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THE PRESENT AND FUTURE STATUS OF PRODUCTION AND CONSUMPTION OF FUELWOOD IN EL SALVADOR

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THE PRESENT AND FUTURE STATUS OF PRODUCTION AND CONSUMPTION OF FUELWOOD IN EL SALVADOR

by

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ROCAP - RENARM Project - Component for the Disemination of
Multiple Purpose Tree Species (MADELEÑA-3)

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EXECUTIVE SUMMARY

According to FAO (1988) Central America lost 31% of its forest area between 1963 and 1985 compared to a loss of 11.4% for all of Latin America. This forest loss is accompanied by the problems of environmental degradation and scarcity of tree products associated with deforestation. El Salvador as the smallest and most densely populated country in the Central American region has one of the severest deforestation problems because of its reduced forest cover (12% of the territory is forest covered and only 3% has natural forest). Studies have indicated that the national consumption of fuelwood has reached the point that consumption is greater than the available sustainable production of woody biomass from the countries tree resources. According to the national energy balance for 1990 prepared by CEL, 51% of the total net consumption of energy and 84% of the total net consumption in residential and commercial sectors in the country is represented by fuelwood. The calorific value of the fuelwood annually consumed in El Salvador if converted the equivalent calorific value in barrels of petroleum would have a value of greater than 153 million US dollars CIF at the 1990 import price.

This study was developed to provide up to date information on the supply and demand of fuelwood in El Salvador. The study combines secondary information from past studies and information obtained from surveys of households, industries, businesses, and enterprises involved in the production and commercialization of fuelwood. To carry out these surveys the country was divided in to 4 agroecological strata based upon present and past land use. A further division separated the Metropolitan Area of San Salvador-AMSS (which was also divided into marginal and non-marginal areas), the urban departmental, and rural areas. Specific surveys were carried out for the residential, industrial and business sectors and distributors, transporters, and producers of fuelwood in all the municipalities in the country selected for the surveys.

A national per capita consumption of fuelwood of 2.12 kg. was determined from the surveys. The total consumption of fuelwood per year is 4,184,266 tons. Of the households surveyed, 89% of those in the rural areas , 48% in the urban departmental areas, and 49% of households in the AMSS marginal areas use fuelwood as their primary source of cooking fuel. Approximately 83% of the total volume of fuelwood consumed in the residential sector is consumed in the rural areas, and 76% of the rural consumption is gathered fuelwood which means that 63% of the national residential consumption of fuelwood is satisfied by fuelwood gathering.

Those households which gather their fuelwood gather it from isolated trees or fences, coffee plantations and brushlands. Isolated trees and fences are often not included as a source of supply but in the study 25% of the fuelwood gathered comes from isolated trees and fences compared to 23% coming from coffee plantations and the rest primarily from brushlands and some from forested areas. This has important implications for fuelwood programs.

Fuelwood prices as reported in the surveys have tended to increase at a rate greater than the rate of inflation (inflation is calculated using the consumer price index reported by the General Directorate of Statistics and Census). Average fuel costs per year for a family of 6 were calculated for families using propane gas or fuelwood exclusively. The annual cost of fuelwood was 1,303 salvadoran colones compared to 449 colones for propane gas. These costs only reflect the cost of fuel and do not include the cost of the stove for gas. The residential survey also indicated that only 2% of the fuelwood users in the rural areas use improved energy efficient stoves, while there were no instances of improved stoves in the urban departmental areas or the AMSS.

The principal area in which charcoal is used is the residential sector of the AMSS. In the households which use charcoal, charcoal is a secondary fuel but a well accepted fuel. The households interviewed where charcoal was used indicated that they plan to continue to use it indefinitely. In a telephone survey of 1000 households in the AMSS, 45% of the households interviewed used charcoal while only 6.6% use fuelwood. The average annual per capita consumption in the households that use charcoal was 19.4 pounds.

The business and industrial sector uses a total of 267,000 metric tons of fuelwood per year compared to the more than 4 million tons used in the residential sector. Major uses in this sector are for bakeries, brick and tile kilns, coffee processing and lime kilns. The industries most likely to increase consumption of fuelwood are the brick and tile kilns which must meet the demand for new housing for a growing population.

The surveys of producers and transporters of fuelwood indicated a heavy reliance on coffee plantations as a source of fuelwood. The majority of the fuelwood commercialized in the country comes from coffee plantations while the non-commercial consumption comes from coffee plantations, fallow lands, and isolated trees and fences. The largest producers and transporters were concentrated in the coffee producing areas while some localized supply of fuelwood to urban departmental centers originated from fallow lands.

An estimate of the sustainable supply of fuelwood was made based upon secondary information available from studies of CEL and CATIE. The sustainable annual supply of fuelwood was estimated at 3,884,298 metric tons which, when compared to the demand for fuelwood results in a deficit of 574,968 tons per year. Demand is greater than the sustainable supply. This deficit gives rise to deforestation and a decline in the productive capacity of the forest resource due to the need to harvest more fuelwood than is produced by the forest through annual growth.

The area of forest cover in the country has actually increased in some instances due to the abandoning of agricultural fields as a result of farmers fleeing the civil conflict. These abandoned areas have grown back in natural vegetation. Due to this the available supply has increased in some areas. Although there has been an increase in forest cover, with the return of peace to the country, people will be returning to the rural areas and clearing that vegetation in order to put the land back into agricultural production. There will probably be

a significant although temporary increase in fuelwood supply which may encourage greater consumption. This period of increased supply will likely be followed by a period of increasing scarcity of fuelwood as those areas of new secondary vegetation are converted to agriculture.

From the results of the surveys and review of secondary information, it is evident that the majority of the fuelwood marketed in El Salvador originates from coffee plantations and is sold in the urban centers of the country. The fuelwood consumed in the rural areas is in most cases gathered by the households that use it and comes from a variety of sources. This has important implications for programs or projects aimed at improving the fuelwood situation.

First, for the urban areas where fuelwood is purchased, there are opportunities for substituting fuelwood with propane gas since the propane gas is cheaper than fuelwood. The major obstacle to that substitution is the inability of low income households to invest in a gas stove. The provision of credit or some other type of assistance to help households of low income purchase stoves could provide the opportunity for many of those households to substitute gas for fuelwood.

Secondly, for rural areas where the households do not purchase fuelwood, it is unlikely that they will change from an energy source which they can gather with no out of pocket cash expenditure to propane gas which requires a cash expenditure for the gas as well as a substantial investment in a gas stove. This is complicated by the fact that real wages in El Salvador have declined over the past several years and unemployment is a problem.

The present deforestation in El Salvador and the associated environmental problems combined with the present deficit in the supply and demand relationship for fuelwood emphasize the need for efforts to try to ease the fuelwood problem which, at the same time, can offer opportunities to increase the forest cover of the country. Recommendations for addressing these problems can be divided into two categories: i) efforts to increase the supply of fuelwood; and ii) efforts to decrease the demand for fuelwood.

Recommendations to increase the supply of fuelwood are divided into recommendations for areas where fuelwood is marketed and for areas where fuelwood is not marketed. In areas where fuelwood is marketed, there are opportunities to establish plantations close to population centers for the purpose of producing fuelwood. These fuelwood plantations can be made more profitable if fuelwood production is combined with the production of other, more valuable tree products such as lumber, posts, rural construction materials. Production of charcoal is another option which could be produced from plantations and provides a fuel cleaner than fuelwood and better adapted to urban areas.

In the rural areas where fuelwood is not marketed, it is recommended that farm and agroforestry plantings be promoted to provide fuelwood and other tree products for home consumption or sale. Research and projects which have been implemented in the 1980's

provide valuable experience for the development of such programs and have had success in promoting tree planting by farmers when they have been able to demonstrate the benefits the trees can provide. This valuable experience should be taken advantage of.

Recommendations for decreasing the demand for fuelwood include substitution with other energy sources, use of improved stoves, and the use of improved kilns for charcoal and brick and tile making. Substitution of fuelwood with propane gas is the most viable option for urban areas where fuelwood costs are high compared to substitutes but not appropriate for rural areas. Household surveys indicated that approximately 10% of the households presently using fuelwood in the urban and metropolitan area would prefer to use gas. This offers opportunities for substitution if some kind of mechanism is developed to help consumers with the initial purchase of stoves. Programs of substitution of fuelwood with residues produced during the processing of sugar and coffee have been successful in the industrial sector and little additional progress is possible there.

The use of improved stoves is needed in all areas of the country but will require research into stove design and extension or marketing programs to promote the stoves. These efforts could possibly be combined with credit programs. More than 95% of the households surveyed reported using open or semi-closed fires for cooking. Past studies have shown that 30-50% savings can be obtained through improved stoves. There are efforts presently being made to promote the Lorena stove with some success. These experiences can provide valuable information to guide future efforts.

The use of improved kilns for charcoal, brick and tile making provides an opportunity to reduce fuelwood consumption in industries which will probably be growing in the future. This is also an area which requires research and the development of programs promoting the use of improved kilns.

The data gathered through surveys and other secondary information available indicate a demand for fuelwood greater than the present supply. This is a situation which requires concrete actions in the short term and long term planning to guarantee a sustainable supply of fuelwood to meet the countries needs. This study makes recommendations but it will be important to consult with those individuals and institutions with research and extension experience in order to design and promote programs to address the fuelwood problem through increasing the supply and diminishing the demand for fuelwood.

Present and Future Production and Consumption of Fuelwood in El Salvador

I. INTRODUCTION

The Central American region has and continues to experience a high rate of deforestation. Between 1963 and 1985, Central America experienced a reduction of 31.3% in the forest area (forest and scrubland), which was the greatest reduction in the Latin American and Caribbean region which experienced a global reduction of 11.4% for the same period (FAO, 1988). According to the "World Resources Report" of 1986, the closed forests of Central America are experiencing a deforestation rate of 2.2% (IIED/WRI, 1986). This present and past deforestation has caused a series of problems for the nations in the region, related to environmental deterioration and scarcity of tree products.

El Salvador, being the smallest (21,000 km^2) and the most densely populated country in the Central American region (248 person/km^2), and having the lowest percentage of the forest cover in the region, has not escaped the problems of deforestation, environmental degradation and scarcity of forest products,. Mansur (1990) reports that 12% of the national territory has forest cover and natural forests barely cover 3% of the total area of the country. According to Mansur's calculations, if the present population growth combined with the demand for forest products associated with this population continues at the present rate, the supply of forest products is not, nor will be sufficient for satisfying this demand and the forest resources will be exhausted (with the exception of coffee plantations) by the year 2004, 12 years from now.

Fuelwood, as an energy source, plays an important role in El Salvador. According to the national energy balance for 1990, fuelwood represents 51% of the total net consumption of energy and 84% of the total net consumption in the residential and commercial sector[1]. If the calorific value of the fuelwood consumed in 1990 were to be converted to its calorific equivalent in barrels of petroleum at the 1990 import price, it would have a value of US$ 156,308,000.00 CIF.

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[1] The total, net consumption of energy includes the sectors: i) residential and commercial; ii) transportation; iii) industry and agriculture; and iv) others. Sources of energy considered are: i) hydraulic energy; ii) geothermic energy; iii) petroleum; iv) coal; v) fuelwood; and vi) organic residues.

According to the data from the national energy balances through 1987, the total volume of fuelwood consumed had shown a decrease. Between 1987 and 1991, the balance shows an increase in total volume consumed, which is also reflected in this study. This increase is most likely due to population increases. Although the total consumption has increased, the percentage of energy use represented by fuelwood consumption in the energy national energy balance has decreased in the period between 1970-1990 (See Figure 1).

The advantage of fuelwood as an energy source is that it is renewable, although at the current rates of consumption, this renewability is not sustainable. According to estimates calculated by Mansur (1990), fuelwood consumption is contributing to deforestation. This is also reflected in other studies prepared by CEL, as well as students' theses. In all of the past cases reviewed, fuelwood demand and consumption is greater than supply. The fuelwood resources are subject to a process of "mining", which reduces fuelwood supply and thus contributes to deforestation.

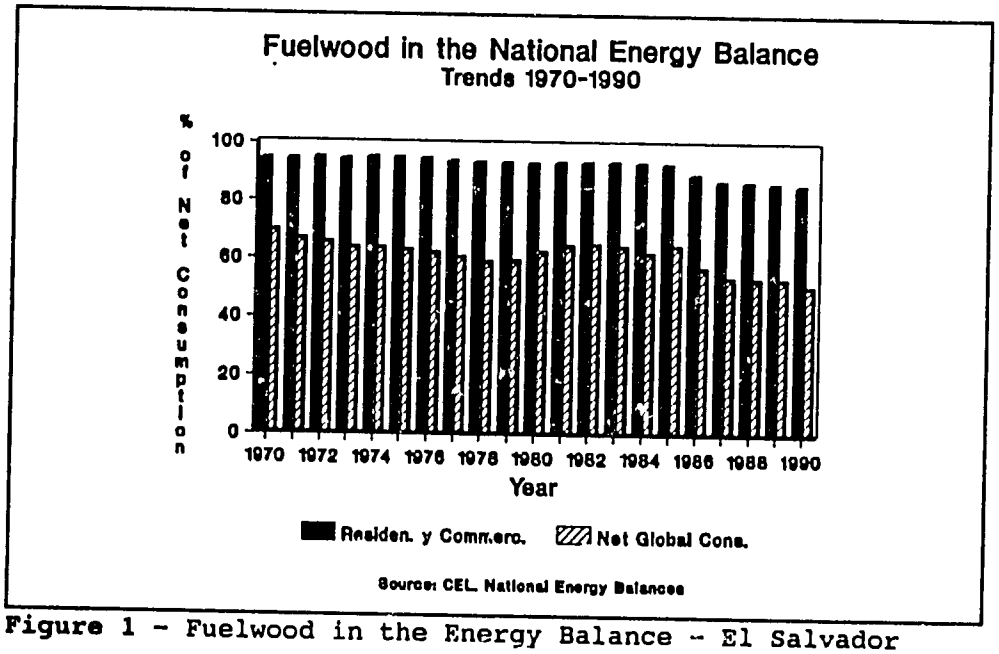

Figure 1 - Fuelwood in the Energy Balance - El Salvador

Recognizing the deforestation and related environmental problems, the government of El Salvador, in collaboration with local NGO's, has worked on the development of a national strategy for the management of natural resources. This effort was limited by the lack of basic information. The government, through the Ministry of Agriculture and Livestock and CEL, requested support from USAID in defining more clearly the fuelwood situation in El Salvador. On the basis of this request, this study was developed.

OBJECTIVES

The specific objectives of the study are:

- Quantify the supply and demand of fuelwood in El Salvador and their tendencies, synthesizing the results of the study with the results of previous studies of CEL and other organizations.
- Identify the efforts carried out to date in confronting the problems.
- Offer suggestions and recommendations based on the information generated by the study and other sources to contribute to the resolution of the problems.

ANTECEDENTS

The problem of forest resources and fuelwood demand as an energy source in El Salvador has been the primary or secondary theme in many studies that have been carried out in El Salvador in the 1980's. The majority of those studies were carried out by CEL. Following is a description of the principal studies carried out in the past:

1. CEL-PNUD. 1980. National Energy Balances

- National survey for quantifying fuelwood consumption for inclusion in the National Energy Balance. The study was limited to measuring the consumption without considering other factors.
- A daily/per capita of 3.15 kg./day was determined at the national level.

2. CEL-OEA. 1985. The current state of production, consumption and marketing of fuelwood in the Municipality of Ahuachapan.

- A detailed study that stratified the municipality on the basis of the available fuelwood supply in an area including coffee plantations.
- Detailed but limited to only one municipality.
- A per capita consumption of 2.55 kg./day was determined for the total population, both consumers and non-consumers of fuelwood.

3. CEL-BID. 1987. Energy demand for final use in the residential sector in the urban and rural areas.

- Limited to fuelwood consumption related to other factors of housing such as monthly income and the method of supplying fuelwood.
- A daily/person consumption at the national level of 2.10 kg./day was determined.

4. CEL-BID. 1987. Evaluation of potential fuelwood resource.

- The first intent since the 1970's to quantify the fuelwood supply in the country, based on an inventory using aerial photographs. In this work, the interpretation of satellite images (LANDSAT) was used.
- An effort was made to quantify the biomass production of the vegetative-types identified in the images. These measurements were developed as a pilot project, which requires follow-up activities to refine the work.
- The first classification of vegetation using satellite images and serves as the basis for future measurements, but refinement and repetition for registering the changes in the vegetative cover are lacking.
- The deficit that exists between the demand and the supply of fuelwood and the effect of the lower calorific value of the species that are utilized for fuelwood under conditions of scarcity were demonstrated.

5. CEL-OEA. 1989. Marketing of fuelwood and charcoal in the metropolitan area of San Salvador (AMSS)[2].

- This study was limited to the AMSS.

Although past studies on the fuelwood situation in El Salvador exist, the present study is justified because: i) many of the past studies have dealt with only one aspect of the problem such as fuelwood consumption at the national level and the fuelwood market in the metropolitan area of San Salvador; ii) in many cases the information has not been widely distributed enough to influence persons that can make policy changes, or promote projects to improve the situation; iii) there is a need to make concrete recommendations on alternatives available for solving the problem.

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[2] The metropolitan area of San Salvador (AMSS) is composed of the municipals of San Salvador, Mejicanos, Soyapango, Delgado, Cuscatancingo, Ayutuxtepeque, Ilopango. and San Marcos of the department of San Salvador, and the municipals of New San Salvador (Santa Tecla), and Antiguo Cuscatlan of the department of La Libertad.

This study makes use of the results of the works already carried out in the past, updates and expands the information available, and provides recommendations for solving the problem of fuelwood supply and environmental degradation caused by fuelwood gathering. This study differs from those in the past in the following aspects:

1. Stratification into agroecological zones based on differences in the availability of fuelwood.

2. Identification of fuelwood sources, both the source of the fuelwood supply as well as the type of vegetation exploited for fuelwood.

3. Analysis of prices and price trends.

4. Division of the AMSS into marginal and non-marginal areas to demonstrate the differences in the fuelwood consumption.

5. An estimation of the supply based on satellite images.

6. Concrete recommendations based on more than 10 years of research on multipurpose trees and the promotion of the MPT systems by the Leña and the Madeleña projects of CENREN-CATIE and other similar efforts.

II. METHODOLOGY

For the development of the methodology, the terms of reference served as a guide. First, the country was divided into three areas based on the scheme used for reporting the population of the country by the General Directorate of Statistics and Census (DIGESTYC): 1) the metropolitan area of San Salvador (AMSS); 2) Urban departmental, which consists of the urban areas of the municipalities with population concentrated in the urban centers, excluding the AMSS; 3) the rural area which covers the other, non-urban areas. The municipalities within the conflictive zones were excluded due to the risks involved in visiting those areas. This division provides a framework that allows the identification of the population at each level and at the same time is a natural stratification with respect to the use of fuelwood, since there is greater use of fuelwood in the rural areas than in the urban areas and greater use in the urban areas than in the AMSS.

STRATA

Urban Departmental and Rural

The rural and urban departmental areas were divided a second time into 4 strata according to agroecological zones, based on the assumption that the existence of fuelwood producing vegetation is dependent upon the land use in these zones and thus will have an impact on the availability and use of fuelwood. These zones are:

1. Northern Zone: includes the northern zone of the country which are hilly lands with strong slopes cultivated using a system of migratory agriculture with fallow areas combined with extensive pasturing. Here, pines mixed with oak and brushlands are found. Since there are pines and brushland, it is assumed that there is more tree vegetation than in the cotton and clean cultivation zones. This zone has also been one of the most conflictive areas in the country and the elimination of some areas from the study was necessary.

2. Clean cultivation zone: includes the municipalities where continuous agriculture predominates and is primarily the central zone of the country. It is relatively flat with little tree vegetation, therefore it is assumed that there is less availability of fuelwood.

3. Coffee zone: includes the municipalities which are predominately coffee cultivating areas. It has steep slopes but covered with tree vegetation. It is a zone where fuelwood is relatively abundant due to the prunings in the coffee plantations. Also, this zone supplies fuelwood to most of the urban centers of the country.

4. Cotton zone: includes the strip on the coastal plains in the eastern part of the country which was previously dedicated to cotton cultivation and was strongly affected by agrarian reform and the civil war. They are flat lands with little tree vegetation. It is assumed that there is less availability of fuelwood, although much of the previous cotton cultivation has been abandoned and replaced by secondary vegetation or agriculture.

Metropolitan area of San Salvador (AMSS)

In the AMSS, a division between marginal and non-marginal areas, defined by MIPLAN and the General Direction of Statistics and Census, was carried out. This division is an important distinction for the use of fuelwood in the metropolitan area. Most of the fuelwood use in the AMSS is located in marginal areas an area which has not been subject to

specific research on fuelwood use in the past. The marginal areas are characterized by spontaneous settlements established in uninhabited zones of the metropolitan area by persons of scarce resources, and refugees of the 1986 earthquake and the civil conflict. There is great variation in the infrastructure, services and the type of construction. Some of the areas have been subject to development programs and the construction of better housing. In the marginal areas, 135 households were surveyed (.45%), and in the non-marginal areas 540 houses were visited(.26%) and 95 surveys conducted to determine fuelwood consumption in households that use fuelwood.

In addition to the survey of households in the AMSS, a telephone survey of 1000 households (.48% of the non-marginal areas) was carried out to determine the degree of fuelwood and charcoal use in households with telephones.

Using the variable of daily consumption per person as an indicator of reliability of the sample taken, a simple average of a sample of 1,023 fuelwood users of 2.19 kg/person/day was calculated with a standard error of the estimate of 0.082.

SECTORS

The study focused on the residential sector with surveys of households, but it also included surveys in the sectors: industrial, transportation, producers and distributors. Questionnaires were designed for each sector and the survey was carried out in the municipalities selected for the sample, according to the sample framework. The questionnaires are available in the office of the Madeleña-3 Project in San Salvador or at CATIE in Turrialba, Costa Rica.

Residential Sector

This was the sector of most interest and on which the work was focused. The objective of the surveys in the residential sector was to define the type of energy used for preparing food, the quantity used per period, its cost, and energy preferences. With respect to households where fuelwood or charcoal is used, data on current and past prices and its variation during the year, the type of stove or fire used, source of supply, species preferences, form and the type of unit purchased and problems with fuelwood supply was collected.

Industrial and Business Sector

As part of the study, surveys of industries and businesses that use fuelwood in the study zone were included to determine the magnitude of the fuelwood use and the tendencies of that use. The industries include coffee processing, sugar mills, lime kilns, salt production and brick and tile kilns. Businesses include restaurants, pupusa[3] shops, bakeries, and cafeterias. The objective of the survey was to understand the production process, the type of energy used, the magnitude of fuelwood use, substitution of fuelwood, energy preferences, current and past prices and variations during the year, sources of supply, species preferences, form and the type of unit in which fuelwood was received and used, and problems with fuelwood supply.

Distributors

With respect to distributors, the objective was to determine the location, the magnitude and the services provided per operation, sources of fuelwood and charcoal, current and past prices and problems with fuelwood and charcoal supply. Distributors include fuelwood deposits, shops, supermarkets, markets and mobile vendors.

Transporters

The transportation sector is the sector that delivers fuelwood to the consumer or to distributors. The objective of the survey was to find out the size and the characteristics of the operation, origins and destination of the fuelwood transported, prices of purchase and sale, quantities of fuelwood transported during the year, and problems with supply. Although they exist, it was difficult to find transporters and in general the degree of cooperation was low. This is due to new regulations that require permits and permission to transport fuelwood and the fear of receiving sanctions or new taxes for transporting fuelwood.

Producers

The producers were defined as persons who, with some regularity, maintain fuelwood production for sale. The objective of the survey was to find out the origin of fuelwood, costs of production, sale prices, and the destination of the fuelwood produced. For the most

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[3] A pupusa is a traditional tortilla filled with meat, pork rind, cheese or beans, which is commonly consumed in El Salvador.

part, fuelwood producers are owners of coffee plantations in the coffee zones. In addition to coffee plantations, there are a few people who are dedicated exclusively to the production of fuelwood.

Table 1. POPULATION OF EL SALVADOR DIVIDED INTO STRATUM OF THE FUELWOOD STUDY AND THE NUMBER OF HOUSEHOLDSAND THE POPULATION OF THE SAMPLE

Location	Stratum	1991	# of Munic.	# households (sample)	persons in sample	persons /household
URBAN	- Cotton	223659	20	48	264	5.50
	- Coffee	417714	47	48	247	5.15
	- North	186189	84	47	281	5.98
	- Clean cultivation	463288	101	48	282	5.88
	- AMSS - Non-Marginal *	817718	10	92	613	N/A
	- AMSS - Marginal	174013	10	135	782	5.79
	TOTAL	2282581	262	418		
RURAL	- Cotton	418068	20	80	439	5.49
	- Coffee	683511	51	160	882	5.51
	- North	804374	84	160	991	6.19
	- Clean cultivation	1230466	107	240	1419	5.91
	TOTAL	3136419	262	640		
	Total URBAN and RURAL	5419000	262			

Cotton = Old cotton zone on the eastern Pacific coast.
Coffee = Coffee zone in the entire country.
North = Northern zone of the country with migratory agricultural and scrublands.
Clean cultivation = Clean cultivation zones, more permanent agriculture.
AMSS = Metropolitan area of San Salvador.
* = In non-marginal areas of the AMSS, only households that used fuelwood were interviewed.

SAMPLE UNITS

The sample was divided into three parts (the AMSS, the urban departmental, and rural areas) and the sampling framework prepared on the basis of the characteristics of these divisions.

AMSS

In the AMSS, the sampling began with a telephone survey of 1,000 households to determine the use of fuelwood and charcoal in non-marginal areas of the AMSS. Households were selected systematically from the telephone directory. The cases with no response were replaced with the following number selected. From this survey it was determined that the use of fuelwood in the households with telephones is very low and less than the percentage at the level of the AMSS registered by the Ministry of Planning in their results from Multipurpose Household Surveys. This difference is due to the inclusion of marginal areas

which have greater use of fuelwood than non-marginal areas. The greatest use of charcoal was registered in the households covered by the telephone survey.

To understand better the use of fuelwood in the metropolitan area, the AMSS was divided into marginal and non-marginal areas with a greater percentage of the sampling in the marginal areas. The focus in non-marginal areas was to determine the quantity of fuelwood used in those households that use fuelwood.

For selecting the sample for the marginal areas, maps developed by the General Directorate of Statistics and Census for the census to be carried out in 1992 were used. In the maps, all of the marginal communities are identified with the number of households in each community. The information was gathered by the personnel of the directorate in preparation for the census. In some of the zones in the AMSS, information was not available from the Directorate and for those cases, information from MIPLAN was used based on their sampling framework used for the Multipurpose Household Survey. All of the communities were listed with the number of households and the sample selected with probability proportional to size (size=number of households).

For the sample in non-marginal areas, assistance was provided by the Sample Research Unit of MIPLAN who provided a selection of their standard sample units used for the multipurpose household survey.

Rural

For the sample of households in the rural area, the municipalities were used as the primary, sample unit (UPM), which is the level of division for which there is population data. For controlling the variability of the population size in the municipalities, the municipalities were selected with a probability of selection proportional to the size of the municipality (Size=population). Within the municipalities, two cantons were randomly selected for conducting the survey and households were selected systematically in each canton. It was necessary to eliminate some cantons that were located in the conflictive zones of the country.

Urban Departmental

The selection of the urban centers for the sample was carried out as a random sub-selection within the municipalities selected for the rural sample.

POPULATION

In 1991 the population in El Salvador was estimated at 5,419,000 inhabitants, according to data from the international database of the U.S. Bureau of Census. The last, national census was carried out in 1971, and the estimations of the population are projections based on that census. The General Directorate of Statistics and Census (DIGESTYC) is preparing a national census in 1992 for the first time since 1971. To estimate the population, for the purpose of this study, the Avance Estadistico from the General Directorate of Statistics and Census published in April of 1991 was used, which estimates the population in 1988. Later, using the percentage increase in comparing the total population of 1988 with the population estimated at 5,419,000 inhabitants for 1991, the population per municipality for 1991 was estimated. It is important to understand that due to the lack of an updated census and the migratory movements as a result of the earthquake and the civil conflict since 1971, the population figures are only a rough estimate of the current situation.

FIELD WORK

A group of surveyors with experience in survey word related to the monitoring and evaluation of the agrarian reform in El Salvador was contracted. For the industrial surveys, only one surveyor, working with the assistant to the principal consultant, was used. The field work was carried out between November 26 and December 20, 1991 beginning with the rural areas and ending in the AMSS. The same group was responsible for coding the questionnaires and preparing the information to be entered into database files using a software package for microcomputers.

During the field work stage, surveyors met every Saturday to submit their work and to plan the work for the following week. The principal consultant or his assistant were present at these meetings for resolving problems and to discuss the work with the surveyors. When the field work and codification ended, each surveyor prepared a summary of the work and their personal assessment of the fuelwood situation and the effectiveness of the surveys based on their field experience.

ADDITIONAL WORK

In addition to the surveys within the sectors, research was carried out on the number of trucks entering the AMSS with fuelwood and charcoal, and the costs and conditions for the purchase of kerosene and propane gas stoves and ranges. The research carried out on

trucks entering the AMSS consisted of locating persons in all of the main entrances of San Salvador. These persons kept records of the type of truck (capacity) and if they carried fuelwood or charcoal or both for a period of a week. The research on the costs of propane gas and kerosene stoves was carried out through visits to businesses in the AMSS that sell stoves. For defining the fuelwood supply, a vegetation map elaborated by CEL based on satellite images was used.

ANALYSIS

The information was entered, verified and summary tables were prepared by an experienced group who specialize in this type of work. This process was carried out between January 4 and March 27 of 1992, the information was submitted to the principal consultant for additional analysis and the final report was prepared. The files verified from the database are maintained in the offices of CATIE in El Salvador and at the central headquarters in Costa Rica, with copies submitted to AID - El Salvador.

III. DEMAND FOR FUELWOOD

The demand for fuelwood in El Salvador comes from three different levels: i) the demand at the residential level; ii) the demand at the industrial level (processing plants, sugar mills, lime kilns, salt producers and brick and tile kilns); and iii) the demand at the level of businesses that use fuelwood for preparing food for sale (bakeries, tortilla shops, cafeterias, and pupusa shops). This demand is directly related to the population of the country and increases at a rate proportional to the population growth, although modified by the process of urbanization and the substitution with other energy sources. Urbanization tends to decrease the fuelwood demand because of the substitution of electricity or other types of energy derived from petroleum, such as propane gas and, on a lesser scale, kerosene. In the industries, fuelwood is substituted with waste products that are produced through the processing of coffee, sugar cane and the use of other energy sources such as tires and crop residues.

To understand better the demand and to identify the sectors with the greatest demand for fuelwood, the country was divided into the different strata previously described, using criteria related to the magnitude of the fuelwood consumption. In the residential sector, a division between the metropolitan area of San Salvador, the urban departmental, and the rural areas was carried out. Later the rural and the urban departmental areas were divided

into: i) the northern zone with fuelwood coming from scrubland and fallow lands; ii) the clean cultivation area with the hypothesis that these areas would have less fuelwood supply; iii) the cotton zone which, for having or having had large extensions of this crop, also does not offer much fuelwood; and iv) the coffee zone which, due to the large extensions of coffee plantations that require annual pruning, has greater fuelwood supply.

In San Salvador, the studies in the past have considered the AMSS as a single unit while there is a great difference in the fuelwood consumption between marginal and non-marginal areas. This was demonstrated through the telephone interviews with a bare 6.6% of this population that cooks with fuelwood, mostly combined with other energy sources. For this reason, the AMSS was divided into marginal and non-marginal areas with greater focus on the marginal areas because of the fuelwood consumed in these areas and because specific information has not been available for these areas in the past.

In the following sections, the fuelwood demand is analyzed utilizing the stratum and divisions established. First, there is a brief discussion of the country's population growth. Later, in a universal way and for each stratum, there is a description of the use, preferences and tendencies in fuelwood consumption and tendencies for change in the demand based on the results of the interviews and the revision of information from other sources.

POPULATION - TENDENCIES

The last national census was taken in 1971. Since then, the country has been subject to a civil war that has caused a migration of thousands of people within the country and emigration of many people outside the country. According to DIGESTYC (1991), El Salvador had a negative, national, migratory balance of 612,563 people from July, 1971 to June, 1988; in other words, during this period the number of people registered leaving the country minus those registered as entering the country, results in a balance of 612,563 people (based on the records of migratory control). CONADES (1988) reports a total of 162 out of 262 municipals with population displaced in 1987, with a total of 396,833 people displaced. Since the country is entering a period of peace, it is likely that a percentage of those that have emigrated will return to the country, which could increase fuelwood demand at a greater level than the increase caused by the population increase.

The data from the General Directorate of Statistics and Census of El Salvador shows an average, annual increase in population of 2.16% between 1972 and 1987, but those who have emigrated are not included in the calculations of the increase. The inclusion of these

persons would give a higher figure. FAO reports a figure of 2.93% (FAO, 1988) as an annual increase which may better reflect the population increase inside and outside the country. It is likely that with peace in El Salvador, there will be a population increase due to the return of a percentage of those that left the country because of the civil war. For that reason, a figure of 2.9% should be used for the purpose of estimating a population increase after 1991. Despite this, it is important to recognize that, with the changes that the country is experiencing now and the number of Salvadorans currently living outside the country, it is difficult to predict what the population increase will be.

RESIDENTIAL SECTOR

The greatest use of fuelwood is in the residential sector of the country. This use includes fuelwood gathered in the rural area, plus fuelwood purchased primarily for cooking. This fuelwood competes or is mixed with other sources of energy and its use is influenced by various factors. The factors measured with the survey and a discussion of the results are presented in the following sections.

Source of energy used and preferred

Tables 2 and 3 and figures 2 and 3 show the number and the percentage of households that use different sources of energy for cooking, and their preferences of energy in the urban and rural areas and in the marginal areas of the AMSS. In all cases the two most common types of energy used and preferred are fuelwood and propane gas, propane gas being the preferred energy source in the urban areas while fuelwood is preferred in the rural areas.

In the marginal areas of the AMSS, 49.3% of the sample use fuelwood for cooking, while another 39.3% use propane gas. Comparing current use with preferences, a great difference was registered since 20.1% prefer fuelwood while 75.7% prefer propane gas. The use of fuelwood is greater than the preference. Also, some of the respondents interviewed claimed that the cost of cooking with propane gas was less than cooking with fuelwood, but explained that the cost of purchasing a gas stove was prohibitive[4]. The investment that

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[4] The cost of a propane gas stove varies from 800 colones for a stove with one burner up to 3,100 colones for a stove with a cabinet and 4 burners.

propane gas requires in many cases is outside the range of what households with scarce resources living in marginal areas can afford.

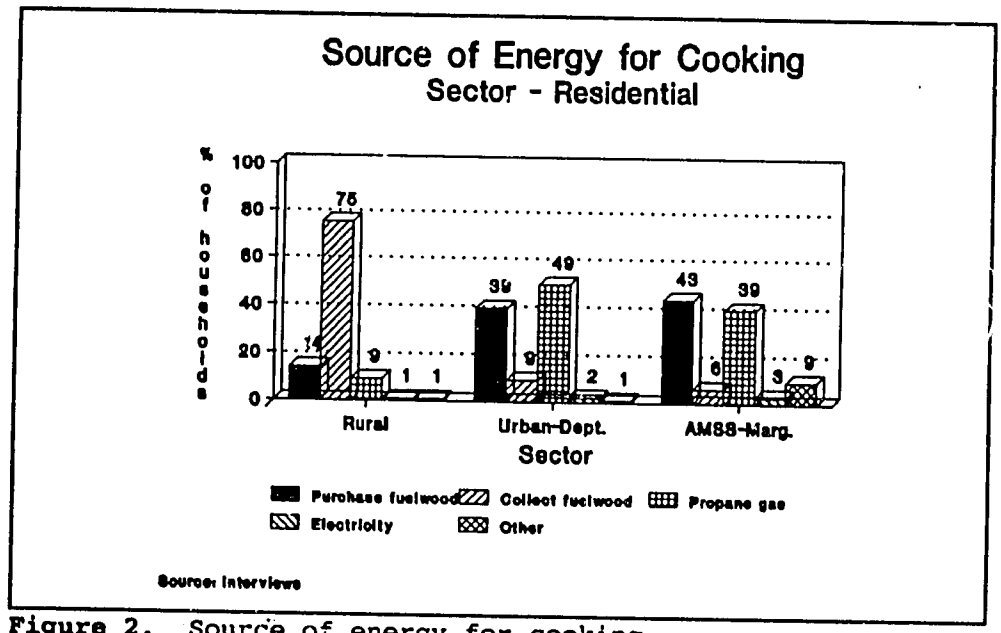

Figure 2. Source of energy for cooking

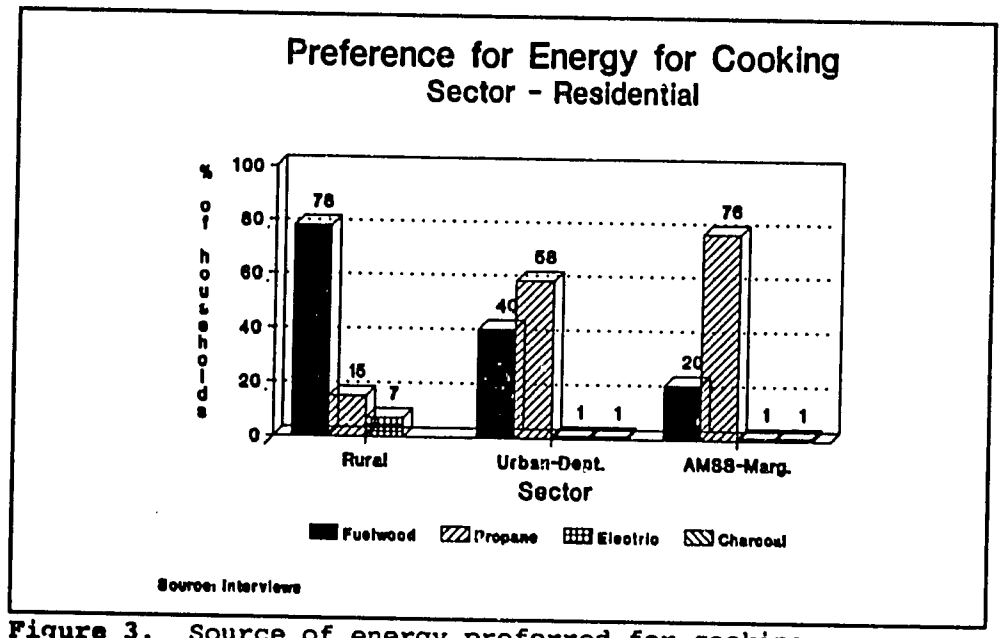

Figure 3. Source of energy preferred for cooking.

This situation presents an opportunity for the substitution of fuelwood with propane gas through a credit program or other arrangements for providing propane gas stoves for households in marginal areas at a low cost or through a system of installment payments.

With respect to preference for other energy sources, there was very little interest in energy sources other than propane gas and fuelwood. Even though other energy sources can be considered, based on the results, the facility of promoting other energy sources and the possibility of acceptance by the people would be less than propane gas.

Table 2. The use of energy sources and combinations of sources in the URBAN DEPARTMENTAL area.

Stratum / Energy Source	Cotton		Clean cult.		Coffee		North	
	No.	(%)	No.	(%)	No.	(%)	No.	(%)
Fuelwood purchased (LC)	3	6.2	22	45.8	8	16.7	12	25.0
Fuelwood gathered (LR)	0	0.0	7	14.6	0	0.0	1	2.1
Propane gas (GP)	29	60.4	4	8.3	21	43.7	23	47.9
LC + LR	0	0.0	1	2.1	2	4.2	0	0.0
LC + GP	13	27.1	10	20.8	12	25.0	7	14.6
LR + GP	1	2.1	3	6.3	1	2.1	3	6.2
Others	2	4.2	1	2.1	4	8.3	2	4.2
Grand Total	48	100.0	48	100.0	48	100.0	48	100.0

Source: Household Surveys.

Table 3. The use of energy sources and combinations of energy sources in the RURAL area.

Stratum / Energy Source	Cotton		Clean cult.		Coffee		North	
	No.	(%)	No.	(%)	No.	(%)	No.	(%)
Fuelwood purchase (LC)	9	11.2	36	15.0	10	6.2	12	7.5
Fuelwood gathered (LR)	54	67.5	157	65.4	143	89.4	134	83.7
Propane Gas (GP)	3	3.8	6	2.5	1	0.6	1	0.6
LC + LR	0	0.0	11	4.6	1	0.6	2	1.3
LC + GP	2	2.5	11	4.6	1	0.6	4	2.5
LR + GP	12	15.0	9	3.8	2	1.3	4	2.5
Others	0	0.0	10	4.2	158	1.3	3	1.9
Grand Total	80	100.0	240	100.0	160	100.0	160	100.0

Source: Household surveys.

In the urban area 48% of the households cook with fuelwood that is purchased or gathered, compared with the 49% who use propane gas. With respect to the difference in the types of energy used and preferred, there is a difference but not as great as in the

marginal areas of the AMSS. Of those interviewed, 40% prefer fuelwood and 58% prefer propane gas. Although the difference is not so great as in the AMSS, there are opportunities here for substituting fuelwood with propane gas, especially in the coffee zones and the north where the difference between the use and preference is greater. Although there is greater fuelwood supply in the coffee zones, the preference for propane gas may be a result of a greater diffusion of propane gas stoves in these areas, due to the fact that they are closer to population centers with greater facilities for obtaining stoves and propane gas.

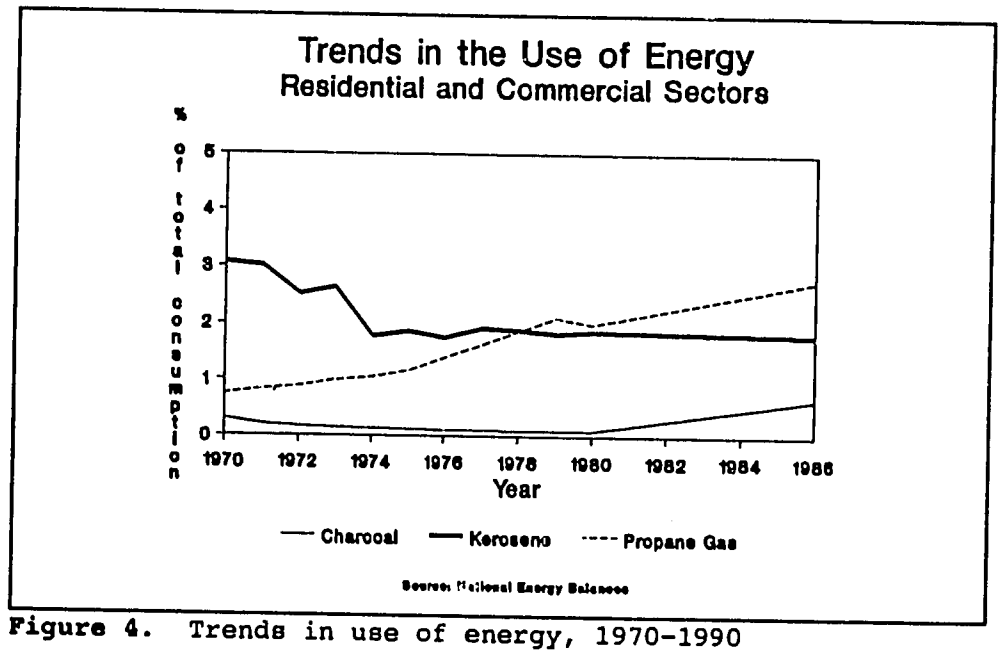

Figure 4. Trends in use of energy, 1970-1990

In the rural area, 89% of the households use fuelwood for cooking, compared to 9% who cook with propane gas. With respect to preferences, 78% prefer fuelwood, compared with 15% who prefer propane gas. In this sector, greater preference is found for electricity (6.6%), although less than the preference for fuelwood and propane gas. Here 12% of the population that use fuelwood prefer other types of energy and could be subject to programs of energy substitution which would decrease the demand for fuelwood.

With respect to the energy sources used and preferred, it is obvious that fuelwood and propane gas dominate. This is also reflected in Figure 4, which shows the changes in the use of the different energy sources throughout the years, based on the data from the national energy balances prepared by CEL. Based on the surveys, it is also obvious that there are possibilities for decreasing in the use of fuelwood by substituting with other types of energy preferred by the population.

Type of stoves

The surveys showed little use of improved stoves for fuelwood. Of the total households interviewed, only 1.6% used Lorena stoves in the rural sector, although there were 3.2% who used closed stoves in the urban sector and 2.7% in the rural sector. Others used mostly stoves that are semi-closed, of the polletón type.

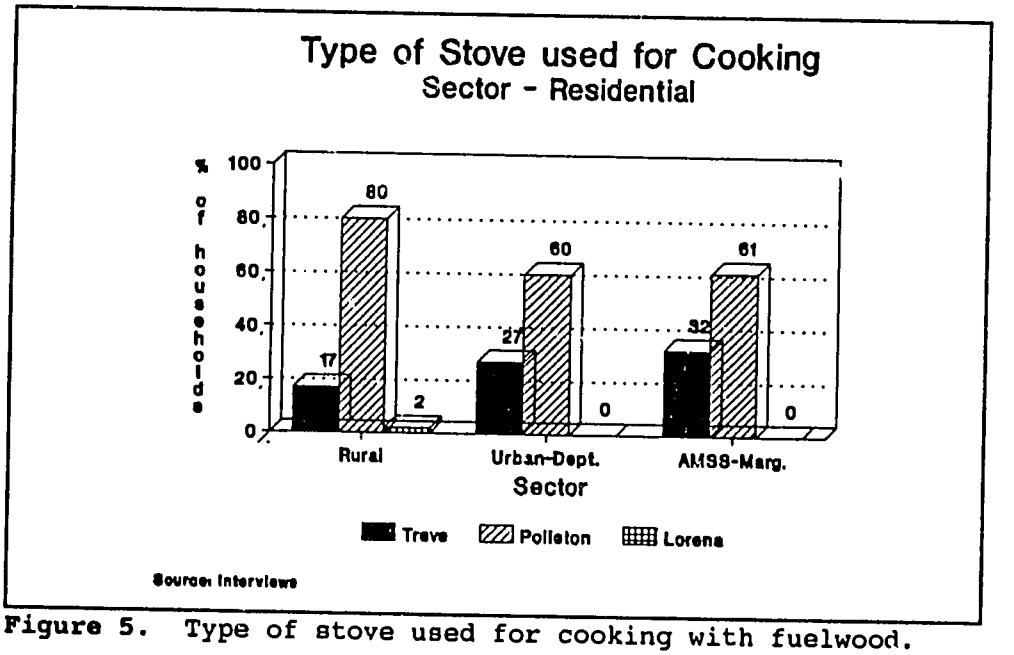

Figure 5. Type of stove used for cooking with fuelwood.

In the marginal areas of the AMSS, 37% of the households use open fires and 63% use semi-closed fires. With respect to the types of stoves, 32.4% use "treves" while 61.3% use the "polletón". In the urban departmental sector, 25.1% of the households use an open fire and 71.7% use a semi-closed fire, and 24.7% use treves, 64.2% use polletónes and 8.5% use brick stoves. In the rural sector 18.3% of the households have open fires and 79% have semi-closed fire with 16.3% who use treves and 80.3% who use polletónes. More detailed information on the stoves and the type of fire used is found in tables 3 and 4.

In the urban and rural departmental areas there is a greater use of open fires in the coffee plantations, which is related to a greater use of treves[5] and less use of the polletón. In all of the sectors and strata, there is little use of improved stoves for cooking with fuelwood. The surveys recorded 11 households in the rural sector that use the Lorena stove

[5] A "Treve" is basically a tripod set over an open fire to support cooking pots while a "polleton" is a semicircle of clay or bricks around the fire used to support cooking pots.

for cooking, which represents 1.5% of the sample in the rural sector[6] The introduction of better stoves is an area where it would be possible to decrease the demand for fuelwood with stoves that are more efficient and use less fuelwood for cooking. Currently there are programs for introducing better stoves in El Salvador, which can serve as pilot projects for disseminating the technology and adapting it to the interests and needs of the rural population.

Source of Fuelwood

The source of fuelwood supply for those who gather is linked to the strata defined for the study. With the exception of the coffee zone, where 76% of the fuelwood is gathered from coffee plantations, in the other strata people gather greater percentage of fuelwood in scrublands (43%)[7] followed in importance by isolated trees.

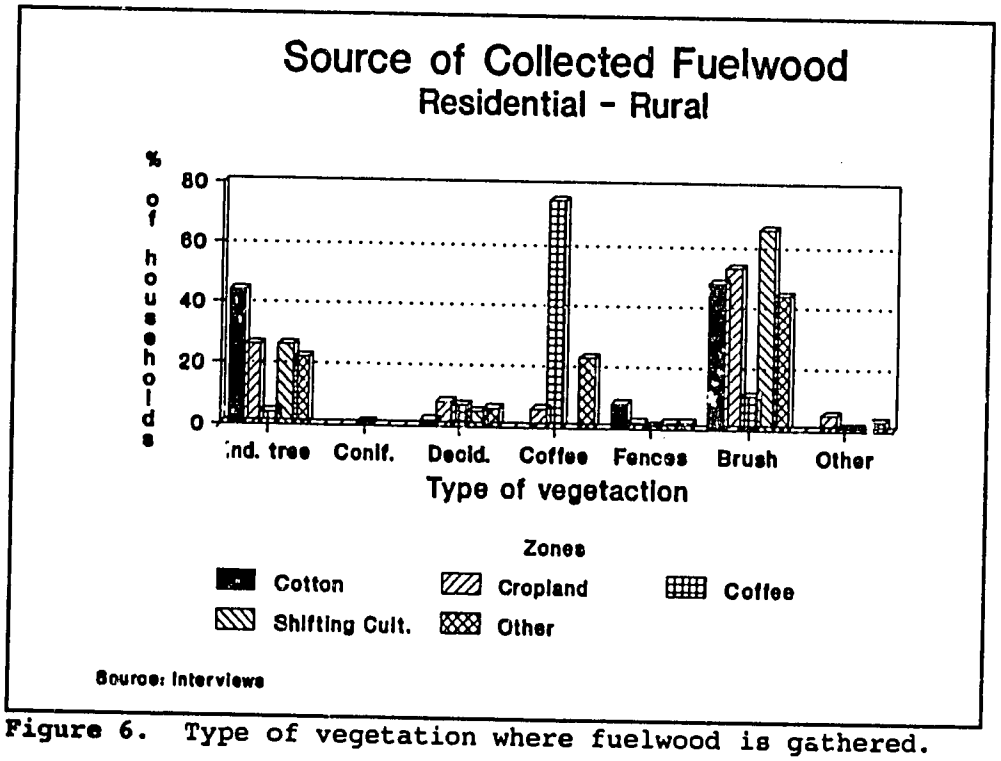

Figure 6. Type of vegetation where fuelwood is gathered.

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[6] The 11 stoves were divided among the departments of Santa Ana(1), Chalatenango(1), Cabañas(3), Usulatan(3), and Morazan(3) in the stratums of the coffee, the northern and the clean cultivation zones.

[7] It is possible that this is related to the increase in the quantity of scrublands in the last 10 years, which will be discussed in the section on fuelwood supply.

The category of isolated (individual) trees together with fences is important and of interest because it is a fuelwood source which often has not been included in the calculation of the fuelwood supply. Only pure stands of the trees are considered as sources of fuelwood supply, but the importance of this source that as a whole provides 25% of the fuelwood gathered compared to 23% that comes from coffee plantations is obvious. Another type of important vegetation related to deforestation is broadleaf forest from which 6.7% of the fuelwood gathered originates.

With respect to fuelwood purchased: i) in the AMSS, the majority of the fuelwood is purchased in shops (53%) and fuelwood deposits (22%); ii) in the urban departmental sector, 33% comes from temporary sales, 30% from fuelwood deposits and 23% is purchased from producers mostly in the coffee zone; and iii) in the rural sector, the small amount of fuelwood that is purchased (17%) comes from temporary sales, producers and, to a lesser degree, from transporters or fuelwood deposits. Based on the interviews of producers, the majority are coffee plantation owners, and it is likely, according to the survey results, that the producers in the other zones are temporary, not permanent, producers.

Form of receiving fuelwood

The information compiled with regard to the unit in which fuelwood is purchased indicates that the most common units in the AMSS are "manojo" and "raja", or small quantities purchased for a short period of time such as a day or a week. In the departmental sector, the "raja" and "manojo" are commonly used units but the "pante" and "tercio" are used more often. In the rural sector, 57% of those interviewed received fuelwood in tercios[8], and another 21% receive fuelwood in pantes, a unit with more volume but which varies in terms of its volume from one place to another. A conversion table, which includes the volumes in steres and the weight of the units used in the study, is found in Annex 3. Table 4 presents a description of the most common units.

Of those interviewed, 87.6% receive fuelwood as roundwood and 10% receive it split. With respect to preferences, 52% indicated that they prefer fuelwood as roundwood compared to 26% who prefer it split. Although approximately 16% of those that receive

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[8] Tercio is the unit for collecting fuelwood and represents the quantity of fuelwood that a person can carry. It has an average weight of 22.8 kilograms with an average volume of .11 meters steres. One meter stere is the volume of stacked fuelwood, which takes up a cubic meter of space. A stere includes the volume of sold wood plus the volume of air between fuelwood pieces.

fuelwood as roundwood would prefer split fuelwood, obviously for the vendor it is better to sell fuelwood as roundwood because he does not incur the extra cost for splitting the wood. Also in young plantations for fuelwood production, the felling operation and the preparation of the fuelwood can be carried out with a machete, which can also involve less cost than using an ax or other type of heavy equipment, that would be required by larger trees.

Table 4. Units of fuelwood.

Unit	Description
Raja	A piece of split fuelwood which often contains the same volume as a bundle.
Manojo	A group of individual fuelwood pieces.
Tercio	The quantity of fuelwood that a person can carry. The most common unit used for gathering fuelwood.
Carga	The quantity of fuelwood that can be transported by an animal.
Carretada	The quantity of fuelwood that can be transported in a cart.
Pante	A pile of stacked fuelwood measured in "cuartas." A "cuarta" is equal to 23-25 cm. A pante measures 8x8x3 to 8x10x4 cuartas.

Species used and preferred

The most commonly used species are coffee, cujin (Inga. spp.), and madrecacao (Gliricidia sepium), although there are a total of 60 species used. In the city, those interviewed did not always know the specie(s) that were being used and accepted what the vendor offered. With respect to preferences, madrecacao was the most commonly preferred species (18.5%). Non-traditional species, such as eucalyptus (Eucalyptus sp.) and teak (Tectona grandis), were not mentioned probably because they are only beginning to be used. With the preference registered for madrecacao, it represents a species that could be successful in reforestation programs aimed at improving the fuelwood supply. In addition to being a preferred species, it is a species that: i) fixes nitrogen; ii) has been incorporated into traditional systems of improved fallow; and iii) can be reproduced with direct planting therefore avoiding the costs of nursery production and the transportation of plants.

Table 5. Tree species used and preferred for cooking.

	Used			Preferred		
Importance / Species	No. 1 (%)	No. 2 (%)	Total (%)	No. 1 (%)	No. 2 (%)	Total (%)
Coffee	12.2	10.7	9.2	12.5	10.5	10.9
Carbón Colorado	4.3	2.1	2.6	7.0	1.1	3.4
Chaperno	3.7	2.6	2.8	4.6	3.0	3.9
Cicaguite	5.7	1.3	3.0	7.9	2.3	4.7
Conacaste	2.1	1.6	2.4	1.1	0.4	0.8
Cujin	13.3	13.0	10.0	11.2	15.7	12.0
Guachimol	1.1	2.1	1.6	2.0	0.8	1.5
Laurel	6.9	8.6	6.7	3.9	10.5	6.8
Madrecacao	13.7	11.5	11.5	22.5	14.6	18.5
Nance	0.4	0.7	0.8	1.1	1.1	1.4
Quebracho	6.0	5.2	5.1	11.4	9.0	10.7
Tihuilote	7.8	4.1	4.9	1.3	0.8	0.9
Tintero	1.4	0.4	0.8	0.2	0.4	0.2

Note: Of all the species registered, these were chosen because of the frequency of their use and preference either at the level of a particular zone or at the level of the entire study.

The species utilized and preferred were similar from one stratum to another, but with differences between stratum related to the predominant vegetation. The species used and preferred at all levels of the study are presented in Table 5.

The preferred species vary between the stratum mainly according to their availability in that stratum. In the coffee zone, coffee and shade trees for the coffee are the preferred species, and of course are better known. There is an influence of coffee plantations in the clean cultivation zone, but combined with other species in the same zone. The northern zone registered a variety of species but always with madrecacao as the main species. The cotton zone presents the greatest variety of species with few predominating. In Table 6, a list of the preferred species by stratum, madrecacao is the only species repeated in all of the zones.

Important results with respect to fuelwood sources and the species used and preferred include: i) the importance of isolated trees in the collection of fuelwood, a resource that often is not included in the fuelwood supply and that can be sustained and increased with agroforestry programs at the farm level; ii) the possibilities of selling fuelwood in

roundwood form, which provides a savings in the costs of operation; and iii) the importance of madrecacao as a fuelwood source, a species that can be included in reforestation programs.

Table 6. Preferred species for fuelwood by stratum.

Stratum	Species	% [a]
Coffee	Coffee	24.1
	Cujin	28.9
	Madrecacao	22.9
Cotton	Coffee	3.3
	Carbón colorado	8.9
	Conacaste	5.6
	Guachimol	10.0
	Laurel	6.7
	Madrecacao	8.9
	Nance	5.6
	Quebracho	11.1
	Tihuilote	6.7
Northern Scrubland	Carbón colorado	10.6
	Cicaguite	26.3
	Laurel	7.5
	Madrecacao	16.9
	Quebracho	8.8
Clean cultivation	Coffee	8.2
	Chaperno	7.1
	Cujin	7.8
	Laurel	6.7
	Madrecacao	18.4
	Quebracho	16.9

[a] The percentage of responses indicating the species as a preferred species.

Fuelwood prices

Fuelwood prices fluctuate depending on the period of the year, the agricultural calendar and they also fluctuate from one year to another. The variations during the year are due to temporary or periodic scarcity related to coffee pruning and periods of greater labor demand in agricultural activities. Variations from one year to another are related to the inflation rate of prices in general and increasing scarcities of fuelwood.

The changes during the year are reported with a variation of up to 100 colones per pante, although this phenomenon is not generalized. In the residential survey in the urban sector, 24.8% of the responses indicated a price variation during the year, and in the rural area only 6% reported price variations. It is likely that the low variation in the rural area is due to the fact that the rural population collects most of the fuelwood used for cooking. Where there were variations, the reasons given for the variation were: i) when there is no coffee pruning, fuelwood becomes scarce; and ii) when the population is involved with their agricultural activities, there is no time to search and cut fuelwood; conditions which result in scarcity. Where there is this variation, there is an opportunity for fuelwood producers to make their business more profitable, planning their production so that it coincides with those periods of scarcity.

The increases in the price of fuelwood in the last few years demonstrate a tendency for prices to increase at a greater rate than the general rate of inflation. Table 7 shows these increases in terms of percentages and an average of the prices reported for the different units used in the sale of fuelwood. In the last line in the table, the inflation rates are reported, calculated on the basis of the information obtained from DIGESTYC. It is evident that in the majority of the cases, the prices have increased at a greater rate than the general inflation rate. In the period 1988-1989, with an inflation rate of 18%, the increases in the fuelwood prices were from 20 to 72%. In 1989-90, with an inflation rate of 24%, the increases ranged from 23 to 62%. In 1990-1991, with inflation of 14%, the increases ranged from -2 to 58%. The small increases in 1990-1991 follow significant increases in previous years and generally are the result of fewer cases.

The lower prices in the AMSS in the case of a manojo is the result of an urban manojo having a volume around half that of the volume of a manojo in the urban sector, but the price per volume is greater in the AMSS.[9] This same phenomenon explains the greater cost of the tercio in the rural areas compared to the urban areas. The volume of the tercio in the rural areas is greater and the price per unit of volume lower. In the case of split fuelwood, average volumes are similar, and the difference can be attributed to the differences in species or the greater quantity of sales in the AMSS.

Figure 7 shows the wholesale price trends for fuelwood in San Salvador, compared to the general rate of inflation for the period 1983 to 1989. Although in the first years of this

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[9] Some of the persons interviewed indicated that the increase in the price of fuelwood is reflected in a smaller volume of wood provided for the same price and of the same unit rather than an actual price increase.

period, the increase in prices for fuelwood was less than inflation, in the last few years, as can be seen from the data in Table 6, the prices for fuelwood are increasing at a greater rate than inflation. This relative increase makes plantations for producing fuelwood, or that have fuelwood as one of the various final uses, more profitable. In the past, financial and economic evaluations of plantations for fuelwood have not provided good results, but with the higher prices now, this situation could change.

Table 7. CHANGES IN FUELWOOD PRICES - Averages of the percentage change in the fuelwood prices for the more common units of measurement.

LOCATION	UNITS	PRICES END OF 1991	1990-1991		1989-1990		1988-1989	
			%[a]	CASES	%	CASES	%	CASES
Marginal AMSS	RAJA	0.99	18	8	53	7	40	7
	MANOJO	1.10	21	63	32	60	40	54
Urban Department	RAJA	1.26	28	14	48	13	62	11
	MANOJO	1.66	6	7	25	7	20	6
	TERCIO	5.86	14	7	62	8	64	6
	PANTE	121.2	25	22	23	24	33	24
	CARGA	29.0	13	3	26	5	30	4
	CARRETADA	101.4	7	5	57	8	60	8
Rural	TERCIO	6.52	29	12	47	31	58	29
	PANTE	125.1	15	44	41	112	38	102
	CARGA	24.5	23	2	38	11	40	11
	CARRETADA	89.4	10	12	43	49	51	48
INFLATION	CPI[b]		14		24		18	

[a] The percentage change in prices is the average of the individual observations for each sector and unit of fuelwood. For example, in the urban area the price of a raja increased an average of 28% between 1990 and 1991.

[b] Inflation was calculated using the consumer price index (CPI), (general index), according to the Consumer Price Index of Nov-Dec., 1991 published by the General Directorate of Statistics and Census.

Problems with fuelwood supply

Although not a majority, persons from some of the households surveyed indicated that they had problems with fuelwood supply. The greatest percentage was in the rural sector with 34% of the respondents indicating problems, followed by the urban sector with 21%, and the marginal AMSS with 6%. In the strata, the percentages were 33% for the northern zone, 30% for the clean cultivation zone, 25% for the cotton zone, and 16% for the coffee zone. When asked to indicate the main problems of supply, 55% mentioned the high cost of fuelwood, 13.5% mentioned difficulties in obtaining fuelwood and 9.3% mentioned greater availability when carrying out the cultural practices in cultivation such as pruning coffee and therefore problems during periods when pruning is not carried out.

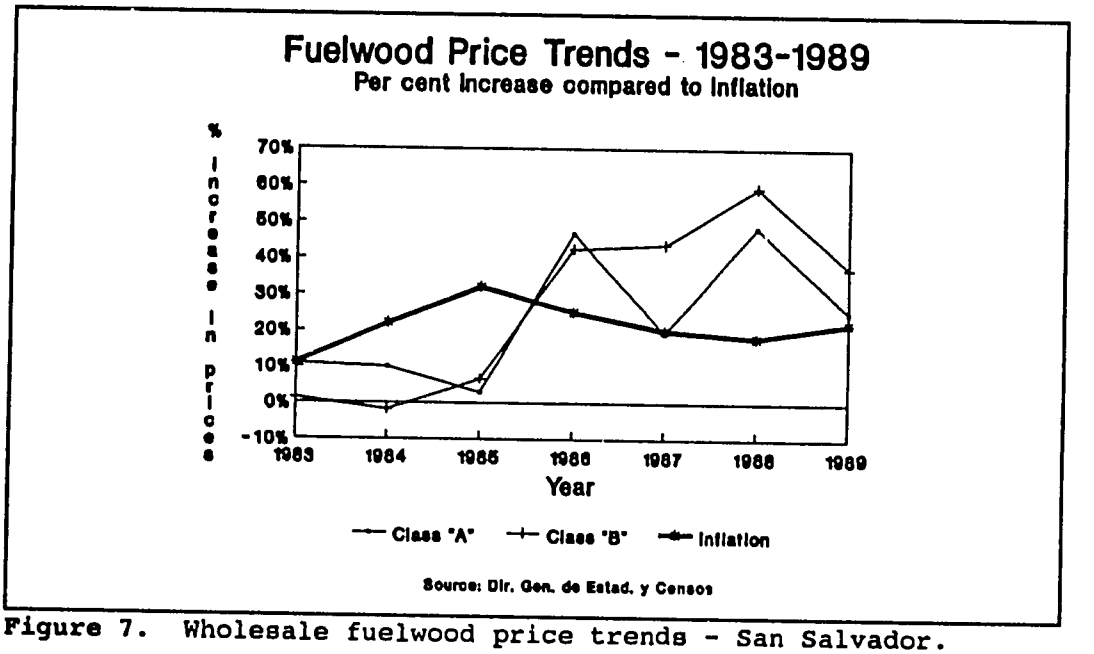

Figure 7. Wholesale fuelwood price trends - San Salvador.

The data indicate that there is less problem in the supply of fuelwood in the coffee zone and that there is an increase in the fuelwood prices that has been noted by the population. On the one hand, the increase in prices can encourage fuelwood production as an activity for generating incomes while, at the same time, it can lead to a substitution of fuelwood with propane gas or another more attractive energy source.

Cost of fuelwood compared to propane gas

In the survey of homes and businesses, those interviewed often demonstrated interest in switching from fuelwood to propane gas as a source of energy for cooking. They mentioned that they felt that the cost of cooking with gas would be less than with fuelwood, but that the cost of a stove was too much of an investment for them. In order to compare the cost for propane gas with fuelwood in a practical way, the homes that only cooked with fuelwood and that only cooked with propane gas were identified. Based on the quantity used and the prices for each type of fuel, the average cost per person per year for each fuel was calculated. It turned out that the cost per capita per year for fuelwood is 217.34 colones, compared to the cost per capita per year for propane gas of 74.78 colones. The cost of cooking with fuelwood is almost 3 times the cost of cooking with propane gas if only the cost of the fuel is considered.

If a home with 6 people (5.8 was the average of the homes surveyed) is considered, it is possible to calculate the savings in fuel costs with propane gas, compared with fuelwood:

Fuelwood 6 * 217.34 = 1,303.04
Propane gas 6 * 74.78 = 448.68

¢ 854.36/home/year

Dividing the cost saved by using propane gas instead of fuelwood by 12 months gives an indication of how much a home could pay as an installment per month to finance a gas stove with the money saved by switching to gas. The amount is ¢71.20. The cost of a propane gas stove would vary according to the type and the number of burners. Average prices charged in San Salvador are presented in Table 8.

Using the savings earned using a propane stove, a year would be required to pay for a stove with two burners if interest payments are not included. Interest varies from 18 to 20%. The businesses selling stoves provide credit to those who purchase stoves, but require that the buyer: i) be employed or can prove that s/he is economically solvent; and ii) have two sponsors (cosigners). These conditions generally eliminate those with scarce resources from accessing this type of credit. Due to these limitations, the cost of a propane gas stove is an obstacle for those interested in substituting propane gas for fuelwood. The introduction of a credit program for persons or households with scarce resources who are interested in changing to propane gas could be an effective mechanism for promoting this substitution in the urban areas of the country.

Table 8. Types and prices of propane gas stoves.

Description of the stove	Price range [a]
Table stove with 2 burners	¢ 800 - 900
Table stove with 3 burners	¢ 1,150 - 1,350
Table stove with 4 burners	¢ 1,450 - 1,675
Stove with a cabinet and 4 burners and oven	¢ 2,800 - 3,100

[a] Prices include the gas tank, hoses, gaskets, and regulator.

With respect to other types of energy sources, the data on the few users of kerosene indicates a cost greater than the cost of fuelwood. Kerosene stoves are much cheaper but only have one burner. The prices for the stove vary from ¢ 49.00 to ¢ 180.00, according to the size of the tank and the brand. There are two types of stoves with two burners: one English and the other national. The English stove costs ¢ 350.00 and the national one costs

¢ 275.00. Kerosene is sold in a bottle of approximately 200 cc. for ¢ 2.00-2.50. In order for kerosene to be an alternative fuel for the people, the price would have to be lower. It has decreased in general use in the residential and the commercial sector, according to the data from the National Energy Balances prepared by CEL.

In the rural areas, while it is still possible to gather fuelwood, it would be difficult to introduce substitutes. Any other alternative energy sources would require cash expenditures, which are not necessary for fuelwood. Collecting fuelwood requires labor but with real wages (adjusted for inflation) decreasing and the problems of unemployment in the rural areas, it is unlikely that a farmer would pay in cash for a stove or fuel for a stove if he has the option of collecting fuelwood. Rural areas offer greater opportunities for improvement through the use of more efficient stoves and the establishment of multipurpose tree plantations for producing fuelwood and the other products that trees can provide.

Per capita use of fuelwood

The results of the measurements of fuelwood use per household for the sample are reported in Tables 9 and 10. The total consumption in the country estimated from the survey data is reported in Table 11. The data from the sample indicates a total consumption at the national level greater than the consumption reported by Martínez (1987) in the report on the demand for energy for final use in the urban and rural residential sector of the country. This increase is due mainly to a greater use per capita in the rural area. The rural area represents 58% of the total population in the country, according to the data obtained from DIGESTYC. This greater use in the consumption in the rural area has a significant impact on the national consumption, due to the high percentage of fuelwood users in those rural areas.

There is an apparent increase in the fuelwood consumption at the rural level, compared to the study in 1987. This increase indicates greater availability of fuelwood, but at the same time the prices for fuelwood continue to increase at a greater rate than inflation, which is a sign of scarcity. The reasons for these conflicts in the indicators of scarcity can have their explanations in factors related to the conflictive situation that the country has experienced in the last decade, which include: i) migration from the rural areas to the urban centers; ii) abandonment of lands previously cultivated in the conflictive zones; and iii) abandonment and lack of management of coffee plantations.

First, due to the conflict, there has been a migration of people from the rural areas to the cities, which has resulted in the abandonment of areas that were previously cultivated.

This tends to decrease the pressure on the existing forest and gives rise to the growth of secondary vegetation on abandoned lands with the tendency to increase fuelwood supply. At the same time coffee plantations, which are an important source of fuelwood for the urban centers in some cases have been abandoned and in other cases because of the conflictive situation as well as the low coffee price are not receiving the appropriate management that includes pruning, a traditional treatment providing an important source of fuelwood. This situation tends to decrease the fuelwood supply in the urban centers and in rural areas of the coffee zones, and drive the prices up. At the same time, the increase of secondary vegetation on land previously cultivated tends to increase fuelwood availability in rural areas leading to greater consumption.

This situation seems to be reflected in the fuelwood consumption per stratum that, contrary to what was expected, shows a greater consumption per capita in the rural areas in the cotton zone than in other zones, and with less consumption per capita in the coffee zones. Tables 9 and 10 show that greater fuelwood consumption was recorded at the level of the cotton zone. The cotton zones have been the most affected in the country outside the conflictive zones in the northern zone, with abandonment of more than 50% of the areas previously cultivated with cotton. After 10 years of war, these abandoned areas have secondary regrowth of a size suitable for producing significant quantities of fuelwood available for fuelwood gathering.

From tables 9 and 10, tendencies in the use of fuelwood alone and in combination with propane gas, which is the substitute or main complement for fuelwood, can be observed. In the marginal areas of the AMSS, 72% of the population uses fuelwood for cooking, and from this percentage, 53% combine fuelwood with propane gas and 35% use only fuelwood. In the homes located in the non-marginal areas that use fuelwood, 62% combine propane gas with fuelwood and 34% use only fuelwood. From those that only use fuelwood, the majority purchase fuelwood and consumption per capita is less than in the urban and rural areas.

In the urban area, the stratum where fuelwood is used most is the area of clean cultivation which also shows greater consumption per capita of fuelwood in the homes that use fuelwood and greater percentage of homes that use only fuelwood compared to other stratum. Of the homes that use fuelwood, the majority purchase it (>75%). The homes that only use fuelwood showed greater consumption in the stratum of coffee. That can be related to the fact that the coffee plantations are the greatest producers of fuelwood for the market, with greater supply of fuelwood in the coffee zones resulting in lower prices.

In the rural areas, in all the strata, more than 90% of the homes use fuelwood to cook. The percentage of those that combine fuelwood with propane gas is greater in the cotton zone (18%) and the clean cultivation zone (11%). Of those that use only fuelwood, a greater percentage of homes that purchase fuelwood also were located in the clean cultivation zone. In general, the homes that use only purchased fuelwood use less fuelwood than homes that gather it. It is likely that programs of substitution of fuelwood with propane gas can be more successful in the cotton and clean cultivation areas since there is already a tendency towards this substitution, a greater use of purchased fuelwood, where the use of propane gas would be a cheaper alternative for cooking. This type of program would have to be located in areas where the population can purchase fuelwood in order to have an impact.

Table 11. Estimated population per stratum and sector and consumption per capita fuelwood per hab./day and total in tons per year.

Sector	Stratum	Population 1991 (estimated)	# of homes 1991	# of homes (sample)	Sample population	Persons /home sample	Kg./hab. /day	Kg./day Total	Tons /year
URBAN	Cotton	223659	40665	48	264	5.50	0.28	63072	23021
	Coffee	417714	81175	48	247	5.15	1.00	417714	152466
	Scrubland	186189	31142	47	281	5.98	0.70	130332	47571
	Clean cultivation	463288	78858	48	282	5.88	2.07	959006	350037
AMSS	Non-Marg.*	817718	210000	92	613	N/A	0.93	196302	71650
	Marginal	174013	30054	135	782	5.79	0.96	166356	60720
	TOTAL URBAN	2282581	373122	418			0.85	1932783	705466
RURAL	Cotton	418068	76186	80	439	5.49	2.98	1245843	454733
	Coffee	683511	131527	160	882	5.51	2.82	1927501	703538
	Scrubland	804374	129869	160	991	6.19	3.59	2887703	1054011
	Clean cult.	1230466	221977	240	1419	5.91	2.82	3469914	1266519
	TOTAL RURAL	3136419	559558	640			3.04	9530960	3478801
TOTAL URB.& RURAL		5419000	932679				2.12	11463743	4184266

* NOTE: In the sample of the non-marginal areas the survey taken only in homes cook with fuelwood that are 25.7% of the homes in the non-marginal areas.

Table 11 shows estimations of fuelwood consumption based on survey results. Approximately 83% of the residential consumption of fuelwood occurs in rural areas, of which 76% is gathered fuelwood. These figures indicate that 63% of the national, residential

consumption of fuelwood is gathered fuelwood. This has important implications for programs with the objective of improving the fuelwood situation in the country.

In order for the families gathering fuelwood to substitute fuelwood with another fuel, such as propane gas, they would need to have a source of income to pay for gas. According to the publication data obtained from CENITEC (Montoya, 1991 and Letona, 1991), there is an increase in the labor supply while the demand is increasing at a slower rate than the supply, which results in unemployment or underemployment of the population in the agricultural sector. Together with this tendency and possibly as a result, the real minimum wage[10] of a rural worker has decreased in real terms in the last few years. This situation makes substitution of fuelwood difficult, since gathered fuelwood does not have a cash cost, while substitute fuels such as propane gas require a cash expense. In this situation, the alternative with greater possibilities of success can be to increase the supply through tree plantations in the rural areas for the purpose of self-sufficiency or lowering the demand through the use of more efficient stoves. In areas where families purchase fuelwood, it is likely that a program of substitution would be more feasible.

Consumption of Charcoal in the Residential Sector

In the interviews in the residential sector only 16 households reported using charcoal for cooking (approximately 1.6% of the households of the entire sample). Of those 16 households, 4 are located in the urban departmental zones and the other 12 in the AMSS. Of those households 3 did not mention another fuel, 6 combine charcoal with propane gas, 5 combine charcoal, propane, and fuelwood, one combines fuelwood and charcoal, and one used fuelwood, charcoal, propane and electricity. These results demonstrate that charcoal use was of little significance in the study as a whole, but with greater importance at the level of the AMSS.

The importance of the consumption of charcoal was very evident in the results of the telephone survey of 1000 households in the AMSS. According to the survey results, 45% of the households use charcoal for cooking while only 6.6% use fuelwood. It is important to note that the charcoal used in those households is not the principal cooking fuel. Of the households that use charcoal (438), 62% use propane gas as the principal fuel while 37% use electricity as their principal fuel. When asked if they planned to continue using charcoal for cooking, 97% of the respondents indicated that they planned to continue using charcoal

[10] The real minimum salary is calculated, including the effect of inflation using the consumer price index.

indefinitely. The average annual consumption per person in the households that use charcoal is 19.4 pounds with a standard deviation of 11 pounds.

Comparing different types of homes (small, medium, and large homes, and apartments), it was found that the percentage of charcoal users by type of home was constant with the exception of apartments. Families in apartments probably use less charcoal since they often have limited space to maintain an open fire in that kind of construction.

The use of charcoal is important in the AMSS as a secondary fuel for cooking. In accordance with the responses to the questionnaire it will probably continue to be an important element in the AMSS. The information from the National Energy Balances shows a trend towards increased use of charcoal in the residential and commercial sectors. In this study, the major use of charcoal is the Metropolitan Area of San Salvador. The only cases of charcoal use reported in the industrial sector were 2 of the 26 cafeterias surveyed.

INDUSTRIAL SECTOR

Although not of the same magnitude as the residential sector, the industrial sector is another consumer of fuelwood, and in cases such as the salt producers in eastern region of El Salvador with a preference for mangrove and the lime kilns in Metapán that prefer pine, the fuelwood comes from natural forests, thus contributing to the deforestation of the remaining forest areas of the country. The use of fuelwood in the industrial sector includes coffee processing, sugar refineries, tortilla shops and pupusa shops in the urban areas. In this sector, there have been changes in the use of fuelwood in the last 10-15 years with greater substitution in some industries while others continue using fuelwood as a principal source of energy. This section summarizes the use of fuelwood in each industry and trends with respect to its use.

The industrial sector includes coffee processors, sugar refineries, lime kilns, salt production and brick and tile kilns. At a more handicraft or small business level are cane moliendas[11], bakeries, pupusa shops, tortilla shops and cafeterias. It was possible to estimate the total fuelwood consumption of a majority of the industries based on the records kept by government agencies and surveys obtained from CEL. In the case of pupusa shops and cafeterias, due to the difficulty in defining the total population, only the tendencies in the use of fuelwood are presented.

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[11] A molienda is a traditional form of processing sugar cane and fuelwood is used in the process of extracting the cane sap and solidifying the sugar.

Coffee Processors

Coffee processing plants are located in the coffee zone of Santa Ana, La Libertad, San Salvador, La Paz, Cuscatlán, Usulatán and San Miguel. The use of fuelwood in the industry is during the drying process, after coffee beans have been washed, after leaving the fermentation basin. The use of fuelwood is decreasing, due to the use of coffee husks and polvillo de pergamino as a substitute for fuelwood. This increase in the use of substitutes began in the early 1980's, according to National Energy Balance: Series 1970-1979. INCAFE, upon taking control of coffee plantations and coffee exporting in the 1980's, promoted the change in the process by purchasing special burners for that purpose. It has been an effort that has provided good results. Fuelwood continues to be used for initiating the drying process but once the process is initiated, fuelwood is replaced by the substitutes.

From a total of 84 plants registered, 15 plants were randomly selected for the survey. The plants use combinations of electricity (13), diesel (only 3), fuelwood (6), and coffee husks and polvillo de pergamino from the processing of coffee. Three plants use diesel only and three use electricity only:

Six (40%) of the plants selected use fuelwood but those plants account for 63% of the total production of the 15 plants. They use an average of 1 cubic meter of fuelwood for processing 24.4 quintal of roasted coffee. The plants that use fuelwood always combine fuelwood with substitutes such as coffee husks and polvillo de pergamino, products of the same process for preparing coffee.

Of the plants visited which use fuelwood, half of them use fuelwood from their own coffee plantations and the other half purchase it from fuelwood producers. The species that are used are those that come from coffee plantations, madrecacao being the preferred species. They receive fuelwood in pantes in roundwood form. They did not indicate problems with the supply of fuelwood required since they are located in the coffee zone where fuelwood from prunings can be easily obtained.

For estimating the total fuelwood consumption of the plants, the annual production reported by PROCAFE of 3,232,300 quintals was used. The survey indicated that 63% of the production from the sample is processed with fuelwood, using 1 cubic meter for processing 24.4 quintals of roasted coffee. For calculating the fuelwood consumption, the following calculation was carried out:

(3,232,300 qq * 0.63)/24.4 = 83,457 m3 (steres) of fuelwood

Of the total, 83,457 m3 steres of fuelwood come in units of pantes from coffee plantations. Converting m3 steres to kilograms, using a conversion rate based on measurements in the field, results in an annual consumption of 35,464,655 kilograms or 35,465 metric tons of fuelwood in the coffee sector. For the purpose of calculating the future use of fuelwood in the coffee plantations, it was assumed that this annual use will be maintained. If coffee production increases, then it is possible that fuelwood use would also increase but with the current prices for coffee, it is not likely that the coffee producers can or will be interested in increasing production.

Sugar mills

Sugar mills are located near sugar cane producing providing areas: Izalco, San Julián, Apope, Aquilares, San Vicente and San Miguel. Initially fuelwood is used for initiating the heating process in boilers and later is replaced with sugar cane pulp which is the product of sugar processing. The use of fuelwood has tended to decrease since most of the energy required for the boilers is provided by sugar cane bagasse.

To obtain data on sugar mills, 4 were surveyed and all of them used fuelwood combined with other energy sources in the production of sugar. According to the data reported by CEL in the Energy Plan 1988-2000, there are 10 sugar mills in the country. Four sugar mills also use electricity and 3 out of 4 use sugar cane pulp to complement or substitute fuelwood. According to the quantity of fuelwood used by the sugar mills surveyed, a production of 2,672 quintals of sugar for each stere of fuelwood used was calculated. Estimating the production of 10 sugar mills based on the production and the use of fuelwood in the sugar mills surveyed, results in an annual consumption of only 908 tons of fuelwood, a small quantity when compared to the total consumption of fuelwood in the residential and industrial sectors.

Sugar mills purchase their fuelwood from fuelwood producers (75%) or from fuelwood transporters (25%). They use madrecacao and cujin and other species but with a greater preference for madrecacao. They receive fuelwood from coffee plantations in pantes as roundwood or split. They indicated some problems with fuelwood supply due to scarcity, prices, and lack of distributors.

For the purpose of calculating the future demand of fuelwood in the sugar mills, it is

assumed that the demand remains stable. It is likely that a majority of the sugar mills that use fuelwood also are using the pulp as a substitute, and therefore it is likely that the fuelwood situation use in the sugar mills cannot be improved much.

Lime Kilns

Lime kilns are located in the Department of Santa Ana in Metapán. It is a traditional rural industry in this area of the country. Fuelwood is used for the entire process of burning limestone with the substitution of between 5 and 10% of the volume of fuelwood consumed by rubber tires. The industry produces 90-95,000 quintals of quick lime during the year, which is marketed individually or through a cooperative. Of the total, 25-30,000 quintals are sold to INAZUCAR for processing sugar. In the National Energy Balance: Series 1970-1979, CEL reports 30 kilns in the country. In the survey of the industries, it was reported that there are currently 51 kilns in production, which indicates an annual increase of approximately 5%. The industry continues being small-scale and family-oriented with individual producers, some associated with a cooperative of lime producers.

The use of fuelwood in this industry is constant and the only reason that it would decrease is scarcity of fuelwood since currently there is no other energy option for producing lime. This industry has been affected by the application of the Forest Law (Ley Forestal) of 1973 which requires permits for transporting fuelwood. This law has received stricter enforcement beginning in 1991 and therefore has decreased the available fuelwood and raised the fuelwood price because the transporters that provide the industry with fuelwood add the cost of fines received to the fuelwood price. It is also reported that the application of the law has been stricter in the area of Metapán. Also, due to the fact that the coffee plantations are remote, much of the fuelwood that is used in the lime kilns comes from natural forests.

Out of 51 kilns in Metapán, 12 were included in the study. Also, the forest agent from the area provided data that was compiled from 42 of the kilns in operation. From the sample, it was determined that the kilns produce an average of 925 quintals of quick lime per batch, using an average of 35.25 pantes of fuelwood and 62.08 tires. Each oven makes an average of 11.08 batches per year. Following is the calculation of the fuelwood consumption:

35.25 pantes/baking x 11.08 bakings/year
x 51 ovens
= 19,919 pantes/year

19,919 pantes x 1.9 m3/pante = 37,846 m3

37,846 x 668 kg/m3 = 25,281,194 kg./year

= 25,281 tons of fuelwood/year

(Note: the calculations are based on measurements of pantes used in the kilns)

The kiln operators that were interviewed purchase fuelwood from transporters (58%) and producers (42%). The most commonly used species are pine and madrecacao, but they prefer pine. They purchase fuelwood in units of pantes in roundwood form and prefer fuelwood in logs. With respect to the origin of fuelwood, 75% come from coniferous forest and 25% from scrubland. Concerning fuelwood supply, all indicated fuelwood scarcity in the zone and 70% mentioned the legal aspects previously mentioned (permits required for transporting) as a problem of supply.

This industry shows an increase in size throughout the years without a decrease in fuelwood consumption, except that related to substitution of tires for fuelwood which represents an environmental problem. There is fuelwood scarcity in the zone, according to the people interviewed, because the enforcement of the forest law that requires permits for transporting fuelwood has increased. The production is small scale with rustic kilns. It is possible that the efficiency in the use of fuelwood can be improved through better kilns but would require an investment in new equipment.

Salt production

The salt producing operations are located in the mangrove zone of La Unión, Usulutan, La Paz, and Sonsonate-Ahuachapan. Fuelwood is used for the process of heating water previously concentrated in the salt-dryers through solar evaporation for obtaining cooked salt that, according to producers, is of better quality than salt that is completely solar dried.

In the salt industry, the use of fuelwood tends to decrease, especially due to the lack of mangrove fuelwood and other tree species and the increase in fuelwood prices. The production of salt using fuelwood is being substituted by production using solar energy. This

change began in the 1970's[12]. The decrease in fuelwood is due in part to the total prohibition of fuelwood extraction from mangrove areas. According to the data obtained from MAG for 1991, of the 131 salt producers registered, there are some 19 salt producers in Usulután and La Unión that produce salt using fuelwood. One of the salt producers visited, which supposedly produces salt by cooking had changed to solar energy.

Based on the data recorded from the 5 salt producing operations interviewed, they require 1 m3 stere of fuelwood for producing an average of 3.37 quintals of salt. Each salt production unit uses an average of 483 m3 (steres) per year and produces an average of 1,628 quintals of salt per year. Using this data, an annual consumption of 3,300,378 kg of fuelwood is estimated in the 18 salt production units, which is equal to 3,300.4 metric tons.

Of the salt-producers interviewed, all of them purchase fuelwood from producers. They use a mixture of species from the zone. With respect to the preferences for species, they mentioned carbón colorado (33%), nacasol (25%), and quebracho (17%). They receive fuelwood in roundwood pantes and prefer roundwood. Fuelwood that is used comes from scrublands (50%), isolated trees (25%) and coffee plantations (25%), although they did not mention coffee species. Of the 5 salt producers interviewed, 3 mentioned problems with fuelwood supply related to fuelwood scarcity in the zone.

The use of fuelwood by salt producers has decreased, due to substitution with solar energy, but there remains a population of salt producers that continues to use fuelwood. This population could decrease with the increases in fuelwood prices although it is likely that if those that continue using fuelwood for producing salt have not changed, they will not change unless there is a significant rise in fuelwood prices.

Brick kilns

Brick kilns are located near highways or transitable roads close to population centers. There is a concentration of brick kilns near Armenia in Sonsonate. Fuelwood is used in the process of baking bricks. Brick production is a small-scale traditional industry important for the construction industry.

The use of substitutes for fuelwood in brick-making is minimum and restricted to the use of coconut husks, grass and corncobs, which are only used for reviving the fire. The

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CEL. 1980. Balance Energético Nacional: Series 1970-1979.

rest of the baking process is with fuelwood and the tendency for its use is constant. A better oven was constructed with the support of ICAITI, but little diffusion of that technology has been noted. This industry, because of its importance to the construction industry, will continue in the future with a probable increase in the operations related to the population increases and for reconstruction of the country.

Table 12 provides data on fuelwood consumption for brick making in the country. The number of brick kilns was determined through research carried out by CEL. There is an obvious economy of scale with respect to fuelwood consumption. Bricks of class 3 consume half of the fuelwood that bricks of class 1 do with regards to the quantity per thousand bricks produced. Also CEL reports an annual consumption in tile-kilns of 6,429 tons per year: an industry that was not included in this study.

Table 12. Fuelwood consumption in brick kilns.

Class	Bricks /baking	Average m3 stere /baking	Average m3 stere/ thous. bricks	Average bakings /year	Total No. of brick kilns	Sample No. of brick kilns	Annual consump. (ton.)
1	1000-5000	7.87	2.33	15.60	206	10	6828
2	5000-9000	13.35	2.03	17.21	533	19	33043
3	9000-47000	4.25	1.13	14.90	477	10	32651
						TOTAL	72522

Source: Data provided by CEL from their research on fuelwood use.
Note: The number of brick kilns in each class was provided by CEL from their research on fuelwood use.

For the purpose of estimating the future demand, it is estimated that the fuelwood consumption for brick and tile production will increase at a rate equal to population increases, recognizing that housing construction, an activity that uses tile and bricks, increases when population increases.

All brick producers interviewed use fuelwood, although combined with substitutes as previously mentioned. A majority of the brick manufactures (67%) purchase fuelwood from transporters and producers (21%) and others purchase from fuelwood deposits, temporary vendors or use fuelwood from their own farms. They use a wide variety of species, the greatest percentage being cujin which is the most preferred species. They receive fuelwood in roundwood pantes, which they prefer. Most of the fuelwood used comes from coffee plantations (67%) and scrublands (20%), and the rest comes from isolated trees. Of the total interviewed, 36% indicated that they have problems with fuelwood supply, mainly due to scarcity of fuelwood in the zone.

For reducing the fuelwood use, a program for improved kilns that can produce bricks in a more energy efficient manner would be important. The other option would be the substitution that would require a strong program of promotion, plus the establishment of the necessary infrastructure for supplying the alternate energy source.

Moliendas

This is a traditional industry dedicated to the production of "panela", processed brown sugar in the form of "atados"[13]. It was not included in the survey but there is recent information from CEL that allows its inclusion as another small industry. Moliendas are traditional and produce a product with a local market tending to maintain a constant level of production. It is likely that they will continue their present fuelwood consumption without major changes.

According to the data from CEL there are some 57 mills in the country with an annual consumption of 9,867 m3 which is equivalent to 7,706 tons of fuelwood.

Bakeries

Bakeries that use fuelwood are located in the peripheral zone of the urban areas of the country, and in the sub-urban zones of the population centers. Fuelwood is used in the ovens for preparing bread and other products such as pastries.

Due to the increase in the prices of electric energy, there are tendencies for the continued use of fuelwood as the principal fuel, which tends to counteract the effect of substitution of fuelwood with propane gas.

Of the 17 bakeries visited, 13 use only fuelwood, 2 combine fuelwood, propane gas and electricity, 1 combined propane gas and electricity and 1 uses only propane gas. For the purpose of estimating the national fuelwood consumption in the bakeries, there are data from CEL from a sample of 406 bakeries at the national level, which determined a national consumption of 80,994 tons of fuelwood per year.

A majority of the bakeries interviewed (60%) purchase fuelwood from producers and transporters and the rest from fuelwood deposits, temporary vendors and shops. They use a

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[13] An "atado" de panela or brown sugar is a sugar cylinder in the form of a funnel that is prepared in molds.

variety of species but primarily madrecacao (41%) and cujin (18%) which they prefer. Most fuelwood is purchased in units of raja (53%), pante (20%), and cartloads (13%) in roundwood form and split, but with a preference for split fuelwood (67%). Fuelwood used comes from scrublands, coffee plantations and isolated trees. Of those interviewed 33% indicated problems with fuelwood supply mostly related to fuelwood scarcity in the zone.

There are possibilities of substituting fuelwood with propane gas in bakeries. The use of fuelwood in bakeries does not have cultural influences as does the production of tortillas, and producers are more open to this possibility if conditions are favorable for obtaining propane gas stoves. For the purpose of estimating the future use of fuelwood in bakeries, it is assumed that this consumption will be constant with the substitution of the use of fuelwood with other energy sources balanced by the increase in the bread-consuming population.

Pupusa shops

Pupusa shops are located in the urban and semi-urban areas of the AMSS, urban departmental and the peripheral zones. The use of fuelwood is greater in semi-urban and peripheral zones of the AMSS.

In pupusa shops, there is a tendency to substitute fuelwood with propane gas. Of the 18 pupusa shops interviewed, 6 use only fuelwood, 7 use only gas and the other 5 combine fuelwood with propane gas. Those interviewed showed interest in changing to gas grills but given their financial situation, they cannot afford to purchase the grill. This cost prohibits the change, although the information compiled indicates a lower cost for cooking with propane gas, when compared to fuelwood.

Pupusa shops purchase fuelwood from fuelwood deposits or temporary vendors. One indicated that he purchased from a transporter and another from a producer. The most commonly used species are coffee (23%) and cujin (19%), although they use a wide range of species. They prefer coffee (27%), cicaguite, cujin, and madrecacao (13% each). The units in which fuelwood is purchased are manojo, tercio, and raja, roundwood (55%), split (36%), mixed (9%), but 45% prefer split fuelwood. The 6 which used fuelwood indicated that their fuelwood comes from coffee plantations. Of those interviewed 27% indicated that they had problems with fuelwood supply related to high prices, seasonal supply and scarcity.

From the survey information, it seems that there are possibilities for changing from fuelwood to propane gas with the cost of a gas grill being the limiting factor. Although the

impact of the pupusa shops in the fuelwood consumption is minimum, it offers a possibility for reducing the demand by substituting with propane gas. Due to the difficulty in estimating the number of pupusa shops, the fuelwood consumption for the pupusa shops was not included in the calculation of the fuelwood demand.

Tortilla shops

Tortilla shops are located in the peripheral zones and in population centers in the urban and sub-urban zones of the country. Compared to the pupusa shops, the use of fuelwood in the tortilla shops is high since, for the most part, they do not use other fuels as a substitute. According to the surveys of 52 shops, 47 use fuelwood only, 3 use only propane gas and 2 combine gas with fuelwood.

The tendency in the use of fuelwood in this industry is constant and increasing in terms of the total volume, which is related to the population increase and the dependence on the use of fuelwood in this business. Only a minimum number of businesses (6% of the sample) use substitutes because consumers prefer tortillas prepared using fuelwood.

For preparing 100 tortillas, .028 m3 stere, equivalent to 9.45 kg of fuelwood, is used. Of the tortilla shops surveyed in the urban area, 30 of them use a total of 662 tons of fuelwood in a year and they represent 8 municipal capitals included in the study. Because the data on the total population of tortilla shops in the country was not available, it was not possible to estimate the total consumption in the tortilla shops.

For estimating (although roughly) the annual, national consumption, it is possible to start from the assumption that these 30 tortilla shops represent the total production in the 8 cities and that that production is representative of the country. There are a total of 259 municipalities in the country. If we assume that the 8 cities are representative and that the 30 tortilla shops represent the total production of the 8 municipalities, the total consumption would be (259/8) x 662 tons or 21,432 tons, not including the additional consumption in the metropolitan area of San Salvador, due to greater population and probably greater dependence on tortilla shops.

Most fuelwood is purchased from fuelwood deposits, shops and eventual vendors, but 20% buy from producers. Although a range of species is used, the most common are coffee (12%), cujin (19%), and madrecacao (11%) with preferences for those species, although madrecacao is the most preferred. They receive fuelwood in rajas, tercios, and manojos,

split or whole but with greater preference for split fuelwood (45%). Of those interviewed 48% indicated that fuelwood come from coffee plantations, 35% from scrublands, 9% from coniferous forests, and 4% from broadleaf forests. Of those interviewed 10% indicated problems with fuelwood supply, which is mostly related to fuelwood scarcity.

Decreasing the use of fuelwood in the tortilla shops would require the use of substitutes that have little acceptance among the population for cultural reasons. One way to decrease the use of fuelwood would be to introduce energy efficient fuelwood stoves that would give the same flavor that fuelwood provides while saving fuelwood.

Cafeterias

Cafeterias are located in the urban areas of the municipalities of the country. Those in the metropolitan area use more propane gas than those that are located in the urban areas, who use both energy sources. Of the 26 cafeterias surveyed, 14 use fuelwood, of which 8 use only fuelwood, 5 combine fuelwood with propane gas and 1 combines fuelwood with propane gas and electricity. Of the 14 businesses that use fuelwood, each cafeteria uses an average of 29,511 kg. of fuelwood per year.

Fuelwood is used for preparing heavier foods such as corn, beans and rice, while propane gas is used for preparing lighter foods that require less cooking time. These businesses could be subject to partial substitution of fuelwood with propane gas if there were greater facilities provided for obtaining propane gas stoves, although there is always a tendency for people to cook beans, corn and rice with fuelwood, even if they have gas stoves. It is probable that the use of fuelwood will tend to stabilize with the decrease due to substitution with propane gas balanced by population growth.

The cafeterias that were interviewed purchase their fuelwood mostly from fuelwood deposits and temporary vendors, although some buy from producers and transporters. They use a variety of species, the most commonly used are: coffee (10%), cujin (15%), and madrecacao (10%) with the greatest preference for madrecacao (20%). Fuelwood is bought in small units such as rajas, tercios, and manojos, although two businesses purchased in pantes. Although most of the cafeterias interviewed purchase roundwood, 57% prefer split fuelwood. Fuelwood comes from isolated trees, coffee plantations and scrublands. Of those interviewed, 20% indicated that there are problems of fuelwood supply due to fuelwood scarcity, economic factors, distance and seasonal supplies.

Because data on the total number of cafeterias in the country was not available, it was not possible to estimate the total consumption in this type of business. But, as in the case of tortilla shops, an estimation based on the sample can be calculated, assuming that the sample is representative of the country. In that case, consumption would be: (259 muni./8 muni.) x 29,511 kg/cafeteria x 14 cafeterias for every 8 municipalities, which results in 13,376 tons per year.

Table 13. Total, annual consumption in the artisan industries and businesses in El Salvador.[14]

Industry	Consumption (metric tons)	Tendencies
Coffee processing	35,465	Has decreased and now tends to stabilize.
Sugar mills	908	Has decreased and now tends to stabilize.
Lime kilns	25,281	Tends to increase.
Salt producers	3,300	Tends to decrease.
Brick kilns	72,522	Tends to increase at a the rate of population increase.
Tile kilns	6,429	Tends to increase at the rate of population increase.
Moliendas	7,706	Tends to increase at the rate of population increase.
Bakeries	80,994	Tends to stabilize.
Tile kilns	21,432	Tends to increase.
Cafeterias	13,376	Tends to stabilize.
TOTAL	267,413	

Source: Elaborated with data from study complemented with data from CEL.

TOTAL DEMAND IN THE INDUSTRIAL SECTOR

Using the calculations for each industry and business in the industrial sector, it is possible to estimate the total demand in the sector. The data by industry and for the total sector are presented in Table 13. Businesses tend to be divided between those that continue

[14] It does not include pupusa shops, tortilla shops and cafeterias.

The Lorena stove program of the CENREN-FAO-PNUD project has constructed some 700 stoves, of which they claim that 90% of them are in use. Other programs are reporting success, although they are just beginning. There is a program through the government extension program that promotes the Lorena stove, using home educators as transfer agents. An educator in Metapán, with five years of experience, explained that at first it was difficult to interest the people to become interested in the stove because fuelwood was abundant. Lately, there has been greater fuelwood scarcity and therefore there has been greater interest in the Lorena stove. Other programs are more recent and it remains to be seen what the results will be in the long run.

Table 14 - Some Lorena stove programs.

Program	No. Lorena stoves	Since
CEL/MAG - Panchimalco	60	1991
CEL/FIS - Los Planes	100	1991
CEL/CATIE/USAID Rio de las Cañas	150	1991
PNUD-FAO-CENREN Agroforestry support to Communities with Scarce Resources	700	1987

Sources: Edgard Espinoza, forest agent - Panchimalco
Ing. Balmore Amaya, CEL., and Ing. Hueso, CENREN.

The program financed by the European Economic Community (EEC) that promotes a portable, clay stove called "Tikuahuit" which is produced in the indigenous community of Santo Domingo de Guzmán, Sonsonate. This stove is claimed to provide a savings of 50% compared to the fuelwood consumed in an open fire. According to those that sell the stove, it has been received well by the people. This type of stove has the advantage of being portable and therefore does not take up much space. For those that continue using fuelwood only for preparing certain foods, especially beans and corn, this type of stove provides them with an alternative to save fuelwood and is adapted well to their needs.

Another program is the construction of an improved oven for producing bricks in the brick-making zone near Armenia. Information on that work was not obtained, although it appears that the extent of that work to date has been the construction of a demonstration unit.

These programs are relatively recent and require more time to be able to judge their degree of success, but they do give an indication of the possibilities and experiences available

from which much can be learned. Improved stoves have been shown to save on fuelwood consumption and therefore should form part of programs directed towards confronting the fuelwood problems in the country.

Fuelwood substitution with other energy sources

Another way to reduce the fuelwood demand is by substituting fuelwood with other types of energy. The experiences available in the country include the substitution of fuelwood with sugar cane pulp in sugar mills and the substitution with coffee husks and polvillo de pergamino for coffee processing, which limits the use of fuelwood to a short period of time to initiate processing. No programs were discovered, although they may exist, which introduce gas stoves through access to credit or installment payments for those with scarce resources. If such a program does not exist, this is an area of work which could contribute to reducing fuelwood consumption.

IV. FUELWOOD SUPPLY

The fuelwood supply is the fuelwood available from the various types of vegetation in the country. The sustainable supply is the percentage of the annual production of biomass that can be used as fuelwood in a manner sustainable in time without diminishing the productive potential of the vegetative cover of the country. The biomass production of the tree vegetation, besides supplying fuelwood, has to supply the needs for timber, tree products used in rural communities, the protection of hydroelectric dams, and environmental protection. In this study, the supply has been quantified through: i) the classification of the types of tree vegetation identified through aerial photographs and satellite images; ii) the estimation of the annual production of woody biomass of each vegetative class; and iii) the estimation of the percentage of that production which can be harvested for fuelwood per year in a sustainable manner.[16]

Past studies have used diverse estimates of the volume of fuelwood coming from the vegetative classes with differences between each estimation for estimating fuelwood supply at the Central American regional level, Dulin's study (1984) used information from various sources, while the latest work carried out by CEL is based on preliminary, research data at the field level. However, the information elaborated by CEL requires refinement since it

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[16] According to Dulin(1984), 60% of the total estimated timber production from woody vegetation is exploitable for fuelwood. The other 40% "is not exploitable because it is not suitable for fuelwood or because it is exploited for other uses (construction, etc.).

demonstrates very high annual yields per hectare compared to other studies. In this study, estimations of the fuelwood supply coming from woody vegetation, based on both studies are presented complemented by measurement data on the fuelwood produced through coffee prunings and in unforested areas.

ANTECEDENTS

Following is a brief description of some of the various studies of the fuelwood supply in El Salvador:

1. Domínguez, Carlos. 1982. Fuelwood consumption in El Salvador: Future perspectives.

- Estimation of the fuelwood supply, based on the production of coffee prunings and fuelwood coming from tree vegetation.

2. Dulin, Paul. 1984. Fuelwood situation in the Central American countries.

- This study estimated the fuelwood supply by entering the existing vegetation maps into a geographic information system. Later, calculating the potential fuelwood production for each type of vegetation, an estimation of the fuelwood supply was produced. The fuelwood supply from coffee plantations was not included.

3. OEA-CEL. 1985. The current state of production, consumption and marketing of fuelwood in the municipality of Ahuachapan.

- This study was limited to the fuelwood supply in the municipality, but estimates the fuelwood production in the coffee plantations on the basis of studies at the field level.

4. CEL-BID. 1987. Evaluation of the potential of the fuelwood resource.

- This study estimates the vegetative cover on the basis of satellite images for the first time. This information was combined with preliminary studies at the field level for determining the biomass production from the vegetation types identified.

5. Mansur, E. 1990. National reforestation plan.

- This study estimates the supply and demand of fuelwood based on the existing vegetation in 1975 and the estimations of woody biomass carried out by Dulin (1984), and the estimation of fuelwood consumption calculated by Ing. Martínez Montalvo in the report of July 1987 carried out by CEL on energy consumption at the national level.

The studies carried out have had to base their estimations on partial information and preliminary results of the biomass production from the different types of vegetation. All estimates include variability but they do provide an approximation of fuelwood supply useful for planning.

It is important to note that not all studies carried out in the past mention the contribution of isolated trees and live fences[17] to fuelwood supply. In this study, 25% of the fuelwood gathered[18] in the rural, residential sector comes from these sources. In the rural sector, the sector where the most fuelwood is used, the fuelwood gathered from isolated trees and live fences represents a significant contribution to the fuelwood supply. At the level of residential consumption, fuelwood gathered from live fences and isolated trees represents 15% of the total consumption.

VEGETATION CLASSES

For the purpose of estimating the fuelwood supply, data on the area of vegetation classes used by CEL, based on their interpretation of 1986 satellite images was used. Table 15 shows each vegetation class with the changes in area from 1975 to 1987, and Table 16 presents the extension, the total volume per hectare and the total, existing volume of timber available for fuelwood in each vegetation class. The available supply is presented in Table 18.

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[17] Live fences are fences in which live trees are used to support barbed wire. The posts are generally established through the planting of cuttings and in many cases provide sources of fuelwood as well as serving as posts.

[18] Fuelwood gathered represents 74.6% of the fuelwood consumption in the rural, residential sector and 62% of the total, residential consumption. Fuelwood consumption in the rural, residential sector represents 83% of the total consumption.

Following is a description of each class, according to the classification of CEL[19]:

1. **Broadleaf vegetation** - Braodleaved tree vegetation with well-defined trunk and heights greater than 5 meters.

2. **Coniferous vegetation** - Includes all natural and artificial pine, cyprus and casuarina plantations that occur as dense and homogeneous vegetative masses or as disperse stands.

3. **Shrub vegetation** - All woody species with a height less than 5 meters and greater than 2.5 meters without a defined trunk and/or with a tendency to branch from the base. It is the typical, vegetative cover of lands in fallow for periods of 4 to 6 years.

4. **Mangrove forests** - Broadleaf tree stands that develop along the coast, especially in estuaries, gulfs and bays.

5. **Coffee plantations** - Plantations for coffee production with shade trees.

6. **Scrublands** - Composed of perennial, woody vegetation, with one or more erect stems and plant height less than 2.5 meters. The production of fuelwood is than that of shrub vegetation.

7. **Miscellaneous vegetation** - All broadleaf, tree species that are not important contributors to fuelwood (fruit orchards, plantations of agro-industrial species, cocoa-palms, etc.) Because they are not contributors to the fuelwood supply, they are not included in tables 15 and 16, although in the species listed as used for fuelwood fruits-trees are found and there is substitution of fuelwood with coconut husk in brick manufacturing.

8. **Planted forest** - Included for specifying artificial forests that are registered with CENREN, which may also be included in the broadleaf vegetation classification.

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[19] Taken from CEL-BID. 1987. Evaluation study of the potential fuelwood resource.

TENDENCIES OF EXPLOITATION, VOLUME PER VEGETATION CLASS AND FUELWOOD PRODUCTION

In this section there is a discussion of the trends of exploitation, management and productivity of each type of vegetation. The area for 1975 is based on the interpretation of aerial photographs, and for 1986, it is based on the interpretation of satellite images. The data was reported by CEL (1988). It is important to understand that part of the difference between the years is due to the difference in the methods of interpretation.

Table 15. Vegetation classes and changes in area 1975-1987.

Vegetation class	Area in hectares	
	1975	1987
Shrub vegetation	77,790	180,303
Fallow	213,900	451,775
Broadleaf vegetation	90,759	251,790
Coniferous vegetation	48,477	28,334
Coffee plantations	210,542	184,951
Mangrove forest	45,283	45,008

Source: CEL, 1988. Primer plan nacional de desarrollo energético integrado 1988-2000.

The estimations of fuelwood production vary between the study carried out by Dulin (1984) and CEL (1977). Since the values in CEL's study are higher than those reported in the literature on the productivity of forests, combined with the fact that the CEL study is a preliminary study, the estimation of the supply is based on Dulin's study.

Dulin estimates that 60% of the annual production of biomass suitable for fuelwood is actually available for fuelwood due to the use of part of this wood for sawing and other purposes besides fuelwood. In the case of CEL's study: i) an estimation of the annual production of each vegetation class was carried out; ii) of this estimation, they calculated a percentage that can be destined for fuelwood for each vegetation class; and iii) upon calculating the supply on the basis of steps i and ii, it is estimated that, of that quantity of woody biomass, 55% would be available fuelwood, the other 45% being vegetation that would not serve for fuelwood or that is used for other purposes. According to CEL's study, the percentage of species of lower value for fuelwood are increasing in the secondary

vegetation relative to the percentage of species suitable for fuelwood. This implies a general decline in the capacity of secondary vegetation to produce fuelwood.

Table 16. Vegetation classes, their area, and the potential supply of biomass and fuelwood based on satellite images of 1986.

VEGETATION CLASS	SURFACE (Hectares) 1986	TOTAL VOL. /Hectare (m3)	POTENTIAL SUPPLY (m3)
Shrub vegetation	180,303	22.60	4,074,848
Scrubland	451,775	7.80	3,523,852
Broadleaf vegetation	251,790	490.00	123,377,100
Coniferous vegetation	28,334	371.00	10,511,914
Coffee plantations	185,794	9.53	7,084,325
Mangrove forest	45,008	126.47	5,692,162
Planted forest	2,334 [a]	120.00	280,080 [b]
Without forest cover	952,676	4.00	3,810,704 [c]
TOTAL	2,100,000		158,354,982
Metric tons			118,766,236
Total metric tons available from the existing vegetation [d]			65,321,430

Source: CEL (1987), Dulin (1984)

[a] Information provided by the forest department of CENREN (1991)

[b] Assumes an average annual growth of 15 m3 and an average age of 8 years for plantations.

[c] These calculation are based on Dulin's data (1984) and the area not covered by classes defined and measured by CEL.

[d] It is estimated that 45% of the biomass is not suitable for fuelwood (CEL, 1987).

Applying the percentage of 55% tends to underestimate the supply due to its application to all vegetation classes. In scrublands, shrub vegetation and in the broadleaf forest, it is possible to find many species that are not suitable for fuelwood in the estimate. But, in the case of coffee plantations, the coniferous forest, the mangrove forest and planted forest that are more homogeneous, there will not be as much biomass that is not suitable for fuelwood. This is especially true in the case of coffee plantations which represent 27%

(according to CEL(1987)) of the woody biomass and in which the potential for extracting fuelwood is based on real measurements of the extraction of fuelwood from prunings.

Broadleaf forest

The latest data elaborated on the basis of the 1986 satellite images shows an increase between 1975 and 1986 in the broadleaf forests from 90,750 to 251,790 hectares (CEL, 1988). Part of the difference is due to the fact that the 1975 data was elaborated on the basis of aerial photographs and those of 1986 from satellite images with the corresponding differences in the interpretation. Also the conflict in the country has been another important factor.

In the conflictive zones, there are lands previously cultivated that have been abandoned and secondary vegetation has grown up. It is likely that much of that vegetation has grown to a size qualifying it as broadleaf forest due to its size (greater than 5 meters in height). In revising the new vegetation maps elaborated on the basis of satellite images, it is possible to identify new forests which would not have existed 10 years ago. This effect tends to increase the fuelwood supply. Despite this apparent increase in the supply, it is likely that much of this area will disappear when the farmers return to reclaim the land for agriculture.

Coniferous forest

The coniferous forest is limited to the northern zone of the country in the departments of Santa Ana, Chalatenango, Morazan and La Unión. Between 1975 and 1986, the area of pine declined from 48,477 to 28,334 hectares. According to the information reported by CEL (1988), this is due to the degradation of the forest, which is being replaced by broadleaf species. This is the forest where the lime kilns obtain fuelwood for producing lime. According to the owners of the kilns, the new laws that require permits for transporting fuelwood have decreased fuelwood supply. This effect can reduce the rate of deforestation or the degradation of these forests, although it is likely that there will always be local pressure on the resource.

Shrub vegetation

This is the vegetation on fallow lands. Between 1975 and 1986, the area of this vegetation class increased from 77,790 to 180,303 hectares. This, as in the case of broadleaf forest, is probably an effect of the conflict that caused the emigration of people and the

abandonment of lands previously cultivated. This change also was reported by McReynolds, et.al. (1989) in the study of the use of agricultural lands and land tenency of 1989, but using another system of land classification. This change represents an increase in the fuelwood supply that will be seen in the next few years when the people begin to cultivate those lands. When this excess shrub vegetation is exhausted, a more acute scarcity of fuelwood will result, following a period of excess supply. Also, it is likely that part of this fuelwood supply will be burned when these abandoned lands are cleared for agriculture.

Mangrove forest

The mangrove forest, according to the data reported by CEL, has been maintained without much change with respect to the total area. In 1975 CEL reported an area of 45,283 hectares and in 1986 an area of 45,008 hectares. Currently this vegetative type is subject to a total prohibition on the exploitation of the forest, although recent incursions have been reported due to farmers searching for land to cultivate and fuelwood. With the prohibition of mangrove harvesting, the practice will be minimal, although local use will continue. Despite this prohibition, this forest has the possibility of providing sustainable fuelwood production and other forest products if adequately managed.

Coffee plantations

Coffee plantations have declined from 210,542 hectares in 1975 to 184,951 hectares in 1986. In addition to this change, the civil conflict and low prices for coffee, have motivated owners of many coffee plantations to stop applying certain cultural practices and managing their plantations as recommended. This has resulted in the lack of prunings and renovations of coffee plantations. If owners begin to manage the plantations adequately, it is likely that the fuelwood supply in the coffee plantations will increase for a time before stabilizing. This may result in lower prices for fuelwood and a false sense of security with respect to the fuelwood supply. It is likely that after this period, fuelwood will become scarce, which will result in price increases and more pressure on other fuelwood sources.

Another change, although of minimal impact, has been the change from shaded coffee to coffee without shade. There is no data kept on this change, therefore it was not possible to determine how much area has been converted to shadeless coffee. The assistance agencies are not recommending shadeless coffee due to the environmental problems that can arise.

Coffee plantations are the areas of woody vegetation where the greatest number of

studies on fuelwood supply have been carried out. These areas provide large quantities of fuelwood (43% of the fuelwood supply), are readily accessible and subject to periodic maintenance. Table 17 shows the range and the averages of yields of fuelwood per hectare per year reported for coffee plantations. To estimate the fuelwood supply, the average of the minimum and the maximum value of production in each class of coffee was used.

Table 17. Yields of fuelwood in m3 per hectare per year for coffee plantations.

Type of coffee	Altitude (masl)	Yield (m3/hectare/year) from	to	aver.
Low altitude	<800	11.4	16.0	13.70
Medium altitude	800-1200	8.0	13.7	10.85
High altitude	>1200	4.6	5.7	5.15
All	NA	6.5	14.3	10.40

Source: Mansur(1990), CEL-OEA (1985)

According to the CEL study in Ahuachapan in 1985, the cost of pruning coffee was not recovered with the sale of fuelwood. The maintenance is a cultural practice which the coffee owner has to carry out and the income from fuelwood is an extra benefit that he receives. This situation tends to devalue the fuelwood in the market. It is possible that with the current low prices for coffee in the world market, fuelwood can become a more important source of income for the owners of coffee plantations.

If there is not a major change to shadeless coffee, the coffee plantations in El Salvador will continue to provide a major part of the fuelwood supply in the country, although in terms of percentage of the total consumption, its contribution will probably tend to decrease. In the next few years, if coffee plantations begin to practice prunings as they should, it is likely that the fuelwood supply from coffee plantations will increase for a time before normalizing. This can cause lower prices for fuelwood and a false sense of security regarding the fuelwood supply. It is likely that after this period, fuelwood will become scarce, resulting in price increases and more pressure on other sources of fuelwood. The interim period will offer an opportunity to execute programs for increasing the supply and reducing the demand in order to avoid problems of supply in the future.

Scrubland

Scrubland vegetation increased from 213,900 hectares in 1975 to 451,775 in 1986, more than doubling. It is likely that this increase, like others, is due to the abandonment of cultivated lands in the conflictive zones. As in the case of broadleaf forests and shrub vegetation, this increase tends to increase the supply, which makes the problem of fuelwood seem less and therefore can cause problems in the future. Due to the large variety of vegetation in the scrublands, it is difficult to arrive at a good estimate of its production.

There is an obvious increase in the fuelwood supply due to the abandonment of lands during the civil conflict in El Salvador. It is likely that this increase will be temporary and when people return to these lands, the excess fuelwood will be exhausted in a few years, causing further scarcity in the country. While the supply is maintained relatively high, programs should be initiated for maintaining the fuelwood supply through plantations, and reducing the demand through substitution and greater efficiency in stoves and ovens that burn fuelwood. Through these efforts it should be possible to avoid greater problems in the future.

ESTIMATE OF THE FUELWOOD SUPPLY

As explained previously, the estimate of the fuelwood supply is based on Dulin's study (1984). Table 18 presents the estimate of the supply, comparing the system of Dulin with that of CEL. Although CEL shows greater productivity in the vegetation classes, removing 45% of the woody biomass, production, since it is not suitable for fuelwood, results in a lower total sustainable supply. If this percentage is not applied to the more homogenous vegetation (coffee, planted forest, mangrove forest, and coniferous forest), the supply estimated by CEL is much closer to the results obtained using Dulin's estimates of fuelwood production.[20]

From the supply calculated, 43% comes from coffee plantations. This quantity is sufficient for satisfying the demand for the fuelwood marketed in the country. It is also a source of fuelwood that may have an uncertain future in El Salvador due to the low prices in the world market for this product. If for lack of a good market and sufficient profitability from the coffee plantations, their owners change the land use, this change could have a severe impact on the fuelwood supply and also on the environment.

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[20] Performing this calculation, the data from CEL provides a sustainable supply of 3,592,810 metric ton of fuelwood.

Following coffee plantations, the most important vegetation class for the fuelwood supply are broadleaf forests that have a wider distribution in the country with a lower level of commercialization. It is likely that this vegetation is used more for gathering fuelwood and other forest products for home consumption. This would also be the case for scrublands, shrub vegetation and the area without forest cover, although at times land clearing for agriculture serves as sources of commercial fuelwood in the zones outside the coffee zone.

Table 18. Vegetation class and fuelwood supply using the classification of Dulin (1984) and CEL (1987) and vegetation maps of 1986, based on satellite images.

VEGETATION CLASS	AREA (Hectares) 1986	Class. of Dulin		Class. of CEL	
		m3/year /ha.	m3/year	m3/year /ha.	m3/year
Shrub vegetation	180,303	1.0	180,303	4.52	814,970
Scrubland	451,776	1.0	451,775	2.60	1,174,618
Broadleaf vegetation	251,790	6.0	1,510,740	6.70	1,686,993
Coniferous vegetation	28,334	1.8	51,001	5.36	151,870
Coffee plantations [a]	185,794			9.53	1,770,617
- low altitude	113,171	13.70	1,550,443		
- medium altitude	48,001	10.85	520,811		
- high altitude	24,622	5.15	126,803		
Mangrove forest	45,008	5.4	243,043	12.65	569,351
Planted forest	2,334 [a]	6.2	14,471	6.20	14,471
Without forest cover	952,676	0.5	476,338	0.50	476,338
TOTAL	2,285,795		5,125,731		6,659,230
Global supply of timber biomass (in tons)					4,994,423
Supply not suitable for fuelwood (tons)					2,247,490
TOTAL sustainable supply (tons)			3,844,298		2,746,932

[a] Data on the area per type of coffee supplied by PROCAFE, 1992. Fuelwood production is the average of the minimum and maximum values of production reported by the studies on fuelwood production in coffee plantations.

It is important to recognize that the production figures for a sustainable fuelwood supply are based on an adequate management of the vegetative stands, exploiting only the

annual growth of the fuelwood species that can be sustainable in the long run. Currently, there are no forests that receive this type of management except for the coffee plantations, nor are there plans for such management. What exists is an indiscriminate exploitation of fuelwood with and without permits, without considering a management that can guarantee an adequate supply in the future. The present management tends to substitute the remainder of natural forests of greater valued species with forests or scrublands of little value.

With the growth of secondary vegetation following the abandonment of previously agricultural lands, there is an opportunity to encourage a management of new forests to make them more productive and of better quality while avoiding the disappearance of the remaining natural forests.

V. SUPPLY-DEMAND RELATIONSHIP

With the supply and demand calculated in the previous sections, the supply-demand relationship of the fuelwood situation can be established. With this relationship, it is possible to estimate if the current fuelwood consumption tends to degrade the fuelwood resource in the country or if there is a balance of supply and demand that provides the opportunity to increase or maintain the forest cover. Table 19 shows this relationship. Subtracting the demand in the residential and the industrial sectors from the sustainable fuelwood supply results in a deficit of 574,968 tons.

Table 19. The annual supply-demand relationship of fuelwood in El Salvador - 1991 and annual deficit in tons, cubic meters, and the equivalent in plantations required for satisfying the deficit.

Sustainable supply of fuelwood in tons	+3,884,298 ton
Fuelwood demand in tons- Residential	-4,184,266 ton
Fuelwood demand in tons - Industrial	-275,000 ton
Fuelwood deficit in tons	**-574,968 ton**
Fuelwood deficit in m3	-766,624 m3
No. of hectares of plantation required to satisfy the deficit *	51,108 ha.

* Assumes an average, annual growth of 15 m3 in the plantations.

The deficit between the supply and demand represents the current demand not provided by the natural growth of the woody biomass in the country. For increasing the production of the forest resource for satisfying that deficit, it is calculated that it would be necessary to have planted and producing some 51,108 hectares of tree plantations with their production dedicated to fuelwood. That deficit at present has to come from the capital (i.e. existing woody biomass) thus decreasing the forest cover and its capacity for production of fuelwood in the future. If this situation continues in the future, the process of deforestation will accelerate more each year, with all of the associated environmental problems.

VI. COMMERCIALIZATION CHANNELS

Commercialization channels are the channels by which fuelwood arrives at the market. For identifying those channels, producers, transporters, and distributors of fuelwood were interviewed. This information is complemented by the information from the study carried out by CEL on the marketing of fuelwood in the metropolitan area of San Salvador (AMSS), which includes information on the origin of fuelwood that arrives in San Salvador.

PRODUCERS

In the areas selected for field interviews, it was difficult to find producers. By the end of the field work, 18 fuelwood producers had been interviewed. Of the 18 producers, 15 obtain fuelwood from coffee plantations, and the others from scrublands or plantations. Producers have dedicated an average of 21 years to fuelwood production with the least time being 2 years for one producer who obtains fuelwood from plantations. With respect to the way fuelwood is harvested, 15 of the producers carry it out manually and 3 combine manual operations with the use of a chainsaw. The average production per producer is 113 pantes per year, equivalent to approximately 311 m3/year. The average production per manzana is 2.2 pantes (in coffee plantations).

Of the producers, 12 sell the product in the area of production and others outside the area. Fuelwood is sold as roundwood in 17 of the 18 cases, with 11 selling dry fuelwood and 7 selling green or wet fuelwood. Nine of the producers sell to transporters, 5 to consumers, 2 to fuelwood deposits and 2 to others.

Here, the importance of coffee as a fuelwood source is noted with the majority of the producers obtaining their fuelwood from coffee plantations. This result may be biased by the fact that it is easier to locate producers from coffee plantations. But, it also verifies the

importance of coffee plantations as fuelwood sources noted in the residential surveys. Here, a level of production with little processing of the product is noted, where most of the fuelwood is sold in roundwood form. Transporters generally process fuelwood (split, bundle) before delivering it to the consumer or other intermediaries. The processing is the job of the transporter. It is interesting to note that there is one producer who obtains his fuelwood from plantations even though he has barely two years experience as a producer.

TRANSPORTERS

Due to the restrictions of the forest laws that regulate the transportation of fuelwood and distrust, it was difficult to interview fuelwood transporters. Eleven transporters mostly (5) from the department of Santa Ana and others from Cabañas (2), La Paz (1), Usulatan (1), and Morazán (2) were interviewed. The majority (7) indicated that the fuelwood transported come from coffee plantations and the other 4 indicated that it comes from scrublands and isolated trees. In the case of Santa Ana, all indicated that fuelwood comes from coffee plantations.

Of the transporters interviewed, a pattern of operations can be distinguished. The transporters from Santa Ana are those that transport the greatest volume of fuelwood and all but one transported fuelwood to San Salvador. The other transporters work with local markets transporting fuelwood coming from scrublands, isolated trees or in one case from coffee plantations to a nearby urban center. They purchase fuelwood from producers (8), intermediaries (2), and farm owners (1). The majority (10) sell to households, the one who does not sell to households is one of the largest operators and provides fuelwood to industries. Of those that sell to households, 6 of them also sell to industries, 4 to distributors and 2 to other transporters.

Interviews with transporters indicate a tendency for coffee plantations to supply the fuelwood demand of the AMSS, while for the urban centers outside the coffee regions, fuelwood comes from scrublands and isolated trees and transportation is managed at a smaller scale than in the coffee centers which are fuelwood producing regions for the AMSS. It is important to recognize that, due to the small number of surveys and the difficulty of finding transporters willing to collaborate, the results are not very reliable, although they demonstrate tendencies in transport of fuelwood that concur with interviews of producers.

DISTRIBUTORS

Of the 31 fuelwood distributors interviewed, 12 were from the peripheral urban areas and 19 were from the urban departmental areas. Of the 31 distributors, 23 were located in barrios, 5 in markets and 3 in colonias. The majority of the distributors were fuelwood deposits selling only fuelwood (16), 10 were shops, 4 were in markets, and 1 was a corn grinding mill (for making tortillas). With respect to the time dedicated to the business, the average was 5.2 years with a range of 1 to 20 years.

The services provided include preparation (17), packaging and bundling (14), and credit (4). The majority (18) receive fuelwood from transporters, 9 receive it from producers, and 2 from others. The average amount sold per year was 99.5 m3, but it is more common to sell between 25 and 50 m3 per year.

What the results of the interviews demonstrate that distributors are generally located in the barrios close to their clients supplying fuelwood purchased from transporters or producers from fuelwood deposits or in shops. This, combined with the fact that transporters for the most part deliver fuelwood to households demonstrates a very personal service to fuelwood users. In the study on fuelwood marketing in the AMSS, it was found that the majority of those that purchase fuelwood buy it in small quantities and at times make daily purchases.

Based on the results of the interviews of producers, transporters and distributors as well as interviews of industries, each link in the process can be visualized, from the producer to the consumer. The most important producers are coffee plantation owners who sell fuelwood mostly to transporters that transport fuelwood to the largest population centers in the country. In second place are the producers who supply to the local, urban markets, using coffee plantations, scrublands or isolated trees as a fuelwood source.

Producers sell fuelwood without processing it and the processing of the fuelwood is the responsibility of the transporters and distributors. Transporters maintain distribution centers for fuelwood storage and processing for preparing it for selling it to distributors or directly to households. Distributors are also involved with the processing of fuelwood for sale. The final sale is carried out through distributors or, in some cases, directly with producers and transporters.

VII. CONCLUSIONS

1. Based on the data of the study, the percentage of fuelwood users in the residential sector (74%) has decreased slightly[21], the use per capita has decreased in relation to the study for the national, energy balance of CEL-1980, and the absolute quantity of fuelwood continues to increase. The fuelwood demand is greater than the sustainable supply by some 575 thousand tons annually, which accelerates deforestation.

2. Fuelwood prices are increasing at a rate greater than the general inflation, which indicates scarcity of fuelwood. This increase in prices makes investments in fuelwood production more profitable. This provides an opportunity to promote systems that include fuelwood production.

3. Information on energy use and preferences of energy indicates that approximately 10% of the population who use fuelwood would prefer to cook with propane gas.

4. It would not be possible to substitute fuelwood totally with other types of energy in the short run nor is it likely in the long run.

5. In the rural sector, the majority of the people cook with fuelwood and obtain it by gathering it, which does not involve cash expenses. It is likely that fuelwood gathering will continue as long as there are sources of supply. To assist these people and to help resolve the fuelwood problem, the most acceptable manner would be through reforestation programs, using agroforestry or multipurpose tree production systems.

6. There is information available for elaborating reforestation projects to help supply the fuelwood demand.

7. There is not an easy or simple solution to the fuelwood problem. A package of efforts aimed at reducing the demand and increasing the supply of fuelwood is needed.

8. In the industries, there has been a general tendency to reduce the use of fuelwood through substitution with other energy sources, with the exception of brick manufactures, tortilla shops and moliendas.

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[21] According to CEL (1980), the percentage of fuelwood users at the national level was 75%, and the results of the survey indicate 74% who use fuelwood as primary or secondary fuel.

9. Given the preferences for energy sources and the problems for the people with scarce resources to invest in propane gas stoves, there are possibilities for greater reduction of fuelwood demand through the substitution of fuelwood with propane gas through programs that facilitate the purchase of gas stoves.

10. With respect to energy alternatives: a) the use of kerosine is expensive and is decreasing; b) electricity does not cover the entire country and it is not continuous; c) propane gas is distributed in the country, is less expensive than fuelwood for cooking, and its use is increasing. The greatest limitation of propane gas is that petroleum has to be imported, which requires foreign currency for payment, contributing to problems with the balance of payments in the country. For example, in 1990, El Salvador imported 2,229,918 barrels of petroleum from Mexico, and 2,582,263 barrels from Venezuela with a total CIF cost of approximately 843 million colones or approximately 117 million US dollars (CEL, 1991). Petroleum imports represent 9.3% of the total imports of the country.

11. The industries that offer the greatest opportunities for reducing the use of fuelwood are brick kilns through the improvement of kilns and small food businesses that can substitute fuelwood with propane gas.

12. The country has experienced an increase in the fuelwood supply due to the civil war and the abandonment of cultivated lands where forest cover has become established. This will help reduce the problems of current fuelwood supply, but will occasion problems in the future when this new source of fuelwood becomes exhausted.

13. The information that exists regarding the fuelwood supply is not very reliable. A system of monitoring the vegetative cover based on satellite images is lacking for documenting the changes in the vegetation to improve the management of this resource. This must be complemented by a reliable system of inventory of the production of different types of forest cover.

VIII. RECOMMENDATIONS

Based on the results of the study, the current, sustainable supply of fuelwood is not sufficient for satisfying the fuelwood demand. It is also obvious that if the problem is not resolved, the country will face greater deforestation and environmental degradation. It is important to search for feasible solutions in confronting the problem. At the same time, the civil war has created new sources of fuelwood supply that will help meet the demand for fuelwood in the short run. It will be important that while this reserve is maintained, activities aimed at reducing the use of fuelwood in the country be undertaken. Following there are a series of recommendations for activities that can contribute to the solution of the fuelwood problem. These recommendations are based on the results of the study, complemented by some of the lessons learned in forestry and rural development in the last 10 years.

There are no easy nor simple solutions. There is a need to develop a series of activities that can satisfy the energy needs of the population, establish a balance between the supply and demand for fuelwood, and maintain and increase the vegetative cover of the country, contributing to the improvement of the environment. Recommendations are divided between those with the purpose of i) improving the fuelwood supply; ii) reducing the demand and finally some related to the monitoring of the fuelwood situation and complementary studies.

IMPROVING SUPPLY

To make recommendations for the improvement of the fuelwood supply through reforestation, the country was divided into two general areas: i) the areas where fuelwood is marketed, which are the urban areas and the coffee zones that supply fuelwood for the urban areas; and ii) the areas where fuelwood is not marketed, which are the rural areas where the people gather the fuelwood needed for household consumption.

Áreas where fuelwood is marketed

In areas where fuelwood is marketed, which are generally located near the urban centers, there are possibilities for creating energy or multiple purpose plantations for producing fuelwood and charcoal. Before making recommendations for communities or specific locations, it would be important to perform a financial analysis of the system to ensure that it will be profitable for the fuelwood producers.

Plantations that are exclusively dedicated to fuelwood rarely are profitable, although with increases in the fuelwood prices, this situation could change. For that reason, establishing multipurpose plantations is recommended as a fuelwood source. Multipurpose plantings have the capacity to generate income in the medium term for owners through thinnings for sale of fuelwood, while the trees that remain reach a greater size with a greater value than fuelwood. This type of system is more profitable for the owner, provides a source of fuelwood, and generates economic resources.

For promoting energy or multipurpose plantations species which can be considered include eucalyptus (Eucalyptus camaldulensis), madrecacao (Gliricidia sepium) and others mentioned in Annex 4. Each species has its advantages, disadvantages and limitations with respect to site. Eucalyptus has the advantages of rapid growth, greater yields, good form and the possibilities of sprouting, but the disadvantage is that it is not known in the market. Madrecacao in comparison is easier to propagate, and according to the results of the study, is the species most preferred by users, but its growth is less than Eucalyptus (see Table 20). Annex 4 contains more detailed information on the other species and systems of production. The Madeleña Project of CATIE-ROCAP has information on rapid-growing species including site requirements, their yields, and economic information on the costs of reforestation, prices and profitability of the products that come from plantations.

Distances of planting for plantations for fuelwood production combined with other products in the long run can be 1.5 meters by 1.5 meters to 2 by 2 meters with a thinning for fuelwood in 3-4 years, leaving the best trees to reach greater size and value. Table 20 shows the yields of 4 species that have been used in forestry and agroforestry projects in Central America. It shows the yield in sites of low, medium and high quality with respect to the growth of the species[22]. It also shows the differences in yields, using different spacings. It is important to recognize that the data is for the total Central American region and gives an idea of the relative growth of the species. The results that are obtained from plantations will vary depending upon the different conditions of site and management. What is evident in the table is that: i) eucalyptus in goods sites yields from two to five times the quantity of biomass compared to the other species, which means that the other species would require from two to five times more land for producing the same quantity of fuelwood as the eucalyptus; and ii) increasing the density of the plantation up to 4444 trees/ha. increases the annual yields of biomass.

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[22] For information on the site conditions necessary for the species recommended, the collection of silvicultural guides of the Madeleña Project can be referred to. They are available in the offices of the Project in San Salvador, or through INFORAT in the headquarter of CATIE in Costa Rica.

Table 20. Yield of species according to site class - Central America
Production per year in metric ton/ha. Based on five years of growth.

	2500 trees/ha.			4444 trees/ha.		
	(2 m. x 2 m.)			(1.5 m. x 1.5 m.)		
Species/ Site class	Low	Medium	High	Low	Medium	High
Leucaena leucocephala	2.8	4.8	7.3	4.2	7.0	10.5
Tectona grandis	1.5	2.5	3.1	-	-	-
Gliricidia sepium	2.3	3.6	4.4	2.4	3.8	4.6
Eucalyptus camaldulensis	2.9	7.8	15.9	5.2	13.4	27.8

Source: Collection of Silvicultural Guides of the Madeleña Project. 1990-1991. And David Hughell. 1990. Models for predicting the growth and yield of: Eucalyptus camaldulensis, Gliricidia sepium, Guazuma ulmifolia, and Leucaena leucocephala in Central America. The guides are available in the offices of the Madeleña Project.

From Table 20, it can be seen that there is a significant difference in yield from one species to another, and that by planting higher densities, the productivity per hectare of trees of five years or less in age is increased. For satisfying the demand for fuelwood, high yielding species are important, and when planted in higher densities, it is possible to increase the fuelwood production per unit of area. According to the experience with the establishment of plantations in the region, densities greater than 1.5 x 1.5 meters of produce fuelwood of small diameter, which does not interest fuelwood users.

The production of charcoal provides another option which, in the case of the community of Las Margaritas in Panchimalco, is more profitable than fuelwood. There is a market in San Salvador for charcoal, which is tending to increase (See Figure 4). Charcoal produces less smoke than fuelwood and has a market for recreational use for barbecuing in San Salvador and can be produced in artificial plantations, avoiding the need to fell natural forests for the production of charcoal, as has been the custom in the past.

Areas where fuelwood is not marketed

In the rural areas where fuelwood is not marketed, fuelwood is obtained in exchange for the labor required for gathering it. In these areas it is likely that the efforts for convincing people to use substitutes would not be very successful because of the cash cost required to purchase substitute fuels, since there is high unemployment in these areas and little opportunity to earn money to pay for a substitute. Labor in the rural areas is not well-paid and there is not much work available. According to calculations carried out by Letona, et.al (1991), between 1965 and 1990, the minimum, real salary calculated based on the

consumer price index (CPI) have decreased approximately 50%[23]. In these areas, there are possibilities for confronting the fuelwood problem through agroforestry plantations for self-sufficiency in fuelwood, and possibly for sale where there is a local demand for fuelwood or the means to transport it. Three systems of planting could be considered:

1. Agroforestry systems - There is experience in El Salvador of the Madeleña Project and the Agroforestry Project of FAO with respect to agroforestry systems at the field level. They should be consulted for selecting adequate systems. The systems for which there exists more experience are live fences, trees in lines around fields and compact blocks of trees.

2. Improved fallow with Gliricidia - A traditional system that can contribute to the fuelwood supply is the improved system of fallow with Madrecacao (Gliricidia sepium). The system consists of planting madrecacao before leaving the agricultural plots to fallow. Madrecacao fixes nitrogen, enriches the soil with organic matter and at the same time produces fuelwood and other tree products. In cleaning the plot for replanting to agriculture, the farmer harvests the fuelwood for his own use or for sale. Madrecacao grows from seed or cutting, and therefore there is no need to work with nurseries and there are no cash expenses involved for the farmer. The farmer or his family can gather the seed which he needs for the plantation, although the production can be improved using good quality seed as is done with seeds for agricultural crops.

3. Protected areas with buffer zones in fuelwood plantations for generating employment and providing fuelwood source.- In many protected areas there are problems with local communities that enter reserves for gathering the fuelwood they need for cooking. This type of practice tends to destroy the integrity of the reserves and causes problems among those responsible for protecting the reserves and the communities instead of encouraging cooperation among the communities and the personnel of the reserves.

One option that would: i) encourage better relationships between the community and the authorities responsible for reserves and parks; ii) supply fuelwood to the communities without destroying the reserves; and iii) improve the well-being of

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[23] The real salaries are salaries received, adjusted for inflation. In saying that the minimum salary has been reduced 50% is to say that the average salary today purchases only half of what the average salary purchased in 1965, the base year.

the communities by establishing buffer zones around the reserve areas for fuelwood production and possibly combine fuelwood production with food production using agroforestry systems such as the taungya system. For implementing a system, there are two principal options which are described as follows:

a) Pure, plantations for fuelwood and other products paying laborers to plant and protect the plantations. This option requires the greatest investment by the state or those that manage the reserves. In this type of system, it is important to pay the people to plant and later continue contracting the people to take care and protect the plantations until the trees become large enough to be used as fuelwood. The experience with this type of plantation is that the people do not become conscious of the need to care for the trees because they value the trees only as they relate to the salary received. This type of program should be accompanied by educational programs and creating awareness emphasizing the need for protected areas and other systems for planting trees.

b) Plantations established by the taungya system assigning plots to families or groups for planting crops in exchange for planting and taking care of trees. In this case each family would be assigned a plot for planting trees and cultivating crops. The same family can be given the right to cut fuelwood in the future. In exploiting trees, they would begin the cycle again. In this system, participants become interested in trees because they have the opportunity to plant crops. When possible, this type of activity must be organized by the same community and accompanied by training and awareness, relating to the value of the reserves and the possibilities of production of benefits through tree plantations. The promotion of agroforestry systems in the community would be a logical complement to this type of program. It would require careful management to guarantee that the people take care of the trees from the start. The right to continue using the system must be linked to caring for the trees. Experience has shown that once people start receiving benefits from the trees, they continue planting and increase their plantings.

c) Community nurseries. Another practice which has been effective in promoting tree planting for fuelwood and house construction in El Salvador has been the establishment of community nursery programs. The advantages of the community nurseries is that they train local communities in tree production making them self sufficient in tree production. This helps minimize the need for additional aid and cash expenditures for plants. In addition, the available experience and expertise with community nurseries provides a good starting point for future efforts.

DECREASING DEMAND

The second way to improve the fuelwood situation is by reducing the demand for fuelwood. This can be done through substitutes or through more efficient use of fuelwood with improved stoves or ovens in the residential as well as the commercial-industrial sector. As mentioned previously, given the present situation, a combination of methods should be considered to improve the balance between supply and demand.

Substitutes

The urban areas of the residential sector offer the greatest opportunities for the substitution of fuelwood with other fuels with propane gas providing the most promising substitute. Although there are other alternatives, propane gas is more readily accepted as a substitute and has an established distribution network in the country. Electricity is not very reliable and those that use electricity need a gas stove when there is no electricity. Kerosine is expensive and its use has decreased steadily in the last twenty years. According to the study, there is greater interest in substituting fuelwood with propane gas than with any other type of energy. At the same time it is important to begin exploring other possibilities such as solar energy for future use.

As the information presented in the discussion of the survey in the residential sector demonstrates, the greatest obstacle in changing from fuelwood to propane gas is the cost of a gas stove and the difficult access to credit for persons with scarce resources. Through programs offering stoves at a reduced price or offering the purchase of stoves from local distributors of propane gas through installment payments, there are possibilities for promoting the substitution of fuelwood with propane gas in places where there is interest in that substitution. The data from the survey indicates that approximately 6% of the homes in the rural sector, 9% in the urban departmental sector, and 37% in the marginal AMSS, who presently use other energy sources, mostly fuelwood, would prefer propane gas. These percentages represent more than 51,700 homes at the national level.

Improved stoves

The use of improved stoves for cooking with fuelwood represents another activity that can be used for reducing the demand. Laboratory studies on the actual use of improved stoves show a 30-50% savings in fuelwood with the use of stoves. In the last 10-15 years there have been several programs that have introduced improved stoves, which represents an

experience that can be drawn upon to design new programs.[24] El Salvador also has had projects introducing improved stoves with some degree of success and there already exists this experience that can support new efforts. The promotion of improved stoves should form part of any new efforts aimed at improving the fuelwood situation.

There are two general types of stoves that can be promoted. The first is a stove similar to the Lorena stove that is used for cooking all foods and is constructed in the home where it will be used and generally has more than one burner. The second type is a portable stove that can be moved to a different place in the house when necessary and has only one burner. An example of a portable stove is the clay stove called "tikuahuit", promoted by a program that is supported by the EEC in El Salvador. Although the tikuahuit can be used as the main stove, it can also be used in combination with other energy sources for preparing foods (for those who prefer fuelwood) such as beans, corn for tortillas and tortillas.

Another difference between stoves is the way they are constructed. In the case of the Lorena stove, each stove is made individually, and the person who makes the stove must know how to do it and later provide maintenance to the stove in order to obtain good results. This requires a high degree of technical assistance or training of those that will make the stoves, whether it be members of the family, members of the community or an extension agent. The training of these persons and providing follow-up assistance involves a cost. In general, these activities are included as components of other extension programs, therefore there is no need to elaborate new programs. In Metapan, the promotion of stoves is an activity of the home educators within the extension program of the Ministry of Agriculture and Livestock (MAG).

The other type involves stoves such as the tikuahuit that can be manufactured by an enterprise, sold and transported to the place of use. They do not require maintenance nor continuous technical assistance, but in general, they have a greater initial cost to the user than the Lorena stove.

Currently there are programs working with the Lorena stove, promoted by CEL, the Agroforestry Project of CENREN-FAO-UNDP that is entering a phase of expansion in the northern zone of the country, and the program with home educators from MAG. The Agroforestry Project of CENREN-FAO-UNDP reports that they have constructed some 700 Lorena stoves with around 90% in use. Of the stoves promoted in the past, the Lorena stove

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[24] Annex 2b presents a bibliography of the publications on stoves, which is available at INFORAT in CATIE.

continues to be the most commonly used. New efforts should include the Lorena stove but also explore other alternatives. In the rural sector, it is likely that the Lorena stove may be the most acceptable alternative due to its low cost. Any stove which requires a cash investment may be difficult to promote due to the fact that the use of fuelwood in the past has been an activity free of cash expenditures or investment. Nevertheless with the scarcity of fuelwood there is more interest in saving fuelwood by using energy efficient stoves.

In the urban departmental sector and the AMSS, where the use of fuelwood is eventual or is combined with the use of other types of energy, a portable stove such as the tikuahuit may have more possibilities for success. It requires little space and can be moved or stored when it is not in use but saves fuelwood and avoids burns. The only limitation is that it is made out of clay and therefore care must be taken when transporting it, to make sure that it does not break. Although it has possibilities in the rural areas, it may be more successful in the urban areas since it adjusts better to the conditions of space and cooking methods.

Improved kilns for producing charcoal and bricks

Improved stoves are not limited to the residential sector. There are possibilities of saving fuelwood with improved ovens for the production of charcoal and bricks. Charcoal represents an alternative to fuelwood in the urban areas, which is appropriate for reduced spaces and is more profitable than fuelwood if there is interest in promoting plantings for energy production for sale. The efficiency of the conversion of fuelwood to charcoal and therefore the yield depends much on the process used for producing charcoal. Table 21 provides an estimation of the quantity of wood needed to produce one ton of charcoal, using different types of kilns and fuelwood with different humidity contents.

The charcoal produced in El Salvador is produced using earthen kilns which are cheap but very inefficient. The yield of a brick kiln is around two times the yield of an earthen kiln, which indicates that charcoal producers can produce two times the quantity of charcoal with the same quantity of fuelwood that they use now if they adopt brick kilns. Part of the problem in the past was the need to produce charcoal at the site where trees were found. If energy producing forests are developed for charcoal as is done today in Panchimalco, there is no need to go searching for raw material. This favors the installation of better kilns that are close to the fuelwood source which will be a forest managed in a sustainable way. This eliminates the need for people to go looking for fuelwood and destroying the natural forest. The other advantage of improved kilns is that they require less labor for preparing and baking each batch of charcoal.

Table 21. Quantity of fuelwood (in m3 solid) required for producing a ton of charcoal.

Type of kiln	Humidity content of fuelwood					
	15%	20%	40%	60%	80%	100%
Earthen	10.0	13.0	16.0	21.0	24.0	27.0
Portable iron kiln	6.0	7.0	9.0	13.0	15.0	16.0
Brick	6.0	6.0	7.0	10.0	11.0	12.0
Retort	4.5	4.5	5.0	7.0	8.0	9.0

Source: FAO. 1983. Wood fuel surveys.
Note: The humidity of air dry fuelwood is 15%.

Another way to improve the efficiency of conversion of fuelwood to charcoal evident in the table is by drying the fuelwood before making charcoal. The volume of fuelwood needed for producing a ton of charcoal if the fuelwood is dried in the air is around half of what is needed if the fuelwood is humid (green 80-100% humid). The combination of better kilns with the dried fuelwood can increase the production of charcoal two or four times the production possible using green fuelwood processed in earthen kilns.

Another advantage of improved kilns for charcoal is that they require less labor. Earl (1974) indicates that an earthen kiln requires 26 mandays for producing a ton of charcoal while a portable, iron kiln only requires 4 mandays. The savings of labor with a brick kiln should be similar to the savings with the portable kiln.

There are possibilities for improving the efficiency of the kilns used for preparing bricks and tiles with better structures. ICAITI has constructed a model close to Armenia in El Salvador. There are no indications of adoption of the model but this is a possibility that deserves more research dealing both with the efficiency of the use of fuelwood as well as possibilities for the use of substitutes. FAO (1983) reports the use of fuel oil for the production of bricks. Some of the brick producers interviewed showed interest in substitutes for fuelwood but did not know what alternatives are available.

Updating the study

In developing programs and projects with the purpose of improving the fuelwood situation in El Salvador, it will be important to carry out a monitoring of the situation in the future for measuring the progress and making changes in the programs when necessary. Also, due to the problems of entering into conflictive zones and with the last census carried out in 1971, the estimates presented are subject to revision, based on the new census and the changes that will be brought about through peace in El Salvador. It would be possible to make an estimation of the fuelwood consumption based on the results of this study together with the results of the census. Also, it is recommended that a new study be carried out, after 3 or 4 years, which could cover the entire country, including the conflictive areas and which were outside the scope of this study also taking advantage of the updated census.

The new census will include a question about the use of fuelwood in homes. This will provide a more accurate indication of how many homes currently use fuelwood in the country. Another source of information and possible collaboration is the AID-GOES Project IPROS (Implantation of continuous, national surveys) who, through MIPLAN, carry out a "Multipurpose Home Survey" every one or two years that also includes a question on fuelwood use.

With respect to fuelwood supply, it will be important to monitor the situation. This can be done through the interpretation of satellite images which would probably be the most economic way, but requires that a standard methodology for interpreting the images be established. CEL has worked in this area and now CONAMA continues the work. Recently the tapes of images were transferred to CATIE through an agreement between CEL and the Watershed Project of CATIE. The General Direction of Statistics and Census is also interested in the geographic information system (GIS), and this offers the possibility of incorporating the population factor into the GIS systems. It would be useful if, among the institutions involved, a standard methodology for interpreting the images can be established. This standardization could even be extended to the regional level to provide a better understanding of the dynamics of the changes in the vegetative cover. The interpretation of satellite images can always be combined with aerial photographs for a greater degree of precision, but a standard for assigning the vegetation classes is essential to any of these efforts.

IX. SUMMARY

El Salvador is confronted with a serious problem of exhaustion of its tree resources. As the results of this study and previous studies have demonstrated, the demand and the use of fuelwood in the country plays an important role in the deforestation and environmental degradation that the country suffers. At the current rate of fuelwood consumption, the demand is greater than the sustainable production of the existing vegetation.

Due to the armed conflict in El Salvador, the effect of deforestation caused by the use of fuelwood has not been as serious as it could have been. The abandonment of agricultural areas by people, due to the problems of the conflict, has favored the growth of secondary vegetation that can be used as a source of fuelwood. With the signing of the peace agreement, it is likely that in the near future areas previously protected by the conflict will be subject to clearing and cultivation and this fuelwood reserve will soon disappear. It is important that while there still exists this fuelwood source, actions aimed at increasing the supply and decreasing the demand for fuelwood be undertaken in order to avoid further deforestation and arrive at a sustainable production of fuelwood.

The options for improving the fuelwood situation include: i) the substitution of fuelwood with other types of energy such as electricity and propane gas; ii) the use of improved stoves in industries as well as homes; and iii) increase in the fuelwood supply through reforestation and agroforestry programs.

The first option applies to urban centers where the users purchase fuelwood and in general confront higher prices for fuelwood than propane gas. According to the results of the study, there are people interested in making this change. The greatest obstacle, according to the interviews, is the investment in a gas stove. This obstacle can be eliminated through credit programs for the purchase of stoves. It is likely that this option would not function in the areas where the people gather fuelwood. Another limitation of this option is its dependence on the derivatives of imported petroleum.

The second option offers a saving of 30-40% in the use of fuelwood and can be an important ingredient in a package aimed at improving the situation. The difficulties here are related to the effort of promotion necessary for encouraging better stoves in the rural area and the cost of stoves for the people. There are recent efforts that are promising, but it will be important to see how these efforts continue to function in the future.

The third option offers advantages in the sense that the scarcity of fuelwood and forest products makes it more attractive for the farmer. There is forestry technology that has been developed in the last 10 years, which is available, already functioning and providing results in forestry and agroforestry projects, which can provide fuelwood and other forest products needed by rural communities where there is less opportunity for substituting fuelwood with other energy sources. This is also an option that can establish a sustainable source of fuelwood, which at the same time helps improve the environment. This option, as do improved stoves, requires technical assistance and promotion at the field level.

The quantity of fuelwood used in the rural areas makes this an important area to concentrate efforts in any program aimed at improving the fuelwood situation. More than 80% of the fuelwood used in the residential sector is used in the rural areas. Due to this greater use, the area offers more opportunity for improving the fuelwood situation.

It is also important to mention the importance of reliable information on the fuelwood use and the changes in the forest cover in the country in order to carry out monitoring of the changes and directing efforts for improving the situation. It is still necessary to work with population data of 1971 and on vegetation data from 1975, or satellite images of 1986 that are not compatible. There is a need to coordinate efforts for generating the necessary information for monitoring the fuelwood situation and making it available to those responsible for making decisions.

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ANNEXES

Annex 1 - Annotated bibilography

Annex 2 - Bibliography - INFORAT - CATIE
a. Fuelwood
b. Stoves

Annex 3 - Conversions

Anexo 4 - Species for reforestation

Annex 1

ANNOTATED BIBLIOGRAFAPHY

CEL 1988. Primer plan nacional de desarrollo energético integrado 1988 - 2000. Gerencia de Planificación Estratégica. San Salvador. El Salvador. 557 p. Available at CEL and AID.

The work is quite comprehensive, including a complete national and sectoral diagnosis, investments, perspectives and the supply of numerous sources of energy.

The diagnosis of fuelwood is found under the subchapter "fuelwood and vegetation residues (biomass)" and "fuelwood prices." In perspectives, fuelwood is included considering mainly the residential sector which reprsentss 88% of the current energy demand. Future growth will increase demand for energy, but there will be a restructuring within this demand, and fuelwood will reduce its proportion to 77% in the year 2000. In the industrial sector, fuelwood will decline from its current position of 33% to 23% in the year 2000. The slight deficit of today will increase in the future. The coefficients of productivity used in this section are not very good. For achieving estimates of the area, satellite images and a sophisticated analysis for producing data on the coverage by stratums of biomass was used.

This work is an important advance in providing updated data for the country.

CEL. 1991. Balance Energético Nacional 1990. Comisión Ejecutiva Hidroeléctrica del Río Lempa. San Salvador, El Salvador. 55 p. Available at CEL.

This is the balance for 1990, which contains information on the use of fuelwood and other energy sources at the national level. It provides updated information on fuelwood consumption based on projections of the information from the study carried out by CEL/E. Martínez-Montalvo in 1987.

CEL/BID (Sorrentino, Adrianna, Edilberto Viar, and Fidel Ramos). 1987. Estudio Evaluación del Potencial del Recurso Leña. Programa de Fortalecimiento de la Capacidad de Planeación en el Campo Energético: Convenio ATN/SF-2369-ES. CEL/BID. 111 p. Disponible en CEL y MADELEÑA (CATIE).

This study summarizes data from surveys carried out by E. Martínez and others, and is used to put together a quantitative framework for addressing the problem of biomass measurement which justifies further studies of natural resources through remote sensing. The steps of the methodology are described for determining the vegetative cover through LANDSAT satellite images (including 4 originals that cover 10km2 each). In the annexes, descriptions of the first phase of the preliminary interpretation of vegetation is presented and a proposal is presented to carry out a second level of inventory which will quantify the volume of vegetation by vegetation types.

CEL/OEA. 1989. Estudio de comercialización de leña y carbón en el área metropolitano de San Salvador. Consultor Mauricio Majano Ochoa. Proyecto Plurinacional de Energía y Desarrollo en el Istmo Centroamericano. San Salvador, El Salvador. 54 p. Available at MADELEÑA.

A study based on surveys originating from 127 surveys of transporters carrying fuelwood to the metropolitan area. Later 45 venders were interviewed, and finally 1,390 homes were interviewed.

Fuelwood prices are presented, preferences per species and margins of commercialization. In less detail data on charcoal use is presented. The total volume of fuelwood or charcoal consumed in the

metropolitan area was not estimated, nor the consumption by home (or per capita). It concludes with recommendations, which describes: the seasonality of sales and prices, reforestation in the departments that supply the metropolitan area (Santa Ana 28%, La Libertad 26%, Cuscatlan 11% and San Salvador 10%); and it was observed that the charcoal market will offer interesting options in the future.

CEL-PNUD. 1980. El Salvador, Centro América: Balance Energético Nacional: Series 1970-1979. CEL-PNUD. San Salvador, El Salvador. 162 p. Available at CEL and CATIE (MADELEÑA) in San Salvador.

This document initiated the preparation of the national energy balances for El Salvador. A chapter of the document is dedicated to fuelwood and contains the methodology and results of a survey of 5,000 homes carried out for determining the fuelwood use at the national level. The survey was national and was restricted to measuring the use per capita of fuelwood without taking into account other factors that influence the use. The work determined a daily consumption per capita at the national level of 3.15 kg./day.

Information is included on the production of fuelwood in coffee plantations and the use of fuelwood in the industrial sector. It was a pioneering work in El Salvador, based on experiences in South America. It served as a basis for the elaboration of the national energy balances and a point of reference for future studies.

CONTRERAS, M. 1984. Estudio de la producción y consumo de leña en la región Occidental de El Salvador. MAG/CENREN/CENTA. Not published. Draft. 19 p. Available at MADELEÑA.

The draft used as a variety of sources of information, including 140 surveys in communities, plus official statistics on number of households and the areas in cultivation. A scheme of fuelwood production on coffee plantations and another for corn wastes is presented. The data summaries do not have the clearly indicated field observations, supporting their conclusions. Finally, prices are reported related to the quality of fuelwood and serve as a point of reference in this region for the year 1983. Also in the annexes there is a list of preferred forest species used as fuelwood in homes.

DOMÍNGUEZ, CARLOS. 1982. Consumo de leña en El Salvador: perspectivas futuras. Tesis de Ing. Industrial. Universidad Centroamericano José Cañas. San Salvador, El Salvador. 73 p.

This work is based on surveys carried out for the Energy Balance: Series 1970-1979. The author was part of the team that carried out this work. It reports the same information that is included in the Energy Balance but goes much deeper and includes future projections and estimates of the effect of stove programs and reforestation. It recommends the elaboration of programs and projects to promote improved stoves and reforestation.

DULIN, P. 1984. Situación leñera en los países Centroamericanos. Serie Técnica, Informe Técnico; CATIE-ROCAP 596-0089. 51 p. and mapas. Available at the ORTON library.

The publication is presented in two parts. The first part is the conceptual framework applied to six countries. The primary factors that are taken into account are described, such as population density and the current land use. Critical areas were determined by combining maps which include growth coefficients for the forest which were estimated to be sustainable. The digitized map system and superposition of information is called CRIES.

The second part provides descriptions by countries (6). Statistics on population, use of land by class, availability of fuelwood and superficial classification of fuelwood scarcity, from satisfactory to very critical are presented.

OBSERVATION: For El Salvador there were no surveys on fuelwood consumption; its land use is for 1973-1975, scale 1:200000; and the population from the Annual Statistics Report of 1979-80 and mapped by municipality. This pioneering methodology has already surpassed the more recent studies.

FAO (ANTONIO MONZON, Consultor). 1991. Política Forestal: Informe y propuesta. Programa de Cooperación Técnica, El Salvador FO: TCP/ELS/0051(A). San Salvador, El Salvador. 181 p.(Report), 136 p.(Proposal).

These documents summarize a consultancy carried out in 1990 on forest policies in El Salvador. Recommendations from the consultant include the modification of the Forest Law, adoption of an incentive policy for reforestation, establishing legal doctrine for the management of natural areas that deserve protection, and administrative reform. The consultant proposes a national plan of reofrestation that promotes reforestation of 207,00 hectares for fuelwood and 69,000 hectares for timber in a period of 20 years (1992-2011). According to the projections of the consultant, this reforestation would serve to counteract the deterioration of the tree resource and beginning in the year 2006, begin recovering the forest stand to the point that when the year 2011 arrives, the forest resource will be at the same level as the resource existing in 1990.

INFANTE G., H.J., I.E. RUIZ S., M.E. DIAZ H., y M.R. IBARRA D. 1990. Factibilidad de implantación de una fábrica de briquetas para la sustitución de leña. Trabajo de graduación. Universidad Albert Einstein. San Salvador, El Salvador.

This work presents information on fuelwood consumption at the domestic, industrial and artesan level in El Salvador as part of the feasibility study. Also, in using the data of the study carried out by Martínez Montalvo (1987), the authors carried out interviews at the the industrial-artesan level, which included measurements of units of fuelwood and consumption by industry with the purpose of estimating fuelwood demand.

MANSUR, E. 1990. Plan nacional de reforestación. UNDP/FAO First draft, consultant. 93p. Available at MADELEÑA

The manuscript is a good introduction to the traditional forest situation in the country. It relates experiences of previous projects with their achievements and the previous reforestation plans. Their new goals are to provide unprocessed wood, fuleood and in the end some timber for local self-consumption. Actions for harvesting in the long rung is proposed with the state as the main agent-promoter. The goals are US$ 27 million with 15,000 hectares of plantations, participation of 90,000 families (on 140,000 has.) and silvo-pastoral improvement on 40,000 has. The predicted term is 10 years. The main limitations identified are lands and financing. The coordination of fund raising through PAFT was mentioned; also the complementarity with the Economic and Social Development Plan of El Salvador.

MARTÍNEZ MONTALVO, EDGARDO A. 1987. Demanda de Energía por uso final en el sector residencial área urbana y rural. CEL-BID. San Salvador, El Salvador. 209 p.

This work presents the results of a survey of 2,315 households on the use of energy in those households. It includes the characterization of households with respect to the number of people, income level, final use of energy, divided between the AMSS, the urban departmental and the rural area.

It was found that 77% of the familes in the national residential sector used fuelwood as a primary, secondary or auxilary energy source with a per capita use of 2.1 kg./day. Of the total population, 37.8% purchase fuelwood, 34.6% gather, and 4.8% purchase and gather fuelwood. A total, national consumption at the residential level of 1174.6 thousand tons was calculated.

TORRES, J. E. 1985. Estudio actual de la producción, consumo y comercialización de leña en el Municipio de Ahuachapan. CEL/OEA. Mission Report. San Salvador 142p. Available at CEL

A stratified sampling (2% of the households, 263 surveys) was carried out for quantifying the total volume of fuelwood, the market flows of fuelwood and charcoal and for identifying possible obstacles in the system. A map of land use in the municipality was prepared relating fuelwood availability to land use. It was found that a commercial import of fuelwood in the municipality is needed (observing that the production of live fences, shade trees, agricultural wastes, etc. are not accounted for). The study concluded that the coefficients of fuelwood productivity are doubtful.

Changes in landlords in the land use observed will make the situation acute in reference to the fuelwood scarcity in the future.

Marketing of fuelwood and present data of the department, with a total of 12 municipalities is presented. For this section 86 surveys in the dry period were added for checking the price variations and the weight of fuelwood.

The residential sector is stratified in the urban areas, Lotificación, coffee plantations, others (without scarcity), and others (with scarcity), with a total of 264 surveys. The productive sector was identified as coffee farms, brick manufacturers, tortilla shops, cafeterias, bakeries for which a total of 80 surveys were carried out.

It concludes with a section on marketing, including some fine hardwood timber species used for sawlogs. This part is oriented more towards specific cases that attempt to characterize a system, instead of quantifying within a specific system.

OBSERVATIONS: At the end of the study there are many recommendations, but it was noted that more home surveys were not carried out because the results of the data demonstrate that the consumption does not differ much from one strata to another.

ANÓNIMO. 1986. Evaluación del recurso leña y usos comerciales del carbón en El Salvador. CEL mimeograph. 32 p.

The manuscript attempts to interpret the implications of various studies and situations observed in referrring to the adequate knowledge on fuelwood consumption. It is observed that the irregularity in the tendencies of the land use, which makes the prognostics for fuelwood production unstable. The diversification in the commercial channels of fuelwood and charcoal and thus the ability to adjust to a large number of particular conditions is commented. With respect to the estimate of a possible sustainable production of fuelwood, coffee plantations, mangroves, degraded forest and scrubland-shrub are identified. Growth data previously reported is used. The primary limitations identified are lands and financing. The coordination in fund raising through PAFT and the complementarity with the Economic and Social Development Plan of El Salvador are mentioned.

ANÓNIMO. 1989. Ventajas y limitaciones de un plan de incentivos para la producción de leña comercial en El Salvador, en Seminario-Taller: Incentivos para la Reforestación con Fines Energéticos en El Salvador.. CATIE-CEL. Turrialba, Costa Rica. p. 87-89. Available at CEL and MADELEÑA (CATIE).

This short article discusses in a general way incentives for fuelwood production at the market level.

Annex 2

BIBLIOGRAPHY - INFORAT - CATIE

a. FUELWOOD

BIBLIOGRAPHIC REFERENCES ON USES, PRICES, MARKERTS, SUPPLY MARKETING OF FUELWOOD IN CENTRAL AMERICA

DATABASE INFORAT/CATIE
NOVEMBER 1, 1991

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c. Ordering information

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NOTE: The publications in the two lists from INFORAT/CATIE are available for consulting at the Orton Library at CATIE in Turrialba, Costa Rica or can ask for photocopies through the:

Forestry information and documentation Service for Tropical America (INFORAT), CATIE, 7170, Turrialba, Costa Rica and through mail you will receive the photocopied material, with the following costs per page:

US$ 0.10 for Central America
US$ 0.20 for the other countries

Annex 3

Table of Equivalences of Market Units of Fuelwood
based on field measurements

Commerical unit	Dimension	m3 stere*	Weight (lbs.)	Weight (kgs.)
Pante	10x10x3 cuartas	3.69	1636.00	742.08
Pante	8x10x3 cuartas	2.95	1309.00	593.75
Pante	8x8x3 cuartas	2.37	1050.00	476.27
Pante	8x8x5 cuartas	3.89	1725.00	782.[illegible]
Pante (salt-mine)	1.9x1x0.82 meters	1.55	1300.00	589.67
Pante (lime kiln)	1.8x1.8x0.9 meters	2.92	2800.00	1270.06
Large raja (quebracho)	63 cm. long	0.015	17.00	7.71
Large raja (pepeto)	76 cm. long	0.012	13.00	5.90
Average raja	70 cm. long	0.011	8.00	3.63
Rajita (madrecacao,pepeto)	65 cm. long	0.00077	0.75	0.34
Rajita (guachipilin)	63 cm. long	0.00077	1.75	0.79
Leño (14 cm. diámetro)	70 cm. long	0.014	10.00	4.54
Carga (24 rajas)	70 cm. long	0.269	192.00	87.09
Tercio (8 rajas)	70 cm. long	0.089	64.00	29.03
Manojo (6 rajitas guachipilin)	70 cm. long	0.00462	6.50	2.95
Manojo (6 rajitas pepeto)	65 cm. long	0.00462	3.75	1.70
Manojo (7 palitos rollizos café)	65 cm. long	0.00308	2.25	1.02

One cuarta = 23 cm.
Approx. 4 samples were taken for each unit. The samples tended to be uniform. The cubic meter stere refers to the volume of the unit of piled or bundled fuelwood which includes the space between the roundwood or splitwood(raja) pieces making up the meter stere. When referring to a unit that is solid such as a raja, a cubic meter stere is equivalent to a solid, cubic meter. Although it varies, a cubic metric stere of piled fuelwood is approximately equivalent to 0.65 solid cubic meters.

Annex 4

SPECIES FOR REFORESTATION

In this annex, some general recommendations are presented, with regard to species for reforestation. The species mentioned are exotic with the exception of oak (Quercus sp.) and madrecacao (Gliricidia sepium). The reason for this is the rapid growth of these species and the degree of knowledge and research available related to their cultivation. This is not to say that it is important to dismiss other native species, but to begin research that can test their value for energy and their relative rates of production. Due to the fuelwood crisis and deforestation in the country, it is important to work with tested species because of their rapid growth, and the knowledge available for their establishment and management.

This annex only deals with very general recommendations. For more information it is recommended that projects working in El Salvador that have experience based on the research as well as practice be consulted. The sources of greater experience in research and application are the Madeleña Project of CATIE and CENREN, CEL in Watersheds and organizations connected with the Madeleña Project of CATIE. The Madeleña Project of CATIE has economic data in addition to silvicultural information on rapid-growing species.

The species have been divided among the general zones. The following are the recommendations:

Coastal Zone

- *Eucalyptus camaldulensis*
- *Leucaena* planted as a seedling.
  (reproduction by seed is very slow in the first year when it is more susceptible to competition.)
- *Gmelina arborea*
- *Casuarina sp.* in soils similar to those of mangroves.

Dry Zone (< 1000 mm./year)

- *Tectona grandis*

Upper Coastal Zone

- *Eucalyptus camaldulensis*
- *Gliricidia sepium*

Altitude greater than 500 meters

- *Gliricidia sepium*
- *Quercus sp.* (management of natural vegetation with sprouts.)

As can be seen from Table 20 of the report, there is a sharp difference among the growth of the recommended species. At the same time, each species requires certain site conditions that are specific for the species that is reflected in the difference in growth according to the quality of the site. There is information on these conditions in publications available through forestry and technical projects working with trees. It is extremely important to utilize these sources of information and technical assistance for assigning species to sites.

Two references that can be used are:

- Collection of silvicultural guides of CATIE

- THE NATIONAL ACADEMY OF SCIENCES, WASHINGTON, D.C.; CATIE, TURRIALBA (COSTA RICA). Especies para leña: arbustos y árboles para la producción de energía; informe de un panel ad hoc. Turrialba (Costa Rica), 1984. 343p.