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TIMOR LESTE
ISSUES AND OPTIONS IN THE HOUSEHOLD ENERGY SECTOR:
A SCOPING STUDY

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Transport, Energy and Mining Sector
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Foreword

This report describes the results of a study conducted between November 2006 and May 2007 that examined the biomass supply and demand situation in Timor Leste by reviewing available data and conducting limited surveys and field investigations. The study team consisted of Selina Shum, Task Team Leader (EASTE); Ernesto Terrado, Household Energy Specialist (Consultant); Keith Openshaw, Forestry Specialist/Economist (Consultant); and Voravate Tuntivate, Survey Specialist/Economist (Consultant). Technical, research and logistics support was provided from the local World Bank office by Joao Jose Augusto Gomes, Operations Officer (EACDF) and Yohanes Usboko, Agriculture Specialist (Consultant). The local surveys were conducted by the Timor Institute of Development Studies (TIDS). The Agricultural and Livestock Global Information Systems Unit (ALGIS) of the Ministry of Agriculture, Forestry and Fisheries (MAFF) provided valuable land use data for the analysis of biomass supply.

INTRODUCTION

The important role of biomass fuels today. Timor Leste is a relatively small country located in the eastern part of Timor Island with an area of about 1.5 million ha and an estimated 2007 population of 1.0 million (see map in Annex 1). At about US$550 GDP per capita, it is one of the least developed countries in the world, with an estimated 40 percent of the population in poverty. However, the development of offshore oil and gas resources in partnership with Australia has recently begun to generate substantial revenues for the Government. The country still faces huge challenges ahead, as it tries to rebuild an economy that was totally devastated during the recent periods of violence and civil unrest.

In the energy sector, several major investment projects have been initiated that would greatly expand the power generation and distribution infrastructure, and make electricity accessible to large numbers of currently un-served urban and rural people. For the household sector, there is no question that improved access to electricity will dramatically improve the quality of life, through superior electric lighting and the capability to use modern, more efficient appliances. Electricity, however, is unlikely to make even a dent in the vast majority of homes as a substitute for other cooking fuels.

The household sector is by far the largest consumer of energy in Timor Leste today. The major end use of energy in this sector is cooking, and biomass (wood) is the fuel of choice. Nearly all urban and rural households use fuelwood for cooking. Other domestic end uses, such as lighting by electricity or kerosene lamps, constitute only a tiny fraction of total household energy consumption. This predominance of fuelwood in the national energy mix is expected to continue in the foreseeable future, a consequence of the still highly rural nature of the economy and the general poverty of the population.

Table 1 provides an approximate comparison of current consumption of all types of fuels used in Timor Leste today:

Table 1. Timor Leste 2006: Useful energy share of major fuels for all sectors

Fuel type	Consumption tonnes/yr	Heating Value, MJ/kg	Utilization Efficiency, Percent[6]	Useful Energy, ktoe[7]	Percent Share
Fuelwood[1]	600,000	15.5	15	33.3	51.9
Diesel [2]	50,000	46	40	22.0	34.2
Gasoline [3]	22,000	47	30	7.4	11.5
Kerosene [4]	3,000	46	35	1.2	1.8
LPG [5]	500	45	60	0.3	0.5
Total	675,500			64.13	100.0

[1] From results of present study.
[2, 3, 5] From Ministry of Natural Resources and Environment publication (2006).
[4] From ADB Power Planning Study (2003) that estimated between 3 - 4 million liters kerosene used per year
[6] Fuewood, kerosene and LPG efficiencies refer to cooking stoves; diesel to power generation, and gasoline to automobile engines.
[7] One toe = 41.9 GJ

It is seen that even at very low utilization efficiency, energy from biomass greatly exceeds that from any other fuel, accounting for about half of all delivered energy from every fuel utilized in all sectors of the economy.

Definition of biomass fuels. Biomass fuels by definition include not only wood and its principal derivative, charcoal, but also agricultural residues, such as rice husks, coconut shells and husks, coffee residues, bagasse and sugar cane wastes. Bamboo, palm fronds, etc are also burnable biomass and are actual and potential fuels. In Timor Leste, however, it was found that the non-wood biomass, as well as charcoal, is rarely used as fuel in households, rural industries and the service sectors. Although these are briefly discussed at relevant points in the present study to provide a more complete picture of biomass consumption patterns in the country, the focus of the analysis is on woody biomass and primarily on its use for energy in the household sector. An analysis of the non-fuel use of forest resources in Timor Leste is not included in the present study.

Burning issues. The critical question to examine is whether the country's heavy dependence on biomass fuels is sustainable or whether there are potential adverse impacts to the environment and household welfare that must be recognized and addressed early on by the Government. There are three major areas of concern: i) land degradation and deforestation caused by fuelwood collection; ii) the impact of reduced biomass supplies on living standards of poor households; and iii) health issues due to air pollution in households who cook with wood, especially in enclosed kitchens.

Already there is evidence of land degradation and localized deforestation in some regions, particularly in the mountainous areas, with consequent soil erosion, increased frequency of flooding and siltation downstream. The FAO estimates that about 3,000 hectares of forest cover is being lost annually[1]. But to what extent can deforestation be attributed to fuelwood collection in Timor Leste?

Compared to modern fuels such as LPG and kerosene, fuelwood delivers the least amount of useful energy in cooking because of the very low efficiency of traditional cookstoves that are used almost exclusively, today. The cost of fuelwood to households is the purchase price or the opportunity cost of time spent collecting. If deforestation is rapidly increasing by whatever cause, are poor households facing significantly higher economic costs and hardships as wood supplies are reduced?

Finally, women in households who cook with fuelwood, especially in indoor kitchens, have been shown from studies in many developing countries to experience high incidence of respiratory and other diseases due to exposure to pollutants from wood smoke. Improved cookstoves can reduce exposure by reducing concentrations of pollutants (through more efficient combustion) and, when fitted with chimneys, by venting the smoke outdoors. At the same time, significant wood savings are achieved. But improved cookstoves programs, while requiring relatively small capital investment, have been found difficult to promote in past World Bank projects elsewhere and requires careful consideration of local markets. What specific local barriers exist that must first be carefully examined and addressed to increase the chances of success of this potentially effective health improvement and demand management measure?

Objectives and methodology of the scoping study. The purpose of the present study is to examine critically the above-mentioned areas of concern and attempt to narrow down the issues and

[1] State of the World's Forests FAO (2005). Other sources cite up to 11,200 hectares of forests lost annually (see Mongabay.com).

associated uncertainties, so that a set of practical options for action by the Government could be identified.

Unfortunately, data and information on fuelwood supply and demand in Timor Leste that could enable even a rudimentary analysis of the current situation are severely lacking. All forest inventory information for the country was destroyed during the period of destructive violence in 1999. No inventory of forest resources at the national or regional level has since been conducted. For above-ground woody biomass supply, therefore, the present study had to devise very broad estimation methods based on available land use information and known growth characteristics of tree species found in the country's forests. On the demand side, the only significant information available was household fuel expenditure data from the 2001 household survey (TLSS)[2] that was found inadequate to quantify biomass consumption and discern patterns of demand. Thus, more focused but still limited surveys of fuelwood consumption in households and other wood-using sectors in the two most populous urban districts of the country (Dili and Bacau) and three selected rural areas were designed and carried out. The results of these activities permitted analysis of fuelwood supply-demand patterns in the country that is "scoping" in nature but more detailed than has been done so far.

[2] The September 2003 ADB Power Sector Development Plan for East Timor report (Volume 1) cites a 2001 household survey undertaken as part of the Poverty assessment Study (PAS), a joint effort of the Government, the World Bank, UNDP, ADB and Japan International Cooperation Agency (JICA). The ADB report calls the survey the "Timor-Leste Living Standards Measurement Survey" or TLSS. This had a national representative sample of 1,800 households from 100 sucos and covered one percent (1%) of the population. Data collection was undertaken between late August and November 2001. The average household size was given as 4.7 and the poverty line was estimated at $15.44 per capita per month or US$ 73 per household/month. The TLSS estimated that 40% of the households live below the poverty line.
At present, the Timor Leste Survey of Living Standards (TLSLS) is being undertaken, under the Poverty Assessment ESW of the World Bank (P092261). No information from this survey is at hand.

PATTERNS OF HOUSEHOLD ENERGY DEMAND

Limited demand surveys

A total of 865 households in urban Dili, Baucau and three selected rural areas in Liquica, Aileu, and Ainaro Districts were surveyed. Some 415 households - 250 from Dili and 165 from Baucau - were randomly selected to represent urban households. About 150 from each of the selected rural areas were randomly selected to represent rural households. The three rural areas were selected purposively,[3] to represent areas *perceived* as wood resource rich (Ainaro), poor (Liquica) and medium (Aileu). Budget limitations and security considerations (many areas of Dili considered unsafe were intentionally excluded) prevented the conduct of a full scale statistical sampling survey of the household sector in all areas; thus, generalizations of the survey results to the entire country made in this report must be interpreted with caution[4].

Household characteristics

A very distinct characteristic of the household sector in Timor Leste revealed by the survey is the high number of household members who eat their meals and sleep in the households in the surveyed areas, some in Dili reporting as high as 25 persons. This is attributed to the large number of the population displaced by the civil unrest and security problems now prevalent in the country, especially in Dili. If households with displaced persons are excluded, the average figure drops to about 8 people, which is still high by international standards. The household size for Baucau is slightly higher than Dili, at 8.4 versus 7.7 persons. In the three surveyed rural areas, the size of households vary from 6.9 persons in Liquica to 8.2 in Aileu, with the average family having close to three children whose ages are less than nine years old. While, as expected, more households in Dili and Baucau have higher incomes than rural households, all surveyed households are, in general, very poor; more than 80 percent earn less than US$100 per month, (Table 2). These results are somewhat different from the 2001 TLSS, which estimated that 40% of the population lives below the poverty line of US$ 15.44 per capita per month, or on average US$ 73 per household/month (Footnote 2 above). Irrespective of what figures are used, - the TLSS or Table 2 below, it is quite clear that most cannot afford to use modern cooking fuels, given the average income and size of these households.

Table 2. Total Household Monthly Income & Family Size

	Urban	Rural	All Areas
Less than $100	72.2%	82.7%	80.8%
$101-$200	26.3%	15.9%	17.8%
$201-$500	1.2%	1.3%	1.3%
$501-$1,000	0.2%	0.0%	0.1%

[3] Purposive sampling is a non-probability selection method where the samples are selected subjectively.

[4] The initial sample design called for simple random sampling using a list of households from the National Statistics Office as the sampling frame. However, budget limitations forced the survey team to resort to area sampling using two-stage sampling technique. As a result, the sample size is rather small given the design effect associated with the two stage techniques. Typically, the sample size must be increased to compensate for the design effect and reduce the error margin, but lack of resources prevented this.

Average total number of persons/household	8.0	7.5	7.6
Average Number of Children < 9 Yrs Old	2.9	2.7	2.7
Percentage of Households with Children < 9 Yrs Old	82.2%	85.1%	84.6%

Source. Survey results.

Consumption patterns in the household sector

Fuelwood as main cooking fuel. The results of the survey indicates that 98.6 percent of all households in the selected areas use fuelwood as their main cooking fuel, with agricultural residues, charcoal, kerosene, and electricity constituting the negligible balance. Although LPG is known to be used by some higher income households in urban Dili, none of the randomly sampled households used it.

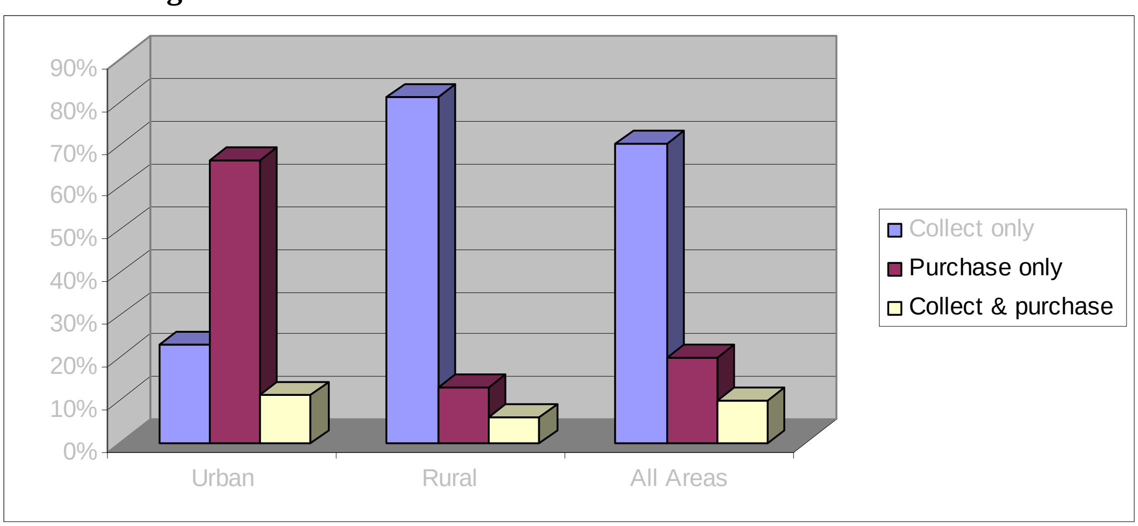
Table 3. Type of Energy Used for Cooking[1]

	Urban	Rural	All Areas
Fuelwood	98.3%	98.9%	98.7%
Agricultural Residues	0.5%	0.4%	0.4%
Charcoal	0.5%	0.7%	0.7%
Kerosene	9.2%	1.6%	3.0%
LPG	0.0%	0.0%	0.0%
Electricity	1.2%	0.7%	0.8%

[1]Note: the totals exceed 100% since some households use more than one type of fuel.

How households obtain fuelwood. The overwhelming majority of rural households (81%) obtain their fuelwood by collection only, whereas the majority of urban households obtain theirs by purchase only. This finding is expected since fuelwood is much more plentiful and easier to collect in a rural setting than in a city like Dili and Baucau.

Figure 1. How Households Obtain Fuelwood



Purchase of fuelwood. For all households who purchase fuelwood, none indicated any difficulty or obstacles in doing so. For rural households, roadside traders appear to be the most important source, with about 87 percent of rural households purchasing from this source. However, urban households tend to purchase their wood from a variety of sources, with 38 percent of respondents citing itinerant peddlers, 28 percent the neighborhood shop or market, and 23 percent citing roadside traders. A picture of the fuelwood trading markets in Dili, Baucau and the three selected rural areas that emerged from the purposive survey is described in Annex 2. It is estimated that the commercial fuelwood trade today has a value of about $6 million annually, and that about 5,700 people are employed full-time (and many more part-time) in the production, transport and trade of fuelwood. This is not huge but is probably larger than in any other fuel sector.

Table 4. Sources of Purchased Fuelwood

	Urban	**Rural**	**All Areas**
Hand-cart/ Peddlers	38.4%	1.2%	7.9%
Neighborhood Store, Market	28.8%	8.2%	11.9%
Roadside	23.1%	87.2%	75.7%
Pickup truck	9.0%	2.3%	3.5%
Other	0.6%	1.2%	1.1%

The amount of fuelwood purchased per transaction was found to vary significantly depending on the frequency of purchase. The most mentioned typical unit of purchase is the "bundle" but the actual weight of fuelwood per bundle appears to vary widely from a few kilograms to as high as 100 kilograms, depending on the location. Typically, it was found that households that purchase fuelwood would stock enough to last them about five to six days (25-30 kg).

Aside from its wide availability, the price of fuelwood appears to be very affordable as well, at this time. In the urban areas of Dili and Baucau, the price was found to range from 6.7 cents[5] to 12.5 cents per kilogram (kg), or on average 9.3 cents per kg. In Liquica and Aileu, the average price was found to be slightly lower at around 7.9 cents per kg. In Ainaro, which has the highest percentage of rural households that obtain their fuelwood by collection only, the small minority of households that purchase fuelwood bought it a price ranging from only 3 to 10 cents per kg. The small difference in fuelwood prices between urban Dili and the rural areas of Liquica and Aileu may be due to the fact that these two rural villages surveyed are both located close to Dili and could be considered as peri-urban.

Collection of fuelwood. Not surprisingly, the vast majority (90%) of the poorest rural households (income less than $100 per month), collect fuelwood for their cooking needs. In contrast, only 37% of the poorest urban households collect it. Undoubtedly, this reflects easier access to fuelwood collection sources in rural areas.

Table 5. Income of Households that Collect and/or Purchase Fuelwood

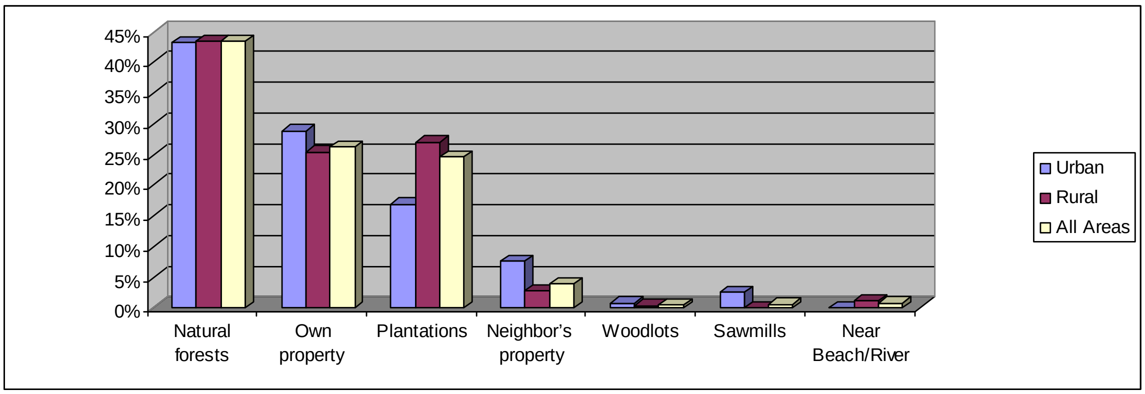
	Urban			**Rural**		
	<US$100	**>US$100**	**All**	**<US$100**	**>US$100**	**All**
Collect only	24.2%	17.7%	22.4%	85.9%	55.8%	80.7%
Purchase only	62.8%	75.2%	66.3%	9.8%	29.9%	13.2%
Collect & Purchase	13.0%	7.10%	11.30%	4.3%	14.30%	6.10%

5 In Timor Leste, the currency unit is the US$.

All household members appear to share responsibility for collecting fuelwood. In rural areas, adult males play the largest role (77%), followed by the adult females (60%). The roles are opposite in towns, where the adult female plays a larger role in fuelwood collection than the male (51% to 45%). This may reflect somewhat higher employment opportunities for adult males in the cities, making them less available for household chores.

The average urban household collects fuelwood every 3.7 days, while rural households collect fuelwood somewhat more frequently (every 2.8 days). The most common source of fuelwood cited by respondents (43%) in all areas are natural forests, which are identified as forested areas in the hillsides and mountains, as well as in the flat lands (see Figure 2).

Figure 2. Sources of Collected Wood



Close to half of urban households that collect fuelwood only travel up to a kilometer, about 28 percent travel between one to three kilometers, and the remaining one quarter travel more than three kilometers. In contrast, slightly more than half of rural households travel up to three kilometers to collect fuelwood, about 27 percent travels within a one kilometer range, and the remaining one fifth travel more than three kilometers. The distance traveled is reflected proportionally in the time spent in collection.

Table 6. Traveling Distance to Collect Fuelwood

	Urban	Rural	Total
Less than one kilometer	47.5%	26.9%	31.8%
One to three kilometers	28.0%	52.3%	46.5%
More than three kilometers	24.6%	20.8%	21.7%

Table 7. Time Spent Collecting Fuelwood

	Urban	Rural	Total
Less than one hour	36.8%	23.1%	26.4%
One to Three-hours	36.8%	59.9%	54.4%
More than three hours	26.5%	16.9%	19.2%

These results do not imply that urban households have an easier time than rural households in collecting fuelwood, but are believed to be more a reflection of the different lifestyles in the two areas. In general, urban households do not have to rely on home cooking for all three meals, and thus require significantly less fuelwood on daily basis (see later discussion of fuelwood consumption). Furthermore, urban household members tend to have less time and opportunity to collect fuelwood, when compared to their rural counterparts.

Perceptions. The survey also reveals that the majority of households in all areas that collect fuelwood do not perceive any significant change in the distance traveled and time spent on collection in the past 3 years, confirming the study team's overall impression of a still highly positive fuelwood supply/demand balance at the national level.

Table 8. Changes in Distance to Collect Fuelwood in the last three years

	Urban	Rural	All areas
No Increase in Distance	62.4%	58.0%	59.1%
Increase One to three kilometers	12.8%	16.0%	15.3%
Increase More than three kilometers	24.8%	25.9%	25.7%

Table 9. Changes in Time Spent Collecting Fuelwood in the last three years

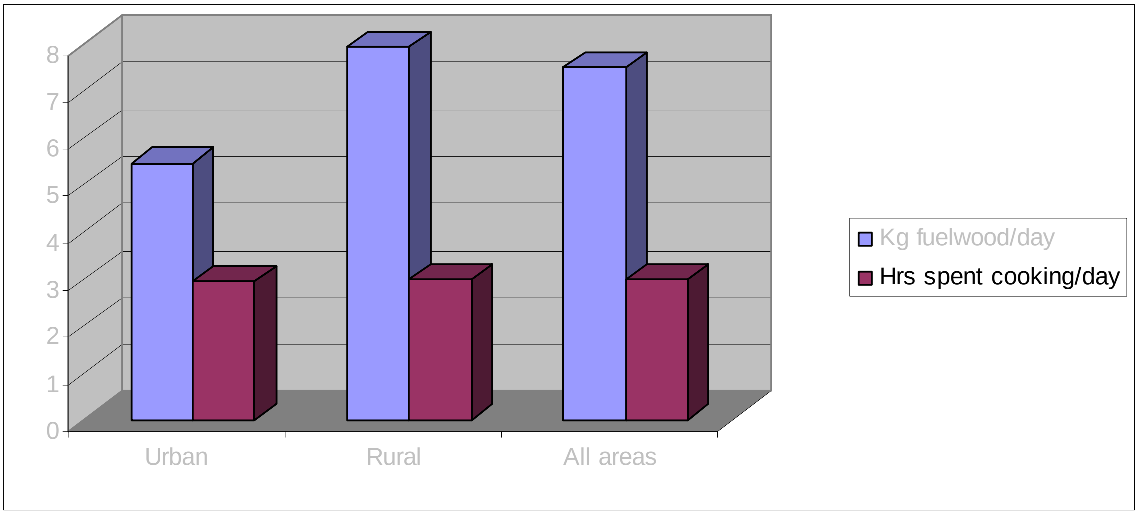
	Urban	Rural	All areas
No increase in Time	73.3%	59.9%	63.2%
Increase One to Three-hours	3.4%	15.7%	12.7%
Increase More than three hours	23.3%	24.4%	24.1%

Fuelwood consumption. Overall, the amount of fuelwood consumed by households in the surveyed areas is estimated to average 6.7 kilogram per household per day, with households in Dili and Baucau consuming 5.4 kg/day and rural households consuming a significantly higher 7.9 kg/day. There appears to be no significant difference in the time spent daily in cooking by households in both cities.

Table 10. Quantity of Fuelwood Used per Day by Urban and Rural Households

	Urban	**Rural**	**All Areas**
Average quantity used per day, kg	5.45	7.91	7.47
Total hrs/day spent in cooking all meals	2.94	2.98	2.97

Figure 3. Amount of fuelwood used and time spent cooking



An analysis of the geographical subset of data suggests that households living in areas where fuelwood is relatively more plentiful tend to use more fuelwood than households in less endowed areas. For example, a comparison of consumption between Dili and Baucau shows that Dili households use significantly less fuelwood (5.0 kg/day) than households in Baucau (6.2 kg/day), (Table 11). A comparison of fuelwood consumption among households living in the three selected rural areas (wood resource poor-Liquica, medium-Aileu, and rich-Ainaro) shows a similar trend, (Table 12).

Table 11. Quantity of Fuelwood Used per Day by Urban Household

	Dili	Baucau	All Urban Areas
Average quantity used per day, kg	4.95	6.21	5.45
Total hrs/day spent in cooking all meals	2.92	2.97	2.94
Total no. of people eating in the dwelling	7.71	8.39	7.98

Table 12. Quantity of Fuelwood Used per Day by Rural Household

	Liquica	Aileu	Ainaro	All Areas
Average quantity used per day , kg	5.22	7.88	10.80	7.91
Total hrs/day spent on cooking all meals	2.23	3.27	3.45	2.96
Total no. of people eating in the dwelling	6.90	8.18	7.30	7.71

Other factors that may affect household fuelwood consumption include: number of persons who eat their meals and sleep in the household, lifestyle differences, type of stoves used and cooking practices. As mentioned earlier, the survey reveals that 7-8 persons eat and sleep at home in all the surveyed households. While the total fuelwood consumption per household is high, the consumption per capita tends to be smaller on average than in countries with smaller households. This is possibly due to some cooking efficiency gains in a large family, i.e., cooking a meal for 8 would not need twice the amount of fuel than cooking for four.

The total number of hours spent cooking or preparing meals daily is likely an indicator of lifestyle differences. This figure is almost similar between urban Dili and Baucau (almost 3 hours per day in each case) but significantly smaller than rural Aileu and Ainaro. However, the average number of hours that households in rural Liquica spend on cooking is even less than in the urban cases, - only 2 hours 14 minutes. Possibly, this could be attributed to the relatively lower availability of wood resources in Liquica than on lifestyle differences, but it could be also be due to less food such as rice and maize that requires cooking.

Improved cooking stoves

Of the 865 total households surveyed only 9 use traditional clay stoves and 12 use “improved stoves” of various types (most likely obtained from one of few ongoing NGO programs or commercial producers). The remainder use three-stone fires, except a few that use a metal equivalent, the steel ring stove. This is unsurprising given the very low income levels of the majority of households surveyed. Three-stone stoves are self made and have zero cost. However, their efficiency is only around 15 percent, meaning much of the energy from fuelwood is simply wasted during cooking. Improved stoves are designed to have higher efficiencies; various programs elsewhere cite an average efficiency of 25 percent for portable improved stoves they are promoting. To illustrate potential savings, if a three-stone stove used by a Dili household is replaced by an improved stove with 25 percent efficiency, only 3 kg instead of the usual 5 kg of fuelwood per day would be needed to cook the same meal, saving about 2 kg per day. It may be misleading to expand this theoretical exercise to the national level and put too much stock on the resulting huge calculated amount of fuelwood conserved, and on the equivalent area of forests “saved”. In practice, other factors, such as the finding elsewhere that some households with efficient stoves may tend to cook more, could dilute the impact. Notwithstanding, it is clear that tremendous amounts of wood resources are presently being wasted with the use of three-stone fires, and any attempt to improve the average combustion efficiency of household stoves would have very significant potential benefits for the country. Technically, stove efficiency is improved by designing for better airflow, adding insulation to conserve heat and directing most of the heat generated to the cooking vessel. The challenge in developing improved stoves has always been, on the one hand, addressing design issues of smoke reduction, durability, suitability for local fuels and user preferences and, especially, keeping costs as low as possible.

In the last decade, the primary objective of improved stoves programs worldwide has shifted to reducing exposure to pollutants in wood smoke (mainly particulates, hydrocarbons, nitrogen oxides and carbon monoxide), that have been found in various studies to significantly increase incidence of respiratory diseases and other ailments in household members, especially for women who do most of the cooking. This is especially important in some countries, such as those in South Asia, where almost all households cook with built-in stoves in enclosed kitchens. The survey conducted in the present study, however, found that 76 percent of Dili households, 87 percent of Baucau households and 89 percent of rural households normally prepare their meals outdoors. It is unclear whether this practice is based on cultural preferences or the fact that most of the houses surveyed were small and indoor space was a premium. In any case, this may diminish somewhat the magnitude of the health issues mentioned, although it must be noted that cooking outdoors only reduces, but not fully eliminates exposure to pollutants from wood smoke. Overall, the importance of supporting a comprehensive improved stoves program in Timor Leste, in the study team's view, remains valid. (Annex 4).

Several local NGOs, notably the Haburas Foundation, the ETADEP Foundation and the Permatil Foundation, with funding from external donors, have been developing and promoting various types of improved stoves since 2001, mainly portable clay stoves for fuelwood and agricultural residues. Some small commercial stove producers are operating in Dili and selling portable ceramic stoves with a metal cladding from $ 5-12 depending on size. They have had little formal training and have few tools, and the efficiency of the stoves is unknown. The impression, however, is that these efforts lack critical mass; only a few hundred improved stoves at the most have been disseminated so far and there is little documentation available on the effectiveness of the stoves or the programs. It is by no means an easy task. The two biggest barriers in Timor Leste are the still relative abundance of fuelwood supplies, i.e., very low prices or easy to collect, and the absence of a culture of purchasing household stoves. Getting households to shift to purchased stoves of whatever cost, even if assured of significant wood savings, will require a well-planned long term effort by the government, in partnership with the NGOs and grassroots community organizations, to educate the public and change some basic consumption behaviors.

Modern cooking fuels

Insignificant role of modern fuels in household cooking. Dili has a very small percentage of households that use kerosene and electricity or use these two modern fuels in combination with fuelwood to prepare their meal.[6] Table 13 shows the share of all types of cooking fuels in the surveyed households in Dili. Kerosene appears to be the only significant modern cooking fuel used[7]. However, since the total number of households that use kerosene for cooking is very small, the survey results have a relatively high error margin. For example, the kerosene consumption of

[6] It should be noted that 'electric cooking' in Dili tends to be limited to use of a rice cooker only.
[7] Kerosene was heavily subsidized during the Indonesian times, with a reported cost of only US cents 10 per liter. Demand was high but dropped sharply after subsidies were lifted.

13 liters per month estimated by the survey must be interpreted with caution, since it may also include some amount used for lighting during periods of electric power supply interruptions. As expected, households that use kerosene for cooking tend to be in the higher income group. About three quarters of these households have income greater than US$100 per month. Presently, kerosene costs about US$1 per liter while a 9 kg cylinder of LPG costs US$65, of which US$45 is the one time cost of the refillable cylinder. Compared to fuelwood, both fuels are more convenient and cleaner to handle ("modern"). In terms of indoor air pollution, LPG is the cleanest, with the lowest amounts of pollutants emitted per kg burned. Kerosene actually has about the same level of pollution as fuelwood, but due to its higher energy density and the higher stove efficiency, the amount of pollutants emitted for cooking the same meal is much lower.

Table 13. Type of Fuels Used to Prepare Meals in Dili

Meal time	**Morning**	**Mid-day**	**Evening**
Fuelwood	91.8%	96.8%	96.7%
Charcoal	---	0.4%	---
Kerosene	4.1%	1.6%	2.0%
Electricity	2.0%	---	0.4%
Fuelwood & Kerosene	0.8%	0.8%	0.8%
Fuelwood &Electricity	---	0.4%	---
Kerosene & Electricity	0.8%	---	---
Fuelwood, Kerosene & Electricity	0.4%	---	---

Interfuel substitution. In the immediate term, very limited interventions appear possible in Timor Leste with respect to promoting the substitution of fuelwood with modern fuels, such as kerosene and LPG. The problem at this time, as has been pointed out above, is their high cost in relation to current household incomes. Subsidizing fuel costs to promote wider usage has been found in other countries to be an inefficient instrument. They tend to benefit rich households rather than the poor (since proportionally more of the higher income households use modern fuels) and, in the case of kerosene, sometimes leading to diversion of the subsidized fuel to transport and other uses. What appears to be more favored elsewhere is subsidizing the first cost of equipment needed to shift to modern fuels, such as purchase of gas cylinders or stoves. Regarding concerns that increased use of LPG and kerosene will increase GHG atmospheric emissions, the strong counter argument is the serious negative health impact of heavy use of solid fuels that may be a more important national and global concern.

Comparative cooking costs. A comparison of the financial costs of cooking in households with fuelwood, electricity, kerosene and LPG is shown in Table 14.

Table 14. Comparison of cooking costs (fuel only)

Fuel	Unit	Energy Content, MJ/unit	Stove Efficiency	Cooking fuel cost, $/Unit	Cooking fuel cost, $/Utilized MJ
Fuelwood	kg	15.5	15%	0.1	0.043
Electricity	kWh	3.6	70%	0.12	0.048
Kerosene	liter	37	35%	1.0	0.077
LPG	kg	45	60%	2.2	0.081

The results show that even at a low assumed cookstove efficiency of about 15 percent, cooking with fuelwood is the cheapest for households, based on the average price of fuelwood in Dili. The next cheaper fuel is electricity but the tariff of US cents 12 per kWh is highly subsidized (the generation cost averages over cents 20/kWh). Also, there is a reliability problem with electricity and only a small percentage of the population has electricity. The above comparison considers cost of fuel only. However, since the cost to households of the three-stone stove is zero, it is clear that cooking with fuelwood would still be the least cost option even if equipment costs are included in the comparison. A comparison on an economic basis may be made for the case of collected fuelwood which comprise over 80% of usage in rural areas. As seen earlier, collection times and distances are short. Also, the opportunity cost of time of household members, especially in rural areas, is likely to be close to zero, given the high unemployment rate. Therefore, fuelwood would still come out as the least cost option in economic terms.

Future structure of demand. Due to the unavailability of information on demographic trends, income growth projections, and trends in the supply and prices of kerosene and LPG, it was not possible to make a quantitative economic forecast of the structure of future household energy demand. However, unless present levels of household incomes rise dramatically, it is considered unlikely that modern fuels will make a dent into current household fuelwood consumption levels in the next decade or so.

Fuelwood consumption in the non-household sectors

The survey of the non-household sectors covered 49 small wood-using industries and 39 service sector establishments. The sampling was purposive; the task was more in the nature of a limited investigation to gain some insights into energy use characteristics of the sectors. The surveyed industries consisted mainly of small neighborhood bakeries, furniture makers and backyard coconut oil processing operations. Most of the surveyed service sector establishments were small restaurants, roadside cafes and institutional cafeterias. Six of the surveyed industries also used agricultural residues. Five of the service establishments used some charcoal. Over 60 percent of wood used in each sector were purchased. The survey obtained information on average wood fuel consumption of the establishments but it was not possible to extrapolate these data to the region or the country as a whole, as the sample size was too small. Furthermore, there appears to be no central record of the locations and total number of these types of establishments now operating in the country. In any case, based on information for similar countries that rely heavily on fuelwood, it is estimated that the total wood consumption for energy of these sectors in Timor Leste would not exceed 10-20 percent of total wood energy.

Summary of biomass demand estimates

The quantities of fuelwood consumed by households for cooking was assumed to represent 85% of total consumption of biomass for energy by all sectors, the others being woodfuel-using industries, mainly in rural areas, and the service sector in both urban and rural areas. It was further assumed that non-energy demand for wood (poles, sawnwood, etc) constitute about 20% of total wood demand. These broad assumptions had to be made because, as already mentioned, it was not possible within the timeframe of the scoping study to obtain more precise estimates of wood energy use in the non-household sectors and the use of wood for non-energy purposes. Due to the peri-urban nature of Aileu and Liquica, survey results for Ainaro were deemed to be more representative of all areas outside Dili and Baucau that are categorized as "rural", comprising 82 percent of the total population. These assumptions result in the figures in Table 15.

Table 15. Summary of wood demand estimates, tonnes air-dried wood per capita

Type of wood demand	Dili	Baucau	Rural[1]	Country[2]
Household fuel	0.26	0.32	0.56	0.51
fuelwood-using industries, service sector	0.05	0.06	0.10	0.09
total wood demand for energy	0.31	0.38	0.66	0.60
non-energy demand	0.08	0.09	0.16	0.15
total wood demand all purposes	0.39	0.47	0.81	0.74

1. Data from Ainaro was assumed to be representative of rural consumption characteristics.
2. Weighted by population, of which 82% considered rural, including parts of Dili and Baucau districts.

BIOMASS SUPPLY

Land area and land use

Land area by region and district. Timor Leste has six broad ecological zones: mountainous areas, the highland plains, moist lowland areas, (along the southern coast), arid lowland areas (along the northern coast), marine and coastal areas, and (small) urban areas. About 60 percent of the land area is classified as forests in various states of tree cover, ranging from relatively untouched virgin forests, through open woodlands to heavily degraded areas.

Various government and international publications provide differing figures for total land area, ranging from 1.461 to 1.492 million hectares, the latter being the figure from the Agricultural and Livestock Global Information Systems Unit (ALGIS) under the Ministry of Agriculture, Forestry and Fisheries (MAFF). The ALGIS figure is used in this report as ALGIS has provided the study team with newly calculated land area information by district that is consistent with this total[8].

The areas of each of the three regions (East, Central and West) and the districts within those regions are given in Table 16 together with the estimated mid-2007 population in those districts.

Table 16. East Timor 2007: Land Area and Population by Region and District.

District	Land area hectares	Population thousands (ha/person)	District	Land area hectares	Population thousands (ha/person)
East	**699,457**	**288.7 (2.42)**	**Central**	**373,130**	**440.3 (0.85)**
Lautem	182,038	62.1 (2.93)	Liquica	53,644	59.5 (0.90)
Baucau	150,543	113.1 (1.33)	Ermera	76,778	111.6 (0.69)
Viqueque	188,381	71.8 (2.62)	Aileu	73,804	39.9 (1.85)
Manatuto	178,265	41.7 (4.27)	Dili	36,408	181.5 (0.20)
West	**419,929**	**271.0 (1.55)**	Manufahi	132,496	47.8 (2.77)
Ainaro[1]	81,114	58.0 (1.40)			
Covalima	119,814	60.5 (1.98)			
Bobonaro	137,561	89.1 (1.54)			
Oecussi	81,440	63.4 (1.28)	**Total**	**1,492,286**	**1,000.0 (1.49)**

[1]Ainaro is in the south west, but in some reports it is under the Central region. Similarly, Manatuto borders Dili to the east and Manufahi is central south.
Sources: 2004 Census, projected to 2007; ALGIS, 2002 data; MAFF.

The central region is the most densely populated with less that 1 ha per person and *mainland* Dili district the densest with only 0.15 ha per capita. While Manufahi is in the south, the other four districts are in the north, which is the dryer part of East Timor. (Annex 1 Map).

[8] In March 2007, at the request of the study team ALGIS re-analyzed the present satellite image to break down land use data by district.

The northern coastal areas have annual rainfall ranging from 500 mm to 1,500 mm, falling in one season – December to February. The southern coastal areas have rainfall between 1,500 mm and 2,000 mm with two peaks in the rainfall – December to February and May to June. The mountain areas, situated in central areas of Bobonaro, Ainaro, Manufahi and Manatuto districts have annual rainfalls of 2,500 mm to 3,000 mm, especially round Ainaro, Same, Lolotoe and Soilbada with precipitation in most months. The average population density in these four districts is low at about 0.4 persons/ha.

Land use types. Twenty-three land use types in Timor Leste are recognized and listed in Table 17.

Table 17. East Timor 2002: Land Area by Land Use Types.

Land Use Type	***Area (hectares)***	***Percentage***
Montane forest	2,611	0.17%
Moist highland forest – single species	2,356	0.16%
Moist highland forest – mixed species	65,104	4.36%
Moist lowland forest – dense species	261,694	17.54%
Moist (open) lowland forest – sparse species	174,991	11.73%
Dry lowland forest – single species (woodlands)	134,612	9.02%
Dry lowland forest – mixed species (woodlands)	189,084	12.67%
Coastal forest	19,309	1.29%
Mangrove	2,203	0.15%
Manmade forest	918	0.06%
Wetland forest swamp	269	0.02%
Subtotal forest area	***853,151***	***57.17%***
Shifting cultivation (recovering area)	6,244	0.42%
Dryland (rainfed) arable	284,297	19.05%
Wetland arable including irrigated areas	49,825	3.34%
Subtotal agricultural areas	*340,366*	*22.81%*
Estate crop area - large (coffee etc.)	68,075	4.56%
Estate crop area – smalllholding (coconut etc.)	6,505	0.44%
Subtotal estate crop	***74,580***	***5.00%***
Grasslands	107,091	7.18%
Savannah	93,375	6.26%
Bare land	2,279	0.15%
Wetlands	404	0.03%
Lakes	1,106	0.07%
Subtotal Grasslands – Lakes	***204,255***	***13.69%***
Village area and mixed gardens	10,753	0.72%
Cities, towns and industry	9,181	0.62%

Subtotal village and cities etc.	***19,934***	***1.34%***
Total	***1,492,286***	**100%**

Source**.** ALGIS, MAFF 2007.

Forests and woodlands comprise about 57 percent of the land area. Closed forests occupy about 22 percent, open forests – 12 percent, woodlands – 22 percent and the remaining 'forest' formations, including recovering shifting cultivation areas, about 2 percent. Arable areas, excluding shifting cultivation, are about 22 percent of the land area, with rainfed arable agriculture accounting for the bulk of this land. Most farmland has been claimed from forest areas, but some have been reclaimed from grasslands.

It is worth noting that the actual area of shifting cultivation is likely to be about five to six times the recovering area. Shifting cultivation has about a fifteen to twenty year cycle. Land is cleared from forest areas and is farmed for two to three years. Then it is allowed to regenerate as secondary forest for 12 to 15 years, before the cycle is repeated. During the rest period, the soil fertility is built up and this is supplemented by burning the branches and twigs on site, when the land is cleared again, to add potassium etc. to the soil. If the regeneration cycle is curtailed, then the agricultural phase is cut to 1 to 2 years, because there is insufficient fertility to support more than one or two years of crops. Thus, the bulk of the shifting cultivation land has a tree cover and is included as 'forest' in the various forest types.

Officially, manmade forests are a very small percentage of the forest area, with teak (*Tectona grandis)* being one of the dominant species. However, there are many varieties of trees and bushes planted along roadsides, in gardens and around houses in towns that undoubtedly are a source of fuelwood.

Estimation of woody biomass stock and yield

Assumptions and methodology. Due to the general unavailability of data, broad assumptions had to be made to estimate *total* above-ground woody biomass growing stock and annual yield. The traditional forest inventory only measures live stem wood, i.e., the volume above a certain breast height diameter (10 to 30 cm), in forest and woodland areas. Sometimes only 'merchantable' trees are measured. Trees, bamboos, palms, bushes and shrubs, etc., that are below a minimum diameter, or are not considered as wood, are normally not measured; neither are branches, twigs and deadwood. Trees outside the forest are usually not counted. However, when determining total potential supply of wood, particularly for fuel, ideally all above-ground woody biomass on all land use types should be considered, since all woody tissue is burnable and dead wood is a premier fuel. The estimates made in the present study include all above-ground woody biomass.

The literature provides some information as starting point. The FAO[9] estimated the average volume of 'timber' wood in forest areas of Timor Leste to be about 79 m^3/ha, (approximately 56 dry t/ha) while the amount of woody biomass is given as 136 dry t/ha (160 air-dry t/ha)[10]. The forest area was estimated as 507,000 ha, similar to the 2002 ALGIS estimate of 529,000 ha of forests, excluding the dry lowland woodlands.

[9] "State of the World's Forests", FAO (2001)

[10] A dry tonne contains zero moisture with a lower heating value (LHV) value of 18.7 MJ/kg, An air-dry tonne contains about 15% moisture with LHV of 15.5 MJ/kg

Godinho[11] estimated the average carbon stock in above-ground woody biomass for three land use types in Timor Leste for 1999. The estimated carbon figures for two types of forest areas totaling 441,000 ha of translate to 154 t (air-dry)/ha, which is close to the FAO figure of 160 t (air-dry)/ha cited earlier. Godinho's paper does not estimate the carbon stock on the remaining 241,000 ha of land in the country. Assuming this part contains 2.5 tC/ha, the stock of above-ground organic carbon in woody biomass would then total 37.6 million tC. This is equivalent to nearly 89.4 million air-dry t of wood on all the land areas.

The above figures provide an estimate of total woody biomass stock for the country. The next step is to obtain estimates for each land use type. For this purpose, forest inventory data for other countries were consulted, namely Benin, Ethiopia, Kenya and Uganda, to obtain average growing stock of woody biomass for the different land use types found in Timor Leste. In addition the UK Forest Management Tables and the World Bank/UNDP ESMAP Inventory of Woody Biomass in sub-Saharan Africa were consulted.[12] The annual yield was then estimated based on assumed 'nominal rotation ages' and the average growing stock, to determine the maximum amount of wood that, in theory, could be removed each year without diminishing the stock. Finally, while in East Timor, the study team's forestry expert performed quick basal area and height measurements on nine land use types to obtain estimates of (live) stem and whole tree volume and mass. Ten percent was added to the final figures to account for dead wood. The resulting estimates of growing stock and annual yield per hectare are shown in Table 18.

Table 18. Above-ground Woody Biomass Stock and Annual Yield Per Hectare by Land Use Types

Land Use Type	Average above-ground mass, tonne/ha[1]	Nominal rotation age, yrs	Average above-ground yield[2], tonne/ha/yr
Montane forest	100	100	2
Moist highland forest – single species	150	80	3.75
Moist highland forest – mixed species	150	80	3.75
Moist lowland forest – dense species	150	60	5
Moist lowland forest – sparse species	65	60	2.17
Dry lowland forest – single species	65	50	2.6
Dry lowland forest – mixed species	65	50	2.6
Coastal forest	40	30	2.67
Mangrove	50	10	10
Manmade forest	150	30	10
Wetland forest swamp	20	20	2
Shifting cultivation (recovering area)	15	15	2
Dryland arable	6	15	0.8
Wetland arable including irrigated areas	3	15	0.4
Estate crop area - large (coffee etc.)	40	20	4
Estate crop area – smallholding (coconut etc.)	70	30	4.67
Grasslands	3	30	0.2
Savannah	3	30	0.2
Bare land	3	30	0.2
Wetlands	5	30	0.33
Lakes	0	-	-
Village area and mixed gardens	70	30	4.67
Cities, towns and industry	3	30	0.2

[11] Godinho L. et al, "Climate change mitigation through carbon sequestration: the forest ecosystems of Timor Leste" Proceedings from the first national workshop on climate change, Dili, 19th November 2003

[12] UK (Forest Management Tables, HMSO 1971). Benin (World Bank 2000). Ethiopia (Ministry of Agriculture, Natural Resource Conservation /TECSULT 2002). Uganda (Dept. of Forestry/Norwegian Forestry Society 1992). Kenya (Openshaw K.1982). In addition, data from the ESMAP inventory of woody biomass in sub-Saharan Africa (*WB/ESMAP 1992)* and general FAO and Indonesian data were consulted.

Note 1. The stock figures are average of all age classes and are not the stocking of mature trees only. Wood weight is given in air-dry tonne (15 % moisture content, wet basis). This is equivalent to 0.85 dry t per t air dry (0.42 tC).
2. Average annual yield = 2 x average above ground mass/rotation age
Source. Estimates by K. Openshaw (2007).

The *nominal rotation age* assumed for each land use type considers not only mature trees (some of which may be more than 300 years old) but all types of woody biomass species, including shrubs, bushes, bamboos and trees, their longevity and management practices. Ideally, the rotation age is when mean annual increment peaks: at this point the average yield is at a maximum.[13] To calculate annual yield, the average above-ground mass is doubled and divided by the rotation age. This assumes that all age classes are represented in the population and, at maturity, the volume or mass will be roughly double the average[14].

Estimated stock and yield for the country. The above figures were then applied to the total areas of the different land use types to calculate the total above-ground woody biomass and yield by land-use types for the country; this is shown in Table 19.

Table 19. Total above-ground Woody Biomass Stock and Annual Yield by Land Use Types

Land use type	Total area, hectares	Total above-ground woody biomass tonne[1]	Assumed Accessibility %	Total accessible annual yield tonne[2]
Montane forest	2,611	261,100	10	522
Moist highland forest – single sp.	2,356	353,400	30	2,650
Moist highland forest – mixed sp.	65,104	9,765,600	30	73,242
Moist lowland forest – dense species	261,694	39,254,100	100	1,308,470
Moist lowland forest – sparse sp.	174,991	11,374,415	100	379,731
Dry lowland forest (woodland) – single species	134,612	8,749,780	100	349,991
Dry lowland forest (woodland) – mixed species	189,084	12,290,460	100	491,618
Coastal forest	19,309	772,360	100	51,555
Mangrove	2,203	110,150	100	22,030
Manmade forest	918	137,700	100	9,180
Wetland forest swamp	269	5,380	100	538
Subtotal forest area	853,151 (57.2%)	83,074,445 (92.7%)		2,690,065 (79.4%)
Shifting cultivation-recovering area	6,244	93,660	100	12,488
Dryland (rainfed) arable	284,297	1,705,782	100	227,438
Wetland arable incl. irrigated areas	49,825	149,475	100	19,930
Subtotal agricultural areas	340,366 (22.8%)	1,948,917 (2.2%)		259,856 (7.7%)
Estate crop area: large (coffee etc.)	68,075	2,723,000	100	272,300
Estate crop area: smallholding (coconut etc.)	6,505	455,350	100	45,535
Subtotal estate crop	74,580 (5.0%)	3,178,350 (3.5%)	100	317,835 (9.4%)
Grasslands	107,091	321,273		21,418
Savannah	93,375	280,125	100	18,675
Bare land	2,279	6,837	100	456

[13] The nominal rotation age is the weighted average rotation of all species. Ideally, the rotation age for individual species is when the mean annual increment (MAI) is at a maximum. This is the point at which current annual increment (CIA) dissects MAI from above.

[14] The yield figures used are relatively conservative compared to net primary production (NPP) figures suggested by rainfall data. NPP is the above-ground annual growth of wood, leaves and other vegetation correlated with rainfall. NPP has been measured for a number of forest types by various researchers. For an annual rainfall of 500 mm the average NPP is about 5 t/ha (dry) per year and for 1,500 mm rainfall it is about 10 t/ha year. As mentioned earlier, annual rainfall varies between 500 mm to 3,000 across the three regions of Timor Leste.

Wetlands	404	2,020	100	121
Lakes	1,106	0	-	0
Subtotal grasslands – lakes (%)	204,255 (13.7%)	610,255 (0.7%)		40,670 (1.2%)
Village area and mixed gardens	10,753	752,710	100	75,271
Cities, towns and industry	9,181	27,543	100	1,836
Subtotal village and cities	19,934 (1.3%)	780,253 (0.9%)		77,107 (2.3%)
Total	**1,492,286 (100%)**	**89,592,220 (100%)**		**3,369,851 (100%)**
Stock and yield per ha		60.04 t/ha		2.26 t/ha
Population (2007 estimate)	1,000,000			
Area, stock and yield per capita	1.49 ha/cap	89.59 t/cap		3.39 t/cap
Organic carbon content (above ground), tonne C		37,707,163		1,418,287

[1]Total biomass = tonnes per ha x area. Quantities are in air-dried tonne, 15% moisture content.
[2]Total accessible annual yield = average annual yield x area x percent accessibility
Sources: ALGIS 2007 for land use. Estimates by K. Openshaw (2007).

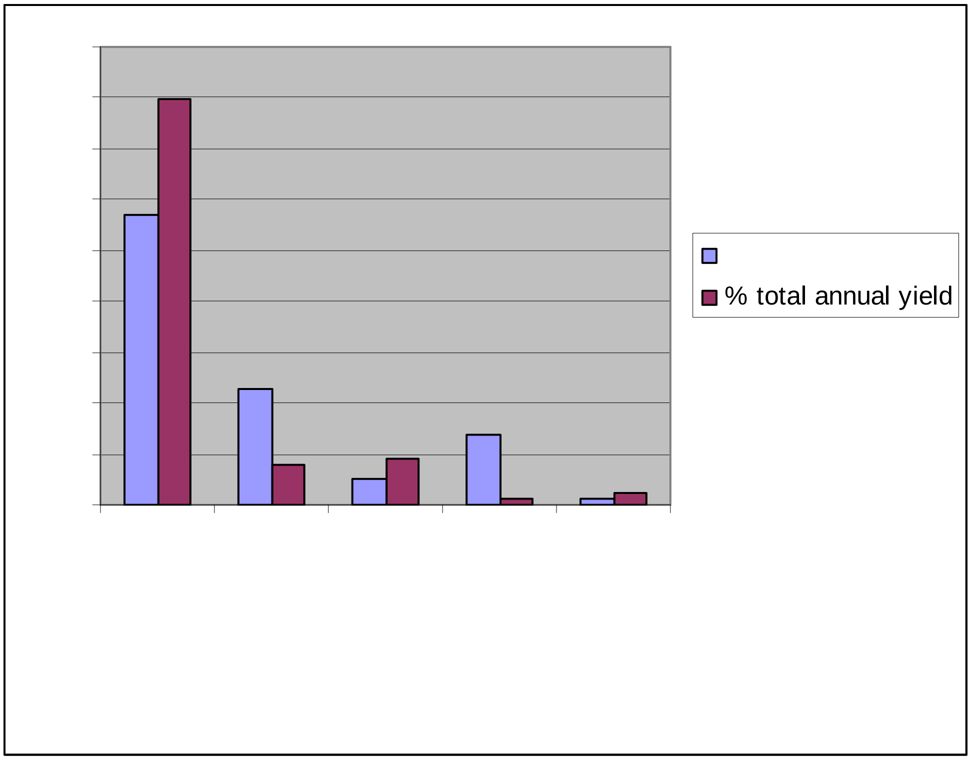
The *assumed accessibility* is the estimated percentage of annual growth in the area that in theory could be harvested sustainably. Because montane and highland forests are vital for watershed management, access to such forests should be restricted[15]. Thus, while the montane forests have an estimated annual yield of 2.0 t/ha, only 10 percent (0.2 t/ha) is assumed useable each year. Similarly for highland forests the assumed accessibility is limited to 30 percent of yield. For all other areas, accessibility is assumed to be 100 percent.

The results show that in 2007, there are nearly 1.5 ha per person. The total estimated stock of above-ground woody biomass on all land use types is nearly 90 million t ad or 90 t ad per person and 60 t ad per ha. Over 90 percent of this stock is in forest and woodland areas, highlighting the importance of these forests as a store of atmospheric carbon.

The estimated total annual yield is nearly 3.4 million t ad, which excludes most of the annual growth from montane and highland forests, since limited accessibility is assumed for them. Nearly 80 percent is from forests and woodlands, 8 percent from farmland and 9 percent from estate agriculture, with the remaining 3 percent from other types (Figure 4). The average yield per hectare is nearly 2.3 t ad and the average per-capita yield for the country is an estimated 3.4 t ad.

Figure 4. Share by Area and by Annual Yield[1]

[15] In reality, almost all kinds of forests are presently open to access for locals because law enforcement is relatively weak. Very few are restricted, in particular those under 'Tara bandu'. This local ritual is intended to protect a certain forest with water resources for locals or ethnic interests. The Forestry Department estimated there were 418,750 ha (29%) of restricted forest (2002 Annual Report of the National Directorate of Forestry and Water Resources, MAFF).



[1]Total land area. 1.49 million hectares. Total accessible annual yield: 3.4 million tonnes

Annual yield per capita: limits on interpretation. Assuming biomass removals are carried out in a sustainable manner, then for the country as a whole, the above annual yield appears to be more than enough to meet the annual demand for fuelwood, poles and sawnwood, that on average is estimated to be about 0.74 tonne air-dry wood/capita (see Table 15). However, two important qualifications must be made with respect to this and later comparisons in this report of wood supply, in terms of annual yield per capita, and demand, in terms of tonnes wood per capita.

First, the annual yield numbers represent biomass material in existing trees that in practice is not totally available for removal, especially through household fuelwood collection. Although as earlier discussed an accessibility factor is assumed for each land use type, this factor refers more to *physical accessibility* of the area to wood collection or extraction, not to *accessibility of the biomass material* itself. For fuelwood collection, which accounts for the bulk of total biomass removals from forests, collectors would first pick deadwood, trash from felled 'commercial' trees and other biomass strewn on the ground, or lop off low tree branches, cut small trees, etc. When these are exhausted, the collector moves on to the next area. There would be little extraction for fuelwood purposes of biomass material from big trees or felling of such trees. Therefore, the annual yield numbers estimated by this methodology in the present study should be considered a *theoretical maximum limit of sustainable biomass extraction* from the forests.

Second, because secondary data were used and very broad assumptions made to estimate the growing stock and annual yield figures, their *absolute* values have high but unknown margins of error. The actual individual tree species that exist in the specific forest and the type of forest management practiced in the area would clearly affect the annual growth figure. If, because of population pressure, the trees near demand centers are cut for whatever purpose before their 'ideal' rotation age, the total yield of the forest would be reduced. Finally, the presence of goats and other browsers may significantly hamper proper biomass regeneration. It was not possible to account for these factors in the present study.

Nevertheless, it is believed that the *relative* magnitudes of the supply estimates for the different districts and regions are valid, and that the numerical comparison of estimated annual yield with estimated demand in a particular area provides a valid *indication* of the true biomass balance in that area.. To simulate a realistic or "worst case" scenario, the annual yield figures used in the comparisons are only 50% of the theoretical maximum yields calculated above.

Wood supply situation by district and region. The estimation of supply needs to be done at the district and regional levels since many wood products have to be available within walking distance for rural and urban people who collect them, and within a maximum radius for transport. This radius depends, among other things, on road conditions and the cost of transport. Observations made by the study team on the presence of fuelwood traders along the main roads leading to Dili indicate that this maximum radius is roughly about 40 km in the case of fuelwood supplies for Dili residents. Table I in Annex 3 summarizes estimated growing stock and yield on every land-use type for each district[16].

As seen in Table I (Annex 3), for all regions and for all districts, except Dili, annual yield figures per person range from 2.0 t in Oecussi to 10.5 t in Manatuto. With country average consumption for all wood products estimated to be 0.74 t/capita (Table 15), *indicatively* every district, except Dili, has an excess supply over demand.

Dili is the only district in the whole country where the estimates show a deficit. For Dili District in the Central Region, the maximum available annual yield per person is only 0.3 t/cap/yr compared to a demand of 0.39 t/cap/yr. This is expected since it is the district with the highest population and smallest total area in the country, Actually, the situation is worse because the analysis did not consider that wood supplies in Atauro Island, which are part of the district, are, for practical purposes, inaccessible to the remainder of the district. Table 20 shows the results of a separate analysis for mainland Dili and Atauro island.

[16] Annex 3, Table I is a summary of the estimated growing stock and yield on every land-use type for each district. The Biomass Supply Report from which this information was taken is a background paper.

Table 20. Estimated Woody Growing Stock & Annual Yield: Dili District

Central Region: Dili district	**Atauro Island**	**Dili Mainland**	**Total**
Estimated woody growing stock (t)	420,568	948,253	1,368,861
Estimated woody biomass yield (t)	19,429	43,037	62,466
Estimated population (2007)	8,500	173,100	181,500
Stock per person (t)	49.5	5.5	7.5
Yield per person (t)	2.3	0.2	0.3
Total area (ha)	10,408	26,000	36,408
Stock per ha. (t)	40.4	36.5	37.6
Yield per ha. (t)	1.9	1.7	1.7
Yield/Stock (%)	4.62	4.54	4.56
Nominal average rotation (years)	43	44	44

Source: Estimates by K. Openshaw (2007)

The figures indicate that while Atauro Island could be self-sufficient in wood products, mainland Dili with an annual yield of just 0.2 t/capita would already experience a serious shortage if its wood demand could only be supplied internally. However, it is evident that Dili obtains fuelwood from sources located up to 40 kilometers from the capital.[17] Nevertheless, the deficit in internal wood supplies coupled with the current lack of forest management suggests that already, there may be over-cutting of trees in the mainland area of Dili district. The observable denudation of some hillsides and mountainous areas around Dili city is a further indication.

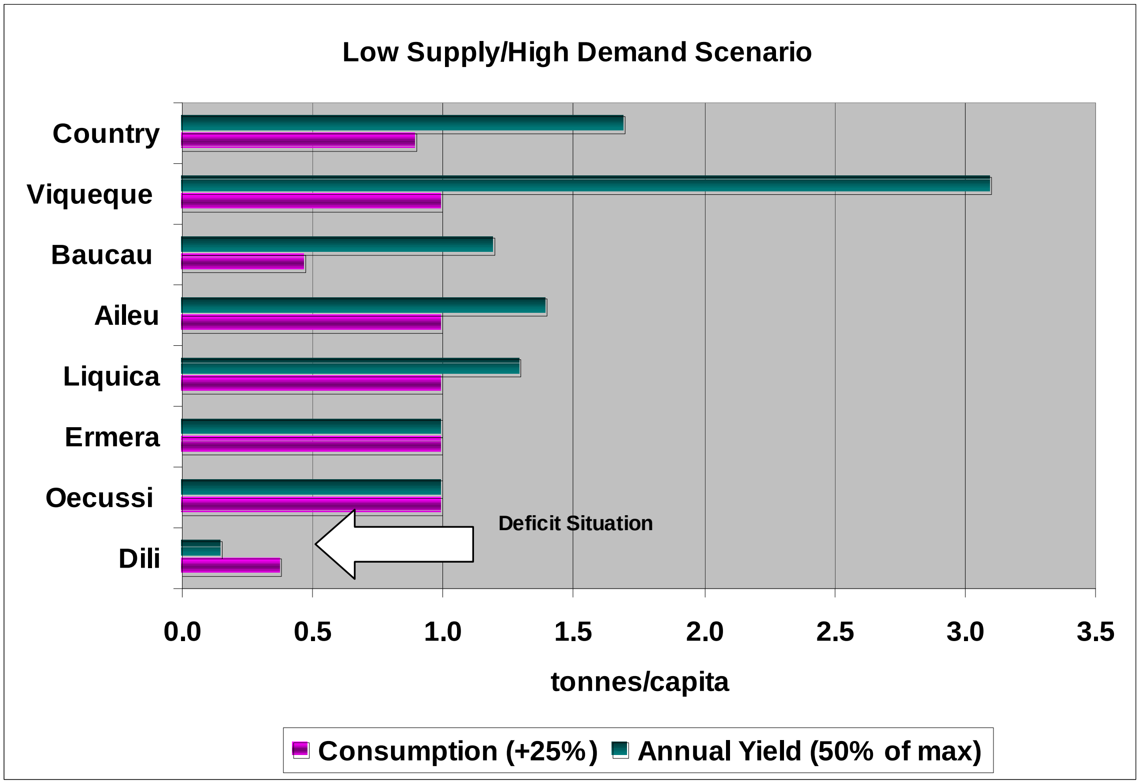
In the Western Region, the enclave district of Oecussi has the lowest annual yield of woody biomass per person, at an estimated 2.0 t ad compared to the estimated average demand of 0.81 t ad. Unless significant amounts are also being obtained from neighboring West Timor areas, already there may be pockets of shortages existing or developing in Oecussi.

The Eastern Region is the region that has the highest figure of annual yield per person. Baucau district in has the smallest area but the largest population in the region. The annual yield is estimated to be 2.4 t ad/cap compared to the estimated demand of 0.47 t ad/cap.

Low Supply/High Demand Scenario. Assuming that the sustainable biomass supply per capita is only 50% of the theoretical maximum and that the per capita consumption in Table 15 has been underestimated by 25%, the ratio of supply to demand indicates that only Dili may be already in a deficit situation. Oecussi and Ermera appear to be just in balance, while Liquica and Aileu have supply to demand ratios of 1:1.3 and 1:1.4, respectively (see Figure 5). The three districts of Ermera, Liquica and Aileu are all around Dili and supply the city's need for fuelwood and poles. It is possible that the wood resources in these Districts may already be under threat. This reinforces the critical need for a proper forest inventory to be undertaken in these districts as well as in Dili, to obtain more accurate data than the estimates made in this study.

[17] Based partly on the study team's observations. In March 2007, some 120 fuelwood traders were counted within 41km of Dili, on the coast road east from Dili to Manatuto. Likewise, on the coast road west from Dili to Maubera, 58 traders were counted within 40 km of Dili.

Figure 5. Comparison of Woody Biomass Supply vs. Demand, Selected Areas



Other biomass fuels. Agricultural residues can be broadly divided in two categories: those that are produced in the field and those produced as a result of milling or other types of processing. It is estimated that over 300,000 tonnes (air-dry) of straw, stalks and other field biomass, and close to 100,000 tonnes (ad) of milling residues are produced annually in Timor Leste. In other developing countries experiencing wood scarcity, these agricultural residues, and even animal dung, are used extensively as household fuel. They are not as convenient to use as fuelwood; some types of residues may require compacting prior to use and most require constant attention while cooking. In Timor Leste, piles of rice husks outside rice mills, and coconut shells and husks in coconut growing areas have been observed uncollected. This strongly indicates that fuelwood is still abundant and easily available to households in almost all parts of the country today.

Some implications of the biomass supply analysis

There is no information that provides a breakdown of the possible causes of deforestation and the type of use to which the lost forest lands have been converted. In general, the possible causes of deforestation include: over-cutting of trees for fuelwood and poles, commercial logging, agriculture (including conversion to cash crops, shifting cultivation, animal grazing), and urbanization (expansion of existing towns or cities into adjacent forest land and establishment of new human settlements), forest fires, etc. The preceding analysis of fuelwood supply and demand suggests that, except in highly localized cases, over-cutting of trees for fuel is *not* the major cause of deforestation in Timor Leste.

There appears to be no large commercial fuelwood traders/suppliers in the country today. Almost all biomass removals for fuel are by small extractors or by collection for own use. Therefore, it is unlikely that any large-scale over-cutting of trees for fuel is happening in most forests, except perhaps in some parts of Dili and surrounding areas.

What was not investigated in the present study is the extent of biomass removals from forests by commercial loggers, noting that during 1999, there may have been excessive destruction of some forest areas due to the breakdown in overall forest protection. Today there is a ban on logging, although it still takes place, because there are few forest guards. Normally, commercial loggers are only interested in large, merchantable trees. Mature trees provide little additional biomass growth. Harvesting these trees is not generally over-cutting; their removal may even enable under-story trees to grow more vigorously. For the purpose of the present study, it is assumed that the magnitude of sawlog and pole removal from forests by this sector is unlikely to approach that for fuelwood consumption for household use, simply because of the sheer number of households. The effect of any over-cutting for timber on the present estimates would be to reduce the magnitude of the ratio of estimated annual yield to consumption per capita but is unlikely to shift the indicated overall balance.

From the preceding analysis it might also appear that, except for the case Dili and the surrounding area, there should be no cause for concern or need for any immediate action by the Government with regard to ensuring sufficiency of fuelwood supplies to households. However, the high population growth rate (over 3%) that the country is now experiencing is likely to change the fuelwood supply demand balance nationwide in the medium term due to two reinforcing factors: a) the resulting increase in overall fuelwood consumption, and b) the decrease in area of forest lands due to inevitable conversion to agriculture. It has been estimated that each new person would need about 0.24 hectares planted to rice or maize to meet a 2,000 kcal/day food requirement. One solution, of course, is to drastically improve productivity of existing agricultural lands. Another is to improve protection of existing forests and plant more trees, starting with areas in and around Dili. Such tree planting should not be confined to forest land; there is considerable benefit in planting trees, particularly short rotation nitrogen fixing species, on farm lands - a practice that could help stabilize, if not increase agricultural productivity.

Forests do not only provide wood products. They provide vital ecological services such as maintaining soil fertility, protecting watersheds that in turn reduce risks of floods and landslides, and protecting terrestrial diversity. Utilization of non-wood forest products (honey, bamboo and rattan furniture, etc) is a significant source of rural income. As shown in this report, the preparation, distribution and marketing of fuelwood is today a highly important source of employment, especially in rural areas, and will continue to be so in the immediate term (see Annex 2). Finally, forests sequester atmospheric carbon and help mitigate global climate change (see next section).

Therefore, separate from the issue of wood use for energy, a continuing goal of the Government in this sector should be to sustainably manage existing forest resources and further increase biomass supply, starting with, but not confined to the Dili District. Many of the forests of Timor Leste are considered under-stocked. Increasing the stocking will not only provide more wood products, but store atmospheric carbon in woody tissues above and below ground and in the soils beneath the forests. The stocking capacity on most forest formations could be increased substantially by: under-planting and inter-planting; through better management, by exclusion of goats to allow for regeneration; and by the selection of superior breeding stock. These areas could be made much more productive and able to provide a larger annual off-take of wood and other products. It is estimated that increasing stocking could provide an additional 1.5 times more annual yield of wood after a twenty year growth period.

Biomass use and climate change.

In relation to the Millennium Development Goals (MDG), three indicators have been identified by the Government as especially relevant to the sustainable development of the natural resources of Timor Leste and sound management of the environment[18]: i) energy use per unit of GDP; ii) carbon dioxide emissions per capita; and iii) number of population using "solid fuels". However, in determining carbon dioxide emissions per capita, it is important to note that the only emissions from fuel combustion that officially is counted are those from fossil fuels, namely diesel, gasoline, LPG and kerosene. This follows formal international guidelines on national carbon inventories[19] and is based on the principle of the carbon–neutrality of biomass combustion. In the process of photosynthesis, sunlight energy fixes atmospheric carbon dioxide into organic substances (mainly cellulose) that help the biomass grow. Upon combustion of a piece of biomass, e.g. fuelwood, the sequestered carbon is released as carbon dioxide back into the atmosphere (the carbon cycle).

For national carbon inventories, emissions of carbon dioxide from biomass fuels are estimated from the land use side, not from combustion activities[20]. Annual gains and loss in biomass carbon stocks have to be estimated from data on biomass growth and wood removals from forests, including fuelwood removal. Since presently, at the national level, the annual growth of woody biomass in the forests (that act as carbon sink) has been shown to exceed demand considerably, the combustion of wood for energy in Timor Leste does not yet cause *net* additions of carbon dioxide to the atmosphere.

[18] "Natural Resources and Environment: Priorities and Proposed Sector Investment Program", GOTL (April 2006).
[19] 2006 Guidelines for National Greenhouse Gas Inventories, Intergovernmental Panel on Climate Change (IPCC), Chapter 2: Energy (April 2007).
[20] In reporting tables, emissions from combustion of biofuels are reported as information items but not included in the sector or national totals to avoid double counting.

CONCLUSIONS AND RECOMMENDATIONS

Summary of conclusions

1. Except for the Dili District, a positive fuelwood supply/demand balance is indicated for most of the country. The analysis is supported by findings of the demand survey and by field observations which found that fuelwood is widely and easily available for collection or purchase, and that market prices are low and affordable to the lowest income groups. A further indication is that while significant quantities of other potential biomass fuels, such as agricultural residues, are being produced and are freely available country wide, virtually no household use them.

2. The current relative abundance and low cost of biomass fuel to households does not imply that there is no scope for efforts to curtail its use. The heavy use of fuelwood by households in very inefficient traditional cookstoves wastes tremendous amounts of the country's biomass resources and has negative impacts on public health due to pollutants in wood smoke.

3. Population growth will gradually erode the current overall positive supply demand balance for fuelwood as a result of increased total wood consumption coupled with decreased area of forest lands due to conversion to agriculture.

4. Unless incomes rise dramatically, modern fuels are not likely to make any significant inroads into current household fuelwood consumption patterns in Timor Leste in the next decade or more. In the immediate term, very limited interventions appear possible that would achieve significant shifting to kerosene and LPG. However, policies that facilitate wider availability of kerosene and LPG, and initiatives that help households cope with the high first cost of shifting to modern fuels, may accelerate the interfuel substitution process somewhat.

5. Overall, deforestation in Timor Leste is very likely not caused by fuelwood collection but by other pressures on the forests, particularly the need to produce more food for a rapidly increasing population. These pressures are manifested by the continued growth in land areas for both arable agriculture and shifting cultivation practices. Some over-cutting of trees due to fuelwood extraction is probably occurring around Dili already.

At the beginning of this report, three questions were posed: a) To what extent can deforestation be attributed to fuelwood collection in Timor Leste? b) If deforestation is rapidly increasing by whatever cause, are poor households facing significantly higher economic costs and hardships as wood supplies are reduced? c) What specific local barriers exist that must first be carefully examined and addressed to increase the chances of success of improved cookstoves programs? Conclusion 5 above answers the first question categorically. On the second question, Conclusion 1 above assures that, as of today, almost all households in all parts of the country do not yet experience economic hardships caused by fuelwood shortage. *When* the situation will change depends on a number of factors that may manifest themselves in the coming years, including the extent to which population growth may induce further land clearing for agriculture, the inroads that may be made by alternative cooking fuels as income levels rise, and the degree of attention that Government may start paying to the household fuel sector. On the third question, the biggest local barrier to any improved stoves dissemination program is the fact that almost all households do not purchase their stoves or fuelwood, making commercialized approaches difficult to do. Alternative approaches must first be carefully studied before launching any major improved stoves program (see Recommended Action 3 below).

The *policy implications* of the above conclusions are clear: (a) the Government must recognize that the biomass sub-sector is very important in Timor Leste and that the supply and demand for biomass fuels must be paid equal attention as the other commercial fuels. However, strategies and actions to manage this energy source involve social, environmental and agricultural development considerations and therefore must be coordinated with the MAFF and the Ministry of Development and Environment; and (b) Forests do not just provide wood products but have vital ecological value. Therefore, separate from the issue of wood use for energy, a continuing goal of the Government in the sector should be to sustainably manage existing forest resources and further increase tree planting on all land use types, starting with actions in districts that have existing or impending supply shortages.

Recommended Actions

The set of recommended actions described below by no means represents the full range of activities that could be usefully carried out in the sector, to address the issues discussed in this report. They include only key actions identified directly from the results of the analysis in the present study.

<u>1. Improve the biomass data base for more effective actions and investments in the sector</u>

This recommended set of priority actions would refine the broad supply-demand estimates of the present study by improving important primary data, particularly biomass. The purpose is not simply to enrich the data base for some undefined future need, but to ensure that investments in reforestation, protection, technical assistance to community groups and wood-using rural industries, etc. are more precisely determined in terms of type, location and magnitude:

- Conduct a *forest inventory* in the Dili District and areas around it up to radius of 40 km on all land use types, to quantify total above ground woody biomass stock and annual yields, and to pinpoint critical areas. The cost is estimated to be between $390,000 and $520,000.

- Conduct a *time series comparison of satellite imagery*, supplemented by ground truthing, to determine more precisely the extent and type of land use changes that have occurred over the years. The results could quantify the rate by which forest lands are being cleared for agricultural and other purposes. It could also resolve existing significant discrepancies between official MAFF figures on land area under agriculture and figures derived by ALGIS from satellite imagery analysis. The cost of this activity, mainly for the purchase of satellite imagery and associated equipment for analysis and ground truthing is estimated at between $30,000 and $40,000.

- Quantify the *extent of biomass removal from forests for poles, sawnwood and other non-energy products*, by both commercial and non-commercial extractors. Estimated consultancy cost: $30,000 and $40,000.

- Compile a *national data base of wood-using industrial and service establishments*, then conduct a more comprehensive randomly sampled survey to determine fuelwood consumption of these sectors. Estimated consultancy cost: $40,000 to $50,000

All of the above suggested activities are within the purview of the MAFF. The institutional strengthening of the National Directorate of Coffee and Forestry (NDCF) and ALGIS, through addition of personnel and necessary equipment to enable them to carry out these tasks effectively, is clearly an imperative.

An inventory of the forest estate is being undertaken in Bobonaro and Covalima districts under the Second Rural Development Project for Timor Leste (RDP II-2005). This is financed by the EU and GTZ is the overall manager with PADRTL from Portugal in charge of the forestry component. At present, trees outside the forest and dead trees will be excluded from the inventory. From a fuelwood perspective all trees should be measured. However, the proposed inventory round Dili could co-operate and coordinate with the team undertaking the inventory in the Western Region and use common equipment and personnel.

2. Support demonstration of community-based agro-forestry initiatives and forest management in critical areas**.**

The objective is to increase the stocking of trees in selected under-stocked areas and bare forest lands and train communities in sustainable forest management. Three types of areas should be selected for pilot demonstration: i) areas of existing or impending wood deficit; ii) watershed areas in critical condition; and iii) agricultural areas for farm tree planting (agro-forestry). The wood-deficit areas would be selected based on results of the proposed forest inventory. However, some degraded areas around Dili could already be selected even prior to the completion of the inventory. The investment component would finance the establishment of selected plots for tree planting and demonstration of appropriate management techniques. The technical assistance component would provide training to participating communities on the technical, social and ownership aspects of land and tree management.

The technical aspects would include land allocation and integrated land use, protection of young tree growth from browsing animals such as goats, thinning practices, planting of fast growing tree species, especially on farmland, contour planting, and watershed protection. Training would also be provided on the cultivation and utilization of non-wood products such as oils, resins, honey etc. for income opportunities. Promotional materials based on the results of pilot project would be prepared and disseminated to other regions.

The study team considers this an important action on the biomass supply side. However, it was found that similar initiatives appear to be already ongoing or being planned by both the NDCF of MAFF, as well as by some NGOs. This recommendation therefore does not propose to start any new initiatives but merely expresses strong support for the existing activities.

As part of the Second Rural Development Project (RDP II-2005), Activity 2.6 specifies "Develop sustainable and economically viable agro-forestry, agricultural, livestock and forestry systems and improve yields of staple crops and coffee crops". Under this, one component is to promote community based watershed and forest management and another is to promote agro-forestry in Bobonaro and Covalima districts. Therefore, this proposed initiative will draw on the experiences in these two districts and apply them initially in areas round Dili.

3. Support a sustainable improved stoves dissemination program of sufficient critical mass.

This recommendation follows logically from the conclusion that tremendous amounts of wood resources are presently being wasted with the use of traditional three-stone stoves, and any attempt to improve the average combustion efficiency of household stoves would have very significant benefits for the country. Compared to the potential benefits, the cost of implementing an improved stoves program is modest. Given current economic realities, promoting improved cookstoves represents an *intermediate approach* towards the goal of avoiding problems associated with the use of traditional stoves, since the more desirable goal of significant switching to modern fuels is not possible to achieve in the medium term. The benefits associated with modern fuels, such as lower levels of harmful air pollution, higher energy efficiency and cleaner kitchen environments, are also obtainable to a certain degree with improved cookstoves. A summary of various stove initiatives in selected countries, both successful and unsuccessful, is given in Annex 4 with an outline for a stove initiative in Timor Leste, based on lessons learnt.

But there is need to change the current very small-scale donor-driven improved stoves dissemination activities currently being carried out by NGOs and small-scale commercial producers into a more comprehensive program with sufficient critical mass. A possible goal could be to disseminate *at least* 10,000 improved stoves over five years, equivalent to about 20 percent of the total number of households in Dili and Baucau. It is recommended to start with Dili and Baucau where the present study has established that most households purchase their fuelwood. The estimated cost of such a program (to be defined in a pre-investment study) is between $0.3 and 0.4 million.

This does not imply changing to a single government implemented program. The private sector (NGOs, commercial producers and community grassroots organizations) should have full responsibility for implementation. The government's role should be limited to facilitating financing (e.g. coordinating donor funds), overseeing the program (stove and material testing, designing molds, quality control, field testing etc.) and conducting public education initiatives. The specific recommendation is first to carry out a study that would assess the status and results so far of all ongoing or completed programs and private initiatives, review lessons from international experiences, and design a comprehensive program that would have a reasonable chance of success. The study would evaluate modalities for achieving much wider dissemination than has been currently attained, including possible support for commercial and self-made household stoves, more innovative application of financing and subsidies, etc. The specific roles of government and the private sector would be defined. The final output would be a detailed and costed five-year implementation plan that would then be evaluated by the Government and the potential financing agencies. The estimated consultancy cost is between $30,000 and $40,000.

Annex 1. Map of Timor Leste

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Annex 2. Structure of Fuelwood Markets in Timor Leste

Fuelwood market/trading in Dili, Baucau, and selected rural areas

This descriptive analysis is based on field observations by the study team and of interviews of 62 fuelwood traders in urban Dili, Bacau and rural Liquica, Aileu and Ainaro Districts. Liquica is considered to be wood resource poor, Ainaro is considered to be a wood resource rich area, and Aileu is in-between. Table 1 shows the breakdown of traders sampled from each area.

Table 1. Total Sample Size

District	Wholesale Trader	Retail Trader	Wholesale & Retail	Sample Size
Dili	2	16	2	20
Baucau	1	12	2	15
Liquica	2	7	--	9
Aileu	2	11	--	13
Ainaro	--	5	--	5
Total	7	50	5	62

Due to security reasons and resources constraints, it was not possible to conduct full-scale statistical sampling. However, an effort was made to ensure that all respondents and areas for the interviews were selected at random.

The data collected suggests that fuelwood markets in the subject areas are relatively well organized. More than half of those interviewed considered themselves to be full-time fuelwood traders. As expected, the overwhelming majority of fuelwood traders in the urban area (about 80 and 73 percent of traders surveyed in Dili and Baucau, respectively) are full-time fuelwood traders. In contrast, only 38 percent of fuelwood traders surveyed in the three selected rural areas are full-time traders. This finding confirms that fuelwood is a more important traded commodity in urban areas than in rural areas, (Table 2).

Table 2. Fuelwood Trading as Occupation

	Dili	Baucau	Liquica	Aileu	Ainaro	Total
Full time	13	11	5	4	0	33
	81.3%	73.3%	55.6%	30.8%	0.0%	57.9%
Part time	3	4	4	9	4	24
	18.8%	26.7%	44.4%	69.2%	100.0%	42.1%
Total	16	15	9	13	4	57

Most traders said they have fixed locations for doing business, including market and roadside stalls or from their own homes (Tables 3 & 4)). All confirmed that they only trade in fuelwood.

Table 3 Location of Fuelwood Business

	Dili	Baucau	Liquica	Aileu	Ainaro	Total
Itinerant trader	0	1	0	0	0	1
		6.7%				1.6%
Fixed location	18	13	9	13	5	58
	94.7%	86.7%	100.0%	100.0%	100.0%	95.1%
Both fixed and moving	1	1	0	0	0	2
	5.3%	6.7%	0.0%	0.0%	0.0%	3.3%
Total	19	15	9	13	5	61

Table 4 Type of Fixed Location

	Dili	Baucau	Liquica	Aileu	Ainaro	Total
House	11	1	1	7	0	20
	57.9%	7.1%	11.1%	53.8%	0.0%	33.3%
Shop at market	2	1	0	0	0	3
	10.5%	7.1%				5.0%
Roadside-rural	2	1	7	6	5	21
	10.5%	7.1%	77.8%	46.2%	100.0%	35.0%
Roadside-urban	4	11	1	0	0	16
	21.1%	78.6%	11.1%			26.7%
Total	19	14	9	13	5	60

Fuelwood market structure in Dili, Baucau, and selected rural areas

The survey found no evidence that fuelwood is traded between the Dili and Baucau. Dili, which appears to be in deficit, receives supply of fuelwood from wood-rich areas outside the city. In contrast, Baucau which appears to have more abundant wood supplies within the city does not seem to on rely on external sources as much as Dili.

Dill. The fuelwood market structure in Dili may be divided into two interrelated market chains, differentiated by type of customers. The first chain comprises traders who are mainly small local neighborhood retailers and itinerant peddlers. The majority of customers in this chain are household consumers, who use the purchased fuelwood directly for cooking.

The second market chain is made up of fuelwood traders who sell their merchandise along the highways leading in an out of Dili. The majority of customers are large users of fuelwood, such as cottage industries, as well as middlemen and retailers. A small number of household customers may also purchase fuelwood this way.

Overall, households account for 67 percent of all fuelwood sold by traders in Dili (including city retailers and roadside traders). Table 5 shows the type of customers in various locations.

Table 5. Type of Customers

	Dili	Baucau	Liquica	Aileu	Ainaro	Total
Household	12	12	8	4	1	36
	66.7%	85.7%	88.9%	30.8%	100.0%	66.7%
Household and others	6	2	1	9		18
	33.3%	14.3%	11.1%	69.2%	0.0%	33.3%
Total	18	14	9	13	1	54

Baucau.. The market structure of fuelwood in Baucau is similar to that in Dili. However, the role of roadside traders outside the city limits appears to be very small; unlike Dili, the survey found only a small number of roadside traders along the highway outside the city.

Baucau has fewer neighborhood retailers partly because it is a smaller city than Dili, but also because more households in Baucau collect their own fuelwood. Households who purchase fuelwood rely on a few established open markets in the city. Overall, traders in Baucau reported that households comprise 86% of their customers, (Table 5).

Rural areas. The results of surveys of fuelwood traders and households in the three selected rural areas suggest that fuelwood markets in the wood rich areas serve as an important part of the supply chain for urban Dili, aside from serving local consumers Interviewed fuelwood traders in Aileu identified several types of customers including households, transporters, other wood traders, and large customers in the service and cottage industry sector. Traders in Aileu reported 31 percent of their fuelwood sales are just for household customers, while traders in Liquica reported selling fuelwood almost exclusively to household customers. Fuelwood markets in the rural areas were found to be much smaller than those in the urban areas. This is consistent with the findings that almost all traders and the majority of households in the rural areas self-collect their fuelwood.

Estimated Amount and Value of Traded Fuelwood

Based on the survey it is clear that fuelwood market in Dili is significantly larger than in Baucau. The survey reveals that on average a trader in Dili sells about 240 bundles of fuelwood per week with an estimated total value of US$23.60 (Table 6). Given the selling price of fuelwood that ranges from US cents 2 to 8 per kilogram, the amount of fuelwood sold by each trader each week could range from 300 kilograms to over a tonne. In contrast, the average trader in Baucau sells only 158 bundles per week with a reported total value of about US$13.63 (Table 6). Based on the same price, the estimated amount of fuelwood sold each week by a Baucau trader could range from 170 to 680 kilogram. The survey also asked respondents to identify the number of fuelwood traders in his/her community. Based on the responses, it is estimated that some 47 and 48 fuelwood traders, in addition to those surveyed, are also actively trading in Dili and Baucau, respectively (a total of 67 in Dili and 63 in Baucau – Table 6). Based on these numbers, it is estimated that the total amount of fuelwood traded in Dili could be as much as 79 tonnes per week, while the total fuelwood traded in Baucau could be as high as 43 t per week.

Table 6. Value (in US$) of Fuelwood Traded per Week

	Dili	Baucau	Liquica	Aileu	Ainaro	Av./Total
Estimated value US$	23.60	13.63	8.22	8.00	2.60	13.99
Number of Traders Surveyed	20	15	9	13	5	62
Number of Other Traders Mentioned	47	48	85	58	3	241
Total Number of Traders	67	63	94	71	8	303

With respect to the rural areas, the survey also found a large number of fuelwood traders. Approximately 94 were identified in Liquica , 71 in Aileu, and 8 in Ainaro (Table 6). The total amount of fuelwood traded each week in the three districts range from 17 to 68 tonnes.

Thus, out of an estimated annual fuelwood consumption of 600,000 t, approximately 85,000 t (14%) is traded. If the average market price in all sectors and all areas is about US$ 70 per tonne, the total value of traded fuelwood is nearly $6 million annually. From a World Bank commissioned survey in Malawi (Openshaw, K 1997),[21] it was found that for every 15 tonnes of traded fuelwood, one person is employed in the business. Assuming the same figure applies to Timor Leste, about 5,700 people could be employed full-time in production, transport and fuelwood trading. Overall, the fuelwood trade probably creates more employment in Timor Leste today than in all the other forms of energy.

Transportation and Distribution of Fuelwood

The most common way for buyers to transport the fuelwood into the city appears to be by motor vehicle. Traders who cited motor vehicle as their means to carry fuelwood used hired transporters, clearly adding to the procurement cost.. However, fuelwood traders in the rural areas tend to use hand drawn cart or self-carried the wood, implying that they deal with much smaller amount of fuelwood than traders in the urban areas (Table 7).

[21] Openshaw, K. 1997. Urban Biomass Fuels: Production, Transportation and Trading Study. A Consolidated Report for Malawi. International Resources Group (IRG) Washington D.C.

Table 7 Means of Fuelwood Transportation from Wood Sources

	Dili	Baucau	Liquica	Aileu	Ainaro	Total
Carry on foot or by hand-drawn cart	3	1	5	6	3	18
	15.8%	6.7%	55.6%	46.2%	100.0%	30.5%
Bicycle	1	0	0	0	0	1
	5.3%	0.0%	0.0%	0.0%	0.0%	1.7%
Animal drawn car	1	1	1	0	0	3
	5.3%	6.7%	11.1%	0.0%	0.0%	5.1%
Motorized vehicle	14	10	0	3	0	27
	73.7%	66.7%	0.0%	23.1%	0.0%	45.8%
Total	19	15	9	13	3	59

Sources of traded fuelwood

Fuelwood traders in the urban areas are more likely to obtain fuelwood by purchasing from rural traders. Although the sample size is very small, there appears to be somewhat different patterns between Dili and Baucau regarding the second most important source of fuelwood. In Baucau it is collecting from community property, reinforcing the results of the biomass supply side study which concluded that Baucau has sufficient wood resources to meet demand. Visual observations also indicate that Baucau has relatively much large communal property. For Dili, the second most important source of fuelwood cited by respondents were collecting from their own property and purchasing from another trader in the city. None cited collecting fuelwood from community property. Furthermore, the responses indicate that fuelwood traders in Dili have to travel a longer distance on average to collect fuelwood than Baucau traders (Table 8). Again, these findings support the conclusion of the supply side study that Dili does not have sufficient wood supplies to meet demand.

Table 8 Sources of traded fuelwood

	Dili	Baucau	Liquica	Aileu	Ainaro	Total
collect or cut wood from own property	3	2	3	9	0	17
	15.0%	13.3%	33.3%	69.2%	0.0%	27.4%
Collect from other private property	1	1	0	2	0	4
	5.0%	6.7%	0.0%	15.4%	0.0%	6.5%
Collect from community property	0	4	7	1	4	16
	0.0%	26.7%	77.8%	7.7%	80.0%	25.8%
Purchase from transporter	0	1	0	0	0	1
	0.0%	6.7%	0.0%	0.0%	0.0%	1.6%
Purchase from rural trader	8	6	1	2	1	18
	40.0%	40.0%	11.1%	15.4%	20.0%	29.0%
Purchase from urban	2	3	0	0	0	5

trader						
	10.0%	20.0%	0.0%	0.0%	0.0%	8.1%
	20	15	9	13	5	62

Table 9 Distance to collect traded fuelwood

	Dili	Baucau	Liquica	Aileu	Ainaro	Total
Less than 1 km	0	2	0	4	0	6
	0.0%	18.2%	0.0%	30.8%	0.0%	11.1%
1 to 3 km	7	4	5	6	5	27
	43.8%	36.4%	55.6%	46.2%	100.0%	50.0%
More than 3 km	9	5	4	3	0	21
	56.3%	45.5%	44.4%	23.1%	0.0%	38.9%
Total	16	11	9	13	5	54

With respect to sources of fuelwood by rural traders, the survey confirms that almost all fuelwood traders collect and/or cut wood by themselves. Depending on availability, the trader would cut or collect wood for free from his own or other's property, including community property. This reflects the fact that wood supplies are relatively abundant in rural areas of Timor Leste and little restrictions on wood extraction from forests exist. To collect fuelwood, the survey shows that fuelwood traders in Liquica have to travel longer than traders in Aileu and Ainaro (Table 9).

The type of wood collected also provides further indications that that Dili has a supply deficit. The proportion of dead wood out of the total amount extracted range from only 10 to 25 percent. Several species of wood are extracted and sold, including *Eucalyptus alba*, *Rhizophora sp.* (Red mangrove), *Hibiscus tilia*, (small mangrove) and *Pometia pinnata* (Fiji longan/Kayu sapi). In contrast, traders in all three rural areas indicate that a most of the fuelwood (about 80%) they collected are dead wood.[22] Moreover, the rural traders tend to extract only one or two species of wood. The most common species of wood being extracted/cut by all traders is *Eucalyptus alba.*

Perception of trends in wood supply and price

Unfortunately, there exists no historical information on wood supply and price to enable examination of the any trend. Consequently, the survey relied on questions designed to assess perceptions and experiences of fuelwood traders. The survey reveals that all rural fuelwood traders and the overwhelming majority of fuelwood traders in Dili and Baucau indicate that they are paying the same price or less for the fuelwood, and their business has remained the same during the past three years (Table 10 and 11). Among the small minority traders who have been paying more for fuelwood during the past three years, four traders in Dili indicated that prices have increased about 10 percent, and two traders indicated that the price have increased 75 percent. Two traders in Baucau indicated that prices have increased 3 and 10 percent, respectively, and another trader said it had increased 70 percent. This finding can be used as a proxy measure to conclude that fuelwood supply in the selected rural areas has for the most part remained unchanged during the past three years. However, the fuelwood supply in Dili and to some extent in Baucau may have declined in some very specific areas.

[22] It should be noted that only two fuelwood traders in Baucau indicate that all of the wood collected/cut are deadwood proportion of dead wood collected/cut. The remaining 13 responding traders did not respond to this question.

Table 10. Perception of Change in Fuelwood Acquisition Cost Over Past 3 Years

	Dili	Baucau	Liquica	Aileu	Ainaro	Total
Pay more	2	3	1	0	0	6
	12.5%	33.3%	11.1%	0.0%		14.6%
Pay less	2	2	0	0	0	4
	12.5%	22.2%	0.0%	0.0%		9.8%
Pay the same price	12	4	8	7	0	31
	75.0%	44.4%	88.9%	100.0%		75.6%
Total	16	9	9	7	0	41

Table 11. Perception of Business Change Over Past Three Years

	Dili	Baucau	Liquica	Aileu	Ainaro	Total
Increased	3	0	0	0	0	3
	15.8%	0.0%	0.0%	0.0%	0.0%	6.5%
Decreased	2	0	1	0	0	3
	10.5%	0.0%	12.5%	0.0%	0.0%	6.5%
Stayed the same	14	7	7	11	1	40
	73.7%	100.0%	87.5%	100.0%	100.0%	87.0%
Total	19	7	8	11	1	46

Conclusion

The survey of fuelwood traders in Dili, Baucau and the three selected areas of Liquica, Aileu and Ainaro indicate that fuelwood markets are highly localized; there is little indication that fuelwood is traded between cities or regions. Baucau relies primarily on internal wood supplies and on close-by areas. The pattern of fuelwood trading and collection suggests that the city has sufficient wood supplies. For Dili, the situation appears to be different: fuelwood traders rely more on sources of fuelwood from outside the city, probably as far as 40 kilometers away. Rural roadside traders appear to play a very important role in supplying fuelwood to the retailers in the city. Additionally, the survey finds that fuelwood traders in Dili tend to collect and sell several wood species, with a large proportion being live wood. These reinforce other findings that Dili may be in deficit. In rural areas, fuelwood markets are relatively smaller and appear to serve only household users. Fuelwood tend to be collected or extracted by traders themselves and sold directly to household customers; wholesalers and transporters do not seem to play any significant role in the rural fuelwood markets. Overall, the survey findings indicate that commercial fuelwood trading is an important economic activity and a significant employment source, particularly in rural areas.

Annex 3

Table I. Estimated Woody Growing Stock & Annual Yield by Region

	Central Region						Western Region						Eastern Region				Country
District	***Liquica***	***Ermera***	***Aileu***	***Dili***	***Manufahi***	***Total***	***Ainaro***	***Covalim***	***Bobonaro***	***Oecussi***	***Total***	***Lautem***	***Baucau***	***Viquequ***	***Manatuto***	***Total***	**Total**
Woody growing stock ('000 t)	2,781	3,550	1,487	1,369	8,332	17,519	4,551	12,215	8,751	2,516	28,032	11,890	6,291	11,529	14,331	44,041	89,592
Woody biomass yield ('000t)	147	225	108	62	286	810	138	427	280	126	971	434	270	443	437	1,585	3,386
Population (2007), '000	60	112	40	182	48	440	58	61	89	63	271	62	113	72	42	289	1,000
Stock per person (t)	46.7	31.8	37.3	7.5	174.3	39.8	78.5	201.9	98.2	39.7	103.4	191.5	55.6	160.6	343.7	152.5	89.6
Yield per person (t)	2.5	2.0	2.7	0.3	6.0	1.9	2.4	6.6	3.1	2	3.5	7.0	2.4	6.2	10.5	5.5	3.4
Total area ('000 ha)	54	77	74	26	132	373	81	120	138	81	420	182	151	188	178	699	1,492
Stock per ha. (t)	51.8	46.2	20.1	36.4	62.9	47	56.1	102	63.6	30.9	66.8	65.3	41.8	61.2	80.4	63	60
Yield per ha. (t)	2.8	2.9	1.5	1.7	2.2	2.2	1.7	3.3	2.0	1.5	2.2	2.4	1.8	2.4	2.4	2.3	2.3
Yield/Stock (%)	5.3	6.3	7.3	4.6	3.4	4.7	3.0	3.5	3.2	5.0	3.5	3.7	4.3	3.9	3.1	3.6	3.8
Nominal average rotation (years)	38	32	27	44	58	42	66	57	62	40	58	55	47	52	65	55	53
Low supply/high/demand scenario																	
Yield per person (t), 50% less	1.3	1.0	1.4	0.2	3.0		1.2	3.3	1.6	1.0		3.5	1.2	3.1	5.3		1.7
Consumption per person (t), 25% more	1.0	1.0	1.0	0.5	1.0		1.0	1.0	1.0	1.0		1.0	0.6	1.0	1.0		0.9
Ratio Supply to Demand	1.2	1.0	1.3	0.3	3.0		1.2	3.3	1.5	1.0		3.5	2.0	3.1	5.2		1.8

Annex 4. International Experience in Woodlots, Community Forest Management and Agro-forestry.

Woodlots and fuelwood plantations have been established throughout developing countries for over 100 years. There are many examples of such efforts. The capital of Ethiopia became fixed at Addis Ababa, because fuelwood plantations were successfully established round it. (US National Academy of Sciences [NAS] 1980 – Firewood Crops). In South Korea, village level forestry groups planted over 640,000 hectares of village woodlots by 1977 to meet the needs for fuelwood. (US NAS 1980). Of course today in South Korea, most fuelwood has been replaced by other fuels, but the woodlots are used for other forest products, recreation and a carbon store.

Community managed forests (CMF) are estimated to cover at least 11 percent of the world's forests, but information about such managed forests is rarely available to those outside the forest themselves, (The International Forest Review, (IFR), June 2007).[23] However, the International Forestry Resources and Institutions research program (IFIR) supported by FAO had monitored CMFs in sixteen countries through ten research centers since 19993. More than 350 communities and 9,000 forest plots have been monitored for more than a decade. Much detailed information can be obtained from IFR and some is described in the IFR article. But in summary, the research has enabled IFIR to codify various CMF initiatives and have particular impacts on new knowledge, policy and local communities and capacity building. In addition, lessons on how to strengthen, extend and sustain such impacts include developing more robust agreements on forest sustainability, network building and expanding networks and outreach programs.

Agro-forestry encompasses a whole range of tree planting options on arable and pastoral farmland. Again it has been practices in various forms for over 100 years. Indeed, shifting cultivation, if properly practiced, can be considered to be one form of agro-forestry. Basically trees are planted on farm to assist in arable and pastoral production. There are exceptions, in the Taugya system; trees are the final crop with arable crops planted under the trees until canopy closure. Common examples of agro-forestry systems are shelterbelts on rainfed and irrigated areas, to decrease the loss of water through evaporation.

Many trees fix nitrogen and if such trees are judiciously spaced on arable land, then agricultural productivity can be at leased maintained if not increased by mulching the leaves into the soil. Most of these trees can be grown on a one to three year rotation and only have minor effects on the arable crops, which is more than compensated for by the additional inputs of nitrogen etc. On pastoral land such trees are used as browse and provide nitrogen-rich fodder to the farm animals, thus increasing the intake of protein rich food.

The various agro-forestry systems and suitable trees are described in publications at the World Agroforestry Center based in Nairobi.[24] Other publication include "Tropical Legumes: Resources for the Future" US National Academy of Sciences, 1979 and "Tree Growing by Rural People" FAO Forestry Paper 64, 1985.

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[23] Fourteen Years of monitoring community-managed forests: learning from IFIRs experience. IFR June 2007, page 670-683. E Wollenberge et al.

[24] This was formerly known as ICRAF – the International Center for Research in Agroforestry. It is a member of the Consultative Group on International Agricultural Research (CGIAR). Its address is P.O. Box 30677-00100 Nairobi, Kenya. www.worldagroforestrycentre.org. It has a sub-office in South East Asia - www.worldagroforestrycentre.org/Sea/.

In Timor Leste, the government is in the early stages of community forest management. The lack of trained staff, especially extension workers is the greatest obstacle at present. However, many local communities do manage their forests, albeit mostly in haphazard and sub-optimal ways. There are some plantations, mainly of teak (*Tectona grandis*) and other timber species. Because wood is not scarce, few if any woodlots are present in the country although the indigenous eucalyptus species and casuarina are ideal for such woodlots. The EUs Second Rural Development Project has nurseries to grow many tree species including fruit trees and nitrogen fixing trees such as *Acacia, mangium, Calliandra sp, Casuarina equestifolia* and *Leucaena leucocephala.* Many of these species are already planted on farm and along the roadside, so farmers are familiar with them. Thus, the proposed interventions are to assist existing initiatives and to bring in expert knowledge from around the world.

Annex 5. Experiences in Improved Stoves Dissemination by the World Bank and other Agencies

Introduction.

The traditional biomass burning three-stone fire is very flexible and accommodates all sizes of pots and pans. It provides a meeting place for families to congregate round during and after meals, giving off heat and some light and keeping mosquitoes etc. at bay. If only viewed as a cooking device, it is inefficient - converting between fifteen and twenty percent of the energy in biomass to 'useful' energy. What is more, if the biomass contains considerable quantities of moisture and the stove is indoors, excessive amounts of products of incomplete combustion (PIC) are produced, especially smoke, wood tar, carbon monoxide, methane etc. especially during lighting: this adversely affect the health of the cook and children in the vicinity of the stove.

Because much wood and other forms of biomass are collected by women and women are the cooks, improving the efficiency of stoves, including directing the smoke outside from indoor stoves, will not only reduce the burden of fuelwood collection, but also improve the health of the cook and children, especially for an indoor 3-stone fire.

However, from experiences in many countries, the families most receptive to more efficient stoves are those that already pay for stoves and/or biomass, or find it becoming scarcer to collect. This is particularly so for biomass products such as charcoal or densified and briquetted biomass. Needless to say, the most successful improved biomass stove programs have been for charcoal stoves where the fuel and the stoves are purchased. What is more, charcoal is a much 'cleaner' fuel because many products of incomplete combustion have been removed at the kiln site and when some are produced in the lighting phase, such as carbon monoxide, the cook invariably lights the portable stove outside and only brings it indoors when it is well lit. To a lesser extent this is true for modified unprocessed biomass, which is generally dried to moisture contents of about 10 percent and therefore, lights more quickly that 'wet' biomass and produce fewer particulates and other PICs. It is also uniform in size and improved stoves can be designed more easily to accommodate such fuels rather than multi-sized wood and crop residues.

Improved stove programs – charcoal.

As mentioned above, improved charcoal stove programs are more successful than improved fuelwood programs. Some have been developed purely by the private sector, such as in Thailand, where the Thai bucket stove is made. This consists of a tapering ceramic firebox and ash box, with a replaceable ceramic grate. It has a metal outer cover, generally made from misprinted Coca Cola sheets etc. with an insulation layer of rice husk ash between the firebox and the metal surrounds. It is made in various sizes and, because of sloping pot-holders; one stove can accommodate three or more sizes of pots/pans. It is suitable for stir-fry meals and cooking rice. The stoves are made at factories that product many ceramic products and therefore, the people have the skill, tools and kilns etc. to produce 'quality' stoves. The efficiency of such stoves is in the region of 35 percent. The Danish Aid Agency had a program to improve this efficiency by looking at the thickness of the insulation layer, the number and size of holes in the grate area and the contact area of the pots and pans. Training for stove makers was also part of the program. Such improvements increased the efficiency by about 5 percent.

Ceramic charcoal stoves are common in Insular and Peninsular Asia and improved stoves are relatively easy to introduce. However, in Africa, especially Eastern Africa, where charcoal is a common urban fuel, the single-walled metal stove was the usual charcoal stove. This had an efficiency of about 20-25 percent. Tests were undertaken to compare the efficiencies of the Thai bucket stove and the East African metal jiko and it was found that the former was about 75%

more efficient than the latter. Therefore, USAID sponsored two programs based in Kenya. The first was the introduction of a ceramic charcoal stove (KCJ- Kenyan Ceramic Jiko) and the second was a stove training program for Eastern and Southern Africa run by a NGO in Kenya.

From the outset, there was collaboration between the project manager, and small entrepreneurs. Various designs were produced, based on a ceramic liner, insulation and a metal cover. These stoves were first tested in the laboratory and then field tested by women's groups and modified to suit the requirements of the cooks. Training was provided in sourcing suitable clay, testing the appropriateness of clay for stove making, providing molds and tools for two or three sizes of ceramic inserts, specifying the size and number of holes in the grate, teaching about the curing time for the clay insert before firing, kiln technology and firing fuels. Local metal workers were trained to make stove covers and a local insulation material – vermiculite - was promoted.

The stoves were assembled by three groups of entrepreneurs – the metal workers, the ceramic liner manufactures and people buying the liners, insulation and metal covers from the producers. The project promoted the stoves through the media, in demonstrations and through women's groups etc. Initially, improved stove producers were given a guaranteed price for stoves that was slightly more than the cost, but producers were encouraged to sell the stoves on the open market. Through this, improved stove manufactures were able to sell stoves below US$ 10 at a profit and the buyers were able to recover the additional cost of the improved stove (US$ 2-4) in one to two months through charcoal saving. Improved stoves spread from Nairobi to other urban areas.

T he second USAID program concentrated on stove training. This was a two-week course based at KENGO, the Kenya Energy NGO, later expanded to Kenya Energy/Environment NGO. This gave training to potential stove makers and government personnel, from countries in Eastern and Southern Africa, in all aspects of improved stove manufacture including bookkeeping and marketing. While improved charcoal stove production was the main thrust, improved portable ceramic wood stoves were also included. Through this training and with support of various donors, improved stoves spread not only throughout the region but to West Africa as well. One such successful program was sponsored by the World Bank in Tanzania. The project manager of this program was the same person who managed the KCJ program in Kenya.

There were other types of improved stove introduced in Africa. The World Bank promoted a double-walled metal stove in Rwanda. This was successful because local metal workers could be trained to make the stove and the ceramic liner stove was relatively more expensive, but had the same efficiency as the improved metal stove. As in Kenya, the metal-smiths were trained; the stoves were laboratory and field tested. It was promoted through the media and demonstrations.

Improved stove programs - fuelwood and other biomass.

While improved charcoal stoves are portable, most fuelwood stoves are fixed and generally custom built in individual houses. It is interesting to compare and contrast the two largest stove programs namely those in China and India. The following table summarizes the two programs.

A comparison of stove programs in China and India

China	India
• Concentrated effort on greatest need and selected pilot counties with biomass deficits.	• Implemented countrywide resulting in dispersion of effort and dilution of financial resources.
• Direct contracts between the central government and the county bypassed much bureaucracy. This generated self-sustaining rural energy companies that manufactured key components, installed and serviced	• Cumbersome administration moving from the center to regional offices, the states, districts and finally the taluka, where the stove program is just one of many national efforts being implemented

stoves and other energy technologies. • Local rural energy offices are in charge of technical training, servicing, implementation, and monitoring for the program. • The latest improved stoves not only save fuel but are attractive. Stove designed to meet local cooking requirements. Essential components factory made. • Adopters pay the full cost of materials and labor. Government helps producers through training, administration, molds and promotion support etc. • The firebox, grate and chimney factory made; chimneys designed for ease of cleaning and to extend above the roof. Chimney insulated to prevent fire and sealed to stop leakage during rains.	locally by the same people. • Stove design at appointed technical institutes with little field testing. Technical training in the hands of various bodies. Monitoring spasmodic. • Stove program driven by targets not acceptability. Many types of stoves, few specifically designed for local use. Few components factory made. • Adopters pay only fraction of cost, but only one stove subsidized. Little training for maintenance and little incentive to replace stove. Government driven. • The firebox generally built on site; some feed boxes cannot accommodate all fuel sizes. Chimney comes in standard sizes and sometimes does not reach the roof height; difficult to clean. If the roof is straw, liable to ignite near a hot pipe and leak.

It can be seen from the above comparisons that in general the Chinese stove program is much more successful than the Indian one, although a few Indian states adopted some of the initiatives in the Chinese program. But the large difference was that the Indian program was dependent on direct one-time stove subsidies; this discouraged buying replacement stoves. In China, the subsidies went to training, molds, determining the needs of the people, promotion etc. Thus if the stoves improved end-use efficiency, household most likely will buy replacements.
In Kenya, a GTZ fuelwood stove program trained rural women's groups to produced ceramic stove liners. These could be packed round with soil and joined together for a two-pot stove. A chimney made from waste metal or clay reinforced with straw molded with the aid of a pipe. The cost of such stoves was in the range of US$ 1-2.

Lessons for an Improved stove Initiative in Timor Leste

What lessons can be learnt for a successful stove initiative in Timor Leste? Fuelwood is the principal cooking fuel and therefore, stoves should be designed to burn this fuel more efficiently.
In general subsidies should not be given directly for stoves, but should be used for training stove makers in producing more efficient and durable stoves, with and without chimneys. Also, money should be used for promotion and quality control and to continually improve stove design etc.
There are various steps which could be used to promote improved stoves.

1. First concentrate on areas where fuelwood is purchased, namely urban and peri-urban areas and rural areas where wood is becoming scarce.
2. Undertake survey to see if people are receptive to improved stoves and at what price.
3. Identify existing 'commercial' stove makers. **These stove makers generally make portable ceramic stoves with metal surrounds**.

4. With the help of the stove makers, design and test stoves in the laboratory. In the field use households to obtain critical insights of the stove in actual use. Modify stoves if and when required.
5. Identify raw material sources, especially clay and metal.
6. Provide training courses in stove making. This should include the provision of simple tools and molds for ceramic liner and grate etc., building and firing kilns, making metal casing, finding suitable insulation, business training.
7. Provide booklets on the steps to make stoves.
8. Undertake quality control and give advice to stove makers and stove sellers.
9. Keep stove makers apprised of new developments.
10. Have a vigorous stove promotion program with demonstrations. Involve the government and leaders in such campaigns. The health aspects should be stressed through posters, radio and TV etc. This should be in combination with improving kitchen practices and the quality of life.
11. **Where custom built stoves are required**, identify stove makers. These are generally rurally based.
12. Undertake a survey of potential stove users and determine what they want and what they are willing to pay.
13. Provide molds and training to these stove makers so that standard fire box sets can be made and perhaps chimneys.
14. If standard ceramic parts are involved, encourage existing pot and brick producers to make these standard parts. As with point 6 above provide training in identifying suitable clay sources, making stoves with molds, building, maintaining and firing kilns etc.
15. Provide training to users in simple maintenance and repair.
16. Make available replacement parts.
17. As in point 8 above, have a vigorous stove promotion program with demonstrations. Involve the government and leaders in such campaigns. The health aspects should be stressed through posters, radio and TV etc. This should be in combination with improving kitchen practices and the quality of life.