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GOVERNMENT OF BANGLADESH
MINISTRY OF ENVIRONMENT AND FORESTS

WOOD ENERGY

FORESTRY MASTER PLAN

ASIAN DEVELOPMENT BANK (TA NO. 1355-BAN)

UNDP/FAO BGD 88/025

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SUMMARY

Biomass fuel is the major energy used in Bangladesh. Agriculture residues dominate the biomass fuel representing 46 percent, while wood energy contributes about 12 percent of the total consumption. Domestic cooking consumes the maximum amount of biomass fuels in both rural and urban areas. It represents 65 percent of the total amounting to 5.11 million m^3 while 35 percent, totalling 2.74 million m^3, is consumed by the industrial sector.

Conservation of fuelwood is an important option for the enhancing natural energy sources. The introduction of efficient, improved stoves can save a significant amount of energy in domestic cooking and paddy parboiling. Reduction of wastage will also bring about improvement in supply. The demand for fuelwood can be substantially reduced using substitutes. Biogas is such an option. Cow dung used for this purpose can produce fuel for cooking and manure for agriculture. Coal, peat and nuclear power are some commercial fuels which should be exploited to reduce the demand of fuelwood. The use of biomass fuels, particularly cow dung and agricultural residues can also be reduced by the increased use of these commercial fuels.

There is a wide gap between the supply and demand of fuelwood. Under the existing system of management the supply in 1993 is estimated as 6.0 million m^3 against the demand of 8.2 million m^3. The gap will further widen by the year 2013. Fuelwood is surplus in certain areas, but the excess cannot be supplied to the energy scarce areas due to high cost of transportation.

There is potential for augmenting the supply of fuelwood by planting trees as well as using improved forest management. Plantation with investment programmes alone will not substantially improve the overall position. There will be deficit of fuelwood in each plan period, ranging from 2.172 million m^3 in 1993 to 3.112 in 2013.

Brick burning is a major consumer of fuelwood in the industrial sector. In spite of the ban, the industry has continued to use fuelwood. The moratorium must be strictly enforced. Alternative fuels like coal needs to be supplied even in the remote areas. A subsidy on the price of coal could be considered for the brick burning and road tarring industries.

Three development programmes have been proposed to minimise the gap between the supply and demand of fuelwood. Financial analysis suggests that these projects are viable and attractive. A research project for introducing fast growing as well as high yielding multipurpose tree species is recommended.

Major Issues

Energy Policy - There is no wood energy policy in the country. A National Forestry Policy, covering some aspects of forestry and the forestry profession exists but does not mention wood energy. There is no guideline or directive for the overall planning and development of fuelwood resulting in poor management and utilization of this forest product.

Demand and Supply Gap - The per capita consumption of fuelwood in Bangladesh is one of the lowest in the world. Even so, there is a shortfall of supply compared to demand. This supply and demand gap is widening and there will be a net deficit of about 3.47 million m^3 of fuelwood by the year 2013.

Uneven Supply - There is no productive government forest in the north and central regions of the country. An acute scarcity of fuelwood exists there. Most of the forests concentrate in the greater Chittagong, Chittagong Hill Tracts and Khulna districts and these regions are surplus in fuelwood. However, the excess fuelwood cannot be supplied to energy starved areas due to the high cost of transportation, creating an uneven supply situation in the country. In the northern region, the per capita annual domestic consumption of fuelwood is only 12 kg, whereas in the southern region, it exceeds 60 kg.

Overuse of Biomass Fuels - Most of the agricultural residues were previously used as fodder and recycled fertilizer. Cow dung was almost exclusively applied in the fields as manure, maintaining the natural fertility of the soils. Due to shortage of fuelwood, the use of agricultural residues and cow dung as fuels has increased depriving the agricultural lands of the recycled fertilizer. In 1991, the total consumption of agricultural residues and cow dung was estimated as about 23 million tonnes against fuelwood consumption of 5.5 million tonnes.

Moratorium on the Use of Fuelwood - The moratorium on the use of fuelwood does not seem to be working with widespread violation of the restrictions. The brick burning industries have been found to use fuelwood in almost all cases. The total quantity of coal imported in 1991 accounts for about 22 percent of the brick burning with 78 percent produced using fuelwood.

Resource Wastage - A substantial amount of wastage of forest resource occurs from the felling of trees to the conversion of logs. Due to economic reasons, in the high forests extraction is confined to only a limited number of commercially important species out of about 400 species. This results in leaving behind about 40 percent of standing trees and felled logs in the clear felled coupes.

Recommendations

The following strategies are recommended to resolve the major issues.

Appropriate Policy - An Energy Policy should be formulated along with development and resource conservation. There should be an holistic approach in fixing overall thrusts and priorities. The potentials and impediments of the biomass fuels, including fuelwood, must be considered along with the commercial fuels.

The proposed Forestry policy should adequately cover wood energy. All relevant aspects of management and utilization should be considered. The planning and development issues need to be integrated with the whole energy sector.

The moratorium on the use of fuelwood for brick burning should be strictly enforced. The supply of alternative fuels has to be ensured, even in the remote areas. Good quality coal needs to be imported until it is available in the country. The following steps are suggested:

a. The ban on the use of fuelwood for brick burning should be continued. An incentive in the form of a price subsidy may be considered for the coal users.

b. Government agencies like Public Works Department (PWD) and Road and Highways Department (RHD) should restrict buying bricks other than coal-fired and exert influence for the effective implementation of the ban.

c. The use of natural gas should be encouraged to reduce the continued use of fuelwood and imported coal. An acceptable arrangement in respect of price and security deposit is required.

d. After brick burning, road tarring is a major consumer of fuelwood. The PWD and RHD should effectively control the use of fuelwood in road tarring. The use of fuelwood should be banned for this use. A subsidy in the price of coal may be considered.

Build Up Fuelwood Supplies - The plantation of trees has the maximum potential to augment the fuelwood supply. There exists prospects for improving the growing stocks by intensifying the management of the existing forests and plantations.

There should be programmes to plant appropriate short and medium rotation tree species in the plain land forests under social forestry. Strip plantation along the marginal and fallow lands should be undertaken with the active participation of the local farmers. People should be encouraged to plant multipurpose fast growing tree species in and around homesteads, schools, colleges, mosques, etc. to augment the supply of fuelwood and timber.

It is necessary to develop appropriate mechanisms for effective participation of the farmers. Site specific, fast growing and coppicing tree species as well as high yielding multipurpose tree species are needed. Research is recommended to achieve the goal.

Conserve Energy - Conservation of fuelwood should be considered as the second most important option. A considerable amount of energy is wasted during cooking due to design weaknesses in the traditional stoves. Improved stoves reduce this wastage and conserve the biomass fuels. Introduction of improved cooking stoves will have a significant positive effect in easing the fuelwood scarcity. The improved cooking stove project is recommended to achieve this goal.

Reduce Wastage - It is uneconomic to use waste timber as fuelwood if it requires transporting to a distant market. Conversion of the wastes to charcoal is a more economic method. It is recommended to manufacture charcoal and wood briquettes from the waste timber left behind during extraction.

Increase Substitutes - There are a number of substitutes for fuelwood. Use of biogas is a possible option. A viable technology exists for its production in the country. Relatively well off rural households using cow dung as manure will be the prospective users of biogas plants. Cow dung will produce both fuel for cooking and manure for agriculture while improving the hygienic conditions of the house and its surroundings. The introduction of biogas plants is recommended.

The use of solar energy for heating, cooking and generating electricity is also a prospective option. The solar timber kiln is found to be techno-economically viable and is being adopted commercially to a limited extent. It is recommended that in the sawmill modernisation programme, there should be a provision for installing this type of seasoning kiln in the sawmill and furniture industries. The other technologies need further research before they are considered for widespread adoption.

There are good prospects for development of local commercial energy sources. The Barapukuria coal mine should be developed as early as possible to meet the energy requirements of industries and households as well as of coal based power plants. Extraction of peat at Madaripur and Khulna needs expediting for domestic and industrial applications. Natural gas supply lines should be extended to the energy starved west zone after construction of the Jamuna Multipurpose Bridge. A nuclear power plant at Rooppur has been found to be techno-economically justified for generation of electricity and should be installed as early as possible. It will help reduce the import of petroleum and supply the cleanest commercial energy in the west zone. It is envisaged that the increased use of commercial fuels will reduce the overall demand of biomass fuels and thus help solve the fuelwood problem.

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INTRODUCTION

General

The Asian Development Bank (ADB*), the United Nations Development Programme (UNDP) and the Government of Bangladesh (GOB) are financing the technical assistance services to prepare a twenty-year Forestry Master Plan for Bangladesh. This Perspective Plan aims at assisting the GOB to decide on priorities for the development and protection of the forest resources of the country.

This report presents the results of a three-month assignment of the National Consultant on Wood Energy as part of the overall planning process for the Forestry Master plan for Bangladesh. The Terms of References for the Consultant are shown in Appendix 2.

Energy Sources in Bangladesh

Wood has traditionally been used as energy for domestic and industrial purposes in Bangladesh. Fuelwood has not lost its significance even with the availability of commercial fuels. In the rural sector, where about 85 percent of the country's total population lives, there is hardly any commercial fuel except for some use of electricity and kerosene for lighting.

The per capita consumption of fuel in Bangladesh during 1989-90 was 6.48 GJ/year which is one of the lowest in the world. Generally, about 25 percent of the total requirement is being imported (BBS, 1991). Seventy-five percent of the country's fuel requirement is met locally.

Traditional energy, comprising biomass is the major energy used in rural and urban areas. Biomass includes fuelwood, twigs, leaves, charcoal, crop residues (paddy husk and bran), plant residues (bagasse, jute stick), and animal dung. In the year 1989-90, the total amount of biomass supplied in the unorganised sector was about 21.5 million tonnes (BBS, 1991). Biomass is used in other sector as well. So a substantial amount of biomass is used as fuel in the country.

There is a sizeable deposit of natural gas in Bangladesh. In the 17 gas fields so far discovered, the total amount of gas is estimated at 36.82 trillion cft (BBS, 1991). Gas is being used in Dhaka, Chittagong, Comilla and Sylhet for household cooking, production of fertilizer, electricity generation and direct energy use in some industries. However, it will not be economically feasible to extend gas to rural areas in the foreseeable future.

About two million tonnes of petroleum and petroleum products are being imported every year. These are used in industry, commerce and transport as well as for domestic purposes.

The demand of 0.05-0.56 million tonnes of coal is met by import (BBS, 1991). It is used almost exclusively for brick burning.

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* For this abbreviation and other terms and conversion factors, see Appendix 1.

Over 1,650 million tonnes of bituminous coal have been discovered at Jamalganj, Peerganj, and Barapukuria. The Jamalganj coal deposit is situated at a depth of 900 metres. Mining costs will be high and commercial use will not be economically feasible in the near future.

A feasibility study has been undertaken for the Barapukuria coal mine. Coal is deposited at a depth of around 150 metres and holds good promise for commercial exploitation. An investment project has been proposed to be undertaken during the current Fourth Five Year Plan period.

Peat deposits are spread over large areas in the Faridpur and Khulna districts. It has been estimated that about 133 million tonnes of dry peat are available in these fields. The total potential for dry peat in the south-west of the country is estimated at 600 million tonnes (BEPP, 1985). A peat development project at Bhagibil near Madaripur has been proposed during the current Fourth Five Year Plan period. A second peat development project at Kolamouza near Khulna has also been proposed to be undertaken by the private sector. It is envisaged that these demonstration type projects will popularise peat for brick burning and domestic cooking (GOB, 1992).

There is only one hydro electricity installation in the country at Kaptai. The five generators of the dam produce 230 MW electricity per year although during the dry season the production is seriously reduced. There are potentials for development of hydro power at Matamuhuri (300 Gwh) and Sangu (200 Gwh). There is no other prospect of hydro power in a virtually flat country like Bangladesh.

Energy Balance

The best way to obtain an overview of the energy supply and demand situation of the country is to study the annual energy balance. No reliable and complete information on the present supply and demand of all types of energy is available. The Bangladesh Energy Planning Project (BEPP) studied this aspect in a comprehensive way for the year 1980-81 (Table 1). Taking it as the base year Bangladesh energy balance for 1989-90 has been roughly estimated by the Planning Commission (1990). These values are presented in energy units in Table 2. A number of important observations regarding the commercial and biomass fuels at the national level can be derived from the balance (Table 2).

a. Biomass fuels contribute 73.2 percent of the total energy consumption of the country, the remaining 26.8 percent is met by the commercial fuels.

b. Agricultural residues overwhelmingly dominate the biomass sector. These fuels account for 46.0 percent of the national consumption.

c. Fuelwood contributes 12.8 percent of the total supply while tree residues account for 4.0 percent of the total consumption.

d. Domestic use of biomass fuels account for 59.5 percent of the total national energy consumption.

e. Out of the total of 133.2 PJ consumed in the industrial sector, 92.7 PJ (69.6 percent) comes from biomass fuels while the remaining 30.4 percent are from commercial energy sources.

The comparison between 1980-81 and 1989-90 energy balances reveals that the total energy consumption has increased from 574.8 PJ to 687.6 PJ. This accounts for a 19.5 percent increase over a period of ten years, about 2.0 percent/A which has occurred mainly due to population growth. The use of commercial fuels has approximately doubled from 96.2 PJ to 184 PJ.

Agricultural residues remain the highest contributor to biomass energy. The supply of fuelwood is however found to increase slightly with the corresponding decrease of dung.

Strategies for solving the problems of biomass energy, particularly wood energy, have to be considered. Planning and development issues related to biomass energy need integrating with the whole energy sector.

Table 1 - Energy Balance of Bangladesh by Source for 1980-81

Source of Energy	Commercial Energy (in Peta Joules)						Traditional Energy (Peta Joules)					Total amount of Energy
	Nat. Gas	Crude Oil	Petr. Prod.	Coal	Elec-tric.	Total Commer. Energy	Agri. resid.	Tree resid.	Fuel wood	Dung	Total Biomass Supply	
SUPPLY												
Primary production	49.4	0.0	0.0	0.0	2.3	51.7	317.3	23.6	60.0	77.7	1,435.8	1,487.5
Imports	0.0	54.0	21.4	6.0	0.0	81.4	0.0	0.0	0.0	0.0	0.0	81.4
Exports	0.0	0.0	-9.5	0.0	0.0	-9.5	0.0	0.0	0.0	0.0	0.0	-9.5
From stock	0.0	0.3	3.0	-0.5	0.0	2.8	0.0	0.0	0.0	0.0	0.0	2.8
Gross supply in PJ.	49.4	54.3	14.9	5.5	2.3	126.4	317.3	23.6	60.0	77.7	478.6	605.0
Gross supply in percent	8.2	9.0	2.5	0.9	0.4	21.0	52.4	3.9	9.9	12.8	79.0	100.0
TRANSFORMED IN												
Refinery	0.0	-54.3	51.9	0.0	0.0	-2.4	0.0	0.0	0.0	0.0	0.0	-2.4
Thermal Power Station	-18.3	0.0	-10.1	0.0	7.3	-21.1	0.0	0.0	0.0	0.0	0.0	-21.1
Losses and Own use	-1.0	0.0	-2.4	0.0	-3.3	-6.7	0.0	0.0	0.0	0.0	0.0	-6.7
Net supply in PJ	30.1	0.0	54.3	5.5	6.3	96.2	317.3	23.6	60.0	77.7	478.6	574.8
Net supply in percent	5.2	0.0	9.4	1.0	1.1	16.7	55.2	4.1	10.4	13.5	83.2	99.9
CONSUMPTION												
Domestic	3.5	0.0	16.2	0.0	1.1	20.8	241.6	23.6	41.3	77.7	384.2	405.0
Industrial	7.7	0.0	12.3	5.0	3.7	28.7	75.7	0.0	16.9	0.0	92.6	121.3
Commercial	1.5	0.0	0.0	-0.0	1.2	2.7	0.0	0.0	1.8	0.0	1.8	4.5
Transport	0.0	0.0	20.8	0.5	0.0	21.3	0.0	0.0	0.0	0.0	0.0	21.3
Agricultural	0.0	0.0	1.4	0.0	0.1	1.5	0.0	0.0	0.0	0.0	0.0	1.5
Others	0.0	0.0	0.0	0.0	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.2
Non energy use	17.4	0.0	3.6	0.0	0.0	21.0	0.0	0.0	0.0	0.0	0.0	21.0
Total cons. in PJ	30.1	0.0	54.3	5.5	6.3	96.2	317.3	23.6	60.0	77.7	478.6	574.8
Total cons. in percent	5.2	0.0	9.4	1.0	1.1	16.7	55.2	4.1	10.4	13.5	83.2	100

Conversion factors:

Natural Gas	1 MMCF = 0.00099 PJ	Electricity	1 Gwh = 0.0036 PJ
Crude Oil	1000 tonne = 0.0427 PJ	Agricultural and Tree residues	1000 tonne = 0.0125 PJ
Petroleum Products	1000 tonne = 0.0427 PJ	Fuelwood	1000 tonne = 0.0151PJ
Coal	1000 tonne = 0.0270 PJ	Dung	1000 tonne = 0.0116 PJ

REVIEW OF REPORTS ON BIOMASS ENERGY

Biomass Consumption by Type

The types of biomass used as energy sources in the country have already been mentioned. These are mainly used in the unorganised sector of the rural and urban areas where no record is maintained about their consumption. A major part of these fuels is not traded and the other part is only locally traded. Reliable statistics regarding their use are either scarce or non-existent. It is obvious that the estimates supplied by the different studies are subject to a large margin of discrepancy.

Table 2 - Energy Balance of Bangladesh by Source for 1989-90

(in Peta Joules = 10^{15} Joules)

Source of Energy	Commercial Energy						Traditional Energy					Total amount of Energy
	Nat. Gas	Crude Oil	Petr. Prod.	Coal	Elec-tric.	Total Commer. Energy	Agri. resid.	Tree resid.	Fuel wood	Dung	Total Biomass Supply	
SUPPLY												
Primary production	163.4	0.0	2.7	0.0	3.3	169.4	316.6	27.2	88.2	71.7	503.7	673.1
Imports	0.0	53.5	48.0	12.3	0.0	113.8	0.0	0.0	0.0	0.0	0.0	113.8
Exports	0.0	0.0	-6.3	0.0	0.0	-6.3	0.0	0.0	0.0	0.0	0.0	-6.3
From stock	0.0	-5.9	-6.8	0.1	0.0	-12.6	0.0	0.0	0.0	0.0	0.0	-12.6
Gross supply in PJ.	163.4	47.5	37.7	12.4	3.3	264.3	316.6	27.2	88.2	71.7	503.7	768.0
Gross supply in percent	21.4	6.2	4.9	1.6	0.4	34.5	41.5	3.0	11.6	9.4	65.5	100.0
TRANSFORMATION												
Refinery	-1.0	-47.5	44.1	0.0	0.0	-4.4	0.0	0.0	0.0	0.0	0.0	-4.4
Thermal Power Station	-69.3	0.0	-8.8	0.0	24.4	-53.7	0.0	0.0	0.0	0.0	0.0	-53.7
Losses and Own use	-9.9	0.0	-4.0	0.0	-8.3	-22.2	0.0	0.0	0.0	0.0	0.0	-22.2
Net supply in PJ	83.2	0.0	69.0	12.4	19.4	184.0	316.6	27.2	88.2	71.7	503.7	687.7
CONSUMPTION												
Domestic	9.3	0.0	23.6	0.0	4.9	37.8	243.0	27.2	67.3	71.7	409.1	446.9
Industrial	14.0	0.0	7.0	9.5	10.0	40.5	73.6	0.0	19.1	0.0	92.7	133.2
Commercial	3.1	0.0	0.0	0.4	3.6	7.1	0.0	0.0	1.8	0.0	1.8	8.9
Transport	0.0	0.0	25.1	2.6	0.0	27.7	0.0	0.0	0.0	0.0	0.0	27.7
Agricultural	0.0	0.0	11.0	0.0	0.9	11.9	0.0	0.0	0.0	0.0	0.0	11.9
Others	0.0	0.0	0.3	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.3
Non energy use	56.7	0.0	2.0	0.0	0.0	58.7	0.0	0.0	0.0	0.0	0.0	58.7
Total cons. in PJ	83.2	0.0	69.0	12.4	19.4	184.0	316.6	27.2	88.2	71.7	503.7	687.7
Total cons. in percent	12.1	0.0	10.1	1.8	2.8	26.8	46.0	4.0	12.8	10.4	73.2	100

(GOB, 1990)

Conversion factors:

1 Peta Joule = 1 Giga Joule (GJ) x 10^6

1 GJ corresponds approximately to the combustion energy of 0.1 m^3 (or 71 kg) of wood.

The first nation-wide estimate of biomass fuel consumption was presented by the Bangladesh Energy Study (BES) financed by the Asian Development Bank under a United Nations Development Programme (1976). The biomass fuels, as estimated by the study for 1973-74, are contained in Table 3. Different biomass fuels have different heat values and this is why these have been converted to energy units.

Table 3 - Biomass Consumption in Bangladesh for 1973-74

Type of biomass	Amount used	Energy factor		Total energy	
	10^6 x tonne	btu/lb	kcal/kg	10^{12} x btu	10^{12} x kcal
Fuelwood	0.5	5532	3089	6.2	1.6
Twigs, leaves	1.5	5532	3089	18.6	4.7
Paddy straw	3.0	5400	3015	36.0	9.1
Paddy husk	4.1	5400	3015	48.0	12.2
Bagasse	1.5	3200	1787	11.0	2.8
Jute stick	1.0	5400	3015	12.0	3.0
Cow dung	6.1	5000	2791	67.2	17.0
Other waste	1.5	5400	3015	18.0	4.6
TOTAL	19.2			217.0	55.0

The population of the country during the period of 1973-74 was 77.8 million. Based on this figure an average per capita consumption of biomass was about 247 kg/A. This amounts to 0.71 million kcal/capita/annum consumption of biomass fuels in the country.

The second study was intensive but it covered only a small area (Islam 1978). It estimated fuel consumption as a part of the study on the problems and prospects of biogas technology as an energy source in rural Bangladesh. The study area of 22 square km incorporated 23 villages of Barisal District. The total population was 16,228. The extract of Islam's biomass data is shown in Table 4.

Table 4 - Biomass Fuel Use in Nabagram Area in 1978

Unit of measurement	Fuel wood	Twigs, leaves	Paddy straw	Paddy husk	Bagasse	Jute stick	Cow dung	Total
Metric tonne	3167	558	868	137	65	236	445	5,476
Kilo calorie (in million)	978.3	172.4	261.7	4.3	11.6	71.2	124.2	1,623.7

From the table the total traditional fuel consumption amounts to 1 million kcal/capita/annum. The total amount of tree fuels including fuelwood, twigs and leaves used were 230 kg/capita/A. On the general question of fuel usage, Islam found a significant seasonal variation in fuel type. In the dry season, agricultural wastes and residues predominate while in the wet season fuelwood, twigs, paddy husk and jute stick are generally used.

An intensive long term study was undertaken by Briscoe (1979) in a single village of Comilla district. It was designed to study energy use in relation to its social structure. The basic result of this study indicates that an average per capita biomass fuel usage was 1.65 million kcal.

A comprehensive national inventory was carried out by Douglas (1981). It incorporates analyses and results of estimation of consumption of wood and bamboo production in Bangladesh. The consumption of fuelwood will be discussed later. Here, the total biomass usage is of concern and is shown in Table 5.

Table 5 - Traditional Fuel Consumption in Bangladesh in 1980

Fuelwood	Fuelwood including branches	Total tree fuel	Total traditional i.e. biomass fuel
0.05 m^3 per capita/annum	0.1 m^3 per capita/annum	189 kg per capita/annum	1.06 x 10^6 kcal per capita/annum

From the table it is apparent that the per capita consumption of fuelwood amounts to 0.05 m^3/annum. The total biomass consumption was estimated as 1.06 million kcal/capita/annum by taking a composite conversion factor for agricultural residues.

The Planning Commission of the Government of Bangladesh undertook a Bangladesh Energy Planning Project (BEPP, 1985) for the entire sector of energy. The biomass energy along with the commercial energy was estimated in detail. The result of the study has already been discussed in the form of energy balances in the previous section.

Bangladesh Bureau of Statistics collects information on biomass consumption from various sources and publishes them in compiled form. Table 6 furnishes such compiled data for the unorganised sector for a period of nine years (BBS, 1991). From the physical unit the total biomass supply has been estimated as energy unit based on a composite conversion factor of 2852 kcal/kg for the biomass fuels.

Biomass Consumption by End-users

Biomass fuels are consumed by various rural and some urban industries of Bangladesh. The following are the endusers under the individual category of industries which need the thermal use of fuelwood and residues in some form or other:

Food processing
- cooking
- baking
- gur making
- sugar making
- confectionery
- dairy product
- fish drying
- sweetmeat

Agro-processing
- paddy parboiling
- tea leaf curing
- tobacco curing
- bidi making
- ginger drying
- turmeric drying
- catechu making
- rubber sheet making

Table 6 - Energy Supplied by Biomass Fuels in the Unorganised Sector

Year	Energy (million tonne)									
	Cow dung	Jute stick	Rice straw	Rice husk	Bag-asse	Fuel wood	Twigs, leaves	Other wastes	Total	10^{12} xkcal
1981-82	5.3	0.8	3.6	4.2	2.4	0.7	2.2	2.2	21.4	61.0
1982-83	5.3	0.9	3.6	4.4	2.5	0.8	2.5	2.5	22.5	64.2
1983-84	5.5	0.9	3.3	4.9	2.4	0.8	2.3	2.3	22.4	63.9
1984-85	5.6	0.8	3.2	4.9	2.3	0.8	2.4	2.4	22.4	63.9
1985-86	5.7	1.2	3.3	5.0	2.2	0.9	2.6	2.6	23.5	67.0
1986-87	5.7	1.2	3.5	3.2	2.3	0.8	2.3	2.3	21.3	60.7
1987-88	6.0	1.2	3.3	4.5	2.4	0.9	2.4	2.4	23.1	65.9
1988-89	6.4	1.3	3.5	4.6	2.3	0.9	2.4	2.4	23.8	67.9
1989-90	6.0	1.2	3.4	4.8	2.3	0.8	2.5	2.5	23.5	67.0

Clay based
- brick manufacturing
- pottery making
- lime manufacturing
- tile making

Metal working
- black smithy
- jewellery
- foundry
- cutlery

Miscellaneous
- road tarring
- soap making
- salt making
- silk cocoon processing
- laundry
- tire retreading
- herbal medicine
- hotel and restaurant, etc.

The heat requirement for a process may vary considerably depending on the quality and type of fuel, capacity of the unit, design of the combustion chamber, and quality of the end-product. This is why the specific heat consumption, i.e., the amount of energy consumed per unit of end-product, also may vary. Information on biomass fuels consumed by all the end-products is not available.

Food Processing Industries

Cooking - The largest share of different types of biomass fuels is consumed by domestic cooking of food in both rural and urban areas of Bangladesh. The per capita consumption of biomass fuels is an important factor in estimating energy demand. The information available from various studies in this regard is tabulated in Table 7.

From the above table it may be seen that the per capita consumption varies from 2.80 to 8.10 GJ/year. The differences are probably due mainly to variation in methodologies adopted ~~by~~ the different workers. Further, the estimates of Douglas (1981) and BEPP (1985) were made on the basis of country wide energy survey while other studies were confined to specific areas. The per capita consumption of 4.44 GJ/year seems to be a reasonable estimate for 1981 (BEPP, 1985).

From the energy balance for 1989-90 (Table 2), it is seen that the total, biomass consumption was 409.1 PJ for 106 million population. Thus the per capita consumption amounts to 3.86 GJ/year in 1990.

Table 7 - Estimated Biomass Fuels Used for Cooking

Studies	percent of sources of biomass				Per capita fuel consumption (GJ/year)
	Fuelwood*	Agriculture residues	Animal dung	Total	
BES 1976	12.5	62.5	25.0	100	2.80
Briscoe 1979	36.0	61.0	3.0	100	6.80
Islam 1980	71.0	24.0	5.0	100	4.90
Douglas 1981	63.0	37.0	**	100	4.46
Quader-Omar 1982	59.0	38.0	3.0	100	8.10
Islam 1982	74.0	10.0	16.0	100	4.46
BEPP 1985	9.6	65.9	24.5	100	4.44

* Fuelwood includes wood, branches, twigs and leaves
** Included in agricultural residues

Bakery - There are approximately 5,000 small bakeries in Bangladesh (BSCIS, 1983). Fuelwood is the main source of energy for baking bread, biscuits, pastry, etc. The specific energy consumption has been estimated as 1.00-1.25 kg/kg of flour (BEPP 1985). On the basis of 37 kg (i.e. 1 maund) of flour consumption per unit per day, the total consumption of fuelwood has been estimate as 85,000 tonnes i.e. 1.28 PJ/year.

Gur Making - It was estimated that 3 tonnes of biomass fuels are required to produce 1 tonne of gur from date palm which amounts to 37.6 GJ/tonne of gur (Aliff 1981). The total amount of date palm juice produced in 1981 was reported as 47,000 tonnes. This gives a total amount of annual consumption of 0.142 million tonnes, generally in the form of agricultural residues, twigs and leaves.

Gur is also produced by processing of sugar cane in rural areas by individual farmers by evaporating the extracted juice in open pans. The extraction of juice is done by animal power although some mechanical crushers have also been used. Air dried bagasse is used as fuel for evaporating the juice. The consumption of bagasse for gur making has been estimated as 1.89 tonne/tonne of gur (BEPP 1985). The total amount of bagasse consumed in 1990 for making 0.468 million tonnes of sugar cane gur (BBS, 1991) is estimated as 0.845 million tonnes.

Sugar - Sugar is produced by processing of sugar cane in sugar mills by the vacuum pan evaporation process. Air dry bagasse is used for evaporating the juice. The specific energy consumption for processing of sugar cane has been estimated as 2 tonnes of bagasse/tonne of sugar amounting to 24.9 GJ/tonne (BEPP 1985). The total consumption of bagasse was 0.368 million tonnes for producing 0.184 million tonnes of sugar in different sugar mills in 1990.

Agro-Processing Industries

Paddy Parboiling - In Bangladesh paddy is parboiled in all districts except the greater districts of Chittagong, Chittagong Hill Tracts and Sylhet where people generally consume unparboiled rice. It is estimated that 60 percent of the total paddy produced is processed at household level, 30 percent by paddy husking units and 10 percent by rice mills. The husks obtained from the units are used as fuel for processing of crops. The specific energy consumption of husk is estimated as 0.32 tonne/tonne of rice. At the household level, paddy straw is used and the specific energy consumption for it is 0.4 tonne/tonne of rice (BEPP, 1985). In 1990, the total production of rice was 17.42 million tonnes (BBS, 1991). The total amount of paddy straw and husk required for parboiling and processing of paddy excluding the three districts may be approximately 5.0 million tonnes of agricultural residues.

Tea Leaf Processing - In tea processing, energy is needed in the form of shaft power and heat for drying. Generally electric motors are used to provide shaft power while for heat generation fuelwood, furnace oil and natural gas are used. The specific energy consumption is estimated as 3-5 kg fuelwood/kg dry tea leaves (BEPP, 1985). In 1990 the net production of tea leaves was 41.38 million kg of which 97 percent was produced in Sylhet and the rest in Chittagong (BBS, 1991). There are many gardens in Sylhet with a natural gas supply. On a total production basis, percentages of tea processed by using fuelwood, furnace oil and natural gas have been estimated as 52 percent, 29 percent and 19 percent respectively (BEPP, 1985). Gas supply was extended to many more tea gardens with corresponding reduction in the use of fuelwood and furnace oil. At a rate of 4 tonnes fuelwood/tonne of leaves, the total fuelwood consumption equalled 0.078 million tonnes on the basis of 45 percent fuelwood use.

Tobacco Curing - Fresh tobacco leaves contain more than 80 percent water and this moisture must be dried by applying adequate processing techniques after harvest to get a good quality product. The leaves are processed either by flue curing or air curing, and only in the flue curing process is artificial heat needed. Both fuelwood and straw are used for curing and on average about 6-8 kg/kg leaves are required (BEPP, 1985). About 0.066 million tonnes of fuelwood and 0.046 million tonne of straw may be estimated as the consumption for tobacco curing in 1990.

Clay Based Industries

Brick burning - The brick burning is an energy intensive operation and consumes a large quantity of heat energy. Fuelwood, coal and gas are used. The use of fuelwood has been prohibited since July, 1989, but most brick industries have continued to use it. According to the Brick Manufacturers' Association (BMA, 1992), there are about 2,500 large brick manufacturing units in the country. About 2,500 million bricks are produced in these units. The common type of brick kiln used is Bull's trench locally known as "chimney bhata". There are also some batch type units spread over the country occasionally producing bricks.

Table 8 - Specific Energy Consumption for Brick Burning

Type of fuel	Fuel Consumption per 100,000 bricks		Specific energy co-efficient GJ/ 1000 bricks	
	Range	Average	Range	Average
Fuelwood	60-92 tonnes	76 tonnes	9.06-13.89	11.50
Coal	25.4-35.6 tonnes	30.5 tonnes	6.20-8.68	7.44
Natural gas	$5\text{-}9 \times 10^5$ cft	7.03×10^5 cft	4.93-8.91	6.96

Table 9 - Estimated 1990 Consumption of Fuelwood and Residues by End-use and Application

Type of Enduse	Type of Energy Used (in million tonne)			(in Peta Joule)		
	Fuelwood	Residue	Total	Fuelwood	Residue	Total
I. Domestic Cooking						
Rural	0.821	24.110	24.931	12.40	301.37	313.77
Urban	3.472	2.232	5.704	52.42	27.90	80.32
Subtotal	4.293	26.342	30.635	64.82	329.27	394.09
Percent of Grand Total	13.32	67.70	81.020	13.32	67.70	81.02
II. Agro-based industry						
Paddy parboiling	-	2.745	2.745	-	34.31	34.31
Paddy processing	-	1.717	1.717	-	21.46	21.46
Tea processing	0.079	-	0.079	1.20	-	1.20
Sugar milling	-	0.324	0.324	-	4.05	4.05
Sugar Cane gur	-	0.839	0.839	-	10.49	10.49
Palm gur	-	0.139	0.139	-	1.74	1.74
Tobacco Curing	0.066	0.046	0.112	0.99	0.57	1.56
Baking	0.081	-	0.081	1.23	-	1.23
Subtotal	0.226	5.810	6.036	3.42	72.62	76.04
III.Non-agrobased industry						
Brick burning	0.754	-	0.754	11.39	-	11.39
Road tarring	0.023	-	0.023	0.35	-	0.35
Soap	0.009	-	0.009	0.14	-	0.14
Pottery	0.034	0.012	0.046	0.51	0.15	0.66
lime	-	0.034	0.034	-	0.43	0.43
Others	0.026	0.049	0.075	0.39	0.61	1.00
Subtotal	0.846	0.095	0.941	12.78	1.19	13.97
Industry Total	1.072	5.905	6.977	16.20	73.81	90.01
Percent of Grand Total	3.33	15.17	18.500	3.33	15.17	18.50
IV. Commercial	0.121	0.040	0.161	1.82	0.50	2.32
Percent of Grand Total	0.38	0.10	0.480	0.38	0.10	0.48
V. Grand Total	5.486	32.286	37.772	82.84	403.58	486.42
Percent of Grand Total				17.03	82.97	100
in million m^3	7.790			7.790		

(GOB, 1991)

Conversion factors: Fuelwood 1000 tonne = 0.0151 PJ Residue 1000 tonne = 0.0125 PJ Fuelwood 1 tonne = 1.42 m^3

Generally, 60 tonnes of good quality fuelwood are required to burn 100,000 bricks. On the basis of a field survey, the consumption of mixed fuelwood was estimated as 92 tonnes/ 100,000 bricks (Aliff, 1981). The BEPP (1985) estimated the specific energy coefficient for fuelwood based on average consumption of 76 tonnes/ 100,000 bricks. Table 8 gives comparative energy consumption for brick burning using different types of fuel.

Pottery - Pottery is a labour intensive rural industry. A large number of items are produced such as pitchers, water jars, grain vessels, kitchen utensils, and a host of other household and decorative pieces. There are about 18,000 pottery and tile making units in Bangladesh (BSCIC, 1983). Both fuelwood and plant residues are used as fuel, the contribution of fuelwood being about 75 percent. Annual consumption of fuelwood and plant residues has been estimated to be about 35,200 tonnes and 11,800 tonnes respectively in 1981 (BEPP, 1985). The present consumption may be assumed as 34,000 tonnes of fuelwood and 12,000 tonnes of plant residues.

Lime - About 28,000 tonnes of lime are produced annually in Bangladesh mostly in the Sylhet region (Aliff, 1981). Generally, available grass is used as fuel at a rate of 1.25 tonnes/ tonne of lime produced. The total fuel consumption is 34,000 tonnes/ A.

Metal Working

Smithies - Smithies, which include blacksmiths, goldsmiths and silversmiths are common small and cottage industries in rural and town markets. Charcoal obtained from cooking stoves is used as fuel in smithies. It is estimated that 1.1-1.5 kg fuel is used per kg metal processed.

Miscellaneous

Road Tarring - Bitumen is melted by heating it in a rectangular pan on open fire by the road side. Melted bitumen is spread over the aggregate lying on the road and then pressed over with a roller. Fuelwood or tree roots are used as fuels for melting bitumen. It has been estimated that the specific energy consumption may be 750 kg of fuelwood per tonne of bitumen. The annual fuelwood consumption is estimated as 22,500 tonnes (Eusuf, 1989).

Soap Making - Soap making is an energy intensive process where a mixture of fat and oils are heated with caustic soda for saponification. Melted caustic soda is then added. The heating period varies from 10-70 hours depending on the quality of soap. Laundry and toilet soaps are produced by different processing techniques.

According to BEPP (1985), about 10,000 tonnes of soap are produced in Bangladesh. Fuelwood is used for heating at a rate of 1 tonne/ tonne of soap resulting in an annual consumption of about 10,000 tonnes.

Other Users - The BEPP (1985) has estimated that in addition to the end-uses mentioned, about 50,000 tonnes of fuelwood and 50,000 tonnes of residues are also used in various industries and village applications. These industries include catechu processing, silk cocoon processing, herbal medicine, hotels and restaurants.

On the basis of the base year estimate of 1981 (BEPP, 1985), the Planning Commission has estimated the consumption of fuelwood and residues by end-use and application for 1990. It is presented in Table 9.

Remarks

There are so many small and cottage industries and applications in the country that it is not possible to obtain reasonable estimates of fuel consumption. In most cases, the data for the year 1980-81 have been referred to and in the meantime some changes either in the quantity of biomass or in the type of fuel/source have taken place. Updated reliable information is lacking in almost all cases.

The use of fuelwood and other biomass fuels illustrates their magnitude and importance in the household and industrial activities. The supply of wood and other biomass energies is thus a vital issue for sustenance of these activities.

Studies on Biomass Energy

The following studies are recommended to be undertaken to gain a better understanding of biomass consumption in the country:

1. A long term study on consumption of biomass by types and uses to improve the quality of the available data base.

2. A long term in-depth study on the supply and demand of fuelwood covering both rural and urban households for consumption, and government forest, village forest and marginal land plantations for supply position.

3. Assess performance of devices used in rural industries like paddy processing, gur processing, bakeries, brick kilns, road tarring, etc. and suggest improvements.

4. A techno-economic feasibility study of mechanical processing like compaction, briquetting and palletizing of agricultural and sawmill residues as substitutes for fuelwood in urban and rural areas.

5. Study socio-economic impacts of biomass conversion programmes, particularly the improved cooking stove, biogas plant, and solar cooker at the household and industrial levels. Study their effects on the health of the people.

6. An environmental assessment of soil organic matter and nutrients to evaluate the impacts of using agricultural residues and animal dung as fuel.

7. A socio-economic and environment impact assessment on the use of coal and peat as substitutes for biomass fuels.

8. Examine the present multisectoral involvement of wood energy with agriculture, forestry, livestock, soil, energy and local governments in order to improve the existing coordination mechanism between them.

SUPPLY AND DEMAND OF FUELWOOD

Supply

Bangladesh has 2.46 million ha of forest land covering 16.7 percent of the total area. Of these areas there are about 0.27 million ha of scattered groves around villages and homesteads all over the country. More than 90 percent of the state owned forest land is concentrated in 12 districts in the eastern and south-eastern region. The Government forest land is unevenly distributed throughout the country with 28 out of 64 districts having no state owned forest.

Accurate information on tree cover density in all forests is not available. Hussain (1990) estimated the average density in government forest at about 57 percent which amounts to 5 percent of the total land area of the country. Taking into consideration of the village trees, the proportion of the tree covered area may be estimated as 7.7 percent of the country. Since 1981 there have been plantations under the Participatory and Marginal Land Plantations in the regions where very little or no government forest is left. The supply of fuelwood along with other forest produces comes from all these sources.

Information on the supply of forest products is available for the Government forests from the records of the Forest Department and different reports. But no reliable information on village forests was available until 1981 when a nationwide detailed inventory was undertaken by UNDP/FAO (Hammermaster, 1981) to assess the total growing stocks of the village groves. This study supported the general statement of Aliff (1978) regarding the contribution of the homestead forests. It was mentioned that the village forests provide 48 percent of the conversion sawlog and 48 percent of fuelwood. In a separate survey Douglas (1981) estimated the rural consumption of wood and bamboo. Following the work of Douglas, Byron (1982) reported that about 75 percent of sawlog and 79 percent of fuelwood come from the village groves. This finding has not been based on the actual survey and thus may be subject to criticism. However, it has highlighted the importance of village forests for the first time.

According to the estimate of Douglas (1981), the per capita standing volume of village groves varied from 0.56 to 0.65 m^3. Hammermaster (1981) estimated the per capita standing volume as 0.73 m^3 based on the population of 1980. In order to update these estimates and to provide a data base in respect of various products including fuelwood, a national village forest inventory was undertaken in 1992 by the Forestry Master Plan (FMP) Project. The per capita standing volume has been estimated as 0.60 m^3. The full report of the survey has been prepared separately by the concerned member of the FMP Project.

Consumption

Domestic Consumption - The maximum amount of fuelwood is consumed by domestic cooking. There has been a number of surveys to estimate the consumption of fuelwood and other biomass fuels for domestic cooking (BES, 1976; Briscoe, 1979; Islam, 1980; Douglas, 1981; Quader and Omar, 1982; Islam, 1982; BEPP, 1985). The per capita consumption has been determined to estimate the total consumption of the country (Table 7). On the basis of base data of 1981 (BEPP,1985), the Planning Commission has estimated the consumption of fuelwood and agricultural residues by end-users for 1990 (Table 9). In 1992 a nation wide household consumption survey was undertaken by the FMP Project. According to the survey fuelwood consumption for domestic cooking has been found to be 3.600 million tonnes (Table 10).

Industrial Consumption - Brick burning is the major consumer of fuelwood in the industrial sector. In spite of the moratorium on the use of fuelwood in the brick industry, about 80 percent of the total brick kilns used fuelwood in 1991. Thus out of 2,500 units in the country (BMA,1992) 2,000 units have used 1.52 million tonnes of fuelwood for producing 2,000 million bricks. The Planning Commission estimated was 0.784 million tonnes for 1990. This value seems to be grossly underestimated. Compared to import of coal for the last ten years, the maximum amount of 558,000 tonnes of coal was imported in 1990 (BBS, 1991). About 91 percent of this was sold for brick burning. If this entire amount was used in the brick industry then about 57 percent of the country's total bricks could have been produced. This was not the case. This aspect has been dealt with in detail in the Biomass Energy Policy section.

Road Tarring - A substantial amount of fuelwood is also consumed in the construction of new roads and maintenance of existing roads. On average, construction of 400 km of new road and maintenance of 1,500 km are undertaken every year (RHD, LGEB, 1992). About 100 tonnes of fuelwood/km for new road construction and 50 tonnes of fuelwood/km for maintenance of existing roads are required. Thus the annual fuelwood consumption for road tarring amounts to 0.163 million tonnes.

Other Industries - For industries like tea processing, tobacco curing, baking, soap making, pottery and other uses, the current consumption values are not available. The estimates made earlier by the Planning Commission for 1990 may be taken as the fuelwood consumption figures for 1991.

The consumption of fuelwood for all these end-uses in 1991 is presented in Table 10.

Table 10 - Consumption of Fuelwood in 1991

Type of use									
Domestic Cooking	Industrial/ Commercial								
	Brick burning	Road tarring	Tea processing	Tobacco curing	Baking	Soap	Pottery	Others	Total
(in million tonne)									
3.600	1.520	0.115	0.079	0.066	0.081	0.009	0.034	0.026	1.930
(in million m^3)									
5.112	2.158	0.163	0.112	0.094	0.115	0.013	0.048	0.037	2.740
Grand Total (Domestic cooking + Industrial/ Commercial uses) = 7.852 million m^3									
Per capita annual consumption = 0.073 m^3									

Supply and Demand Balance

The supply and demand position of fuelwood is based mainly on the village forestry surveys undertaken by the Forestry Master Plan Project (1992). The country has been divided into seven strata for the convenience of the study. The existing supply position in all the strata has been estimated. The probable supply of fuelwood has also been estimated for the next twenty years.

The demand estimates have been made on the basis of consumption of 1991 (Table 9). The demand figures for the next twenty years have been estimated based on the projection of the population in four 5-year periods. The present trend of consumption has been considered in determining the demand of fuelwood.

The supply and demand positions of fuelwood from different sources and areas under status quo with normal working and present trend of demand are presented in detail in Appendix 3. The total position of supply and demand is shown in Table 11.

Remarks

If the restriction on tree felling is effectively enforced, there will be no supply of fuelwood from the national forests. The supply will come only from the village forests and marginal land plantations. This will result in an obvious deficit of fuelwood in each area whether there is or is not forest in that area. In order to minimise the shortfall a better condition of supply is considered where status quo with normal working is envisaged. This will improve the supply position considerably due to exploitation of the forest produces from all reserve forests and unclassed state forests. The supply will however be much lower than the demand (Table 11).

There will be a significant amount of shortfall in each plan period. The deficit will be most severe in the northern and central regions of the country where there is very little government forest left. Due to favourable condition of the natural tree coverage, the greater Chittagong and Chittagong Hill Tracts have surplus of fuelwood. Fuelwood is a low price commodity and as such it will not be economic to transport from this area to deficit areas. To be economic it has to be produced locally. This calls for adopting appropriate strategies to overcome the shortfall of fuelwood in each deficit area of the country.

Table 11 - Status Quo Supply and Present Demand Trend, 000m³/A

Zone	Source	1993	1998	2003	2008	2013
Northwest	Total Supply	882	969	1062	1174	1300
	Domestic	1289	1404	1520	1636	1751
	Industrial/ Commercial	719	791	870	957	1053
	Total Demand	2008	2195	2390	2593	2804
	Balance +/-	-1126	-1226	-1328	-1419	-1504
Northcentre	Total Supply	763	843	927	1033	1155
	Domestic	1162	1267	1372	1476	1580
	Industrial/ Commercial	650	714	785	863	950
	Total Demand	1812	1981	2157	2339	2530
	Balance +/-	-1049	-1138	-1230	-1306	-1375
West	Total Supply	546	597	656	727	813
	Domestic	722	786	851	916	981
	Industrial/ Commercial	442	486	535	588	646
	Total Demand	1164	1272	1386	1504	1627
	Balance +/-	-618	-675	-730	-777	-814
South	Total Supply	860	931	1001	1146	1346
	Domestic	567	618	669	720	771
	Industrial/ Commercial	281	309	340	374	411
	Total Demand	848	927	1009	1094	1182
	Balance +/-	+13	+4	-8	+52	+164
Southeast	Total Supply	857	932	1027	1334	1518
	Domestic	877	956	1035	1113	1192
	Industrial/ Commercial	490	538	592	652	717
	Total Demand	1367	1494	1627	1765	1909
	Balance +/-	-510	-562	-600	-431	-391
Northeast	Total Supply	391	434	478	531	590
	Domestic	643	701	759	817	875
	Industrial/ Commercial	360	395	434	578	525
	Total Demand	1003	1096	1193	1295	1400
	Balance +/-	-612	-662	-715	-764	-810
Hill Tracts	Total Supply	1880	1788	1678	1577	1486
	Domestic	49	53	58	62	66
	Industrial/ Commercial	23	26	27	31	34
	Total Demand	72	79	85	93	100
	Balance +/-	1808	1709	1593	1484	1386
All Regions	Total Supply	6179	6494	6829	7522	8208
	Domestic	5309	5785	6264	6740	7216
	Industrial/ Commercial	2963	3260	3583	3942	4337
	Total Demand	8272	9045	9847	10682	11553
	Balance +/-	2093	-2551	-3018	-3470	-3345

ASSESSMENT OF BIOMASS ENERGY POLICY

Introduction

Policy is the key factor for achieving the desired results. In Bangladesh, there is a National Forest Policy (1979) which contains a statement of some aspects related to forestry and the forestry profession in a very general and vague form. It lacks many relevant issues and it is not surprising that wood energy is not mentioned.

A National Energy Policy was issued under a memorandum of the Ministry of Petroleum and Mineral Resources in 1980. In that energy Policy as well, there was no mention of wood or biomass energy. This policy soon lost its effectiveness and went into oblivion. At present there is no energy policy aiming at overall energy development of the country. However, the importance of formulating such a national energy policy has been felt recently by the concerned ministry and steps are being taken in this regard.

There has been over exploitation of forest products beyond the sustainable yield in the country causing depletion of the tree resource. In order to arrest this situation, the Ministry of Environment and Forest issued an executive order in September, 1989 imposing a moratorium on felling of forest trees in order to maintain biodiversity. However, Khulna News Print Mills and Karnafuli Paper Mills are allowed to continue the extraction of their raw materials. The facility for limited exploitation of forest produces has been extended to BFIDC since July 1991, although it only became operational from January, 1992.

Impact of Ban on Felling

It is almost three years since the imposition of the ban, a reasonable period to assess the effect of this policy. Unfortunately, there are no reliable statistics on forest products. No information is available on the total supply of timber and related products before or after the moratorium. No report has been published regarding inflow and outflow of timber in the market nor is any information available about the sources of timber. In the absence of the pertinent data the member of the Wood Energy Team visited the various timber markets in Dhaka and Chittagong.

In the timber market there is no evidence of appreciable adverse effect due to the moratorium. Timbers of all important species of forest origin are available. The usual supply of forest timbers has been hardly interrupted since 1989. When the timber merchants and dealers in Chittagong and Dhaka were asked about the source of their purchases they said that the timbers were bought from the seized stock of the FD. Some reported that most of the timbers were from their old stock. Others confessed that the timbers were purchased from the middlemen who collected from illicit felling from the forests. The latter statement regarding the source of purchase seems to be a factual one.

A general shortage of timber exists in the country but this shortage has not been aggravated appreciably after the imposition of ban. There has been more or less normal supply of timber in the market. The normal economy of the market is being maintained as is evident from the price structure of the timber.

The average unit prices of some important commercial timbers have been collected from the Chairman of the Bangladesh Wood Traders and Sawmill Owners's Association in Dhaka (Rahman, 1992). The information regarding the prices of these commercial species which are generally sold in Chittagong and Dhaka timber markets are shown in Table 12 (Rahman, 1992). The species along with their distribution are as follows:

Species Distribution

i) Teak (Tectona grandis) Chittagong, Chittagong H.T., Cox's Bazar, Sylhet
ii) Champa (Michelia champaca)- do -
iii) Telsur (Hopea odorata)- do -
iv) Gamar (Gmelina arborea)- do -
v) Chapalish (Artocarpus chaplasha)- do -
vi) Shil kori (Albizzia procera)- do -
vii) Garjan (Dipterocarpus spp)- do -
viii) Jam Sygyzium grandis)- do -

The table reveals that the average prices of eight species from 1982 to 1989, i.e. prior to moratorium, varies from Tk 236 to Tk 706 per ft^3. The average increase in the price was 5.2 percent to 29.3 percent for the period. There was an abnormal increase of price in 1984 for almost all the species. Compared to the previous year, the percent increase in price in 1984 was

Table 12 - Dhaka Sawntimber Prices

Year	Average Prices of Different Species in Tk/cft (percent increase of price)								
	Teak	Champa	Telsur	Gamar	Chapalish	Shil Koroi	Garjan	Jam	Average all species
1982	525	245	250	200	180	200	145	140	236
1983	550	270	270	250	200	220	165	145	259
	(4.8)	(10.2)	(8.0)	(25.0)	(11.1)	(10.0)	(13.8)	(3.6)	(9.7)
1984	650	415	375	280	280	280	200	200	335
	(18.2)	(53.7)	(38.9)	(12.0)	(40.0)	(27.3)	(21.2)	(37.9)	(29.3)
1985	750	475	440	325	300	325	210	210	383
	(15.4)	(14.5)	(17.3)	(16.1)	(7.1)	(16.1)	(5.0)	(5.0)	(12.2)
1986	900	525	550	375	325	350	245	235	438
	(20.0)	(10.5)	(25.0)	(15.4)	(6.7)	(7.7)	(17.7)	(11.9)	(14.4)
1987	1100	650	575	425	365	380	270	250	502
	(22.2)	(23.8)	(4.5)	(13.3)	(12.3)	(5.7)	(10.2)	(14.9)	(14.6)
1988	1150	650	600	450	410	450	335	275	540
	(4.5)	(0.0)	(4.3)	(5.9)	(12.3)	(18.4)	(24.1)	(1.9)	(7.6)
1989	1200	650	620	475	450	460	365	325	568
	(4.3)	(0.0)	(3.3)	(5.6)	(9.8)	(2.2)	(9.0)	(18.2)	(5.2)
1990	1200	750	750	520	465	530	400	350	620
	(0.0)	(15.4)	(21.0)	(9.5)	(3.3)	(15.2)	(10.0)	(7.7)	(9.2)
1991	1250	750	750	525	500	560	430	375	643
	(4.2)	(0.0)	(0.0)	(1.0)	(7.5)	(5.7)	(7.5)	(7.1)	(3.7)
1992	1250	750	750	635	600	650	560	450	706
	(0.0)	(0.0)	(0.0)	(21.0)	(20.0)	(16.1)	(30.2)	(20.0)	(9.8)

12.0 percent to 53.7 percent resulting in an average of 29.3 percent. The reason for such an abrupt rise in price cannot be explained except that there was probably more shortage of those commercial species in that year. From 1990 to-date, i.e. after the moratorium, there has been no appreciable adverse effect on the supply of timbers for furniture and construction purposes. As such no abnormal change of price is observed in the timber market. The average price of all species ranges from Tk 620 to Tk 706 per cft. It is interesting to note that the average percent increase in price was between 3.7 percent to 9.8 percent which are comparable with those of the previous years. This indicates that the supply has been more or less steady from the forest sources even after the moratorium.

Ban on Use of Fuelwood in Brick Burning

Brick burning is one of the major commercial activities in Bangladesh and is generally confined to the dry season, December-May. There are about 2,500 large manufacturing units in the country (BMA, 1992). About one million bricks are produced in a unit by burning 4-5 batches of bricks in a year. Thus the total annual production of bricks may be estimated as 2,500 million (BMA, 1992). Energy in the form of fuelwood, coal and natural gas is used for producing these bricks. It was estimated that, on an average, 76 tonnes of fuelwood, 30 tonnes of coal and 0.7 million cft of gas are required to produce 100,000 bricks (Table 8). No updated information is available on the proportion of different fuels used in brick burning kilns. However, the BEPP (1985) reports that in 1981, out of the total of 1,700 brick burning units, 60 percent, 30 percent and 10 percent of bricks were burnt by fuelwood, coal and gas respectively. The BEPP further mentions that the total consumption of fuelwood in 1981 was 4 million tonnes of which 1.63 million tonnes were estimated to have been obtained by over cutting. This included over cutting of 1.25 million tonnes from village groves and 0.38 million tonnes from reserve forests.

In response to the general concern regarding the rapid depletion of the forest resource, the Government of Bangladesh imposed a ban on the use of fuelwood for brick burning in 1983-84. However, the implementation of the order had to be suspended because a suitable substitute fuel was not fully available.

Initially, there was enthusiasm for the use of natural gas in the brick fields. Although new gas connections have been extended to some areas, its use is confined to only a few brick fields. Technically, both coal and gas are superior fuels having much higher caloric values than that of fuelwood. These fuels produce stronger brick than that using fuelwood. In spite of these advantages coal and gas are not preferred. The reason may be ascribed to the following:

a. Fuelwood is comparatively easily available even at the isolated areas. It is claimed that the outturn in fuelwood fired kilns is higher than those of coal and gas fired ones due to high instantaneous combustion.

b. Coal is imported and its availability cannot be ensured in all localities. A frequent complaint is that the imported coal is generally of inferior type which entails a higher amount of coal per batch.

c. There is no gas connection in 57 districts of the country. In the brick fields where there are already gas connections, the brick manufacturers are not utilizing the facility. On a new arrangement each brick firm with double sections has to deposit an amount of Tk 1,200,000 as a security against the use of gas for brick burning. This has prohibited the use of gas in most of the cases.

Fuelwood has continued to be used unabated in the brick fields. This is causing serious depletion of the forest, particularly the homestead and farm forests of the northern part of the country where there is virtually no government forest. Finding no other alternative, the Ministry of Environment and Forest imposed a ban on the use of fuelwood in brick burning in July, 1989. The brick manufacturers, in effect, were forced to use coal instead of wood. But how far this moratorium has been effective remains to be assessed.

The official statistics of coal import and use in Bangladesh is shown in Table 13 (BBS, 1991). Since the imported coal was reported to be inferior quality, the total number of bricks burnt have been estimated on the basis of the specific energy consumption of coal as 35.6 tonnes/ 100,000 bricks.

Table 13 - Availability of Coal

Year	Total import (000 tonnes)	Sold for use for brick burning (000 tonnes)	No. of bricks burned by coal (million)	Brick burning as percent of total import	Coal burned bricks as percent of total 2,500 million bricks
1981-82	295.2	260.8	732.5	88.3	29.3%
1982-83	190.4	100.0	280.8	62.3	11.2%
1983-84	62.0	68.0	191.0	109.6	7.6%
1984-85	98.0	67.0	188.2	68.4	7.5%
1985-86	148.0	10.0	28.1	6.7	1.1%
1986-87	233.0	33.0	92.7	14.2	3.7%
1987-88	202.0	162.0	455.1	80.0	18.2%
1988-89	54.0	47.0	132.0	87.4	5.3%
1989-90	558.0	505.0	1,418.5	90.5	56.7%
1990-91	200.0	200.0	561.8	100.0	22.4%

It is assumed that the amount of coal sold was entirely used for brick burning. It is seen from the table that out of the annual total of 2,500 million bricks, 28.1 to 1418.5 million bricks/ year were produced during the last ten years. This represents 1.1 to 56.7 percent of the total bricks. During the field visits it has been observed that only a limited number of firms have actually used coal for brick burning. In Chittagong, Dhaka, Khulna, Sylhet and other places where fuelwood of reserve forests are available, the brick manufacturers have fuelled them in spite of the restriction. In the northern region, homestead and farm species like babla (Acacia nilotica), tentul (Tamarindus indica), bel (Aegle marmelos), koroi (Albizzia procera), raintree (Samanea saman), mango (Mangifera indica), etc. and even bamboo stumps have been used.

It is encouraging to note that in the first year of ban, i.e. 1989-90, about 91 percent of the total import of coal was sold. If this entire amount was expended for brick burning, 56.7 percent of the country's total bricks could have been produced. In the following year, coal import was reduced from 558,000 tonnes to 200,000 tonnes and the total amount was sold. This represents 22.4 percent of the total bricks burnt in the country.

It may be pointed out here that the actual amount of coal used cannot be obtained from the sale record only. Coal is also used in some other industries as well. The sale of coal during the current year is not yet available, but it is gathered that most of the coal imported through the government source is still lying in the depot for sale. However, coal procured by the private firms was sold out. Instead of being used, heaps of coal have been piled in many brick fields to deceive the authorities. All this indicates that about 10 percent of the total units may be using coal and a maximum of 10 percent may also be using gas. This leaves out 80 percent of the total units which employ fuelwood for brick burning. Thus 2,000 units producing 2,000 million bricks require 1.52 million tonnes, about 2.16 million m^3 of wood energy. This huge amount of fuelwood is being extracted partly from the reserve forests but mostly from homestead and farm forests.

It is evident that there has been widespread violation of the government ban with many legal actions taken against the offenders. A maximum punishment of six months imprisonment or a penalty of Tk 10,000 was imposed. This punitive measure has not discouraged offenders. Realising this, the government has recently (1992) made the order more severe. The order now allows the law enforcing authority to inflict a punishment of six months imprisonment or a fine of Tk 50,000 or both for each offence. In addition, the entire amount of bricks may be confiscated if these are manufactured by using fuelwood.

Remarks

Price is the best indicator of the supply position. It is evident from the price of the timber that the supply has been more or less steady in the market. The moratorium on felling has not worked. The timber market continues to be fed with illicit timber depriving the government of the revenue. In almost all cases of brick burning the ban has not worked. The intention of the government has been defeated. The following are some options to alter the situation:

1.If the moratorium continues, it has to be strictly implemented. However, it will be a difficult task. The government has already taken some steps in respect of brick burning by modifying the order. Supply of alternate fuel has to be ensured even in the remote areas. Good quality coal needs to be imported until it is available in the country. An incentive in the form of price subsidy may be considered for the users of coal.

The government agencies like Public Works Department and Roads and Highways Department are the major users of bricks. These agencies can restrict buying bricks other than coal-fired and thus exert influence in the effective implementation on the ban of use of firewood in brick making.

The use of natural gas should not be restricted for brick burning as was done in the past. Instead, it's use should be encouraged to reduce the continued use of fuelwood as well as imported coal. An appropriate arrangement in respect of pricing and security deposit should be found.

Next to brick burning, road tarring is a major consumer of fuelwood in the industrial sector. The construction and maintenance works are almost entirely undertaken by the government agencies and as such the use of fuelwood in road tarring can be controlled effectively. The use of fuelwood should also be banned in road tarring. A subsidy in the price of coal may be considered in this case as well.

The ban on felling could not be fully enforced due to many factors. The requirement of timber has to be met through some means either by local source or by import. The import of timber was tried in the past, but was not a successful alternative. Selective felling of trees may be an alternative. This will ensure supply of timber in the market and also limit the illicit felling.

There is presently an unusual situation of high demand of bricks under the highway development programmes. Once the programmes are completed, the maintenance of these roads will need less brick and thereby reduced energy needs.

ASSESSMENT OF IMPROVED COOKING STOVES

Introduction

There are about 20 million households in 64 districts of Bangladesh (BBS, 1991). Fuelwood, agricultural residues and animal dung are the main sources of energy for cooking and other purposes for these householders. The BEPP (1985) has estimated that about 80 percent of the total biomass is being consumed for domestic cooking only. The per capita consumption of biomass fuel for cooking was also estimated as 4.44 GJ/year. Due to depletion of tree cover and swelling population an acute shortage of fuel energy exists in the country. It is likely to aggravate further due to increase in population. To avert the situation it is necessary to decrease the demand by conserving the fuel energy along with augmenting biomass fuel supplies. Properly designed improved cooking stoves may save the fuels considerably and thus can contribute to a national energy conservation programme.

Traditional Stoves

There are a number of different types, such as insitu built and movable, and models, such as one, two and three-mouth traditional stoves used for rural and urban domestic cooking. Locally designed hearths are also used in small rural industries using biomass fuels. Most of these stoves are made of mud cylinder with three raised points on which cooking pots rest. The conversion efficiency of these types of stoves ranges from 5-15 percent (Khan, 1988). The low value is attributable to the following factors:

a. Heat transfer to the pot is poor due to the large distance between the fuel bed and the pot.

b. Much of the flue gas leaves the stove without coming in contact with the pot due to the large size of the flue gas openings. This lowers the convective heat transfer.

c. The combustion air cannot reach the bottom of the stove because of too much depth causing incomplete burning of the fuel.

The improvement concept lies with the modification of these design weaknesses. Further assessment of the performance of the stoves is necessary to develop the strategy for the design and diffusion of improved stoves.

Development of Improved Stoves

During the late 1970's a number of institutions and agencies started research and development activities on improved stoves. These activities were limited to mainly domestic cooking stoves. Some models developed by them are considered here.

BCSIR Models - The Institute of Fuel Research and Development under the Bangladesh Council for Scientific and Industrial Research (BCSIR) has developed some models of improved stoves. These models may be categorised into three types, one-mouth, two-mouth and three-mouth stoves. Each of them has some variations in its basic model. Most of the models are made of mud and fitted with a grate for better distribution of air through the combustion chamber and have air entry holes and an ash pit. The multi-mouth models are provided with chimneys for smoke outlet. The initial models are suitable for use with fuelwood. Some modifications have been made in other designs by discontinuing the grates for use of other biomass fuels like agricultural residues and leaves. One-mouth stoves, both insitu built and portable one, are intended for an average family whereas multi-mouth designs can be used for larger families as well as for community cooking. The BCSIR claims that these models have the potential to save 50-80 percent of fuelwood and other biomass fuels compared to traditional stoves (Khan, 1988). The price of the former stove is Tk 75 each and the later stove costs Tk 300 for constructing a unit.

BUET Model - A two-mouth insitu built model was developed by the Chemical Engineering Department of the Bangladesh University of Engineering and Technology (BUET). The stove is made of mud which has two hearths side by side, the first being used as a combustion chamber and the second one for the exit of flue gases. The stove can accommodate fuelwood and other types of biomass fuels. Ash is collected in the first hearth and the stove offers improved performance in respect of fuel saving when both the hearths are used simultaneously. It is claimed that this model can save 40 percent of fuel used in traditional stoves (Islam, 1984).

Sheba Model - A model, called "Sheba chula" has been developed by a retired Assistant Social Welfare Officer at Rangpur town (Fazilatunnessa, 1985). It consists of three components - bottom, middle and top. The bottom portion acts as the base, ash pit and provides space for air inlet. The middle portion is fitted with wire net and acts as the air distributor while the top portion is the combustion chamber, providing space for fuel entry and acts as a seat for the cooking pot. The top and the bottom portions of the stove can be made of bricks or with mud clad with sheet metal. The stove is suitable for burning fuelwood. It has been estimated that this model has the potential to save 50 percent of the fuelwood used in traditional stoves (Islam, 1984). The portable stove was sold at Tk 50 for each unit in 1982.

Improved Stoves Projects

Community Forestry Project-I - In 1981, a project titled, Community Forestry Project-1 was initiated with the financial assistance of ADB. It was a programme of 6-year duration with a total cost of Tk 428 million and the implementing agency was the Forest Directorate. There was a component in this project for the promotion of wood fuel energy saving devices. Due to implementation difficulties it could not be activated and in 1985 was dropped from the project.

Bangladesh Energy Planning Project (BEPP) - Based on the analysis of the supply and demand of the total energy sources including biomass fuels, the BEPP (1985) formulated an Energy Master Plan for the country upto the year 2000. Its frame work was an integrated energy development plan consisting of two components, (a) Rural Energy Development Plan (REDP) and (b) Recommended Commercial Energy Development Plan (RCEDP). Apart from other projects the REDP recommended the implementation of the following projects:

-Fuelwood enhancement
-Improved biomass fuel burning stoves and devices
-Insulated box type cookers
-Biogas plant
-Solar cookers

The introduction of the stoves was intended for urban and rural cooking and biomass fuel consuming industries. The investment for the improved stove project was estimated as follows (Table 14).

Table 14 - Estimated Investment for the BEPP Improved Stove Project

Year	1986-90	1990-96	1996-2000	Total
Million Tk	12.0	93.0	110.0	215.0

Third Five Year Plan - During the Third Five Year Plan period (1985-90), Tk 200 million was allocated for different projects related to traditional, new and renewable sources of energy based on the recommendation of the investment projects of BEPP (1985). The allocation for research and development on the improved stoves and biogas was Tk 20 million and for promotional activities was Tk 55 million. It was proposed to manufacture and distribute 700,000 improved single-mouth stoves and 10,000 improved multiple-mouth stoves. The IFRD was identified as the implementing agency. Accordingly, a project titled, "Fuel Saving Project" was undertaken by the IFRD under the Science and Technology Division of Ministry of Education. The total budget was Tk 19.75 million for the period of 1987-88 to 1989-90. It was later extended upto June, 1991.

Assessment of Improved Stoves

Assessment of the Different Models - The Department of Agriculture Extension (DAE) under the initiative of the Planning Commission made an evaluation of three different models of improved stoves designed by BCSIR (single mouth with grate), BUET (two-mouth) and Mrs. Fazilatunnesa (single mouth with a grate). The tests were conducted by the Agriculture extension Training Institute. The comments on the tests are as follows (BEPP, 1985):

The improved stove of the BUET was found to be better than the double stoves being normally used in rural areas. This model needs to be introduced on a wider basis. The BCSIR and Sheba models were also found to give better performance when used with fuelwood, but were not suitable for other biomass fuels. Thus, it may not be possible to popularize these models in rural areas since straw, leaves, etc. are also used as fuels. The test report also mentioned that for BCSIR and Sheba models there is a need to split the normally available fuelwood to smaller pieces involving additional labour.

Subsequently, the BCSIR has modified its initial models to accommodate both fuelwood and other biomass fuels. The innovator of the Sheba model has also made some minor changes in her earlier model.

Assessment of the Improved Stove Projects - The improved stove programme under the Community Forestry Project-I was the first government attempt for its implementation in Bangladesh. The programme did not receive due attention of the implementing agency, i.e., the Forest Directorate. The improved stove was an unfamiliar technology to the forestry sector planners as well as to the Forest Directorate. There was neither any trained manpower nor any motivated personnel in the Directorate for promotion of the improved cooking stoves. In addition, there was no network of grass root level extension workers. As a result, there was no progress in the programme, and subsequently in 1985 the component was dropped during the review of the main project.

The "Fuel Saving Project" was a full-fledged organised programme undertaken by the IFRD of BCSIR during the Third Five Year Plan period. It was reported that out of the total budget of Tk 19.75 million, Tk 11.25 million was allocated. The entire amount was spent for the project over a period of four years (STD, 1992). Against the target of 315,000 improved stoves, 160,721 units were set up in 33 upazillas. Six NGOs were assigned for the extension works. About 4,000 men and women were trained in those areas to further train the intending users. There were provisions for monitoring and evaluation activities but these could not be undertaken due to non-availability of a transport.

It is not so important whether or not the full target could be achieved for the project. The main factor is the degree of acceptance for such an extension type of work. No evaluation report on the number of improved stoves actually is in operation and no information for acceptance/rejection is available to assess the performance. The monitoring, follow-up and evaluation activities could not be undertaken due to non-availability of a transport and adequate fund. Thus whatever physical and financial progress have been achieved, proper assessment cannot be made at this stage. The implementing agency has recently started the evaluation work with its normal limited budget. It is gathered that the overall success of the technology will be around 10-15 percent of the total units of stoves extended to different users. It may however be mentioned that the initial adoption rate of 30 percent can be considered as a reasonable success for an extension type of programme like this.

In general, the following are the shortcomings and limitations for the failure or low rate of acceptance of the improved stove programme in Bangladesh:

a. A particular model of improved stove has been assumed as perfect and considered for universal application without due consideration to variations in the type of fuels, users' need, etc. As a result, a model that could be suitable for a particular situation, e.g. urban household using fuelwood, has been demonstrated in an inappropriate surrounding, e.g., rural household and poor urban household using mixed biomass fuels.

b. Lack of identification of beneficiaries is a problem. In urban areas where gas is not available, fuelwood is purchased for cooking. The rich and middle class sections of the rural areas also buy fuelwood and other biomass fuels. Thus fuelwood saving due to adoption of the improved stove can be translated into cash savings in these areas. For this reason the improved stoves have better prospect of being accepted by those who actually purchase biomass fuels.

c. Lack of interactions between the researchers and users is another problem. Adequate attention needs to be given to assess the users' need as well as to develop standard models of improved stoves based on field level testing and evaluation.

d. Lack of proper understanding on the part of the stove promoters about the factors that affect stove diffusion. There is a bias of some research and development institutions in promoting a model developed by them even though it may not be the most appropriate for the location.

e. Absence of an appropriate organisation which has grass root level workers for the extension. This leads to dependence on other agencies for the diffusion activities and these agencies may not have expertise on the technology.

f. Lack of adequate and uninterrupted funding to complete the work. As a result a particular research institution was found to discontinue the stove research at the end of a specific funding period and then a new agency came forward to initiate almost similar work. This results in gathering of limited experience by many researchers.

g. For successful diffusion of stoves women have a more prominent role to play than men. This issue has not been taken care of in the previous projects.

Remarks

Energy conservation is one of the most cost effective options for the increasing energy resource. The BCSIR and BUET have developed some potentially useful designs of the improved cooking stoves to achieve this end. These have been made over a period of ten years after limited field testing. However, further refinements and modifications may be needed to meet the requirements of a particular location and end-use.

A detailed assessment of the existing model is needed to develop the strategy for their effective diffusion. Regular monitoring and evaluation should be an integral component for the project. Adequate logistic support should be provided for this purpose.

The improved stoves have high prospects for fuel saving project in Bangladesh. So, a properly planned and adequately financed improved cooking stoves project can go a long way to conserve the fuelwood and other biomass energy.

Detailed recommendations in respect of the improved stoves are furnished in the Development Opportunities and Strategies section.

DEVELOPMENT OPPORTUNITIES AND STRATEGIES

Introduction

The per capita annual consumption of fuelwood in 1991 was 0.073 m^3 which is one of the lowest in the world. Even at this level there is shortfall of supply compared to the demand. The moratorium on cutting trees has made the situation more acute. It is evident from the supply and demand position as shown in Table 11. The gap between the demand and supply of fuelwood is widening. If the tree resource is not managed properly on sustainable yield basis there will be a net deficit of about 3.35 million m^3 of fuelwood by the year 2013 even in a normal working condition. This is a high figure which is difficult to make up by following any single approach. It is thus necessary to adopt multi-strategies to tackle the problem. The following are the suggested strategies for achieving this end.

a. Enlarge fuelwood supplies
b. Conservation of fuelwood
c. Reduction of wastage
d. Reduction of demand by using substitutes
e. Reduction of demand by using commercial fuels

Enlarging the Fuelwood Supply

The agro-ecological condition of Bangladesh is such that trees can be grown almost everywhere. Therefore, the plantation of trees should be considered as the primary strategy to augment the supply. Before suggesting for new planting, it is considered pertinent to examine the existing areas and growing stocks of the different forests (Table 15).

Table 15 - Distribution of Forests Growing Stock

Forest type	Location	Area million ha (percent of the country's total)	Growing stock million m^3 (Tree cover density=m^3/ha)	Major Products
i) Mangrove (Tropical evergreen)				
a) Sundarbans	South-West	0.57 (3.90)	13.19[1] (23.1)	Timber, pole, fuelwood, pulpwood and thatching material
b) Coastal	Along the coast	0.10 (0.68)	5.05[2] (50.5)	Fuelwood and pulpwood
ii) Hill forest (Tropical moist evergreen)				
a) Managed forest	Eastern part	0.67 (4.59)	28.32[3] (42.3)	Sawlog, pole, fuelwood, thatching material and bamboo
b) Unclassed state forest (Scrub forest)	Hill Tract districts	0.73 (5.00)	Not known (denuded)	Bamboo, thatching material and fuelwood
iii) Plain land forest (Tropical moist deciduous)	Central and north-west region	0.12 (0.82)	1.13[4] (9.4)	Sal and short rotation exotic species for pole and fuelwood
iv) Village forest	Spread all over the country on homestead land	0.27 (1.85)	54.68[5] (202.5) 54.47[6] (201.74)	Timber, pole and fuelwood

1 Chaffey et al., 1985
2 GOB, 1990. Resource Information Management System Data Bank. FD (Personal communication)
3&4 Chowdhury and Hussain, 1989
5 Hammermaster, 1981
6 FMP, 1992

Sundarbans Mangrove

The Sundarbans forests are managed under selection felling system followed by natural regeneration. The growing stock of this forest has depleted from 20.3 million m^3 in 1960 to 13.2 million m^3 in 1984 resulting in 35 percent depletion of resources over the past 25 years (Forestal, 1960; Chaffey et al., 1985). There is no scope for plantation in the Sundarbans excepting the improvement of the growing stock by removing the causes for degradation. An integrated resource development programme funded by the UNDP has already been undertaken by the Forest Department to work in this regard.

Coastal Mangrove

The coastal afforestation in Bangladesh is the largest artificial mangrove forest in the Asia Pacific region. The tree cover density of this forest is more than double the natural mangrove forests. The growing stock is thus satisfactory. The principal species successfully planted is keora (Sonneratia apetala). The trees in many areas are almost mature enough for extraction. If the moratorium on felling is lifted, there will be a substantial supply of fuelwood. A large percentage of keora is reported to be infested with beehole borer and needs immediate sanitary cutting. There is however scope for further plantation along the vacant coastal belt. Fuelwood would be available from this forest.

Managed Hill Forest

The hill forests are managed by clear felling system followed by artificial regeneration. The forests are composed of a huge number of very low yielding species. These need to be replaced by high yielding species like teak (Tectona grandis), gamar (Gmelina arborea), etc. The natural forests produce very low increment of 0.6 m^3/ha/year, whereas teak plantation can easily provide MAI of 10 m^3/ha/year. There is a possibility of increasing the productivity of hill forests by converting at least half of the natural forests into plantation forests. However, environmental aspects need also to be considered. There will be a substantial amount of fuelwood along with sawlogs from this forest.

Unclassed State Forest

The unclassed state forests (USF) in the Chittagong Hill Tracts have been badly denuded during the past years. The shifting cultivation practice is the single greatest threat to the conservation of the ecosystem in the USF. The traditional practice of shifting cultivation system was stable and self-sustaining with a fallow period of 10-15 years enabling adequate restoration of soil fertility. But the population pressure has reduced the fallow period to about three years resulting in unproductive grass land. One of the major tasks to augment the supply of fuelwood is to bring these denuded areas back to productive lands. Under various development programmes an area of about 58,000 ha has been afforested by 1990 and the remaining 0.677 million ha needs to be afforested. Appropriate short and medium rotation tree species should be planted following suitable models. If a plantation programme can be implemented successfully these forests can contribute a significant amount of fuelwood along with other products. At present 1.845 million m^3 of fuelwood may be harvested which may decrease by 0.10 million m^3 every 5-year period.

Plain Land Forest

The sal forests were being managed on a coppice regeneration system. For conservation, all exploitations in these forests has been suspended since 1972. However, more than 30 percent of the forest area has been cleared by encroachment after the ban. Due to increasing population pressure it is becoming increasingly difficult to undertake any plantation programme successfully. There is always the threat of damaging the plantation and further encroachment. Under this condition, normal silviculture systems usually followed by the Forest Department do not seem to be practicable in these forest areas. It is necessary to involve the local people in reforesting the denuded forest. It calls for a different system of management where people participation is ensured not only in managing the trees, but also in protecting them from devastation.

Village Forests

About 2 percent of the total land area of Bangladesh is under village forests which consist of trees grown within the homestead area and in and around farm land. More than half of the village forest is covered by fruit and palm trees. These are managed by individual owners. The tree cover density of the village forest is 201.7 (FMP, 1992) which is 4 to 21 times higher than the government forests (Table 15). About 66 percent of the total fuelwood supply comes from these forests. There is a general concern that the village forests are being exploited beyond their sustainable yield. However, the recent survey (FMP, 1992) has confirmed that there is no such depletion of the growing stock (Table 15). In addition, there are young trees in the homesteads which will contribute towards maintaining sustainable yield. Village tree resources have reached almost saturation point. There are old and diseased trees which need to be replaced by an improved variety. There are farm lands where agroforestry can be profitably practised. For this, suitable tree species need to be suggested.

Marginal and Fallow Lands

There are marginal and fallow lands which are not available or suitable for cultivation. These include roads, highways, embankments, railways and culturable wastes. Most of the lands under this category are owned by different government departments and local government bodies. Strip plantation of trees on the sides of these lands has already been initiated by the Forest Department under the Community Forestry and Upazila Afforestation programmes. However, not much land has been covered and there remains an ample scope for further plantation of trees.

Prospects of Expanding

Along with the main products like sawlog and pole there will be a steady supply of fuelwood from all types of forests during the normal working period. There is however scope for enhanced supply if management of natural forests and plantations is intensified. Prospects for new plantations are listed below.

a. Acute scarcity of land exists in the country and as such the land under the unclassed state forest should not be left denuded. It should be brought under productive plantation following some appropriate management systems. If high yielding species like Eucalyptus camaldulensis, Gmelina arborea, Acacia auriculiformis, are considered for block plantation or other type of plantation, USF may provide a substantial amount of fuelwood following an appropriate rotation period. There is a scope for practising a social forestry system in these areas.

b. It is reported that there are 25,104 km of roads/highways including LGEB top quality roads, 169,827 km of Council/feeder roads, 29,528 km of embankments, 30,115 km of canal banks, and 2,746 km of railway lines. Strip plantation along these will provide a huge amount of fuelwood along with other products. Here as well participatory forestry needs to be followed in order to manage and protect the trees. It is necessary to develop an appropriate mechanism for this system. This aspect will be dealt in detail by the Participatory Forestry Specialist of the FMP.

c. There are 76,923 ha of encroached forest land in which woodlot as well as agroforestry has been introduced since 1981.

More than 500 million seedlings can be planted on both sides of the total 257,320 mileage including in the encroached forest land involving the villagers nearby.

It is seen that there are potentials for augmenting the supply of fuelwood by planting trees following appropriate practices. The traditional management systems have produced low yield

Table 16 - Scenario I Supply and Present Demand Trend, 000m³/A

Zone	Source	1993	1998	2003	2008	2013
Northwest	Total Supply	895	983	1202	1380	1700
	Domestic	1289	1404	1520	1636	1751
	Industrial/ Commercial	719	791	870	937	1053
	Total Demand	2008	2195	2390	2593	2804
	Balance +/-	-1113	-1212	-1188	-1213	-1104
Northcentre	Domestic	1162	1267	1372	1476	1580
	Industrial/ Commercial	650	714	785	863	950
	Total Demand	1812	1981	2157	2339	2530
	Balance +/-	-1036	-1124	-1036	-1030	-868
West	Total Supply	575	628	652	870	1095
	Domestic	722	786	851	916	981
	Industrial/ Commercial	442	486	535	538	646
	Total Demand	1164	1272	1386	1504	1627
	Balance +/-	-589	-644	-734	-634	-532
South	Total Supply	847	917	1075	1236	1355
	Domestic	567	618	669	720	771
	Industrial/ Commercial	281	309	340	374	411
	Total Demand	848	927	1009	1094	1182
	Balance +/-	-1	-10	+66	142	173
Southeast	Total Supply	870	969	1185	1563	1986
	Domestic	877	956	1035	1113	1192
	Industrial/ Commercial	490	538	592	652	717
	Total Demand	1367	1494	1627	1765	1909
	Balance +/-	-497	-525	-442	-202	177
Northeast	Total Supply	399	443	536	619	770
	Domestic	643	701	759	817	875
	Industrial/ Commercial	360	395	434	578	528
	Total Demand	1003	1096	1193	1295	1400
	Balance +/-	-604	-653	-657	-676	-630
Hill Tracts	Total Supply	1880	1788	1678	1577	1486
	Domestic	49	53	58	62	66
	Industrial/ Commercial	23	26	27	31	34
	Total Demand	72	79	85	93	100
	Balance +/-	1808	1709	1593	1484	1386
All Regions	Total Supply	6242	6585	7449	8554	10054
	Domestic	5309	5785	6264	6740	7216
	Industrial/ Commercial	2963	3260	3583	3942	4337
	Total Demand	8272	9045	9847	10682	11553
	Balance +/-	-2030	-2460	-2298	-2128	-1499

resulting in an acute shortage of fuelwood (Table 11). It is therefore considered essential to increase the supply of forest products including fuelwood by improving the forest management system. It will, obviously, involve financial investments. Two scenarios of investment in respect of increasing fuelwood supply have been considered. These are:

a. Scenario I supply with present trend of demand.

b. Scenario I investment supply scenario with investment programmes for reduction of demand.

Details of potentials of fuelwood supply with status quo investment scenario have been discussed by the Management and Production Specialist of the FMP. Tables 16 and 17 give the fuelwood balances under Status Quo and Scenario 1. Table 18 shows the position with Scenario 1 possible with the improved supply position due to wood energy demand reduction program investment, assuming the present trend of demand of fuelwood. Appendix 3 has full details of supply and demand position under all scenarios, including the Scenario 2 position.

Table 17 - Scenario 1 Fuelwood Demand-Supply Balance. $000m^3/A$

Zone	Source	1993	1998	2003	2008	2013
Northeast	Total Supply	895	983	1202	1380	1700
	Domestic	1289	1404	1520	1636	1751
	Industrial/ Commercial	719	791	870	937	1053
	Total Demand	2008	2195	2390	2593	2804
	Balance +/-	-1113	-1212	-1188	-1213	-1104
Northcentre	Total Supply	776	857	1121	1309	1662
	Domestic	1162	1267	1372	1476	1580
	Industrial/ Commercial	650	714	785	863	950
	Total Demand	1812	1981	2157	2339	2530
	Balance +/-	-1036	-1124	-1036	-1030	-868
West	Total Supply	575	628	652	870	1095
	Domestic	722	786	851	916	981
	Industrial/ Commercial	442	486	535	538	646
	Total Demand	1164	1272	1386	1504	1627
	Balance +/-	-589	-644	-734	-634	-532
South	Total Supply	847	917	1075	1236	1355
	Domestic	567	618	669	720	771
	Industrial/ Commercial	281	309	340	374	411
	Total Demand	848	927	1009	1094	1182
	Balance +/-	-1	-10	+66	142	173
Southeast	Total Supply	870	969	1185	1563	1986
	Domestic	877	956	1035	1113	1192
	Industrial/ Commercial	490	538	592	652	717
	Total Demand	1367	1494	1627	1765	1909
	Balance +/-	-497	-525	-442	-202	177
Northeast	Total Supply	399	443	536	619	770
	Domestic	643	701	759	817	875
	Industrial/ Commercial	360	395	434	578	528
	Total Demand	1003	1096	1193	1295	1400
	Balance +/-	-604	-653	-657	-676	-630
Hill Tracts	Total Supply	1880	1788	1678	1577	1486
	Domestic	49	53	58	62	66
	Industrial/ Commercial	23	26	27	31	34
	Total Demand	72	79	85	93	100
	Balance +/-	1808	1709	1593	1484	1386
All Regions	Total Supply	6242	6585	7449	8554	10054
	Domestic	5309	5785	6264	6740	7216
	Industrial/ Commercial	2963	3260	3583	3942	4337
	Total Demand	8272	9045	9847	10682	11553
	Balance +/-	-2030	-2460	-2298	-2128	-1499

Impacts of Low Investment Supply

There will be no substantial improvement of overall supply position of fuelwood due to low investment in the forest management and production systems. There will be still a deficit of fuelwood in each plan period. The overall deficit ranges from 2.03 million m^3 in 1993 to 3.47 million m^3 during the fourth 5-year plan period under Status Quo and Scenario 1. With Scenario 2, supplies improve greatly, allowing increased fuels starting to become available by the 3rd 5-year period.

The north-western and north-central regions are the most deficit areas where there is very little government forest cover left. Fuelwood is collected mostly from the homesteads and farm lands. Under the Status Quo programme, no significant change or modification has been suggested for augmenting the fuelwood supply for these areas. The position of supply will, therefore, remain unchanged.

In the west and north-west areas there will be shortfall as well. There will be, however, improvement in supply in the southern areas where there are mangrove forests. Apart from regular supply from the mangrove forests, there will be fuelwood from the large plantations along the coastal areas. It will thus be possible to meet the fuelwood demand of these areas from 1998 and onward. As expected, Chittagong and Chittagong Hill Tracts will be surplus in respect of fuelwood. This surplus cannot be transported to deficit areas due to high transportation cost.

This indicates that the low investment programmes related to supply will not have any significant impact on the fuelwood supply position. Other strategies must be adopted along with this investment programme. Strategies related to consumption of fuelwood need to be considered. This aspect is discussed in the following sections.

Conservation of Fuelwood

1. **Improved Cooking Stoves**

Conservation of fuelwood should be considered as the second important option for the augmenting energy resources. Augmentation by plantation needs a lead time of a few years to plant and grow the trees up to maturity, but conservation can take effect immediately after the adoption of the technology.

It is estimated that about 30.6 million tonnes of biomass fuels are consumed annually in Bangladesh for domestic cooking (Table 9). Due to shortage, only 14 percent of the total consumption comes from wood fuel which represents about 4.3 million tonnes, equivalent to 6.1 million m^3. A substantial amount of energy is wasted due to inefficient traditional stoves used for cooking purposes. Laboratory research indicates that these stoves can be improved by making some simple modifications. The thermal efficiency can be increased from 5-15 percent in the conventional stoves to about 30 percent in the improved ones. It is claimed that the efficient stoves have the potential to save 50-65 percent of the existing fuel use (Eusuf and Khan, 1991).

There has been a considerable amount of research and development activities in the past in Bangladesh. Different models have been developed to suit the different biomass fuels. Attempts have also been made to disseminate this energy saving technology. Detailed information for acceptance/rejection is not available to evaluate the performance. However, no appreciable adoption of the technology is evident. This calls for assessment of the factors responsible for low adoption. Lack of identification of beneficiaries and lack of regular monitoring and evaluation to assess the users' need in order to modify the existing design or to develop appropriate design have been considered to be the main constraints. The general shortcomings and limitations for the very low acceptance of the improved stoves in the country have been elaborated earlier in the Assessment of Improved Cooking Stoves section.

Table 18 - Scenario 1 Fuelwood Demand-Supply Balance, Including the Effect of the Recommended Energy Demand Reduction Programmes *

Zone	Source	1993	1998	2003	2008	2013
Northwest	Total Supply	895	983	1202	1380	1700
	Domestic	1289	1350	1364	1364	1463
	Industrial/ Commercial	499	563	470	587	614
	Total Demand	1788	1913	1834	1951	2077
	Balance +/-	-893	-930	-632	-571	-377
Northcentre	Total Supply	776	857	1121	1309	1662
	Domestic	1163	1218	1231	1231	1320
	Industrial/ Commercial	450	509	514	530	554
	Total Demand	1613	1727	1745	1761	1874
	Balance +/-	-837	-870	-624	-452	-212
West	Total Supply	575	628	652	870	1095
	Domestic	721	756	764	764	819
	Industrial/ Commercial	319	359	367	381	401
	Total Demand	1040	1115	1131	1145	1220
	Balance +/-	-465	-487	-479	-275	-125
South	Total Supply	847	917	1075	1236	1355
	Domestic	567	594	600	600	644
	Industrial/ Commercial	184	209	208	211	219
	Total Demand	751	803	808	811	863
	Balance +/-	+96	+114	+267	+425	+492
Southeast	Total Supply	870	969	1185	1563	1986
	Domestic	567	594	600	600	644
	Industrial/ Commercial	184	209	208	211	219
	Total Demand	751	803	808	811	863
	Balance +/-	+96	+114	+267	+425	+492
Northeast	Total Supply	399	443	536	619	770
	Domestic	644	674	681	681	731
	Industrial/ Commercial	249	281	284	293	307
	Total Demand	893	955	965	974	1038
	Balance +/-	-494	-512	-429	-355	-268
Hill Tracts	Total Supply	1880	1788	1678	1577	1486
	Domestic	49	51	52	52	56
	Industrial/ Commercial	15	17	17	17	17
	Total Demand	64	68	69	69	73
	Balance +/-	+1816	+1788	+1609	+1577	+1486
All Regions	Total Supply	6242	6585	7449	8554	10054
	Domestic	5310	5562	5621	5620	6029
	Industrial/ Commercial	2056	2321	2248	2419	2530
	Total Demand	7366	7883	7869	8039	10054
	Balance +/-	-1124	-1298	-320	+515	+1495

* Scenario 1 development and reduced demand from recommended energy conservation program

In urban areas where gas is not available, fuelwood is purchased for cooking. Thus the savings in fuelwood due to use of improved stoves can be translated into cash saving. For this reason improved stoves have better prospect of being accepted by urban than rural users. Moreover, the urban population can easily have access to improved technology. The project is thus primarily intended for the urban domestic cooking and industrial applications in 57 districts headquarters where there is no gas supply.

2. Implementation

Based on past experiences and bearing in mind the constraints, appropriate methodical approach will be followed for the implementation of the improved cooking stoves programme. A provisional selection of the models may be as follows:

- The BCSIR single-pot model with a grate may be considered for the urban households using fuelwood.

- Multi-pot insitu built stove model of BCSIR may be considered for the urban community units.

- The insitu built mud stove of BUET may be considered for extension in households using fuelwood and other biomass fuels.

The final selection of the models should be made on the basis of the action research. The strategies for extension and dissemination of the selected models have to be formulated accordingly.

3. Saving of Fuelwood

Laboratory research indicates that the efficient stoves have the potential to save 50-65 percent of existing fuelwood. It is thus envisaged that it should at least be possible to achieve a 40 percent saving of existing fuel use at the user level.

It is estimated that there will be about 10 million urban populations in 1993 in the 57 municipality areas where there is no gas connection. Taking the size of household as 5.32 persons (BBS, 1991), the number of household in these areas stands at 1.88 million. The Forestry Master Plan Project has estimated the annual per capita consumption of fuelwood in urban areas in 1991 as 0.065 m^3 which equals to 0.045 tonne.

If 1000,000 improved stoves are constructed and disseminated in each 1993-98 and 1998-03 periods and also assuming that 30 and 40 percent of the households accept them respectively during the plan period, then saving of fuelwood can be calculated as 0.123 million m^3 and 0.389 million m^3 for those periods.

Assume that after 10 years the final acceptance of the improved stoves will increase from 45 percent to 50 percent in 2003 and 55 percent in 2008 due to promotional and extension/ dissemination activities. This means that 1000,000 and 1100,000 units will be in operation during 2003-2008 and 2008-2013 periods, respectively. In addition, 500,000 new stoves will be extended in each third and fourth plan period. The total saving in fuelwood in 2003-08 period and 2008-13 period will be 0.784 million m^3 and 0.852 million m^3 respectively.

Financial Saving

The market price of fuelwood has been observed to vary from Tk 50-100/ maund depending on the fuelwood species and location. The price is likely to increase in 1993 and 1998. Assuming the present lowest rate, the price of fuelwood is Tk 1,350/ MT. The financial saving due to saving in fuelwood for the entire plan period can be calculated. The prospects of fuelwood and financial savings are presented in Table 19.

Reduction of Waste

1. Introduction

There is a substantial amount of wastage of forest resources in various stages. It occurs right from felling of trees to the conversion of logs. Thus any strategy to reduce these losses will result in improvement of the supply position.

Table 19 - Prospects of Fuelwood and Financial Savings, (million)

Item	Units	Year				
		1993-98	1998-03	2003-08	2003-13	Total
Total urban households	No.	3.62	4.04	4.38	5.03	17.07
Fuelwood and other biomass using urban households	No.	1.88	2.16	2.65	2.83	9.52
Prospective users of improved stoves	No.	1.00	2.00	2.50	3.00	8.48
Expected number of improved stoves to be in actual use		0.300	0.800	1.250	1.650	3.95
Fuelwood Saving Prospect m^3)	M^3	0.123	0.389	0.784	0.852	2.15
Prospect of Financial Saving	Tk	116.10	369.90	745.20	810.00	2,041.20

There are more than 400 wood species in the natural hill forests of Bangladesh. Among them only a limited number of major species, not more than 40, are being extracted by the Bangladesh Forest Industrial Development Corporation (BFIDC). These are used commercially since the technological properties of these species are known. The rest of the species are not utilised or under utilized due to lack of the properties required for evaluating their end-uses. Finding no suitable use, this huge number of timber species is being left in the forests due to high transportation cost. The necessity of utilizing these hitherto unknown species has been felt for a long time. A research project has recently been completed by the Bangladesh Forest Research Institute (BFRI) to provide information in this regard. Various properties of 45 commercially less acceptable species have been determined and appropriate end-uses of these species have been recommended. The utilization of these species will reduce the wastage to some extent. The wastage due to logging and conversion processes may also be minimised by applying appropriate practices. These two aspects have been dealt with in detail by the Wood Processing Specialist of the FMP.

Apart from commercially important species, there are small logs, tops and branches which are not considered profitable due to the high cost of logging. A substantial wastage also occurs by retaining high stumps while felling. All this results in leaving behind 40 percent of standing trees and felled logs in the clear felled coupes (IUCN, 1991; Razzaque, 1988). These wastes are burnt as debris at the time of plantation. With the serious shortage of fuelwood, utilization of this timber in some form or other must be made.

From the stand point of economy, it is not feasible to transport low value timber from the source of supply to a long distance fuel market. It thus favours the conversion of wood to charcoal at the source.

2. Charcoal from Wastes

Charcoal is a carbonized wood consisting mainly of carbon, between 60-80 percent. It has a fine porous structure which aids the combustion of the carbon and tars burning with a short hot flame without production of smoke. It is not readily ignited, but once ignited, burns steadily giving much of its heat by radiation from the burning fuel bed. Wood, on the other hand, burns with a long flame and requires an efficient stove to achieve maximum efficiency.

Charcoal, unlike wood, is unaffected by insects or decay fungi. It can be stored indefinitely without deterioration. The friable nature of charcoal is an advantage in domestic use as pieces of the exact size required can easily be broken from larger lumps.

Charcoal has a calorific value about double that of air dried wood and nearly four times that of green wood. Charcoal is much lighter than wood since its density is one fraction of the original wood. It thus offers a saving in transport cost. Table 20 presents typical heat values of some fuels.

Table 20 - Calorific Values of Charcoal and Some Other Fuels

Fuel	Units	Btu	Kcal
Wood (air dried)	kg	3,100-3,400	3,799-4,190
Charcoal	kg	5,700-6,600	6,984-8,096
Coal	kg	5,700	6,984
Kerosene	kg	9,100	11,174
Natural gas	m^3	2,800	54,473

a. Consumption - Charcoal is useful as a fuel needed not only for domestic use but also for the metallurgical industry and as a raw material for chemical products. In Bangladesh, charcoal is produced for a wide variety of uses. There is however, no reliable statistics for its exact use and the amount consumed for different purposes. Latif (1982) roughly estimated that about 20,700 tonnes of charcoal are used annually in Bangladesh.

b. Production - Wood can be turned into charcoal using a wide range of carbonizing processes. These range from the traditional system of earth mound/pit kilns to highly complex, continuous rinsing gas retorts. For obvious reasons, the simple technology involving less capital investment is desired in Bangladesh. There are about 40 mound type mud kilns and 50 pit type mud kilns in the areas around Chittagong Hill Tracts and Khulna. These are of small capacity kilns ranging from 0.8 to 1.1 MT of charcoal/annum. There was an attempt by the BFIDC in the past to manufacture charcoal from the wastes of the Chittagong Hill Tract forests. Due to various reasons like lack of proper planning, appropriate technology and production arrangements, it did not materialise.

The conventional methods results in low yield, not more than 18-22 percent of the input of wood. With a view to increase the yield and quality of charcoal, the BFRI has been conducting research for the past few years. The initial finding is encouraging. The quantity and quality of charcoal can be substantially improved with some simple modifications. Thus the wastes of the trees can be profitably utilized by converting them into charcoal by using improved kilns modified by the

BFRI. There will be some unutilized materials, charcoal fines, etc., which can also be used for manufacturing briquettes. Briquetting needs simple technology which can be developed by the BFRI or adapted from the existing ones to suit our conditions.

Reduction of Waste

It is estimated that there will be about 100.000 m^3 equivalent to 70.400 tonnes of waste timber in the Chittagong hill forests during the 1993-98 period. Assuming the efficiency of the charcoal kilns as 20 percent and 75 percent utilization of the waste timber, the amount of charcoal produced only from the hill forests will be 10.560 tonnes.

During the 1998-03 period and onward their will be 150.000 m^3 equivalent to 105.600 tonnes of waste timber in the hill forests. During the second, third and fourth plan period, the amount of charcoal expected to be produced only from the hill forests amounts to about 15.840 tonnes.

The prices of charcoal can be estimated assuming the cost of charcoal as Tk 5/kg against the present market price of Tk 10/kg. For 1993-98 period and for each of the other three periods the prices will be Tk 52.8 million and Tk 79.2 million, respectively.

The prospects of production of charcoal and its related aspects are shown in Table 21.

Table 21 - Prospects of Production of Charcoal From Hill Forests

Item	Units	Year			
		1993-98	1998-03	2003-08	2008-13
Waste timber from the hill forests	000 MT	70.40	105.60	105.60	105.60
Prospect of Charcoal production	000 MT	10.56	15.84	15.84	15.84
Charcoal equivalent to fuelwood	000 m^3	30.00	45.00	45.00	45.00
Price of Charcoal	Tk million	52.80	79.20	79.20	79.20

Reduction of Demand by Using Substitutes

1. Biogas Plants

a. Introduction - Due to shortage of fuelwood animal dung is being used in domestic cooking in rural areas. It amounted to 71.7 PJ representing about 10 percent of the total consumption of the country's energy in 1990. The agricultural lands are thus being deprived of the natural fertilizer. A technology which turns animal dung to perform dual purposes such as energy as well as fertilizer is a desirable one. The production of biogas is such a technology which helps to achieve this end.

Biogas is a combustible gas obtained by anaerobic decomposition of animal and agricultural residues such as cowdung and other animal manure, night soil, household garbage, etc. The technology is simple and it needs to preserve the waste out of contact of air and to collect the gas from the top. The gas, predominantly consisting of methane and carbon dioxide, may be used for cooking, lighting and other purposes. The left over residue is an improved fertilizer.

b. Biogas Plant Studies - A considerable amount of studies have been conducted on the production and utilization of biogas over the last 15 years. The Institute of Fuel Research and Development of BCSIR, Chemical Engineering Department of BUET, Agricultural Chemical Department of BAU and Environment Pollution Control Department (EPCD, now Environment Department) are the major organisations involved in biogas development activities. Three distinct designs of the biogas plant have been developed/adapted for introduction in Bangladesh. These are:

-floating gas holder type plant
-fixed dome type plant
-bag type plant

A biogas plant requires dung from five adult cows to generate enough gas for daily cooking of a family of six-seven members. The cost of a family size plant of 3 m^3 gas capacity varies from Tk 5,000-10,000. Work is continuing in the IFRD to improve upon the digester design including its cost reduction.

c. Assessment of Biogas Plant Projects - There are no statistics as to the total number of biogas plants installed to-date in the country. It is gathered that more than 400 demonstration plants, have been set up in different locations. There have been several evaluations on the biogas projects. Implementation, Monitoring and Evaluation Division of the Planning Ministry evaluated the biogas plant project of the EPCD and the main findings are as follows (IMED, 1984):

Upto 1984, 219 plants were installed of which 110 plants of fixed dome type were unsuccessful, while 109 floating gas type plants were successful. The total investments were met from the government grant.

-The demonstration plant may be installed at government cost in each upazila. A part of the expense should be contributed to by the prospective users.

-Promotional and extension activities should be strengthened.

A Danida International Development Agency study group reported the following (Kock, 1984):

-Out of a total of 249 plants, 73 percent were found to be in operation.

-68 percent plants were privately owned, 26 percent by government organisations and 6 percent by others

-Most plant owners had over 1 ha of farm land and 6 head of cattle.

d. Bottlenecks in Plant Extension - In spite of its technical viability the biogas plant technology has not yet found widespread application. The following are some of the bottlenecks which have impeded its acceptance:

-The investment cost of the biogas plant is the main constraint which is prohibiting the average rural family to adopt it. The initial high cost has been reduced substantially by the IFRD.

-Lack of sufficient dung. The majority of the rural families do not have the minimum four-five cows to get enough gas for daily cooking and lighting.

-Gas storage is a problem which discourages some farmers from adopting it.

-Lack of understanding and appreciation of the technology are hindering its introduction.

2. Prospects for Fuelwood Demand Reduction

About 3 m^3 biogas may be produced daily from the droppings of four-five cows which is sufficient for cooking and lighting for a family of six-seven members. It is proposed that after proper assessment of the potential users, 10,000 biogas plants will be installed in each plan period totalling 40,000 units. It is envisaged that 10,000 units will be in use after two years of research and development during the 1993-1998 period. Therefore, the total amount of biogas production in this period is estimated as 32.4 million m^3.

During the 1998-2003 period, if another 10,000 units are introduced, then total number of units expected to be in operation is 15,000 which will produce biogas of 81.0 million m^3. Assuming that after 10 and 15 years, the total units to be in actual operation will be 20,000, which will produce biogas of 108.0 million m^3.

Gas equivalent to fuelwood can be estimated by using the conversion factor of 10,000 m^3 gas = 3.114 m^3 of fuelwood.

The prospects of biogas production and its related aspects are presented in Table 22.

Table 22 - Prospects of Biogas Plants and Related Aspects

Item	Units	Year			
		1993-98	1998-03	2003-08	2008-13
Number rural households	000	18,320	19,790	21,200	22,610
Number Prospective biogas plant users, households	000	10	20	30	40
Number of biogas plants expected	000	10	15	20	20
Biogas production	000 m^3	32.4	81.0	108.0	108.0
Reduction of fuelwood demand	000 m^3	0.101	0.252	0.336	0.336
Financial saving as gas equivalent to fuelwood	Tk million	96.9	239.4	319.2	319.2

Solar Energy

Bangladesh, because of its favourable location, receives an abundant solar radiation throughout the year. It receives 280 x 10^9 Mwh/year which is 100,000 times the energy generated as electricity in the country (Hossain, 1985). A fraction of this inexhaustible energy is being consumed by nature to produce biomass. If an additional fraction of the incoming energy is utilized, the country's energy scenario will change. However, the solar radiation reaches the earth in a very dilute form and its conversion to useful energy cannot be achieved efficiently unless an appropriate technology is employed. There are prospects to substitute some conventional and commercial energies with solar energy. The following are some of them.

Traditionally, there have been solar thermal applications in salt making and drying of fish, paddy and other agricultural products in the natural conditions. These do not involve any elaborate technique excepting proper exposure of the material in the sunshine. Since these are entirely dependent on the nature, there is no control over the time and quality of the products.

Water heating between 60-80° C can conveniently be done by solar heaters. The textile industry is one of the major industries in the country where water heating upto this temperature range is needed. There is a bright possibility of substitution of commercial energy by solar energy in textile and other industries requiring hot water. It needs a technology which is simple to design, build and maintain at a low cost. This type of heating may be used in hotels and restaurants for supplying hot water. The technology using concentrating collectors can give temperatures up to 300° C and may lead to their applications in different types of industries. These will, however need backup systems for cloudy and night periods.

There are possibilities of utilizing solar energy in domestic cooking, paddy processing, palm and sugar cane gur making. Solar cookers of the box type or dish type with a reflector have been developed to serve this purpose. The University of Dhaka, BCSIR and BUET are involved in research and development activities. Attempts were made in the past to popularise solar cookers, but were not be successful due to following reasons:

-Prior changes in social habits required.

-Evening meals may have to be cooked early, around noon.

-For the dish type solar cooker, it is necessary to periodically buff the reflector surface which cannot be done locally by the users.

In India and other countries solar cookers have become acceptable. In this country these should work for at least half the year and can save a substantial amount of energy. However, it may be necessary to develop appropriate type of solar cookers to suit our conditions.

There have been some successful developmental efforts in solar timber drier. Timber drying is an energy intensive operation requiring a substantial amount of heat energy. In Bangladesh, most of the timber is partially dried by air drying which is a very slow method and results in poor quality products. To overcome these shortcomings, artificial driers have been introduced. These need steam for heating and humidification. There are seven dry kiln plants in Bangladesh with 47 dry kiln units. In all the dry kilns waste timber is used for the production of steam. These dry kilns need about 50,000 m^3 of fuelwood annually for the production of steam. In order to save the conventional energy, a solar heated timber kiln has been developed at the BFRI. It is an inexpensive and simple technology which is found to be technically feasible and economically viable for drying timber. Apart from saving of fuelwood, the use of solar kilns would have a positive effect on wood conservation in Bangladesh. The satisfactory performance of the solar kilns has encouraged the wood based industries to adopt the technology. Nineteen prototype solar kilns have been installed by both private and public industries of the country as an extension service of the BFRI solar drying programme. (Sattar, 1990). It is recommended that, in the sawmill modernisation programme, there should be a provision for installing this type of seasoning kilns in the sawmill and furniture industries.

There are some solar drier designs for drying food crops, vegetable, fish, etc. The BUET and some NGOs have adapted drier models to suit our conditions. There have been extension works to popularise the technology. However, it has not been able to make any break through.

Photovoltaic (PV) electricity is becoming popular in many countries. The problem with solar electricity generation is that PV power is available only when the sun shines and therefore electricity has to be stored. This requires a large additional investment. In rural areas, the need for storage batteries is considered minimal. The power supplied during sunny hours should directly pump water and run agrobased industries while the energy requirement at night for lighting a village home is small. Apart from investment on batteries, the balance of the system cost for PV generation is incurred mainly on array structures, electrical wiring and electronics.

Low labour cost make these less expensive in Bangladesh. The price of solar cells has been coming down at a rapid rate. The cost of PV electricity is now US $ 1.25/Kwh as against US $ 3.00/Kwh in 1980. Solar cell is cost effective to meet the demand of isolated location throughout the world. It will be more so in Bangladesh.

The windspeed of Bangladesh is generally low averaging only 3-5 km/hour. In the coastal areas with annual average speeds of 12-13 km/hour and also in some inland locations with fairly good speeds, windmills may be installed. The cyclones and northwesterlies pose a problem since low cost windmill structures are likely to be damaged. The windspeed is high during the monsoon months when the solar radiation is low. So hybrid generation of electricity using wind turbines and solar cells may be considered for coastal islands.

Reduction of Demand by Using Commercial Fuels

In Bangladesh, all the four types of commercial fuels, oil, gas, coal and electricity are being used in varying degrees. The demand of fuelwood may be reduced by the increased use of these commercial fuels. The following are the existing positions and potentials to achieve this end.

1. Oil

There is only one known oil deposit at Haripur, Sylhet. It has a resource of 40 million barrels, of which 30 percent is reported as recoverable. Presently the well is producing 350 barrels of crude oil per day. The total requirement of petroleum of the country is about 2 million tonnes, most of which is met by import. The exploration activities, need to be accelerated for discovery of new gas fields to augment the local supply of petroleum. There is no possibility of significant increase in the use of oil in the near future.

2. Coal

Bituminous coal reserves have been discovered in three locations - Jamalganj (Bogra), Peerganj (Rangpur) and Barapukuria (Dinajpur). The estimated coal reserve at Jamalganj is 1,000 million tonnes and is located at a depth of about 1,000 metres. Extraction of coal at this location has not yet been possible due to existing techno-economic reasons. It may not even be possible in the foreseeable future for commercial exploitation.

Barapukuria and Peerganj coal reserves have been reported to be 250 million tonnes and 400 million tonnes respectively. A feasibility study has recently been completed for the Barapukuria coal mine. Coal is found to be deposited at a depth of 150 metres and it is techno-economically feasible for commercial exploitation. An investment project has been undertaken during the current Fourth Five Year Plan period for its development. If it is implemented, coal is expected to be available during the 1998-2003 period. The import of coal needs to be continued until such time it is not available within the country.

3. Peat

There are 600 million tonnes of peat deposits spread over large areas of the country, of which 133 million tonnes are located in Khulna and Faridpur regions. The average depth of peat layers in these regions varies between 2.0-2.5 metres with the overburden layers of 1.0-1.5 metre. A peat development project at Bhagibil near Madaripur and another project at Kolamouza near Khulna have been undertaken during the current Fourth Five Year Plan period. These are demonstration type projects designed to popularise peat for domestic and other uses. Due to shortage of energy, the people around those areas have already started using peat in spite of its pungent odour. It is, necessary to expedite the extraction of peat for domestic cooking and industrial uses like brick burning, road tarring, etc.

4. **Natural gas**

It is reported that in the 17 gas fields so far discovered, the total reserve of natural gas is estimated at 36.82 trillion cft of which 25.66 trillion cft is recoverable. Gas is being distributed to the seven cities in the eastern zone of the country for household cooking, production of fertilizer, electricity generation and direct energy use in some industries.

The west zone is in a difficult situation with respect to energy supply. For this reason the proposed Jamuna Multipurpose Bridge will have the facilities for gas and power interconnectors for transfer of gas and electricity from east to west zone. There will be provision for laying pipeline only and gas will not be transferred immediately after construction of the bridge. A study ascertaining the correct reserve of gas will be undertaken and in the event enough gas is available, it will then be considered to transfer gas over the bridge. There is no possibility of availability of natural gas during the 1993-98 period.

5. **Hydropower**

The total hydropower potential is reported as 1,500 Gwh/ annum at three locations of the country. There is only one installation at Kaptai which generates 230 MW electricity per annum. However, power generation capacity depends on the availability of water and, in turn, depends on intensity and duration of rain in the watershed areas of the Kaptai reserve. Two other potential sites on the Matamuhuri and Sangu rivers, if developed, would augment the supply of electricity.

6. **Nuclear Power**

There was a decision in the early sixties to install a nuclear power plant at Rooppur, Pabna to generate electricity but this has not yet been implemented. A 300 MW nuclear power plant has been found to be justified both technically and economically. If implemented, it is envisaged that nuclear power will be in the grid during 1998-03 period. It will help reduce the import of petroleum and supply the cleanest commercial energy in the west zone.

Impacts of the Development Programmes

There are many strategies to bridge the widening gap between the supply and demand of fuelwood. Plantation of trees should be considered as the primary strategy to augment the supply. Two scenarios of investment have been considered compared to the status quo. Scenario provides only slight improvement in the overall supply position (Table 17). The supply will be virtually static in all regions, except for the southern region. Under this region, there will be regular supply from the mangrove forests and from the large scale plantations along the coastal areas. It should be possible to meet the demand of this area from 1998 onward. There will be an overall deficit in each plan period ranging from 2.09 million m^3 in 1993 to 3.3 million m^3 in 2013 (Table 11). This calls for adopting strategies related to consumption of fuelwood.

Scenario 2 offers much better change of substantially improving rural fuel supply. Three development programmes, improved cooking stoves, charcoal kilns and biogas plants have been proposed for inclusion as Scenario 2.

1. **Financial Analysis**

The financial analysis of the programmes has been undertaken separately to assess the financial viability and attractiveness. The major benefits will come from the savings of fuelwood. The analysis is based on 20-year period. The results of the analysis suggest that all the programmes are financially attractive and yield IRR between 20 to 54 percent as shown in Table 23.

Table 23 - Summary of the Financial Analysis

Project	Average annual investment cost (million Tk)	Average annual benefit (million Tk)	IRR (%)	NPV @ 12% (million Tk)
Improved Cooking Stoves	37.76	575.50	45	1724,920
Charcoal Kilns	10.10	14.52	20	13,784
Biogas Plants	16.35	48.72	54	153.519

2. Programme Benefits

The potentials of benefits in terms of fuelwood savings are summarised in Table 24. These benefits are expected to be obtained from the three energy saving programmes as well as implementation of two wood energy policies. A revised supply-demand balance of fuelwood will evolve if these benefits are incorporated. Table 18 shows such supply-demand balance, the details of which are shown in Appendix 3.

Table 24 - Summary of Prospects of Fuelwood Saving

Project/Policy	Fuelwood (million m³)			
	1993-98	1998-03	2003-08	2008-13
Development projects				
- Improved cooking stoves	0.123	0.389	0.874	0.852
- Charcoal equivalent to fuelwood	0.030	0.045	0.045	0.045
- Biogas equivalent to fuelwood	0.101	0.252	0.336	0.336
Subtotal	0.254	0.686	1.165	1.233
Policy implementation				
- Brick burning	0.809	1.079	1.349	1.618
- Road tarring	0.089	0.114	0.130	0.147
Subtotal	0.907	1.193	1.479	1.765
Total	1.161	1.879	2.644	2.998

Remarks

There will be a significant amount of saving of fuelwood due to introduction of the energy saving programmes. These savings range from 0.254 million m³ in 1993 to 1.233 million m³ in 2013. Compared to the proposed modest investment, these savings may be considered as quite substantial. In addition, savings are expected to derive from the beneficial effects of the policy implementation. Brick burning and road tarring consume the major share of fuelwood in the industrial sector. If the use of fuelwood is stopped in these industrial applications, there will be a significant savings of fuelwood amounting to 0.907 million m³ in 1993 and 1.765 million m³ in 2013. The total savings can bring noticeable change in the supply and demand situation of fuelwood (Table 24). The shortfall in the north and central regions will come down quite appreciably. The west, south-east and north-east regions will also have less adverse effects of deficit. For economic reasons, the demand of fuelwood has to be met from the local supply. Surplus fuelwood can be utilized locally by converting to charcoal which is considered environmentally more desirable for urban use.

To meet the demand of the deficit areas, fuelwood plantation programmes have to be intensified. Scenario 2 is considered for high investment in forest management. This investment is expected to meet much of the shortfall of fuelwood which still exist in the five regions (Table 17). However, commercial fuels like coal, peat, gas and electricity from nuclear power are expected to be made available during the plan period. These energy sources will also ease the fuelwood shortage problem.

INVESTMENT REQUIREMENTS

Improved Cooking Stoves

a. **Objectives** - Domestic cooking consumes the largest share of fuelwood and other biomass fuels. The general objective of the improved stoves project is to reduce the wastage and conserve the biomass fuels. The specific objectives are as follows:

- To develop or adapt suitable improved cooking stoves for different end-uses.

- To replace the traditional stoves with improved stoves.

- To save fuelwood and other biomass fuels in order to ease fuelwood problems.

- To improve environmental conditions surrounding the energy consuming stoves.

b. **Beneficiaries** - The main beneficiaries would be primarily urban households using the stoves for domestic cooking and for industrial applications in 57 districts headquarters where there is no gas supply.

c. **Implementing Agency** - In Bangladesh, formal research and development activities of the improved stoves are being undertaken by the IFRD of BCSIR. Cumulative research experience in a particular research organisation is useful for effective implementation of the project. The IFRD may be considered as a potential implementing agency.

1. **Implementation**

a. **Research** - Research should be undertaken to asses the existing improved stoves to identify improvements and appropriate mechanisms for diffusion and dissemination of the stoves developed in different organisations, particularly the BCSIR and BUET. The strategies for extension and dissemination of different models have to be formulated based on the research.

b. **Training** - Training materials should be prepared based on the research. Programmes have to be organised for the trainers, manufacturers, technicians and users, particularly women, in all 57 districts of the country.

c. **Production and Manufacture** - Trained technicians and artisans will undertake production and manufacturing of the improved stoves under the supervision of the implementing agency.

d. **Extension and Promotion** - The success of extension will largely depend on the efficiency of organising the training programme. The implementing agency will support all expenditures and provide technical assistance to the extension workers. Considering that it is not cost effective to maintain a separate extension network, the services of existing extension agents which have direct links with the users may be taken. The NGOs, REB, Women's Cooperative, Social Welfare extension network, etc., may be considered for the purpose.

The implementing agency will undertake all promotional activities to create mass awareness of conservation of fuelwood through the improved stoves. Publicity campaigns through the mass media, educational institutions, social organisations, district level workshops and exhibitions should be organised.

e. Financing - The research, training, extension and promotion components will be financed by the implementing agency from the project costs. The expenditures for initial construction and setting up of different types of the improved stoves will also be borne by the implementing agency.

Trained technicians and stove manufacturers may be supported by organising credit to initiate manufacturing on a large scale commercial basis. Credit support may also be organised for the users to install improved devices in industry and community cooking areas.

f. Monitoring and Evaluation - In order to assess the progress and adjust the implementing strategies, the implementing agency will undertake regular monitoring and follow-up activities. The project should periodically be evaluated independently.

g. Backup Service - In each district there should be one trained graduate technician who will impart necessary back-up services as well as look after the improved stoves installed in the area. For this purpose a mini centre has to be created in each 57 districts

Table 25 - Improved Cooking Stove Investment Requirements

Item	Quantity	Amount Tk million				
		1993-98	1998-03	2003-08	2008-13	Total
a) Research and development		5.00	3.00	-	-	8.00
b) Construction and setting up improved stoves	3000,000 units	125.00	125.00	62.50	62.50	375.00
c) Training of trainers and users	57 districts	6.00	6.00	6.00	6.00	24.00
d) Promotional activities including exhibitions and workshops	57 districts	8.00	8.00	8.00	8.00	32.00
e) Mobile audiovisual unit	2 units	7.50	-	7.50	-	15.00
f) Vehicle + Bicycle	2 units+114 units	1.50	-	1.50	-	3.00
g) Extension and dissemination	57 districts	5.00	5.00	5.00	5.00	20.00
h) Monitoring and evaluation	57 districts	5.00	5.00	5.00	5.00	20.00
i) Travel		1.50	1.50	1.50	1.50	6.00
j) Fuel and oil		1.50	1.50	1.50	1.50	6.00
k) Pay and other recurring expenditures	57 centres	25.00	25.00	25.00	25.00	100.00
Total		191.00	180.00	123.50	114.50	609.00

h. Policy Support - A country wide programme on large scale dissemination of improved stoves cannot be successfully implemented without the active support of policy planners and decision makers. Policy supports are needed to achieve inter-agency collaboration and coordination at national as well as field levels.

The methodical approach recommended for the implementation of the project has been detailed in the earlier section.

Table 25 shows the investments required for implementing the improved cooking stoves.

Charcoal from Wastes

a. Objectives - The general objective of the charcoal project is to reduce the wastes left in the forests after logging in order to maximise the wood utilisation. The specific objectives are as follows:

- To develop appropriate technologies for the production of charcoal and briquettes.

- To manufacture charcoal and briquettes commercially utilising wastes.

b. Beneficiaries - Charcoal and wood briquette users, in particular, smithies, restaurants, laundries, rubber processing industries, ceremonies, farmers and for producing certain chemicals.

c. Implementing Agency - The Bangladesh Forest Research Institute will develop appropriate technologies for charcoal and wood briquette production with BFIDC undertaking production and marketing activities.

1. Implementation

The following approach is recommended for the implementation of the project:

a. Research - Research should be undertaken to assess the existing traditional charcoal kilns and identify possible improvements. The BFRI models will also be assessed and modified to suit the conditions of the country. The final selection of the models should be based on the results of the research.A provisional selection of the models may be as follows:

- Mound type mud kiln for one time use at the site of felling.

- Mound type brick kiln for long time use.

- Portable drum kiln for long time use at the site of felling.

- Briquetting equipment will be adapted from the existing models.

b. Training - Training materials should be prepared based on the research. The BFRI will impart training to the trainers, manufacturers, technicians and other relevant personnel of the production and marketing agency, i.e. BFIDC. Emphasis should be given to training the local people at the felling sites.

c. Production and Marketing - The charcoal and briquetting kilns will be constructed under the supervision of the BFRI. Trained technicians will undertake production of charcoal and briquetting under the supervision of the BFIDC field officials. Marketing arrangements will be made by the BFIDC for the products.

d. Extension and Promotion - Simple and inexpensive mud kiln technology will be disseminated to the local people so that they can also manufacture charcoal. NGOs and other organisations involved in the extension works may be considered for extension purposes.

The implementing agency will undertake promotional activities to motivate the people/organisations to use the improved fuel like charcoal and wood briquettes.

e. Financing - Research and training will be financed by the BFRI from the project costs. The expenditures for the construction of charcoal kilns, extension and promotional activities will be borne by the BFIDC on a commercial basis. Table 26 shows the investments which are required.

Table 26 - Charcoal Briquetting Investment Requirements

Item	Quantity	Amount Tk million				
		1993-98	1998-03	2003-08	2008-13	Total
Research component						
a) Research and development		3.00	1.00	1.00		5.00
b) Equipment	4 Nos.	7.00	3.00			10.00
c) Training	10 Nos.	3.00	2.00	2.00		7.00
d) Vehicle	1 No.	1.50				1.50
e) Contingencies		2.50	2.00	2.00		6.50
Subtotal		17.00	8.00	5.00		30.00
Production component						
a) Charcoal kilns Mound type mud and brick	30 Nos.	0.60	0.15	0.15	0.20	1.10
Portable drum type	100 Nos.	2.00	0.05	0.05	0.10	2.20
b) Briquetting equipment	8 Nos.	0.30	0.30	0.30	0.30	1.20
c) Weighing balance	10 Nos.	0.25		0.25		0.50
d) Crosscut saw	2 Nos.	0.20				0.20
e) Transport						0.00
Jeep	2 Nos.	1.50		1.50		3.00
Truck	6 Nos.	6.00		6.00		12.00
Motor Cycle	6 Nos.	0.15		0.15		0.30
f) Fuel		1.00	1.00	1.20	1.40	4.60
g) Pay and other recurring expenditures		3.00	4.00	4.00	5.00	16.00
Subtotal		15.00	5.50	13.70	7.00	41.20
Total		32.00	13.50	18.70	7.00	71.20

Biogas Plants

a. Objectives - The general objective of the project is to reduce the demand of fuelwood by a substitute like biogas. The specific objectives are as follows:

- To develop or adapt suitable plants for the production of biogas.

- To supply alternative improved fuel to the villages for cooking and lighting.

- To help replenish the farm lands with natural fertilizer.

b. **Beneficiaries** - The beneficiaries are primarily rural farmers using the plants for domestic cooking and for paddy parboiling in fuelwood scarce districts, particularly the north-western region.

c. **Implementing Agency** - The Institute of Fuel Research and Development of the BCSIR may be considered as the potential implementing agency.

1. **Implementation**

Based on experiences and evaluation of past efforts, the following approach is recommended for implementation.

a. **Research** - Research should be undertaken to assess the biogas plants developed or adapted so far by the different organisations. The floating gas holder type plant may be provisionally selected. Further improvement on the design of the digester, use of other biomass, particularly water hyacinth and cost reduction, may be taken up to make the technology more attractive to the users. The final selection of the design should be based on the results of the research.

b. **Extension and Promotion** - The potential for biogas users should first be assessed before undertaking any extension work. The need for fuel, economic size of the plant and availability of dung should be considered. The success of the extension will largely depend on the selection of the proper endusers. Those areas which have the lest fuelwood, particularly the northern part of the country, should be given priority.

The implementing agency will undertake promotional activities to create awareness and appreciation of the biogas technology in general, and conservation of natural fertilizer in particular. This promotional programme may be coordinated with the Improved Cooking Stove Programme.

c. **Training** - Training programmes have to be organised for the trainers, manufactures, technicians and users, particularly women, for operation of the plants.

d. **Manufacture** - Standard design of biogas plants should be made available according to the general need of the consumers. Credit facilities may be extended to the biogas plants built under the supervision and participation of trained personnel.

e. **Financing** - The research, training, extension and promotion components will be financed by the implementing agency. The initial expenditures in the form of subsidy may be covered from the project's cost. A portion of the expenditures may be charged from the users. (Subsidies to the extent of 90 percent are given in India (Eusuf, 1985)).

f. **Monitoring and Evaluation** - Regular monitoring and evaluation of the progress of the biogas project should be undertaken. Improvements and adjustments, if necessary, may be made according to the evaluation report.

g. **Backup Service** - There should be adequate backup services for the biogas plants installed in each locality. The technicians recruited for the Improved Cooking Stove project may be trained and utilized for this purpose as well.

The investments required for implementing the biogas plants project are shown in Table 27.

Table 27 - Biogas Plant Investment Requirements

Item		Quantity	Amount Tk million				
			1993-98	1998-03	2003-08	2008-13	Total
a)	Research and development		5.00	3.00	-	-	8.00
b)	Manufacture and setting up of biogas plants	40,000	75.00	75.00	75.00	75.00	300.00
c)	Training of trainers and users	40	0.50	0.50	0.50	0.50	2.00
d)	Promotional activities	20	1.00	1.00	1.00	1.00	4.00
e)	Extension and dissemination	40	1.00	1.00	1.00	1.00	4.00
f)	Monitoring and evaluation	20	0.50	0.50	0.50	0.50	2.00
g)	Travel expenses		0.50	0.50	0.50	0.50	2.00
h)	Contingencies		1.00	1.00	1.00	1.00	4.00
Total			84.5	82.5	79.5	79.5	326.00

Wood Energy Plantation Research

a. **Objectives** -The general objective of the project is to select site specific fuelwood species for large scale plantation in different localities in order to help solve the fuelwood shortage problem. The specific objectives are as follows:

- To select the most suitable species out of the indigenous and exotic tree species for raising fuelwood plantations with reference to a particular site.
- To determine the optimum spacing of the selected species.
- To determine the rate of growth and yield and their return in terms of biomass.
- To raise pilot plantations in different dendroecological regions.

b. **Scope** - The 1981 Second Forestry Programme was introduced in Bangladesh to undertake fuelwood plantations on farms and marginal lands. The rural people, who are the worst sufferers of the fuelwood scarcity, are interested in participating in plantation activities. There is a need to develop an appropriate mechanism for effective participation of the farmers.

Large scale plantation is needed to cope with the widening gap between the supply and demand. The availability of suitable species, knowledge of proper spacing and economic rotation age, etc. are the pre-requisites. BFRI has been conducting research to achieve this end. Eucalyptus camaldulensis, one of the most suitable species, now being planted in many areas, is the outcome of BFRI's research. Initial research works on other twelve species such as, Acacia auriculiformis, A. nilotica, Albizzia lebbek, A. chinensis, A. procera, A. lucida, Casuarina equisetifolia, Cassia siamea, Dalbergia sissoo, Leucaena leucocephala, Albizzia falcateria and Samanea saman have been completed. Verification of the research findings in actual field conditions is needed. The final recommendations should be based on such on-farm trials. This calls for pilot plantation of the promising species, particularly fast growing, coppicing, multipurpose trees, which will generate useful information and also serve as demonstration plots.

c. **Beneficiaries** - Beneficiaries will be the Forest Department and participatory farmers.

d. **Implementing Agency** - The Bangladesh Forest Research Institute, Chittagong will be the implementing agency.

1. **Implementation**

The following approach is recommended.

- Research on thirteen fuelwood species already undertaken should be continued. While selecting new species, emphasis should be given to multipurpose tree species.

- Selected species should be raised as pilot plantations in different dendroecological regions.

- Data on growth and yield will be taken and total biomass assessed.

- Observe variations in the physical, chemical and nutritional properties of the soil before and after the plantation in each location.

- Observe the incidence of pest and disease in the plantations.

- Prepare volume tables of the selected species to facilitate better management and exploitation of the species.

- Final selection of species, particularly of the exotic species, to be.made on the basis of research.

- The technology of the plantation of fuelwood species should be packaged and transferred to the FD, concerned NGOs and farmers.

Table 28 show the investments required for implementing the energy wood plantation research project.

Table 28 - Wood Energy Plantation Financial Requirements

Item	Amount Tk million		
	1993-98	1998-03	Total
a) Research expenses	2.00	2.00	4.00
b) Nursery preparation and plantation	5.00	5.00	10.00
c) Maintenance and improvement of research plots	2.50	2.50	5.00
d) Equipment and accessories	10.00	-	10.00
e) Water facilities	1.50	-	1.50
f) Power facilities	2.00	-	2.00
g) Transport - Pickup	1.50	-	1.50
h) Fuel and oil	1.00	1.00	2.00
i) Travel expenses	0.50	0.50	1.00
g) Contingencies	2.00	2.00	2.00
Total	28.00	13.00	41.00

APPENDIX 1
ABBREVIATIONS, TERMS AND CONVERSION FACTORS

PROJECT 372001/16
FORESTRY MASTER PLAN
BANGLADESH (TA NO. 1355-BAN)

ASIAN DEVELOPMENT BANK
MANILA PHILIPPINES
DATE: 18 AUGUST 1992

WOOD ENERGY

APPENDIX 1
ABBREVIATIONS, TERMS AND CONVERSION FACTORS

ABBREVIATIONS

ACCF	- Assistant Chief Conservator
ADAB	- Association of Development Agencies Bangladesh
ADB	- Asian Development Bank
ADT	- Airdry Metric Tonne
AWB	- Asian Wetland Bureau
BARC	- Bangladesh Agricultural Research Council
BCIC	- Bangladesh Chemical Industries Corporation
BEPP	- Bangladesh Energy Planning Project
BES	- Bangladesh Energy Survey
BFD	- Bangladesh Forest Department
BFIDC	- Bangladesh Forest Industries Development Corporation
BFRI	- Bangladesh Forest Research Institute
BMA	- Brick Manufacturers Association
BMRE	- Balancing Modernisation Rehabilitation and Expansion
BSCIC	- Bangladesh Small Scale Cottage Industries Corporation
BSCIS	- Bangladesh Small and Cottage Industries Corporation
BTU	- British thermal unit
CAI	- Current annual increment
CCB	- Copper sulphate, Sodium dichromate and Boric acid
CCF	- Chief Conservator Forests
CF	- Conservator Forests
cft (H)	- Cubic feet hoppus (.785 x true cubic foot)
cft (T)	- Cubic foot true volume (1.27 x Hoppus cubic foot)
CHT	- Chittagong Hill Tracts
cm	- Centimetre
crore	- Ten million
DCCF	- Deputy Chief Conservator
DCF	- Deputy Conservator Forests
DFO	- Divisional Forest Officer
ESCAP	- Economic and Social Commission Asia Pacific
FAO	- Food and Agriculture Organization of the United Nations
FDTC	- Forest Development and Training Centre
FIRR	- Financial Rate of Return
FMP	- Forestry Master Plan Project
FRM	- fibrous raw materials
Giga	- measurement unit, equals 10^7
GJ	- giga joules
gm	- gram
GR	- Game Reserve
GS	- Game Sanctuary
GWh	- giga watt hours
ha	- Hectare
hp	- Flywheel horse power
hr	- Hour
IDRC	- International Development Research Centre, Canada
Kcal	- kilocalorie
kg	- Kilogram
KHM	- Khulna Hardboard Mill
km	- Kilometre
km^2	- Square kilometre
KNM	- Khulna Newsprint Mill
KPM	- Karnafuli Paper Mill
KRC	- Karnafuli Rayon Complex
kw	- kilowatt
lakh	- one hundred thousand
LGEB	- Local Government Engineering Board
LPC	- Lumber Production Complex (Kaptai)
m	- Metre
m^2	- square metre
m^3/ha/A	- Cubic metre per hectare per annum
MAI	- Mean annual increment
max	- Maximum
md	- Man day
MEOF	- Ministry of Environment and Forest
min	- Minimum

mm	- Millimetre
MMCF	- million cubic feet
MT	- Metric Ton
MW	- mega watt
MWh	- mega watt hours
NACOM	- Nature Conservation Movement
NEMAP	- National Environmental Management Action Plan
NGO	- Nongovernment organization
No.	- Number
NRS	- Natural Regeneration Strip
ODA	- Overseas Development Agency
Peta	- measuremetn unit
PJ	- peta joules, equals 10^6 giga joules
POTHIKRIT	- Nongovernment Organization
POUSH	- Nongovernment Organization
PWD	- Public Works Department
RF	- Reserve Forest
RHD	- Roads and Highways Department
SIDA	- Swedish International Development Agency
SPPM	- Sylhet Pulp and Paper Mill
TEX	- Timber Extraction (Kaptai)
Tk	- Taka
UNCED	- UN Conference on Environment and Development

TERMS

agroforestry - A set of landuse systems that combine trees with pasture, arable crops, and/or animal production on the same land unit, either simultaneously or in short sequence. This agroforestry is a set of technologies or practices, as distinct from a program or policy. Certain agroforestry technologies find valuable application in programs of social forestry or community forestry.

amenity forestry - Forestry for the purpose of recreation, pleasure, or general beautification of an area or a settlement.

beel - deep water , central portion of an haor.

bidi -inexpensive cigaratte

dao - Large hand-held work knife

dumb barge - Barge requiring towing or pushing, a high-sided vessel used for water transportation and without propulsion means on board

gur -raw sugar

hoar - dish-shaped freshwater swamp.

mahal - Contract block, wood or bamboo

mahaldar - Wood Contractor

yarding - Moving logs from stump site to roadside

water bar - Earthen berm installed across road ways to control water flow to prevent road erosion.

social forestry - The use of trees, and/or tree planting, to pursue social objectives (usually betterment of the poor). Social forestry is a program that may include many elements of agroforestry. It often includes, but is not interchangeable with, community forestry, which has a narrower meaning. A broader discussion of the term follows in the chapter section on case studies.

wasteland - Land that is currently producing useful biomass grossly below its potential. The reasons for underproduction may be many and varied, from technical (salinity, acidity or alkalinity, waterlogging) to social (disputed ownership or rights) or political (forest department or community ownership).

CONVERSION FACTORS

US $ 1	- Tk 38.8
Tk	- US 0.0258
1 m^3	- 27.7 cft Hoppus
1 cft(H)	- 1.2732 cubic feet true - cft(t)
1 cft(t)	- one cubic foot true solid volume
maund	- 37.33 kg
1 km	- 0.621 miles
1 ha	- 2.471 acres
1 litre	- 0.220 imperial gallons
ton	- 2,000 lbs
tonne	- 1,000 kilograms

teak	- 1,080 kg/ m^3, green weight
gamar	- 650 kg/ m^3, green weight
melocanna	- 450 kg/ m^3, green weight
1000 culms muli bamboo	- 1.8 ADT
1000 culms other bamboo	- 1.6 ADT
Raw ton	- 0.67 ADT

APPENDIX 2
TERMS OF REFERENCE

PROJECT 372001/16
FORESTRY MASTER PLAN
BANGLADESH (TA NO. 1355-BAN)

ASIAN DEVELOPMENT BANK
MANILA PHILIPPINES
DATE: 18 AUGUST 1992

WOOD ENERGY

APPENDIX 2
TERMS OF REFERENCE

The Terms of Reference for the Wood Energy Specialist are:

1) Review existing data and reports on biomass energy consumption, by types (e.g., fuelwood, crop residue, dung, etc.) and by end uses.

   Estimate requirements in the next ten years and compare with available supply; assess the prospects to enhance supply, keeping in mind the advantages and disadvantages of any alternative fuels.

2) Recommend further studies which may be necessary to gain a better understanding of biomass consumption in Bangladesh.

3) Assess the possible impact of relevant Government biomass energy policy upon tree resources, in particular the ban on the use of fuelwood in the brick industry.

4) Examine the concept of developing more efficient stoves, and critically assess earlier and ongoing efforts to introduce innovations in this regard.

5) Recommend strategy to address the fuelwood supply shortage which would balance supply and demand as quickly as possible.

6) Develop project profiles of potential projects to implement the strategy, including a broad outline of objectives, scope, implementation arrangements, and investment requirements.

7) Prepare a consultancy report, in English, containing the findings and recommendations.

APPENDIX 3
FUELWOOD SUPPLY AND DEMAND

PROJECT 372001/16
FORESTRY MASTER PLAN
BANGLADESH (TA NO. 1355-BAN)

ASIAN DEVELOPMENT BANK
MANILA PHILIPPINES
DATE: 18 AUGUST 1992

WOOD ENERGY

APPENDIX 3
FUELWOOD SUPPLY AND DEMAND BALANCE

1 - FUELWOOD SUPPLY AND DEMAND BALANCE, 000 M^3/ A

1a. STATUS QUO SUPPLY AND PRESENT DEMAND TREND

Zone	Source	1993	1998	2003	2008	2013
North West	Natural Forest	1	2	2	3	3
	Long Plantations					
	Medium Plantations	-	3	3	4	4
	Public Program	24	21	20	26	38
	Village Forest	857	943	1037	1141	1255
	Total Supply	882	969	1062	1174	1300
	Domestic	1289	1404	1520	1636	1751
	Industrial/ Commercial	719	791	870	957	1053
	Total Demand	2008	2195	2390	2593	2804
	Balance +/-	-1126	-1226	-1328	-1419	-1504
North Central	Natural Forest	4	6	10	15	20
	Long Plantations					
	Medium Plantations	-	3	4	6	10
	Public Program	24	25	24	34	49
	Village Forest	735	809	889	978	1076
	Total Supply	763	843	927	1033	1155
	Domestic	1162	1267	1372	1476	1580
	Industrial/ Commercial	650	714	785	863	950
	Total Demand	1812	1981	2157	2339	2530
	Balance +/-	-1049	-1138	-1230	-1306	-1375
West	Natural Forest					
	Long Plantations					
	Short Plantation					
	Public Program	28	27	29	37	54
	Village Forest	518	570	627	690	759
	Total Supply	546	597	656	727	813
	Domestic	722	786	851	916	981
	Industrial/ Commercial	442	486	535	588	646
	Total Demand	1164	1272	1386	1504	1627
	Balance +/-	-618	-675	-730	-777	-814

South	Natural Forest	110	110	110	110	110
	Long Plantations	-	-	-	-	-
	Medium Plantations	21	21	14	71	172
	Public Program	12	11	9	10	13
	Village Forest	717	789	868	955	1051
	Total Supply	860	931	1001	1146	1346
	Domestic Industrial/ Commercial Total Demand	567 281 848	618 309 927	669 340 1009	720 374 1094	771 411 1182
	Balance +/-	+13	+4	-8	+52	+164
South East	Natural Forest	29	29	29	29	29
	Long Plantations	5	5	10	10	31
	Medium Plantations	23	23	28	239	294
	Public Program	24	21	21	23	28
	Village Forest	776	854	939	1033	1136
	Total Supply	857	932	1027	1334	1518
	Domestic Industrial/ Commercial Total Demand	877 490 1367	956 538 1494	1035 592 1627	1113 652 1765	1192 717 1909
	Balance +/-	-510	-562	-600	-431	-391
North East	Natural Forest	4	4	4	4	4
	Long Plantations	7	7	7	7	7
	Medium Plantations					
	Public Program	12	18	21	29	39
	Village Forest	368	405	446	491	540
	Total Supply	391	434	478	531	590
	Domestic Industrial/ Commercial Total Demand	643 360 1003	701 395 1096	759 434 1193	817 578 1295	875 525 1400
	Balance +/-	-612	-662	-715	-764	-810

CHT	Natural Forest	45	45	45	45	45
	Long Plantations	10	18	8	7	16
	Short Plantation					
	Public Program					.
	USF	1825	1725	1625	1525	1425
	Total Supply	1880	1788	1678	1577	1486
	Domestic Industrial/ Commercial Total Demand	49 23 72	53 26 79	58 27 85	62 31 93	66 34 100
	Balance +/-	1808	1709	1593	1484	1386
All Strata	Natural Forest	193	196	200	206	211
	Long Plantations	22	30	25	24	54
	Medium Plantations	44	50	49	320	480
	Public Program	124	123	124	159	221
	Village Forest	3971	4370	4806	5288	5817
	USF	1825	1725	1625	1525	1425
	Total Supply	6179	6494	6829	7522	8208
	Domestic Industrial/ Commercial Total Demand	5309 2963 8272	5785 3260 9045	6264 3583 9847	6740 3942 10682	7216 4337 11553
	Balance +/-	2093	-2551	-3018	-3470	-3345

* Public Program = Strip Plantation, Agroforestry, Wood lot and Khet land.
* USF = Unclassed State Forest * Long and medium rotation plantations.
* 1,845,000 m^3 from USF, decreasing by 100,000 every 5-year period.

1b. SCENARIO 1 WOOD SUPPLY AND PRESENT DEMAND TREND, 000 m^{3}/A

Zone	Source	1993	1998	2003	2008	2013
North West	Natural Forest	1	2	2	3	3
	Long Plantations					
	Medium Plantations	-	3	10	19	38
	Public Program	37	35	50	58	109
	Village Forest	857	943	1140	1300	1550
	Total Supply	895	983	1202	1380	1700
	Domestic Industrial/ Commercial Total Demand	1289 719 2008	1404 791 2195	1520 870 2390	1636 937 2593	1751 1053 2804
	Balance +/-	-1113	-1212	-1188	-1213	-1104
North Central	Natural Forest	4	6	10	15	20
	Long Plantations	-				
	Medium Plantations	-	3	75	150	300
	Public Program	37	39	56	64	142
	Village Forest	735	809	980	1080	1200
	Total Supply	776	857	1121	1309	1662

	Domestic Industrial/ Commercial Total Demand	1162 650 1812	1267 714 1981	1372 785 2157	1476 863 2339	1580 950 2530
	Balance +/-	-1036	-1124	-1036	-1030	-868
West	Natural Forest					
	Long Plantations					
	Medium Plantations					
	Public Program	45	43	62	70	155
	Village Forest	530	585	590	800	940
	Total Supply	575	628	652	870	1095
	Domestic Industrial/ Commercial Total Demand	722 442 1164	786 486 1272	851 535 1386	916 538 1504	981 646 1627
	Balance +/-	-589	-644	-734	-634	-532
South	Natural Forest	110	110	110	110	110
	Long Plantations					
	Medium Plantations					
	Public Program	20	18	25	26	45
	Village Forest	717	789	940	1100	1200
	Total Supply	847	917	1075	1236	1355
	Domestic Industrial/ Commercial Total Demand	567 281 848	618 309 927	669 340 1009	720 374 1094	771 411 1182
	Balance +/-	-1	-10	+66	142	173
South East	Natural Forest	29	29	29	29	29
	Long Plantations	5	5	10	10	31
	Medium Plantations	23	48	68	279	492
	Public Program	37	33	48	45	84
	Village Forest	776	854	1030	1200	1350
	Total Supply	870	969	1185	1563	1986
	Domestic Industrial/ Commercial Total Demand	877 490 1367	956 538 1494	1035 592 1627	1113 652 1765	1192 717 1909
	Balance +/-	-497	-525	-442	-202	177
North East	Natural Forest	4	4	4	4	4
	Long Plantations	7	7	7	7	7
	Short Plantation	-	-	-	-	-
	Public Program	20	27	39	58	109
	Village Forest	368	405	486	550	650
	Total Supply	399	443	536	619	770

	Domestic Industrial/ Commercial Total Demand	643 360 1003	701 395 1096	759 434 1193	817 578 1295	875 528 1400
	Balance +/-	-604	-653	-657	-676	-630
CHT	Natural Forest	45	45	45	45	45
	Long Plantations	10	18	8	7	16
	Short Plantation	-	-	-	-	-
	Public Program	-	-	-	-	-
	USF	1825	1725	1625	1525	1425
	Total Supply	1880	1788	1678	1577	1486
	Domestic Industrial/ Commercial Total Demand	49 23 72	53 26 79	58 27 85	62 31 93	66 34 100
	Balance +/-	1808	1709	1593	1484	1386
All Strata	Natural Forest	193	196	200	206	211
	Long Plantations	22	30	25	24	54
	Medium Plantations	23	54	153	448	830
	Public Program	196	195	280	321	644
	Village Forest	3983	4385	5166	6030	6890
	USF	1825	1725	1625	1525	1425
	Total Supply	6242	6585	7449	8554	10054
	Domestic Industrial/ Commercial Total Demand	5309 2963 8272	5785 3260 9045	6264 3583 9847	6740 3942 10682	7216 4337 11553
	Balance +/-	-2030	-2460	-2298	-2128	-1499

* Public Program = Strip Plantation, Agroforestry, Wood lot and Khet land.
* USF = Unclassed State Forest * Long and medium rotation plantations.
a From 190 ha of medium rotation new plantations.
b From 935 ha of medium rotation new plantations.

1c. SCENARIO 1 WOOD SUPPLY AND RECOMMENDED PROGRAMS, 000 m^3/A

Zone	Source	1993	1998	2003	2008	2013
North West	Natural Forest	1	2	2	3	3
	Long Plantations					
	Medium Plantations	-	3	10	19	38
	Public Program	37	35	50	58	109
	Village Forest	857	943	1140	1300	1550
	Total Supply	895	983	1202	1380	1700
	Domestic Industrial/ Commercial Total Demand	1289 499 1788	1350 563 1913	1364 470 1834	1364 587 1951	1463 614 2077
	Balance +/-	-893	-930	-632	-571	-377

North Central	Natural Forest	4	6	10	15	20
	Long Plantations	-				
	Medium Plantations	-	3	75	150	300
	Public Program	37	39	56	64	142
	Village Forest	735	809	980	1080	1200
	Total Supply	776	857	1121	1309	1662
	Domestic	1163	1218	1231	1231	1320
	Industrial/ Commercial	450	509	514	530	554
	Total Demand	1613	1727	1745	1761	1874
	Balance +/-	-837	-870	-624	-452	-212
West	Natural Forest					
	Long Plantations					
	Medium Plantations					
	Public Program	45	43	62	70	155
	Village Forest	530	585	590	800	940
	Total Supply	575	628	652	870	1095
	Domestic	721	756	764	764	819
	Industrial/ Commercial	319	359	367	381	401
	Total Demand	1040	1115	1131	1145	1220
	Balance +/-	-465	-487	-479	-275	-125
South	Natural Forest	110	110	110	110	110
	Long Plantations					
	Medium Plantations					
	Public Program	20	18	25	26	45
	Village Forest	717	789	940	1100	1200
	Total Supply	847	917	1075	1236	1355
	Domestic	567	594	600	600	644
	Industrial/ Commercial	184	209	208	211	219
	Total Demand	751	803	808	811	863
	Balance +/-	+96	+114	+267	+425	+492
South East	Natural Forest	29	29	29	29	29
	Long Plantations	5	5	10	10	31
	Medium Plantations	23	48	68	279	492
	Public Program	37	33	48	45	84
	Village Forest	776	854	1030	1200	1350
	Total Supply	870	969	1185	1563	1986
	Domestic	567	594	600	600	644
	Industrial/ Commercial	184	209	208	211	219
	Total Demand	751	803	808	811	863
	Balance +/-	+96	+114	+267	+425	+492
North East	Natural Forest	4	4	4	4	4
	Long Plantations	7	7	7	7	7
	Short Plantation	-	-	-	-	-

	Public Program	20	27	39	58	109
	Village Forest	368	405	486	550	650
	Total Supply	399	443	536	619	770
	Domestic Industrial/ Commercial Total Demand	644 249 893	674 281 955	681 284 965	681 293 974	731 307 1038
	Balance +/-	-494	-512	-429	-355	-268
CHT	Natural Forest	45	45	45	45	45
	Long Plantations	10	18	8	7	16
	Short Plantation	-	-	-	-	-
	Public Program	-	-	-	-	-
	USF	1825	1725	1625	1525	1425
	Total Supply	1880	1788	1678	1577	1486
	Domestic Industrial/ Commercial Total Demand	49 15 64	51 17 68	52 17 69	52 17 69	56 17 73
	Balance +/-	+1816	+1788	+1609	+1577	+1486
All Strata	Natural Forest	193	196	200	206	211
	Long Plantations	22	30	25	24	54
	Medium Plantations	23	54	153	448	830
	Public Program	196	195	280	321	644
	Village Forest	3983	4385	5166	6030	6890
	USF	1825	1725	1625	1525	1425
	Total Supply	6242	6585	7449	8554	10054
	Domestic Industrial/ Commercial Total Demand	5310 2056 7366	5562 2321 7883	5621 2248 7869	5620 2419 8039	6029 2530 10054
	Balance +/-	-1124	-1298	-320	+515	+1495

* Public Program = Strip Plantation, Agroforestry, Wood lot and Khet land.
* USF = Unclassed State Forest * Long and medium rotation plantations.

APPENDIX 4
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FORESTRY MASTER PLAN
BANGLADESH (TA NO. 1355-BAN)

ASIAN DEVELOPMENT BANK
MANILA PHILIPPINES
DATE: 18 AUGUST 1992

WOOD ENERGY

APPENDIX 4
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