Biomass Fuel and Its Utilization in Sri Lanka

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ABSTRACT

At present biomass fuel consumption in Sri Lanka is 9 million tonnes per year, made up of 7.9 by households and 1.1 by industries. This accounts for 71 per cent of the primary energy consumption in the country. The biomass fuel comes from crop plantations (mainly rubber and coconut), forests, scrub and waste land, and home gardens. Although there is a scarcity of fuelwood in some areas, taking the country as a whole there is no shortage. In the future, however, there will be a growing scarcity unless timely action is taken to raise fuelwood plantations and to increase the use of agricultural wastes (e.g. coir dust, paddy husk) as biomass fuel.

INTRODUCTION

Biomass takes a prominent place in the national energy budgets of many Third World countries. In Sri Lanka, in 1985, 71 per cent of the primary energy consumed came from biomass fuel and the balance was shared between oil (19 per cent) and hydropower (10 per cent).[1]

Sri Lanka is a small island state situated between latitudes 5° 54' and 9° 52' N and longitudes 79° 39' and 81° 53' E. It has a land area of 65,610 km^2 and an estimated population of 15.6 million (mid 1984). In the last national census, in 1981, it was estimated that 94 per cent of the households used biomass fuel for cooking.[2] Besides households, a large number of small industries use fuelwood as the source of energy. The fuelwood and other biomass fuel come from forests, tree crops, home gardens, and scrub and waste land.

Sri Lanka imports all its requirements of oil. Hydropower and biomass fuel are the only available indigenous sources of energy of any magnitude, and, seeing their relative contribution to the primary energy consumption and the limits to the development of hydropower, biomass fuel will undoubtedly continue to dominate the energy scene in the forseeable future. Because of the importance of biomass fuel, several studies have been carried out on various aspects of the subject in recent years and information, previously lacking, is now available concerning the consumption and sources of biomass fuel, the quantities of available agricultural wastes which could be used as fuel, the forecasts of demand and supply, and so on. This review brings together the information now available on biomass fuel and its utilization in Sri Lanka.

BIOMASS FUEL CONSUMPTION

Household Consumption

In an island-wide sample study carried out by the author in 1983 it was estimated that the total annual consumption of biomass fuel (wood and other biomass material) by households in Sri Lanka was 7.5 million tonnes.[3] That was the first comprehensive scientific assessment made of the fuelwood consumption in Sri Lanka, and the consumption proved to be appreciably higher than what was assumed up to that time. The consumption *per caput* for the country as a whole was 496 kg per year. Taking only the rural sector, where fuelwood is the exclusive domestic fuel used for cooking, the *per caput* consumption was 526 kg per year.

The same study gave the breakdown of the biomass fuel used by households as follows: rubber wood 18 per cent, crop wastes (mainly wastes from the coconut tree) 28.8 per cent, and other fuelwood 53.2 per cent. The rubber wood consists of wood coming from rubber plantations which are felled for replanting and also from dead trees and branchwood collected by households living in and around the plantations. The category 'crop wastes' consists mainly of the products of the coconut tree - wood, fallen palm fronds (particularly the woody rachis and petiole), husks, and shells. Besides coconut wastes, other crop wastes such as uprooted tea bushes, manioc and cinnamon sticks, arecanut wood, etc. were included in this category. All biomass fuel which did not fall into the categories of rubber wood or crop wastes was collectively placed in the third category 'other fuelwood'.

Rubber and coconut plantations are found in distinct agro-ecological regions and the fuel derived from them are of special importance in the respective regions. In the study referred to above, the island was divided into four agro-ecological zones. The proportions of the different types of biomass fuel consumed by the households in each of the zones is given in Fig. 1. The southwest sector of the country is the most densely populated, and in this region the two crop plantations coconut and rubber play a dominant role in supplying the energy needs of the people.

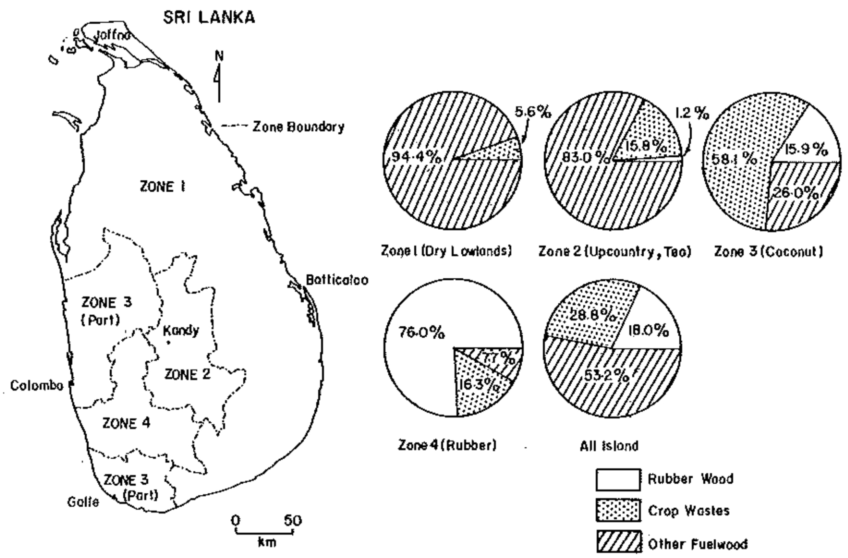

Fig. 1 Agro-ecological zones and percentage composition of the biomass fuel mix consumed in each zone.

Studies carried out by the Forest Resources Development Project (FRDP) of the Ministry of Lands and Land Development confirmed the findings of the writer that the consumption of biomass fuel by the household sector was much higher than previously assumed. The FRDP estimate for 1985 is 7.9 million tonnes.[1] The thermal energy content of this quantity of biomass fuel is estimated at 120 million GJ.

Procurement of household biomass fuel

In the rural sector the vast majority of households (80 per cent) obtain all their biomass fuel by gathering it themselves. However, in urban areas the majority of households have to purchase at least a part of their fuelwood requirements. Where biomass fuel is gathered there is no direct monetary cost involved. Only in a small proportion of the households was the distance of collection found to exceed one mile (1.6 km).[3] This would imply that much of the collection is made from crop plantations or waste and scrub land or secondary forest, found in proximity to villages. There are exceptions to this. In many hill country areas, for example, fuelwood is removed from high forest resulting in steady forest degradation.

Of the three categories of biomass fuel mentioned in the above study "other fuelwood" accounts for 53.2 per cent of the consumption.[3] This category includes all the fuelwood from the forest, all the biomass fuel gathered from waste and scrub land and also from private lands and estates (excluding rubber wood and crop wastes). Owing to the presence of biomass fuel available for collection from alternative sources in proximity to their homes, many households could avoid trudging to the forest, and it is therefore assumed that the proportion coming from the forest is not large. Nanayakkara suggests that the fuelwood obtained from forests accounts for less than half of the 53.2 per cent.[4] In other words, out of the 7.5 million tonnes estimated to have been consumed by the household sector (1983 estimate) probably no more than 20-25 per cent came from the forest and that too mainly from already degraded secondary forest. The inference is that, except in a few areas, fuelwood removal is not at present a major cause of deforestation. It should be noted that in referring to fuelwood coming from the forest we are speaking largely of fuelwood removed by villagers. Official supplies of fuelwood from state forests are made by the State Timber Corporation through its depots situated in a few towns, but the sum total of the sales to households through this channel represents only a very small proportion of the 20-25 per cent referred to above.

In the towns, fuelwood, whatever the source, is generally a traded commodity. In 1985 the average price of fuelwood varied from Rs 23.70* to Rs 36.20 per 50 kg in the different zones.[1]

Household cooking devices

The commonest biomass fuel cooker is the semi enclosed mud stove built out of brick and mud on the kitchen hearth. The cooker has no chimney. A close second to the mud stove is the three stone open fireplace.[3]

Some government institutions and private organizations have been engaged in trying to develop and popularise improved cooking stoves. The Ceylon Institute of Scientific and Industrial Research and the Industrial Development Board have, in collaboration with tile manufacturers, developed improved fuelwood stoves built out of clay. Laboratory and field tests have been carried out on these stoves and savings of fuelwood of up to 37 per cent compared with the traditional mud stove have been noted.[5] These models are portable, small, and compact, and should be suitable for urban homes.

The Sarvodaya movement has developed a two-pot cooker which has to be built *in situ* on an earthenware frame (Fig. 2). It is built using a mixture of cowdung, anthill earth, ash and sand. It is suitable for rural homes, and the Ceylon Electricity Board (CEB) has developed a programme for installing the cooker in rural houses. The frame is supplied to the householder at a subsidized price of Rs 15 (the actual cost is Rs 30) and an expert stove builder assists in the construction of the stove.

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* In 1985 US$1 = Rs. 27.00

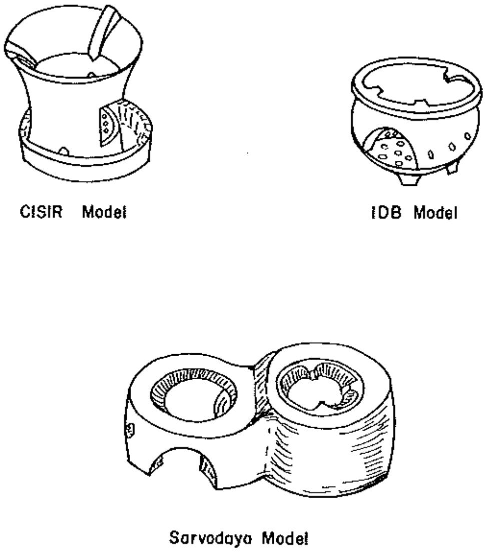

Fig. 2 Improved fuelwood cookers.

Seventeen thousand stoves were installed in 1985 and 45,000 in 1986 in rural houses in the administrative districts of Hambantota, Ratnapura, Kandy, Nuwara Eliya, Kegalle, Kurunegala, Matara, Kalutara and Gampaha. Feedback information from the users indicates that the cookers are popular and that a distinct saving in the use of fuelwood has been observed. The CEB expects to expand the programme in the next few years.

Alternative household biofuels

Charcoal The use of charcoal as a household fuel in Sri Lanka is of recent origin. The availability of large quantities of fuel-quality wood in forests being cleared under the Mahaweli Development Project prompted the State Timber Corporation to start a project for producing charcoal both for domestic use and export. Since charcoal had not been used as a household fuel earlier, the project had to include plans to develop and produce a cheap charcoal cooker and to popularise the use of charcoal for cooking. The target group was the urban households.

Charcoal contains twice the quantity of energy contained in wood by weight basis. One of the problems with fuelwood is that, being a bulky commodity, it is uneconomical to transport it over long distances. By converting fuelwood to charcoal we are producing a fuel with a very high energy content and its economic distance of transport will be appreciably greater than that of wood.

A suitable charcoal cooker made out of clay was developed by the Ceylon Institute of Scientific and Industrial Research in collaboration with the State Timber Corporation (STC). The charcoal is marketed by the STC in packets of 3 kg, and the current selling price is Rs 9.90 per packet. The charcoal is made available to households in Colombo and other provincial towns. A small export market has also been developed. The use of charcoal in 1984 is given in Table 1.

The advantages of using a charcoal cooker over the traditional wood stove are : (a) the charcoal cooker is smokeless and soot-free, (b) it uses the heat more efficiently, and (c) the fuel is compact and easy to handle and transport. The disadvantages are : (a) it is more difficult to ignite the charcoal, (b) regulating the fire is not easy, and (c) at current prices cooking with charcoal is more expensive than

Table 1 Charcoal use (tonnes).

Year	Households	Industries	Export
1984	611	360	1282
1985	562	586	1668

with wood fuel, though the difference is not great.

Biogas This is the gas that is produced when animal dung or other organic matter undergoes anaerobic digestion. It consists mainly of methane and carbon dioxide. The presence of methane makes biogas inflammable and therefore usable as a fuel. In recent years biogas plants have been installed in different parts of the country, and by 1984 it was estimated that several hundred plants had been set up. A comprehensive survey of the biogas plants carried out by the author showed that most of the plants were of the household size (digester volume of 6m^3) and the fixed dome model.[6]

The above study revealed that, out of the biogas plants inspected, 61 per cent were functioning satisfactorily providing biogas for cooking or for lighting or for both. The remaining 39 per cent were either not functioning at all or were supplying very little gas owing to gas leaks, inadequate input of dung or poor plant management. The most common raw material used was cowdung. The study concluded that: 1). An assured daily supply of feedstock (generally cowdung) in adequate quantity is the first pre-requisite for installing a biogas plant; 2). For biogas extension to be successful a competent technical unit should be available and readily accessible to users to assist and advise on construction, management, repair and maintenance; 3). A well managed biogas plant of 6m^3 size could provide sufficient biogas for a good part of the cooking and lighting in a rural household of four or five members; and 4). Expanding the use of biogas among households will continue to depend on the availability of subsidies to meet a part of the cost of constructing the plant.

Industrial Consumption

Wood is the principal fuel used as the source of energy in many light industries in Sri Lanka. The consumption in 1985 was estimated at 1.1 million tonnes which is only about one-seventh of the household consumption.[1] The main industries using fuelwood and the percentage consumption of each (given in parenthesis) are as follows: drying of tea leaf (33), small hotels and eating houses (15), brick and tile kilns (13), desiccated coconut and coconut oil (11), tobacco curing (10), bakeries (8), rubber manufacture (6), and others (4).[7] In the category 'others', a wide range of uses such as lime kilning, road tarring, pottery, parboiling of paddy, preparation of indigenous medicines, and cottage industries like the manufacture of treacle are included. The thermal energy content of the 1.1 million tonnes of fuelwood used in industry is estimated at 17.5 million GJ.

In contrast to the household sector where an appreciable proportion of the biomass fuel consumed consists of sticks, twigs, coconut fronds, and other materials, which are gathered, in the industries wood billets form the vast bulk of the biomass fuel used. It is estimated that 49 per cent of the fuelwood used by industry consists of rubber wood and 38 per cent, fuelwood from natural forests.[1] The balance comes from forest plantations, home gardens, estate cuttings, and crop wastes (e.g. paddy husk).

The average rate of fuelwood consumption of seven different industries are given in Table 2.[7] As fuelwood becomes scarce it will pay to make an evaluation of the wood energy conversion technologies now used in the various industries to improve the efficiency and to reduce consumption.

Table 2 Fuelwood consumption per unit of production in different industries.

Product	Unit	Fuelwood consumed (kg)
Tiles	1000 nos.	2670
Bricks	1000 nos.	500
Coconut oil	1000 kg	300
Desiccated coconut	1000 kg	1500
Tobacco	0.4 ha	7000
Rubber	1000 kg	1000
Tea	1000 kg	3300

The fuelwood coming from natural forests and forest plantation is supplied to industry mainly by the State Timber Corporation (STC). Natural forests and fuelwood plantations are temporarily released to the STC by the Forest Department, and the corporation harvests and markets the fuelwood. The land concerned may either be that which is to be released for some alternative use or that which would continue to remain under the jurisdiction of the Forest Department. In the latter case it is reforested by the Department.

Certain fuelwood using agencies in the government sector like the Janata Estates Development Board, the State Plantations Corporation and the Ceylon Ceramics Corporation have been encouraged to raise fuelwood plantations themselves to cater to at least a part of their needs. The Ceylon Tobacco Company, a large private organization, also raises fuelwood plantations.

Forecast of consumption

A Preinvestment Survey on Forest Industries Development estimated the 1963 consumption of fuelwood by the household sector to be the equivalent of 11.6 ft^3 (265 kg) *per caput.*[8] It was surmised that there would be a partial replacement of fuelwood by kerosene and liquid petroleum gas in the years following the survey and that there would therefore be a decline in consumption of fuelwood *per caput.* The forecast for 1975 was 8.5 ft^3 (195 kg).

From recent studies, it is obvious that the *per caput* consumption assumed by the Preinvestment Survey, like many others prior to 1983, was a gross underestimate. Nevertheless, the predicted trend, namely, a drop in the *per caput* consumption of fuelwood, was seen to take place. Many households in the urban sector began switching over from fuelwood to kerosene for cooking. And in some industries like tea, wood-fuelled burners were being replaced by oil-fired ones. However, the oil crises of the seventies arrested this trend. In the household sector, many houses using kerosene for cooking did not at first feel the full impact of the fuel crisis of 1973-74 because the selling price of kerosene was kept low through a price subsidy. But when the subsidy was reduced it was no longer economical to use kerosene for cooking and in all but the affluent households there was a return to fuelwood.

The fuelwood consumption by households in the future will tend to increase in the same proportion as the growth in population. However, if there is a substantial replacement of the traditional mud stove and the three stone open fire with improved stoves there would be greater economy in the use of fuelwood, and hence some decline in consumption *per caput* could be expected. Taking these factors into consideration the Forest Reources Development Project has estimated the requirements

Table 3 Forecast of biomass fuel consumption by households and industries.

Period	Annual estimated consumption (million tonnes)	
	Households	Industries
1984-85	7.9	1.13
1986-90	8.4	1.16
1991-95	9.0	1.22
1996-2000	9.5	1.27
2001-2010	9.9	1.28
2011-2020	10.2	1.26

of biomass fuel by the household sector for the next 35 years. These long term forecasts are given in Table 3.[9]

Another trend that would almost certainly manifest itself in the future is that of households having less time to scour the countryside collecting wood and other biomass fuel such as sticks, twigs and coconut fronds. At any rate, in the new settlement areas, such biomass material is getting scarce and settlers are already beginning to be concerned about the scarcity of fuelwood. This means that a plan for biomass fuel supply in Sri Lanka will have to make provision for raising fuelwood plantations in strategic areas. Special attention should also be focused on developing technologies for using the types of biomass material that are now largely going waste such as coir dust and paddy husk.

The demand for fuelwood in the industrial sector will also grow but probably at a slower rate than the growth of the industries themselves owing to the introduction of energy saving technologies. The Forest Resources Development Project expects the demand by industries to peak around the year 2000 and drop slowly thereafter.[9] The forecasts are given in Table 3.

THE RESOURCES

The 1985 consumption of biomass fuel in Sri Lanka was estimated at nine million tonnes, comprising 7.9 million tonnes by households and 1.1 million tonnes by industry. Taking the country as a whole there is no shortage of biomass fuel to meet the demand. Locally, however, there are scarcities in some areas. Fuelwood is a bulky, low value commodity, and it is therefore uneconomical to transport it from surplus to deficit areas if the distances involved are great. In 1986 it was estimated that the maximum economical distance of transport of fuelwood by road fell between 100 and 150 km.[9]

Table 4 gives the expected fuelwood surplus or deficit in the period 1986-1990 in each of the zones (see Fig. 3) recognized by the Forest Resources Development Project (FRDP).[7] These figures were arrived at taking into account all the available types of biomass material that it would be practicable to use as fuel irrespective of whether or not they are so used now. The estimated consumption during this period was matched with the estimated availability in each zone in drawing up these balances. FRDP has projected the supply and demand position much further in time, up to 2020. It has predicted that, with the existing resources, the fuelwood balance for the island as a whole will remain positive up to the year 2000, though the local deficits will increase in the two zones now experiencing a shortfall. After the year 2000 the surplus will turn into a deficit in most areas unless

Table 4 Forecast of the annual biomass fuel balance for the period 1986-90.

Zone	Surplus or deficit (1000 tonnes)
Colombo	- 443
Northern wet	+ 881
Southern wet	+ 479
Up-country	- 88
South-eastern dry	+ 306
Central dry	+ 188
Northern dry	+ 377
Whole country	+ 1700

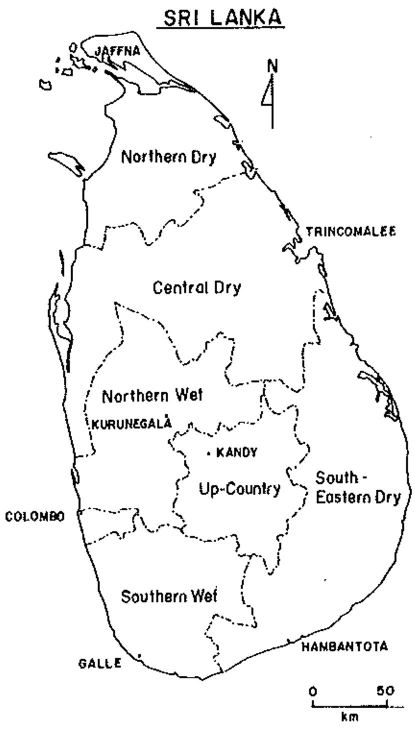

Fig. 3 Zonal division used by the Forest Resources Development Project.

timely action is taken to raise fuelwood plantations. FRDP has used these data to stress the need for better and more complete utilization of the available biomass fuel resources and to indicate the areas where it would be necessary to raise fuelwood plantations and increase fuelwood planting in farm lands and other non-forest locations.

Natural and man made forests

At present the forests of the country are probably the source of no more than around 25 per cent of the fuelwood consumed. Nevertheless, the natural forests and forest plantations represent a rich resource which could provide a large and sustained supply of fuelwood if managed properly. In fact with the increasing demand, forests particularly fuelwood plantations, will have to play a more important role as a source of biomass fuel in the future.

Sri Lanka's forest area which was 28,995 km^2 in 1956,[10] dropped to 16,318 km^2, or 24.9 per cent of the land area, in 1981 (Fig.4).[11] In the natural forests of the dry zone (see Fig. 3), the main species is *Drypetes sepiaria* which alone makes up as much as 29 per cent of the total standing timber volume. This tree has a highly fluted trunk and at present its only use is as fuelwood. In the case of tree species which are felled and converted into logs, the branchwood goes as fuelwood. Elsewhere in the country

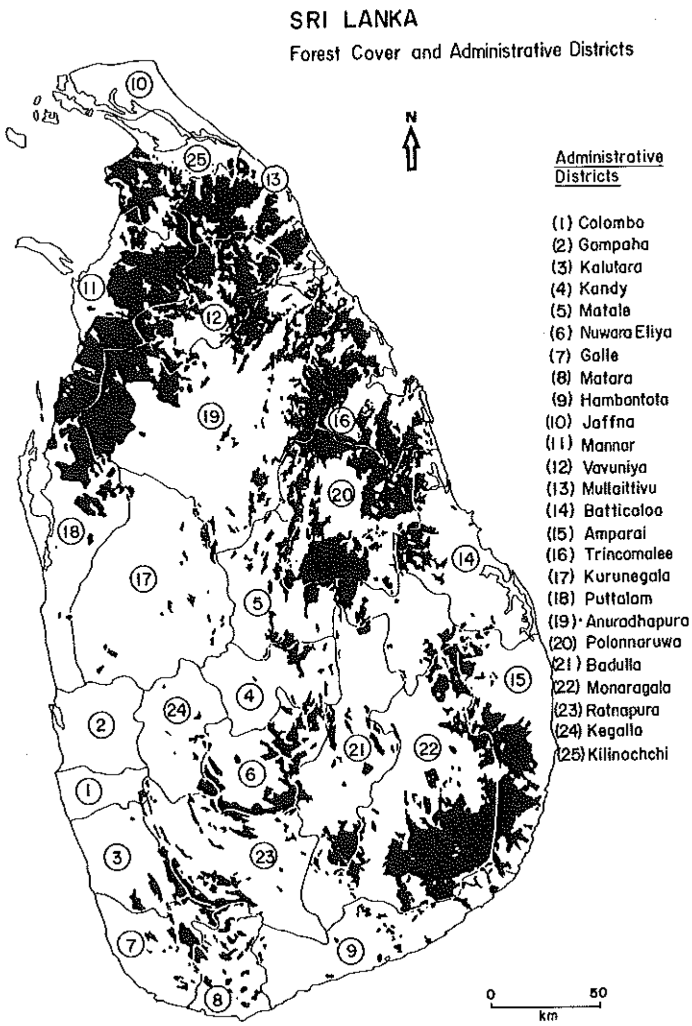

Fig. 4 Forest cover (1981) and administrative districts.

i.e. in the wet and montane zones, the proportion of fuelwood coming from the natural forest is much smaller than in the dry zone.

Plantations of *Eucalyptus camaldulensis* and, more recently, *E. tereticornis* have been raised on a relatively small scale in the dry zone to serve as a source of fuelwood. In the montane zone, particularly in the grasslands, different species of eucalyptus (notably *E.grandis* and *E. microcorys*) have been planted, and these plantations serve as a valuable source of fuelwood for domestic use and for the tea factories in the upland region.

Although at present the proportion of fuelwood supplied through official channels from the state forests is very small, there will be increased and widespread demands for regular official supplies in the future. While the increase in population will raise the demand, the area of natural forest from where fuelwood could be gathered will continue to shrink as more and more forest land is taken up for alternative uses. In addition, the land outside the forests from where households could gather fuelwood (e.g. scrub and waste land) will diminish in area. The pressures so created are evident even now in new settlements where fuelwood scarcities are beginning to be felt. The Forestry Master Plan envisages the planting of fuelwood species in the zones where shortages are expected to occur. During the period 1985 to 2000 it is proposed to raise 63,000 ha of fuelwood plantations on the island. Of this, 36,000 ha are to be raised as farmers' woodlots.[12] So far, very little success has been achieved in attempts to obtain farmer's participation.

For industrial needs every encouragement will be given to the different industries to raise their own fuelwood plantations. For example, tea estates could extend their fuelwood holdings by afforesting any unused estate land or land obtained on long lease from the government.

Scrub and waste land

A fair proportion of Sri Lanka's land area consists of scrub and waste land. These areas, if nothing else, serve as useful sources of biomass fuel for villagers. The 1956 forest inventory estimates the area of abandoned shifting cultivation, which is in fact scrub, waste land or early secondary forest, at nearly one million hectares. The area must undoubtedly be greater now. Small shrubs like *Hedyotis fruticosa* and *Wendlandia bicuspidata* (both in the wet zone) are cut and removed from waste lands for use as fuel. In the future, with improvements in the economic condition of the people, it is likely that a smaller proportion of families than now will depend on gathering to meet their biomass fuel needs. Moreover, as land gets scarce, much of what now remains derelict will be pressed into some form of use thereby reducing the area which could be scoured in search of fuelwood.

Calorific value of wood

The literature on biofuels contains data on the energy content of fuelwood, but the information given is often incomplete as the moisture content of the tested samples is not given. Hence such data from different sources cannot be compared. Table 5 gives the calorific value of some Sri Lanka dry zone forest species based on tests carried out by the Ceylon Institute of Scientific and Industrial Research. The tests were carried out using a bomb calorimeter and the calculations were made on the oven-dry weight.[13] In the present paper, taking into account the fact that biomass fuel is air-dry and not oven-dry and that it consists of sticks and crop wastes besides woodfuel, computations of the thermal energy content were made using values ranging from 3450 to 3800 kcal per kg.[14]

Table 5 Calorific values of the wood of some Sri Lanka species (based on oven-dry weight).

Species	Calorific value (kcal/kg)
Drypetes sepiaria	4657
Mitragyna parvifolia	4809
Manilkara hexandra	4664
Chloroxylon swietenia	4778
Schleichera oleosa	4771
Acacia leucophloea	4797

Coconut

Few species, if any, could beat coconut as a multipurpose crop. Fuel is just one of the many uses to which the parts of the coconut palm can be put. The large palm fronds as they dry and fall, the remains of the spadix, the husk and the shell, and the trunk itself can all be used as fuel. In fact in the study carried out by the author referred to earlier it was found that 28.8 per cent of the biomass fuel consumed by households was made up of crop wastes and that these consisted mainly of products of the coconut tree.[3]

It is difficult to estimate precisely the area of coconut plantation. This is because a large number of holdings are small and many home gardens in the southwest coastal zone contain coconut trees. The total area of coconut is estimated to be about 4,500 km^2. Coconut is found in the southwest coastal areas and in the "coconut triangle" - the area lying within the lines joining Colombo, Kurunegala and Chilaw.

It is estimated that the coconut plantation in the country carry a total of about 60 million coconut palms.[15] In a tree, as the fronds mature, they dry and fall, and the mean number of dry fronds produced by a tree in a year may be taken as 14. Assuming that the mean weight of biomass fuel (air-dry) produced by one tree in the form of fronds, spathes and spadix stalks in a year is 35 kg, the thermal energy content of the yield for the whole country amounts to 30.3 million GJ. A good part of this material is no doubt used as fuel as is indicated by the large contribution coconut wastes make to the biomass fuel consumed by households.

The wood of coconut palm becomes available for use when a coconut land is taken up for replanting. Since the wood has other uses (e.g. for making rafters) only a small proportion of it is used as fuel.

The average annual production of nuts in the period 1979-1982 was 2,300 million. About 60 per cent of the production goes for household consumption (the cooking of food), 28 per cent making copra for oil extraction and 12 per cent for manufacture of desiccated coconut.[16] The 2,300 million nuts produce on equal number of shells annually. On an average the shell of a nut has an air-dry weight of 177 g.[15] The shells of the coconuts that go for household consumption are used as biomass fuel in cooking. The thermal energy content of this quantity of shells is 3.9 million GJ. As to the shells produced in the manufacture of copra and desiccated coconut, some are used for producing the heat required in the production process itself while the rest are supplied to manufacturers of charcoal. Only a small proportion of the shell charcoal is used locally. The major part is exported. A small part of what is exported is converted to activated carbon before export.

The average air-dry weight of the husk of a coconut may be taken as 370 g. The coconut husks, where produced in bulk, are used for extracting the fibre. This is done mechanically, and in the process a large quantity of soft tissue (commonly called 'pith') mixed with short fibre is obtained as a by-product. This material comes out as coir dust and it amounts to 60 per cent by weight of the air-dry husk. The coir dust collects as large heaps of unwanted material around fibre mills. The coir dust absorbs water readily and its very high moisture content prevents its direct use as a fuel. The Ceylon Tobacco Company developed a relatively cheap technology for drying the material. It is a two stage process. First the coir dust is pressed between rollers to extract a good part of the water. The material is then exposed to a forced hot air draught till its moisture content drops to a point at which it could be converted into briquettes by compression. Despite the improved technology, the cost of production of briquettes is still appreciably higher than the price of fuelwood, but the product may prove competitive in the future when fuelwood grows scarce. In the coconut estates some of the husks are buried in the soil to form a mulch. In households where the coconuts for domestic use are dehusked in the home the husk is used as biomass fuel.

Rubber

The total area of rubber plantation in Sri Lanka is 2,300 km^2. The crop is confined to the low and middle elevations, in the south-west and south-central parts of the island. When oil and overmature rubber is felled for replanting much of the wood goes as fuel while some of the larger sized logs are used for conversion into plywood or sawn timber. As stated earlier, in the country as a whole, 18 per cent of the biomass fuel used by households and 49 per cent of that used by industry consist of rubber wood. Within the rubber growing areas, the contribution of this crop to the fuelwood used by both households and industries is far greater than is reflected in the above-mentioned figures. In the future, however, these levels of production may not be maintained, for, if the demand for rubber logs for sawing and for plywood production increases, this enhanced demand would be met by using some of the material that would otherwise have been converted into fuelwood.

Paddy

Paddy is grown in nearly all regions of the island. The total area of paddy lands is estimated at 5,100 km^2. In many areas two crops (yala and maha) could be raised in one year. Paddy husk and straw are the by-products which have a potential use as fuel. About 20 per cent by weight of the paddy grain consists of husk. The paddy production in 1985 was 2.66 million tonnes and about a fifth of this would have consisted of the husk. Paddy husk has an average energy content of 3,600 kcal per kg (based on the air-dry weight).[17] It is used as a fuel by some households living in proximity to rice mills from where the husk is obtained either free or at a nominal price. A paddy husk domestic stove is improvised using a discarded paint or powdered milk can. In the Matale district a paddy husk clay stove has been developed.[17] The paddy husk is compacted into the stove leaving a passage for the air to enter through a side vent and pass through the mass of husks laterally and upwards.

Paddy husk is generally used as a source of heat for parboiling paddy in the mill itself. The husk is also used on a small scale in brick kilning and tobacco curing. It has the potential for use in the production of masonry cement, the husk providing the heat and silica required for the process. Despite of many possible uses described above, there is still a large quantity of paddy husk going to waste and being disposed of by burning. Increased use of this material as a fuel could reduce the demand for fuelwood.

Straw is the other underutilized by-product of paddy. The grain to straw ratio in paddy cultivation is 1:1. At present straw is used for a variety of purposes: as a mulch in paddy fields, as a raw material in the manufacture of paper, as an animal feed, and for thatching the roofs of village houses. It could also be used for producing biogas and as the medium on which to grow edible mushrooms. Despite these many uses, actual and potential, there is a considerable quantity of straw that still goes to waste.

Other biomass fuel resources

Tea and other crops also provide some biomass material which is used as fuel. Up-rooted tea bushes are a valuable source of fuel in the tea estates, where household fuelwood is scarce. Likewise, biomass material from sugar cane (bagasse), palmyrah, cinnamon, manioc, etc. are used when and where they are available.

Fellings in home-gardens, estates, roadsides, etc. form an important component of the biomass fuel consumed by households, but estimates of their contribution to the biomass fuel mix are not available. Non-forest fuelwood resources could be increased by planting in farm lots and home gardens and these would form a valuable addition to the biomass fuel resources of the future.

Peat

There is a surface deposit of peat at Muthurajawela, north of Colombo. The total usable area of peat land, with a deposit of over one metre in thickness, is 240 ha. The estimated availability of peat in this area is 3.14 million m^3 or 258,000 tonnes of dry matter. The average moisture content of the usable peat was found to be 89.4 per cent and the average sulphur content on a dry weight basis, 4.59 per cent. The ash content varied from 5.3 to 44.7 per cent of the dry weight.[18] If the peat is to be used as a fuel the high sulphur content of the material and the need to make extensive surface excavations in a marshy area close to the city of Colombo are distinct disadvantages. At any rate the peat deposit is, as far as national resources go, relatively insignificant, and even if it is decided to exploit it the impact on the energy budget of the country will be very small.

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