3. Humid Areas Without Marginal Land

This is a special category. Although trees grow well, land, without alternative, higher value uses, is not available for tree production. Data are available for only one country with this characteristic, that is Bangladesh. There are several sets of data available for Bangladesh. Other areas such as the central plain of Thailand, Central Luzon in the Philippines, parts of Burma could be similar. (47, 70, 187, 194)

Fuel	Percent of Energy Supplied
Wood	5 to 25%
Twigs	5 to 25%
Dung	5 to 15%
Crop Residue	35 to 70%

The data from Bangladesh provide another indication of the relationship between fuel use and income. As in India, the poor are likely to rely heavily on tree waste and crop residue while the better off families use more wood and better qualtiy twigs.

4. Humid Climates With Marginal Lands

Most of the humid tropical lands are hilly or mountainous and the hillsides are not well suited to traditional agricultural crops. These hills provide convenient lands for fuelwood production.

a. Several small studies have been done of fuel use in Indonesia. (109, 135, 162)

Fuel	Percent of Energy Supplied
Wood	15 to 30%
Twigs	major fuel
Dung	probably negligible
Crop Residue	Some, from tree crops

b. In Liberia tree products are very readily available and are almost the only fuel used for home cooking. A significant share of the fuel is from split wood. (pers. observation) A similar situation is found in Sierra Leone. (119a)

c. From limited systematic data, split wood and twigs are the predominant fuels in much of the Philippines, although crop residue from the coconut is a common fuel in the areas where this crop predominates. (pers. observation)

d. Scattered bits of data from Thailand indicate that tree products form the primary fuel base. There is some use of crop residue, but it appears not to be the predominant fuel base.

B. Types of Biomass Fuels

These surveys give the following general information on types of biomass fuels used.

1. Tree Parts(used in some measure in most areas)
   - split wood
   - branches and twigs

leaves
Wood is a luxury fuel in many parts of the world and is mainly used in urban areas and by families with higher incomes.

2. Woody Shrubs- used particularly in semi-arid areas, little data available.
3. Crop Residue-used very widely, even in humid climates, but primarily in rural areas. Examples of important residues are:
   rice straw-Bangladesh, China, India
   rice husk-Bangladesh, India
   millet stalks-Upper Volta, Mali
   Jute stalks-Bangladesh
   Cotton stalks-Egypt, Ethiopia, India
   Coconut husks and fronds-Philippines, Indonesia
   Oil palm wastes-Liberia, Malaysia
   Old rubber trees-Liberia
4. Animal Wastes-Used in many countries, in some environments there is a well defined preference system for different types of dung. For some uses dung is preferred to wood

C. Probable Mix of Household Fuels By Environment

One has to be cautious in making generalizations about cooking fuel mixes because of the complexity and variability which exist. Nonetheless, there are some guidelines which are useful in indicating likely patterns which will help in knowing what to look for until better quality information becomes available.

Figure One summarizes an interpretation of the data found in these studies. Fuels used appears to depend on climate(rainfall and temperature), population density, terrain and income level.

In a causal sense, the argument as to why fuels other than wood predominate in certain conditions runs as follows:

a) Trees grow relatively poorly where rainfall is low or in cool alpine climates. Consequently, wood us a relatively expensive fuel in these areas.

b) If agricultural population density is high, land values are higher and crops higher in value than trees are favored for available land.

c) If there is little marginal (hill) land few trees will be grown.

d) Where incomes are low, low quality (value) fuels will be more commonly used.

1. Figure One shows that in more arid environments, rainfall below 600mm, tree products are not likely to be a continuing source of household fuel. At the most arid end of this spectrum, say below, 350mm, and when population densities are low, mining of shrubs will provide an important fuel. As population pressures grow, mining will exceed natural regenerative capacity. Since wood is expensive to farm other fuels will be adopted. The higher income groups will adopt commercial fuels, while the poor will

turn to dung.

In some developing countries analogous conditions are created by low temperatures. Thus, in high altitude conditions tree growth may be sufficiently slow to negate the use of wood as a fuel even though there is relatively high rainfall. The altiplano of South America and perhaps parts of Nepal are of this nature.

2. In areas with rainfall above 1200mm tree products and crop wastes, particularly those from tree crops, will be the predominant fuels. For areas where the population pressures are high the poor will burn twigs and junk parts of the tree. The better off will use split wood. A special case for this environment is where there is little marginal land. Food crops get the first priority, trees second. In Bangladesh, despite adequate rain in much of the country, tree products are not used for fuel because of the intense use of land for food or commercial crops. No data are available, but it seems likely that in the central plains of Thailand and the Philippines somewhat similar situations have developed. Where the land is hilly trees are usually available on the hills.

D. Conclusions and Need for information

We know much about the overall pattern of fuel use in the traditional sector. We can make broad guideline statements about probable fuel mixes if we know the general climatic conditions and population density along with level of development. Wood is important in some areas. In other areas it is unimportant. Generally the rural poor are the least likely to use wood. On a worldwide basis, it seems unlikely that more than 10% of the energy needs of the rural poor are met by wood, with perhaps another 25% coming from tree wastes of one type or another.

If one is to address household fuels, it is necessary to know what the specific local situation is. Thus, there is a strong need to develop information on local fuel mix, for those countries in which we are considering the development of projects designed to ameliorate the household energy problem. We also need to develop good information on relative prices of fuels and accessibility by social class.

ACTUAL AND "PREFERRED" FUELS FOR VARYING CONDITIONS

Increasing Population Pressure →

CLIMATE/ TERRAIN	LOW POPULAT.	HIGH POPULATION	
A. Arid, Alpine	farmed wood mined shrubs dung	hi income	commercial
		lo income	dung, mined shrubs
B1. semi-arid, flat	mined wood crop residue	hi income	commercial, farmed wood
		lo income	crop residue, dung, tree waste
B2. semi-arid, hilly or cool	mined wood crop residue	hi income	commercial, farmed wood
		lo income	crop residue, tree waste, wood, dung
C1 humid, flat	mined wood	hi income	commercial, farmed wood
		lo income	crop residue, tree waste, dung (dry seas)
C2, humid, hilly	mined wood	hi income	commercial, farmed wood
		lo income	farmed wood, tree waste, crop residue

FIGURE ONE

III A HOLISTIC VIEW OF BIOMASS PRODUCTION (47,68,110,132,163,171,175,187,194)

The modern era is often referred to as the age of specialization. The Renaissance man, able in many different fields, is considered an anachronism. We are engineers(chemical), social scientist(behavioral) or members of some other increasingly narrowly defined discipline. Our economic activities are similarly specialized. The family farm, self-sufficient in many crops, seems to have suffered the same fate as the Da Vincis. Today's farmer is a specialist in wheat, in corn, in oranges. He produces a single product for sale; with the income earned from that sale he buys the things he needs from the market place.

The Third World has not reached the age of specialization, particularly in the rural areas. A farmer in the Sahel grows a grain, herds some animals, does some crafts at home, perhaps goes to the city as a laborer in the dry season, if he is near the sea, or a river, perhaps he supplements the family's meager resources with a little fishing.

Crops in the Third World are in a sense analogous in their ubiquitous functions. The farmer doesn't grow a grain crop for food alone. From the tender parts of the stalk of the plant he will obtain feed for his work animals. The tougher parts will be a fuel for his cook stove. He may use any excess stalk as a plant mulch. Perhaps the stalk will also supply some construction material as thatching or as binder for mud brick. His animals produce food, fuel and fertilizer. The Third World farmer wastes little for he lives with no margin for such wastage.

We have tended to think about third world problems in terms of our own environment of specialization. We send a food grain specialist to look at rice. The specialist thinks of rice as exclusively a food crop. The energy specialist, in contrast, is likely to look only at energy use of biomass. In Bangladesh, the specialist may advocate the use of high yielding grains to supply more food, without considering that the adoption of these grains may reduce the farmer's fuel supply by reducing stalk production.

The Third World farmer buys little of what he needs to survive. He produces it himself. He produces it in very large measure as one form or another of biomass. From one perspective he is the supreme generalist. And, it is from the perspective of the generalist that his problems are probably best addressed. The farmer needs advice on and/or technology to produce a mix of biomass which will meet his total needs. If he is to consider a change in his production mix to produce more food, he needs to know if that change is going to mean less fuel and feed. Conversely, if he is to produce more wood for fuel, he must understand what this implies in terms of total biomass availability.

A. The Farmer's Needs

The farm family has a multiplicity of needs. The closer it operates to subsistence the greater the extent to which its needs must be produced from local resources. Those resources are primarily the biomass production potential of the area. The basic needs can be classified as follows:

Food--In the first instance the farmer needs sufficient food to meet the nutritional requirements of his family.

Feed--Typically the third world farmer is dependent on animals for a variety of necessary functions, such as motive power, cultivation power, and food. He must produce on his land the biomass to feed these animals.

Fuel--For reasons of taste, digestibility and preservation, much of the biomass the farmer consumes for its food content has to be cooked. The fuel for that cooking is another drain on his biomass resources.

Fertilizer--To maintain the productivity of his land, the addition of minerals and perhaps organic matter is necessary. Next year's biomass production depends in part on this year's fertilizer. His sources of fertilizer are, largely, the biomass production of his farm unit.

Construction--His shelter is usually constructed in some measure from the biomass of his land.

Exports--Few, if any, farmers are totally subsistence. Some foods, cloth, construction materials, health services are among the items which must be purchased. He must produce surplus biomass, or labor, for sale, or export from his system, to enable the purchase of the minimal necessities from the outside.

B. Some Examples of Holistic Views of Biomass Production

This line of thought was triggered by frequent references to the desirability of not burning dung or crop wastes because of their importance as fertilizers to assure next year's food supply. Clearly, cooking is as necessary an act as fertilization and it occurs nearer in time, since fertilizer use does not bring benefits before the next harvest. How reasonable were those monothematic calls for not burning dung?

The answer to that question is not simple; it is quite complex, in fact. As a minimum, it is necessary to understand actual competing uses for biomass, if one is to understand enough to develop a reasonable answer. A search through the literature has produced three relevant examinations of total biomass production and use in the developing world. These studies do not exhaustively cover biomass produced and used, but they do cover a considerable percentage. Two studies are from delta villages in Bangladesh and one from the altiplano of Peru. They are from areas in which there is little or no surplus biomass. Therefore conclusions from these studies are going to be most representative for areas where population approaches the supportable limits, given the technology being employed.

An examination of these data should be useful in understanding how some of the third world's farmers have adapted their biomass production to meet their total needs. The data illustrate how secondary products from a crop grown for a primary output, usually for food or for export, are used to meet other needs. While we may think of rice as a food crop, in the delta of Bangladesh rice provides multiple products including fuel for cooking, feed for work animals and straw for compost and construction. While the food is necessary for human existence, so are the fuel and other outputs of the rice plant.

1. Dhanishwar in Bangladesh. (194)

This is a village in the floodplain where the primary crops are rice, jute and mustard. There are 422 people in the village with a total cultivated area of 147 acres. The biomass use by crop is as follows:

Percent of Needs Supplied By
Source of Biomass

Need	Rice Direct	Rice As Dung	Jute Sale	Jute Stick	Mustard Sale	Various Others
Food	80					20
Fuel	70	8		13		9
Feed	80+					10+
fert.		80				
const.	2			30?		??
Export	10		67			23

By volume, the total uses for biomass are:

Food	13%
Fuel	30%
Feed	24%
Fert.	15%
Const.	4%
Export	6%

The recording of biomass was not complete. Some feed came from grazing which was not recorded and the recording of the limited wood used, primarily for construction, is believed to be incomplete. Nonetheless, the data indicate the general pattern of use.

By volume, feed and fuel are the big consumers of biomass. Food is the fourth leading use in terms of volume. The village is almost totally dependent on rice and jute, with rice supplying the large majority of the needs except for export. In this village, rice is not only a food crop, it is the very basis for the existence of the village and its "residues" meet needs that in the long run are as important as grain for food.

2. Ulipur in Bangladesh (47)

This village is somewhat similar to Dhanishwar. However, it is located on a river and its people rely to a degree on fishing for their sustenance. The fish catch is sold and some grain and fuel purchased, since the village is not self-sufficient in either of these items. Ulipur would appear to be even poorer than Dhanishwar. It, however, has a more diversified production base.

Percent of Needs Supplied
By Source of biomass

	Village Produced				Gathered		Purchased	
Need	Rice Direct	Rice As Dung	Fish	Wood	River Wood	Other	Grain	Other
Food	45		3				52	
Fuel*	47	2		11	5	14		6
Feed*	53					30est		
Fert.*		48				27est		10
Const.		some						
Exprt			>75					

* These needs are partly met from minor crops in the village.

The total uses of village produced biomass is as follows(est):

	Percent
Food	18
Fuel	49
Feed	26
Fert.	5
Const.	<5
Exprt	<5

In contrast to Dhanishwar, Ulipur relies on the river for fish and for a variety of biomass which is gathered along the banks. That is the village obtains biomass which is not grown on village lands. The gathered items range from drift wood and bamboo to weeds and discarded rice straw. A portion of the families in the village own no land and live almost exclusively off what they can get from the river. These families must sell the fish they catch in order to buy their food and some of their fuel.

Although Ulipur has a more diversified economy than Dhanishwar, the basic pattern is the same in one important respect. The villagers produce no specific crop for fuel, fertilizer and feed. Rather they burn plant stalks or leaves, and whatever they can scavenge from along the river. Thus, they burn rice straw and husk, jute stalks, the doinshah plant, waste from chilis and so forth. With the significant fishing population without access to land, fuel is a particular problem.

Ulipur is flooded every year and as a consequence must produce floating rice. This rice has a high proportion of stalk to grain. At the time of this study in 1979, the government was said to be building a dike to protect the village from flooding. It was intended to persuade the villagers to switch to a high yielding variety of rice--which has little stalk relative to grain. From data on this village it is possible to make an indicative computation of the effect of a change over to a high yielding rice on the ability of the village to supply its needs.

The following estimates come from the study of biomass production in Ulipur. (47)

--ratio of grain to stalk--floating rice	-1 to 5
--ratio of grain to stalk--miracle rice	-1 to 1
--ratio of total biomass production of floating rice to that of miracle rice (given similar cultivation)	-1 to 1

That is, data is offered indicating that miracle rice, for similar growing conditions, produces no more biomass than the floating variety, rather it reallocates production from stalk to grain. Since the villagers rely on the stalk as well as the grain, the reduced stalk production involves some losses for the village. Using the above data, it is possible to make some crude estimates of the effect of a full switch from floating to miracle rice.

The products from floating rice are allocated as follows:

Food - 1 part
Feed - 2 parts
Fuel - 3 parts

If the total mass produced remains unchanged and if feed is given priority over fuel, the allocation of parts from miracle rices would be:

Food - 3 parts
Feed - 2 parts
Fuel - 1 part

Thus, the amount of food is tripled, the feed element is held constant and the rice contribution to fuel is cut by two thirds. Cultivating floating rice, Ulipur produces about half of the food grains it consumes and about 75% of its fuel requirements. The indicative computations suggest that if high yielding rice is substituted, the village will have a surplus of about 25% above its own grain needs. However, fuel production will fall to less than 50% of needs. Thus, such a change implies the need to develop a new fuel source.

3. The Peruvian Altiplano-Nunoz
(132,171)

A study on biomass production in an area of the Peruvian altiplano shows another example of a well established system in which there is almost no reliance on wood for fuel. In this case rather than rice, the basic product of the people is their animals. The animals survive by grazing. Unfortunately, the study on which this analysis relies for data does not cover the production of grasses. It only looks at the "farmed" outputs.

The villagers rely on two sources of sustenance. Their main food comes from potatoes and grains, a majority of which are purchased. The animals provide wool, meat and by products for export. The animals also provide meat for food and dung which is of vital importance as a fertilizer for the small potato and grain crops. The dung is also the dominant source of fuel available, both for cooking and, in this cold climate, for heating.

The animals are probably fed some of the crop residues, but the study available does not discuss such use. In this particular case it is the population of animals and the productivity of the high valley grasses which determines the ability of the land to support people. The villagers have developed a system in which there is a balance between the needs for fuel, fertilizer and labor and grasses to support the animals. Again, the people are poor and little biomass seems to be wasted.

The animals supply all of the export products which provide the money to import 85% of grain consumption. The animals provide over ninety percent of fuel and provide the fertilizer to produce a major share of the 15% of the grain crop which is grown within the village. The animals are as ubiquitous in Nunoz as is the rice plant in Dhanishwar.

The few small trees which grow at this altitude are considered too valuable as sources of construction material to be cut for fuel. There is strong competition between the use of dung for space heating and cooking and as fertilizer for the potato and grain crops. The study is somewhat vague on this point, but it appears that the limited production of grain results from the lack fertilizer.

C. Relative Quantities of Biomass Required for Meeting Basic Needs

It is possible to make crude estimates of the relative quantities of biomass required to meet the four basic needs of food, fuel, feed and fertilizer. The estimates provided here are only relevant for near subsistence villages, dependent on agricultural crops. This is, however, a common condition in AID recipient countries and therefore the computations should be relevant in many circumstances.

1) Assume a requirement for 2,000 kcals of food per day per capita, from grain. This implies a need for about 0.6 kg of grain per day or 210 kg of grain per capita per year.

2) Cooking requires from 2 to 3 calories of fuel per calorie of food, under a variety of traditional conditions. The daily fuel requirement to cook 2,000 kcals of food(using the mid-range figure) is 5,000kcals. A kilogram of air dry wood will contain about 3,000kcals. Thus, the annual requirement, per capita, for fuel is about 580 kg of wood, or its equivalent in other fuels. This can be lowered if more efficient stoves are employed. However, the heat requirement is greater for some grains. Various studies of actual fuel used suggest that typical per capita

consumption figures are the the range of 400 to 1,000kg per year.

3) Animal(work or dairy) to human population ratios vary, but an average of one animal per five people is representative for settled subsistence agriculture. Work animals consume 5 to 10 times more food than do humans. Using a seven to one food consumption ratio, an estimate of 0.85 kg of feed per day per human is obtained.

4) Fertilizer requirements are less easily estimated. In the three village studies, the quantity of fertilizer used is about equal to food consumed. I shall assume for these calculations, one kg of fertilizer for each kg of food.

The quantities of biomass required per capita per day are approximately those shown in the table below. For villages which have important trade or for villages which depend heavily on animal grazing, it seems likely that somewhat different numbers will apply.

	Daily Per Capita Biomass Needs	
Food	0.60kg	15%
Fuel	1.60kg	39%
Feed	0.85kg	21%
Fert.	0.60kg	15%
Total	3.65kg	90%

*About 10% is assumed to go to other needs.

These estimates are quite similar to those for the actual measurements in Dhanishwar. They should be usable for general planning purposes until more location specific estimates are developed.

D. Conclusions and Needed Information
(40,86,142,154)

In subsistence areas, the villagers have developed a mix of biomass products to meet their needs for food, fuel, fertilizer, and feed, as well as other needs. Typically a single crop will provide the biomass required to meet two or more of these needs. Thus, any crop change for the purposes of better supplying one need may well have side effects on the villagers ability to produce biomass to meet their other needs. Fuel projects cannot be looked at without considering side effects on food, feed and so forth.

The solution seems to be to adapt a holistic view, where total biomass production and aggregate needs are examined during project planning. We have few studies using such a holistic view. There is need for a greatly expanded data base in this area.

IV DEFORESTATION AND FUELWOOD GATHERING

Many persons have expressed concern about the disappearance of tropical forests and have wondered what could be done to slow down, if not reverse, the decline in forested area. Published statistics have shown that 80% or more of tree products in the tropical countries go for use as fuel. Combining the concern and this statistic, some have concluded that fuelwood gathering is the root cause of deforestation. A simple extension leads to the conclusion that development of fuelwood production projects can be a means for slowing the loss of tropical forests. There are two fundamental flaws in this logic which limit the validity of this conclusion.

1) On a worldwide basis, estimates of fuelwood consumption are sharply overstated. The basic reference numbers, those from the FAO, indicate "fuelwood" consumption figures which are too high by up to 400%. The basic FAO document on the projected fuelwood deficit(86) states on Page 5 that, "the people in rural areas and in towns under 100,000 are assumed to depend on firewood." This assumption is applied in all countries. While the FAO document does indicate, on careful reading, that their term fuelwood is meant to include agricultural and other wastes, summaries are presented repeatedly as fuelwood deficits. The deficits are related to forest productivity. As shown in an earlier section wood, from harvested trees, constitutes, on a worldwide basis, less than 25% of traditional fuel use.

This definition by the FAO results in estimates of fuelwood consumption which are overstated by a factor of four, or more. In the areas where the wood deficit is stated to be most severe, wood is even less commonly used. Thus, in most areas of acute fuelwood scarcity, fuelwood use is less common than world average.

2) The FAO estimates are often used to relate fuelwood gathering to a reduction in forested areas. In reality, there are many countries in which surveys show that very little fuelwood is gathered from forests. In general, the populations live far from the forests. Fuelwood is burdensome to carry, so it is gathered close to home. Both common sense and available data indicate that fuelwood is not likely to come from forests.

The earlier data cited from Indonesia, Bangladesh and India indicate that 25%, or less, of fuelwood comes from anything which could be called a forest. There is a similar study for Kenya. Most wood comes from home lots, roadsides and so forth. Application of this relationship to the FAO data, would reduce the fuelwood gathering in forests by another factor of four or five.

Thus, FAO estimates which show that fuelwood makes up about 80% of the volume of mass removed from forests are highly misleading. If the above correction factors are applied, 4 to 1 and 5 to 1 reductions in estimated fuelwood removals from forests are implied. If such corrections are applied, rather than 80% of forest mass removals going for fuelwood, the percentage is reduced to about 15%. Separate calculations for FAO regional estimates of fuelwood as a percent of forest removals in Asia, produce similar conclusions. These computations are based on satellite information on reductions in forested areas. The mass contained in the deforested areas just about equal the quantity of materials which are said to be removed for timber and pulp purposes. That is, based on satellite evidence, reductions in forested area can be almost totally explained from commercial forestry removals, suggesting that fuelwood gathering does not relate to deforestation. Thus, the estimates showing fuelwood as representing the large majority of material removed from tropical forests appear to be highly misleading.

This conclusion has distinct limits as to validity given available data. Close to urban centers where commercial gathering of fuelwood takes place, there is evidence that fuelwood is gathered from forests to some degree. Since most Third World populations are primarily rural this is a lesser problem than might be initially thought. For arid areas where trees are small at maturity and therefore relatively easily harvested and where nomadic or semi-nomadic life styles exist, it may be that fuelwood gathering is more destructive of what are nominally called forests. No systematic data, could be found, on this environment to specify what is actually happening.

There is probably little need for additional information in this area. Fuelwood gathering is not a terribly important factor in deforestation, with the probable exception of some arid areas. In these areas there is a strong need to understand more about ecological interactions.

V Trees, Dung and Ecology

The implication of what is said in this paper is that it may make sense to burn dung or crop residues. These are fuels which are cheaper and more accessible. They are the by-products of crops grown for commercial or food purposes. Their production does not make exclusive use of limited biomass production potential. In some areas the only way to get wood is to grow it on land which is suitable for a crop which will produce some food. In some areas wood is a terribly expensive crop to grow. In these cases, wood is probably not a desirable nor a practical solution to home fuel needs, either on paper or in reality.

The assertions which have been made that it is ecologically undesirable to burn dung, compared to wood, are too simplistic. The village of Nunoz in the Peruvian altiplano seems to have had a stable system involving the use of dung as a fuel which dates back for many hundreds of years. Written references to the use of dung as a fuel in the Middle East date back at least 3000 years. People in these areas have survived for a long period burning dung.

This is an issue of extreme complexity, about which we have little knowledge. Perhaps, we are not correct in arbitrarily saying that the poor should switch from cheap dung and rice straw to expensive wood. Perhaps, we should look at the possibility of improving the ecological consequences of having to burn these crop and animal wastes. We must know more about this subject, I believe, before we make arbitrary prescriptions as to what is an acceptable fuel and as to what is not acceptable.

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APPENDIX A

INDICATIVE ESTIMATES OF THE COSTS FOR FARMED WOOD UNDER DIFFERENT RAINFALL REGIMES

I. INTRODUCTION

Much of the fuelwood consumed in the developing world is "mined" from naturally generated trees. Since these trees often grow on land which has limited alternative uses their development costs are virtually zero. However, when mining of trees exceed the natural regeneration rate additional fuelwood supplies can only be produced by farming of trees. Farmed wood is likely to be considerably more expensive than mined wood since development (planting and maintenance) costs will have to be included in wood price.

This appendix examines typical yields for various climatic conditions and expected development costs in order to specify indicative costs for farmed wood.

II BIOMASS PRODUCTION POTENTIAL

Various estimates have been made for the theoretical maximum biomass production potential under different climatic conditions. The estimates which are used for the calculations in this paper are taken from the Holdrige life tables(110).

Holdridge shows probable biomass production as a function of rainfall, temparature and humidity-balance. Most of the countries of interest to AID are in the tropical areas where temperature is sufficient for maximum biomass-production potential. Thus, biomass(wood) production potential is primarily dependent on the average rainfall for the area.

Figure Two shows estimates of maximum biomass production potential for likely field conditions. The data are derived largely from Holdridge's tables, but are modified by field experience in Africa and the Philippines.

III WOOD DEVELOPMENT COSTS

Field experience has shown that tree planting and maintenance(development) costs are also associated with rainfall. Trees survive and grow less well in arid climates. In arid areas animals are more prevalent in the food chain and with scarce biomass trees become a potentially important food for the animals. Thus, there is more need for tree care and protection, increasing the development costs.

Figure Three shows the assumed development costs per hectare for trees planted and maintained intensively enough to obtain the yields shown in Figure Two.

IV COST OF HARVESTED WOOD

Harvested wood costs, for indicative purposes, can be estimated by computing the development costs which must be incurred and amortizing these costs over the expected lifetime yield of the trees. A component must be added to this for harvesting expenses.

The annual yields used in this computation are shown in Figure Two. The lifetime yields are computed as follows:

1. Rainfall below 700 mm
   assume two harvests, at six and twelve years after planting. Average yield is obtained from Figure Two.
2. Rainfall from 700 to 1200mm
   assume two harvests, at five and ten years after planting. Average yield is similarly obtained from Figure Two.
3. Rainfall above 1200mm
   assume three harvests, at four, eight and twelve years after planting. Yield from Figure Two.

All development costs are converted to present value estimates at time of planting and summed. This sum is counted as total investment and amortized over the life of the trees at twelve percent a year, with payments assumed to fall due at time of harvest.

Figure Four shows the results of the estimation. The relationship shown explains, clearly, why wood is so expensive in arid environments. In environments of less than 700 to 800 mm of rain per year, wood becomes more expensive than petrolem on an effective unit of heat basis.

These computations assume fairly high yields, relative to current field experience, in the low rainfall conditions. It seems unlikely that wood can be produced much more cheaply than the costs indicated, at least, at the arid end of the scale on Figure Four.

These estimates do not include components for the cost of transport nor for land rent. In areas close to cities land rents are likely to be high. For distant areas transport costs will be significant. Similarly, in areas with little marginal land, rents will add a significant component to wood costs.

These estimates should be used with care because they are generalized and particular circumstances may change some of the factors involved. Nonetheless, they provide a general picture as to wood production costs and indicate why in some regions the relative competitiveness of wood is likely to be good and in others to be poor.

FIGURE TWO

YIELD Vs RAINFALL

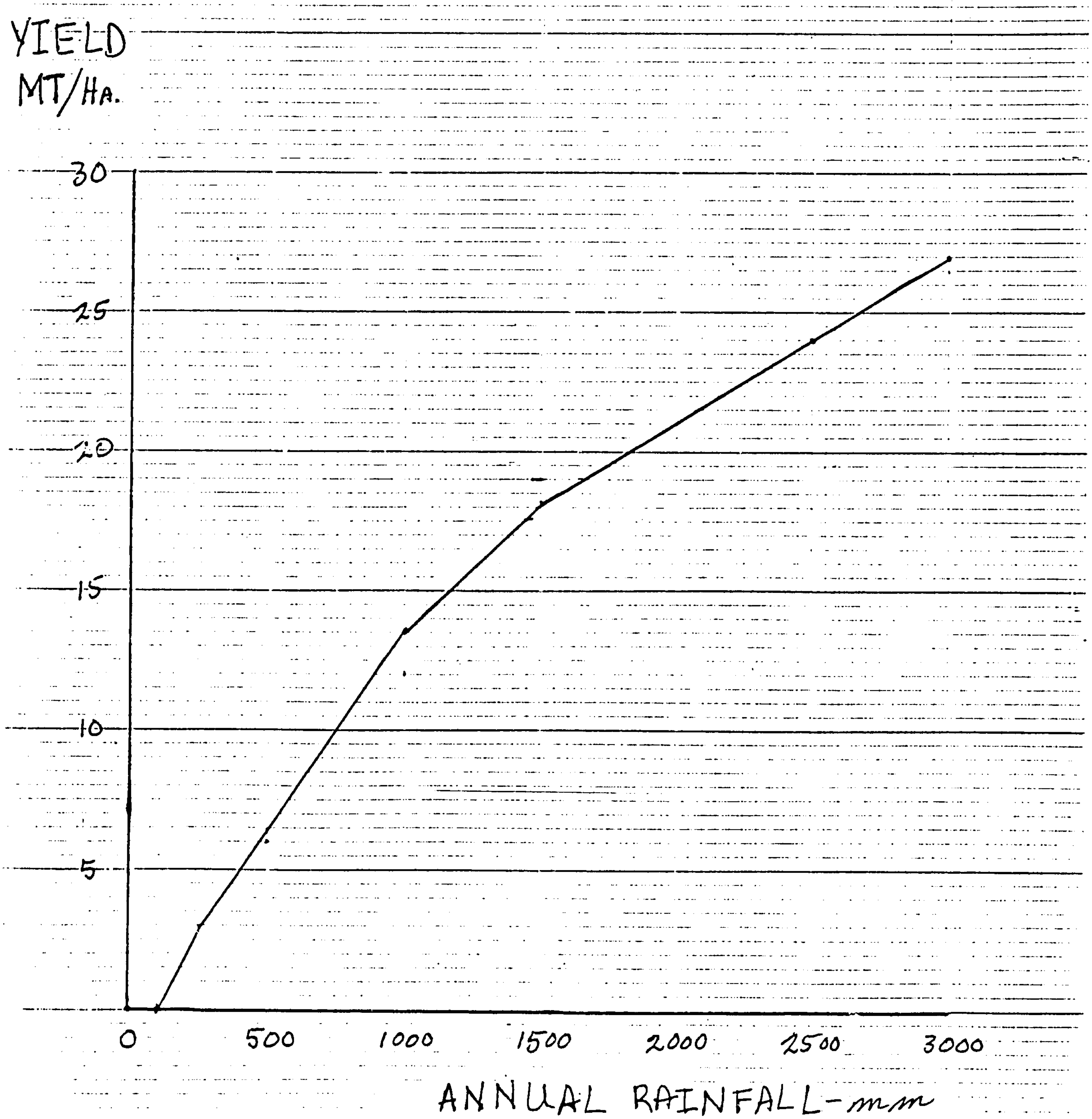


FIGURE THREE

COSTS Vs RAINFALL

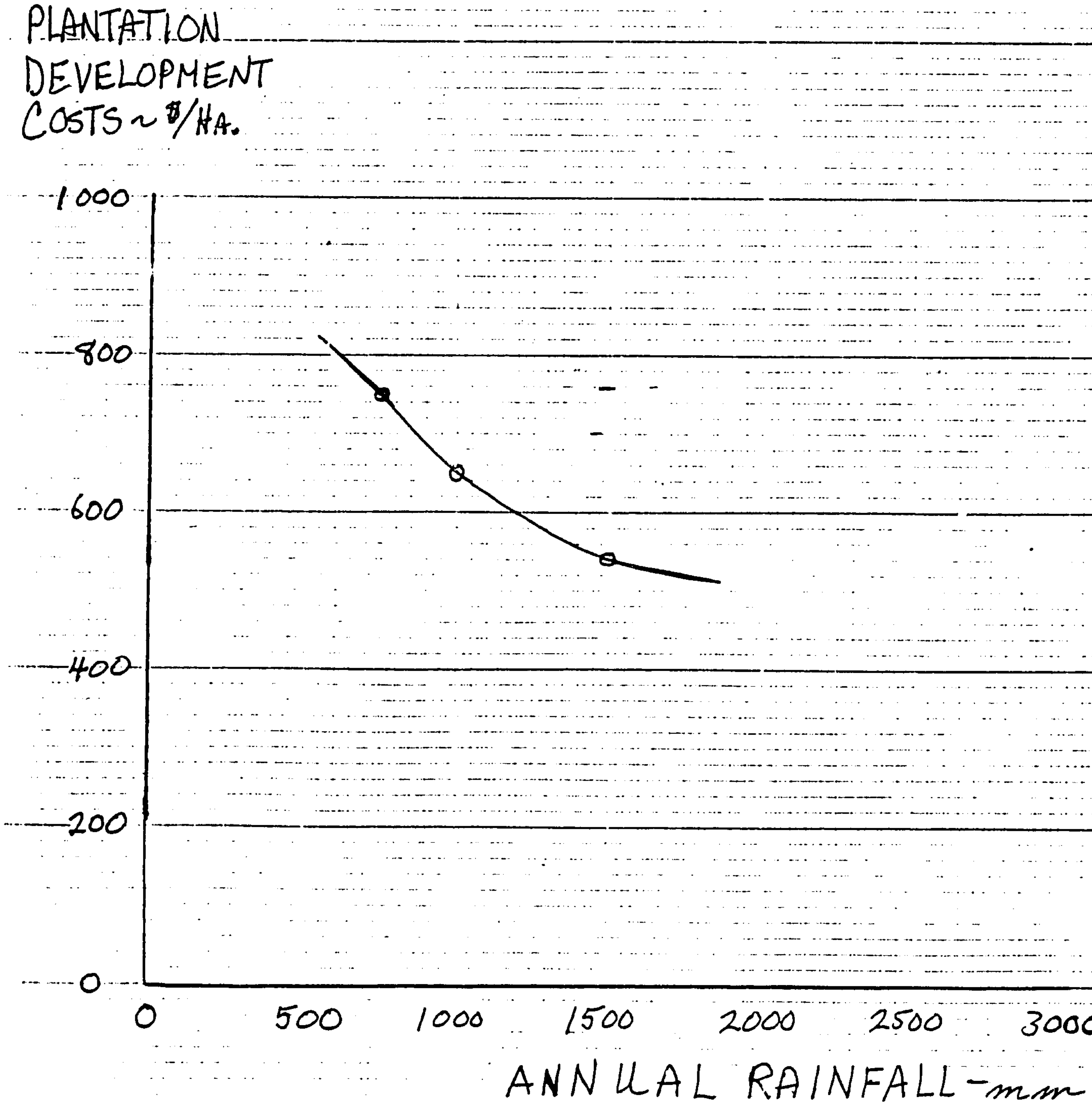
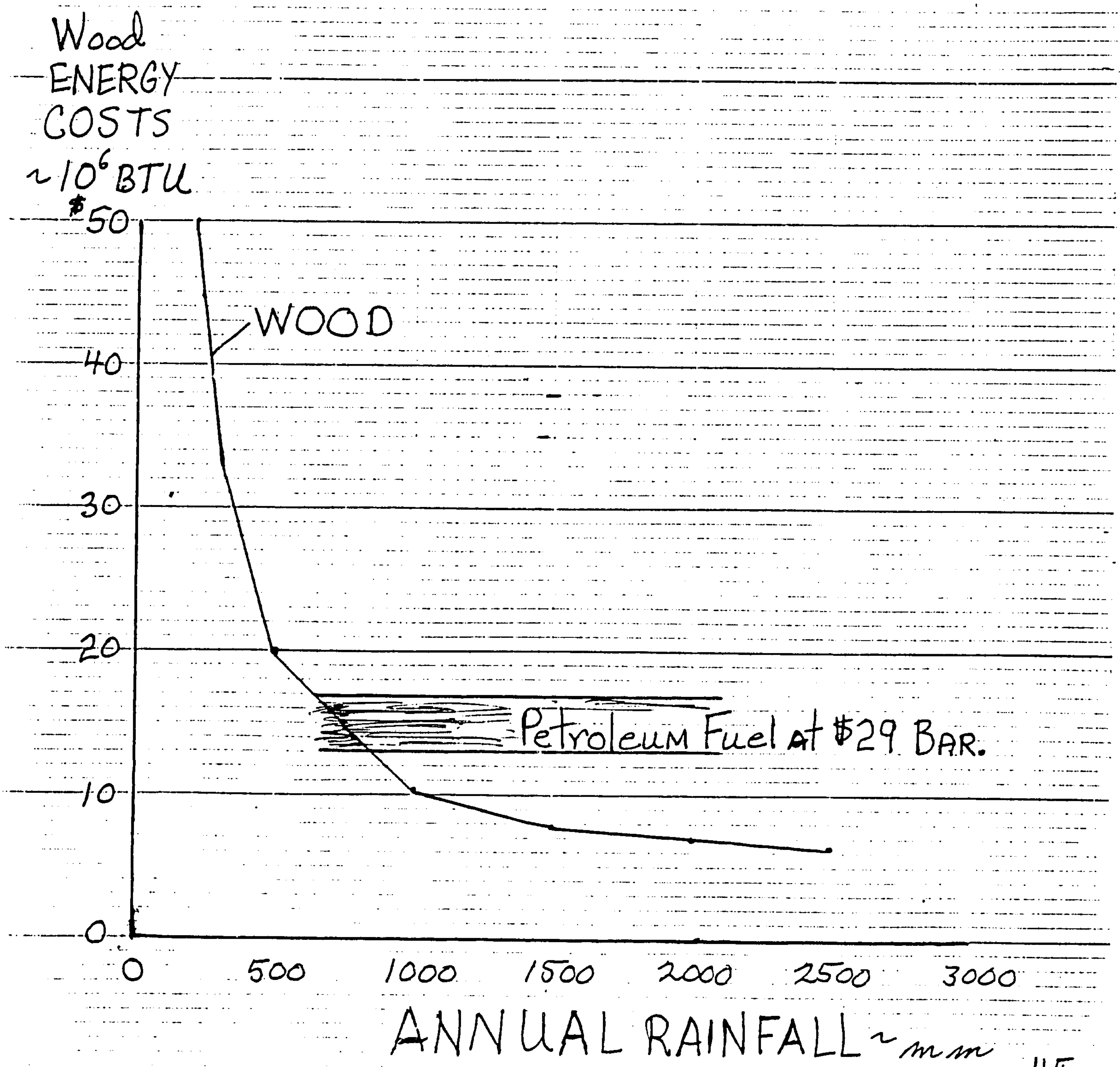


FIGURE FOUR
WOOD ENERGY COSTS vs RAINFALL



APPENDIX B

SUMMARY OF BIOMASS POINTS IN
AID ENERGY POLICY PAPER

AID recently published an updated policy paper on energy. This short note extracts the main points which that paper contains with regard to biomass energy matters.

1. Page 1, c1, para2. "These countries, especially the poorest, share the common problem of inadequate energy supplies--to fuel economic growth and to cook food."

2. Page 1, c1, para2. "These requirements for energy have led...[to] environmental degradation from an overexploited traditional fuel resource base."

3. Page 1, c1, para6. "AID will promote development of the most cost-effective energy supplies...especially in rural areas."

4. Page 1, c2, para4. AID will "direct significant attention to biomass fuels, and especially fuelwood research."

5. Page 2, c1, para3. "And traditional fuels(fuelwood, charcoal, crop residues, dung) are the principal source of energy for cooking."

6. Page 2, c1, para4. "...two major trends in energy have negatively affected economic development...depletion of wood and other traditional fuels to supply energy for domestic use."

7. Page 2, c2, para6. "Over the next two decades, population in AID-recipient countries is likely to increase by nearly 50 percent, adding a massive new energy demand on presently marginal supplies."

8. Page 3, c1, para1. "Fuelwood(wood, leaves, branches) is a major source of energy for cooking, because it is an historically available source gathered without cash. Unfortunately, the sustainable supply of fuelwood is declining in many regions as an expanding population clears land to increase food production and supply fuelwood.

9. Page 3, c1, para2. "The consequences of deforestation not only affect domestic needs. Other results are soil degradation...and, in extreme cases, desertification."

10. Page 3, c1, para3. "As shortages of traditional fuels increase, more and more human energy is required to collect energy, or to generate cash income to pay for fuel."

11. Page 3, c1, para4. "For many countries, however, the alternatives to using fuelwood for cooking have limitations: Burning crop wastes and dung deprive the soil of organic fertilizers that, to maintain productivity, must be replaced by

chemical fertilizers at considerable cost."

12. Page 3, c2, para2. This paper cites several factors as causing energy problems "...and most importantly, a lack of capital."

13. Page 4, c2, para7. "AID will promote the most cost-effective energy project alternatives on the basis of comprehensive economic analysis."

14. Page 5, c2, para1. "Particular attention will be paid to the energy requirements of rural areas supporting agriculture and employment as well as to meet the need for domestic fuels."

15. Page 5, c2, para6. "AID's orientation gives it a particular interest in energy activities directly supporting the rural economy..."

16. Page 6, c1, para5. "AID will...help developing countries undertake primary data collection to understand how much energy, in what form, by what groups, and the likely sources to support agricultural and rural development progrsm."

17. Page 6, c2, para4. "AID will direct significant attention to biomass fuels, consistent with AID forestry policy...and the need to supply domestic energy. AID should support efforts to expand production and conversion of fuelwood, crop residues, and possibly energy crops in countries with appropriate resources."

18. Page 6, c2, para5. "AID can help...[in] defining the nature and magnitude of the scarcity problem..."

19. Page 7, c2, para9. "AID will undertake a major fuelwood research initiative."

20. Page 8, c1, para4. "AID will...analyze economic, financial, social, and institutional issues surrounding fuelwood production, marketing and distribution."

21. Page 8, c1, para7. "AID will select energy systems for research and field testing with the best economic potential (without subisdies) to meet the most significant end-uses."

22. Page 8, c2, para6. AID will "...investigate the use of biomass and other renewable energy systems for urban application."

COMMENTS ON THE POLICY PAPER
(BIOMASS CONCERNS ONLY)

I. OVERALL CONCEPT OF PAPER

The paper moves the concept of the energy sector forward in important ways. It recognizes the cooking fuel problem and it does not speak of a crisis, but rather a continuing and probably worsening shortage/cost situation. See particularly 1, 6, 7 and 10 above.

II. TECHNOLOGY DRIVE FOR FUELWOOD

It speaks of the need for appropriate solutions and of economic considerations. See 3, 13, 20 and 21 above. The paper, however, is technology driven by fuelwood. See 4, 17, 19 and 20 above. While the paper recognizes that crop residue and dung are fuels for the traditional sector, except for a passing reference to crop residues in 17, above, the emphasis is on fuelwood without consideration as to its appropriateness nor to its cost. This is probably the major weakness of the paper and will likely result in significant misallocation of resources if a better balanced view is not adopted.

III. RESTRICTED ENVIRONMENTAL CONCEPTS

The environmental concepts regarding fuelwood and deforestation and burning of dung are one-sided. While the points being raised are important, only one view of the situation is presented. There is an important need for better balance. See 2, 8, 9 and 11 above.

IV. FUELWOOD GATHERING AND DEFORESTATION

The view is maintained, though softened that fuelwood is an important cause of deforestation. Available evidence, which is imperfect but plausible, suggests that very little of tropical deforestation relates to fuelwood gathering. This is not really a major point in the paper, but it does continue a mind set which is somewhat off the mark. See 8 above.

V. NEED FOR BETTER DATA

The paper makes some important points on the need for better data collection. See 16 and 18. Given our limited understanding of the traditional fuel sector and of appropriate response to scarcity, more emphasis should probably be given to data collection as part of or a precondition for fuel related assistance projects.

VI HOLISTIC VIEW OF BIOMASS PRODUCTION

The interaction of biomass use and production for fuel with biomass use and production for food, feed, fertilizer, construction materials, etc. is touched on only insofar as there is a concern expressed about the burning of dung and crop residues (the fertilizer interaction). Limited biomass productive capacity must be allocated in a manner to meet a variety of human needs. Fuel use and production cannot, in many environments, be separated from these other uses. There is a need for a holistic view of biomass production which is almost completely absent in this paper.

APPENDIX C

COMMENTS ON BANGLADESH ON-FARM FORESTRY PID

APPROVED OCTOBER, 1984

I. INTRODUCTION

This brief paper will review the Bangladesh Farm Forestry PID and make comments as to subjects which were not well discussed in the PID. The primary purpose is to show by concrete example the program implications of some of the findings from the wood energy review.

II. MAJOR POINTS IN THE PID

The emphasis in this section is on the PID's overall perception of the situation and of the appropriate corrective actions.

A. Stated Goal--Improve the well-being... [of] rural population by increasing overall production of forest resources to...per capita...[availability of] fuelwood reaches 9 cu.ft. (See logframe.)

B. The PID argues that if the burning of dung and crop residue is to be eliminated it will be necessary to supply 9 cu. ft. of wood per capita for cooking. (See page 3 and logframe.)

C. The PID indicates a continuing decline in per capita consumption of wood and an increasing tendency for the rich to no longer allow the poor to gather straw from their lands for fuel purposes. Bangladesh is said to be one of the world's lowest in fuelwood consumption per capita. Figures showing higher levels in India, Sri Lanka, etc. are given as justifying increasing the Bangladesh fuelwood supply. (See page 3.)

D. The PID states that the effects of the project will be felt after 15 to 30 years when research and institutional capabilities will mature. (See page 4.)

E. Assistance will go to the Bureau of the Forestry.

F. There is an assumption that on-farm trees are being cut down at a rate 5 to 10 greater than the rate at which they are planted. (See page 3.)

G. It is stated that the poor families without agricultural land can benefit from the project because they can grow wood on their homesteads. (See page 10.)

H. The PID cites a population density, overall, for Bangladesh of 1700 people per square mile. (See page 3.)

III. COMMENTS

A. Currently fuel wood consumption in the rural areas of Bangladesh is very low. Such wood as is burned is burned by the larger landowners.

B. The stated goal of a supply of 9 cu. ft. per capita would be enough to supply almost 100% of the rural areas cooking requirements.

C. Currently supplies of cooking fuels in the rural areas are severely constrained. Consequently, whatever biomass that can be found is burned, this means use of rice straw, jute sticks, weeds and so forth.

D. The constraint of cooking fuel availability appears to be per capita biomass production potential and the competing uses to which that production potential must be put.

E. Micro studies have suggested that homestead area available for biomass growth is severely restricted, especially for the poor and that all available area is already used.

F. Simple ca[illegible]ions, assuming moderate fuelwood yields, suggest that, wit[illegible] current population, about 12% of total land area would h[illegible]o be planted to trees to meet the per capita target of 9 cu. ft. In the time frame of the project (15 to 30 years from now) the percent of land needed to meet those fuel wood targets for the larger population would be in the range of 20 to 24%. These percentages are with reference to total area, if corections are made to exclūde land occupied by housing, streams, roads and so forth the percentages would increase to at least 14% for today's population and 25% for the future.

IV. CONCLUSIONS AND RECOMMENDATIONS

It is doubtful that wood is the answer to the cooking fuel problem. Currently the people rely, in large measure, on residues. They use available land only for trees which produce food and fodder and construction materials. The wealthy burn some of the products from these trees, but not much. The amount of land required to produce fuelwood is very large in an environment where population is bumping against the limitation of total biomass potential.

It seems highly likely that a multipurpose crop, probably rice, will continue to supply the local fuel needs. Land must be put to the highest productivity use and currently the farmers decide that the highest value use is rice. I doubt that the farmers are wrong. Homestead areas are very modest, but even so the homestead's land is used for higher value outputs. When the outputs are from trees, they are construction wood, fruit, sometimes fodder and perhaps medicines. Fuelwood is too low in value to compete for this high quality production area.

Thus, the PID proposes a project to pursue what is probably an inappropriate solution to the cooking fuel problem. It proposes spending resources on research and demonstration on a plant which currently provides a very small portion of fuel and that mostly for the wealthy. This is a situation which is likely to remain that way into the future.

Nonetheless cooking fuel supply is a major problem which faces Bangladesh. We do not understand very well the question of how to achieve optimum allocation of limited biomass production potential so as to produce the maximum social good. I would suggest that this project be modified to examine the question of producing required fuel supplies within the context of a holistic view of the biomass production potential. Further, the definition of fuel should be expanded to include any biomass suitable for burning. Fuel use should be examined in competition with food, feed and fertilizer and perhaps construction material.

This would provide the opportunity for breaking some new ground for the countries such as Bangladesh which are reaching the point of total supportable population without major overall changes in biomass production technology.