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Household Fuel Availability and Homegardens in Selected Locations of Bangladesh

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Foreword

The 'fuelwood crisis' is one of those phenomena that is more debated than properly investigated.

Bangladesh can be expected to be one country in Asia most severely affected by wood fuel shortages. This is particularly true due to high population densities, scarce forest resources and low per capita incomes. Increased use of crop residues and animal waste for household use and agricultural processing have serious environmental and socio-economic implications.

This report by Dr. Zainul Abedin and his colleagues at the On-Farm Research Division of the Bangladesh Agricultural Research Institute (BARI), provides ample evidence of a widespread fuelwood shortage in Bangladesh. It also describes and analyzes various dimensions of the crisis, and how different land-size categories of the rural population, living under different ecological conditions, are affected.

The report helps demonstrate that the fuel crisis must be seen in the context of rural poverty and that this should also be reflected in the design of solutions. Many of the resource poor seek solutions which make maximum use of limited development opportunities on the only land they have available i.e. their homesteads. Such development efforts would have to be geared towards the various needs of these households. That may include the need for fuel, but this need is never the only and seldom the major need.

The need, and the advantages, of investigating homestead fuelwood resources and uses in an interrelated manner has been apparent for some time. This study provides an excellent example of a methodology for doing so, and serves as an example for similar studies to be initiated elsewhere.

The importance of the topic and the methods are reflected in the interest of both the Winrock International-managed Forestry/Fuelwood Research and Development Project (F/FRED) funded by U.S. Agency for International Development and the FAO Regional Wood Energy Development Project to collaborate in supporting the study and jointly publish this report.

Abstract

Studies were conducted at six agro-ecologically different Farming Systems Research sites of Bangladesh Agricultural Research Institute to understand the nature and function of homegardens, the nature of fuel shortage and the relationship of fuel shortage to the kind of trees grown on the homesteads. Attempts were also made to understand the interrelationships among fuel shortage, biomass utilization and growing of trees by different farm categories in different ecological conditions.

Fuel shortages existed at all of the sites in all farm categories, but the magnitude of fuel shortages varied among sites. Smaller farmers suffered the most. Although the materials used as fuel were the same, their relative contribution across sites and among farm categories varied. Cowdung was the main fuel material at Patuakhali and Barind but it was uncommon at Rangpur. People compensated for the fuel shortage by collecting crop residues, cowdung, leaves and twigs by reducing cooking times or the number of items, and by purchasing fuel materials. Smaller farmers resorted mainly to collection.

Trees grown on the homesteads played a significant role in providing fuel and support to creeper vegetables. Tree species composition varied among the different ecological areas and there was evidence that, over the year the species composition had changed due to the need for food, fuel and fodder. No tree was planted solely for the purpose of providing fuel; rather this was only one of the selection criteria. Further, most farmers opined that space was not available to plant more trees. The problems faced by the farmers and future research issues were examined.

Both projects wish to express their gratitude to BARI, and to Dr. Abedin and his team for this convincing example of farmer-oriented research.

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List of Vernacular Words

'Aus' rice	: Photo-insensitive rice varieties sown or transplanted during the early kharif (March-June) season and harvested during July-August.
'Aman.' rice	: Photo-sensitive rice varieties transplanted (broadcasted in case of Deep Water Aman) in the kharif season (mid June in case of transplanting and early kharif in case of broadcasting) and harvested during mid October-mid December.
'Boro' rice	: Photo-insensitive rice varieties transplanted during December-mid March and harvested during May-July.
'Cheera'	: Flattened rice prepared by pounding unhusked rice with a pestle ('Dheki') following overnight soaking and prior roasting.
'Muri' & Khoi'	: These are two different types of popped rice. 'Muri' is prepared from husked rice by heating in sands. But 'Khoi' is prepared from unhusked rice.
'Khichuri'	: Rice and pulse cooked together.
'Gur'	: Molasses (doughy solid or syrupy liquid raw sugar prepared from the juice of sugarcane or of *Phoenixsylvestris* by pan-evaporation method.
'Rooti	: Home-made bread prepared from wheat flour
'Pitha '	: Different types of home-made cakes
'Dal'	: Pulse soup
'Kharif' season	: 16 March - 15 September
'Rabi' season	: 16 September - 15 March
'Nara'	: The submerged part of Deep Water Aman rice stem left in the field at the time of harvest.

I. Introduction

Increasing population pressure has compelled humans to exploit nature more extensively and intensively to meet the increasing basic needs of food, shelter, clothing and fuel. In the past few decades, efforts to increase food production have received priority. Thus, the natural vegetation has been replaced by cultivated crops and the agriculture in the cultivated lands has been intensified as much as possible. These human activities have created numerous environmental and social problems. For example, deforestation has resulted in a shortage of fuelwood and timber, and has hastened soil erosion and the degradation of soil fertility; a fodder shortage due to lack of grazing lands has seriously the limited to animal production; the use of crop residues and animal dungs as fuel has limited organic matter recycling in the soil resulting in soil fertility degradation.

Among these adverse consequences of the imbalance strategies for increasing food production, the shortage of fuelwood is the most serious. Food and fuel demands are almost equally important because most of the foods need to be cooked in order to be edible. Though humans have invented or discovered the modern energy sources, such as electricity, natural gas, and petroleum products, these fuel resources are not commonly available to households in the rural areas of Bangladesh. Trees still provide at least 90 percent of the energy requirement of the millions of people in the developing countries (NAS 1980). Among the traditional fuel materials, fire wood is the most efficient, producing 14.6×10^6 BTU energy per long ton, compared to 8.3×10^6, 12.1×10^6, 2.1×10^6 and 12.1×10^6 BTU per long ton of cowdung, jute stick, rice straw and rice hulls, respectively. Presently, however, firewood provides only 3.6 percent by weight of total household fuel in Bangladesh whereas cowdung provides 23.8 percent of the household fuel (BBS 1982).

In addition to fuel, trees provide fruit, timber, building materials, fodder, shade, wind breaks and soil protection. Trees play an important role in the risk management strategies of the household economy. They provide cash for social ceremonies, economic hardship, the marriage of son or daughter, meeting school expenses, and for buying land and other assets. (Abedin et al. 1988).

In spite of the felt importance of the trees, there is no plan for sole plantation of trees in Bangladesh. Planting trees in the homestead and crop fields in a planned manner within the existing production systems of the individual farms seems to be the only way of augmenting tree production. In fact, the farmers have traditionally grown various trees on the homesteads and crop lands depending on their needs and experience. This led to a diversification of tree species (Hossain and Abedin 1986).

The homesteads are more reliable than the crop lands for growing trees in both physical and socio-economic terms. In physical terms, the homesteads are less vulnerable to flood hazards and, thus are more suitable for raising trees. In socio-economic terms, homesteads are more stable, because farmers never sell their homestead before their crop lands. Thus, most of the landless people in Bangladesh still have their own homestead. Therefore, the homestead is a fixed asset for the poor farmers and obviously plays many important roles in their household economy. For lack of sufficient crop land and/or other resources, the landless and marginal farmers try more than the larger farmers to meet the needs of their families, including food, fuel and fodder, from this homestead. It is also the site for the cultivation of fishes, post-harvest processing of crops, and various crafts and cottage industries. Therefore, the homestead is not only the home of the family but also an important production system, especially for poor farmers. It has been reported that the estimated 304,000 ha of homestead in Bangladesh provides 85 percent of all wood consumed, 90 percent of all fuelwood used and 90 percent of bamboo used (Douglas 1982). It is also estimated that 10 percent of the standing volume of wood on the homestead is removed every year, indicating that even the homestead plantations are under tremendous pressure.

To supplement income to the household, to manage risk and for various other purposes, farmers have been growing trees in the crop fields for a long time. Retention of voluntarily sprouted trees and planting of trees in the crop fields is an old practice in Bangladesh. Growing of tree species, such as *Acacia nilotica, Artocarpus heterophylus, Phoenix sylvestris,* and *Borassus flabellifer,* has been reported by Aktar and Haque (1986) and Abedin et al. (1988). Preliminary information reveals that economic pressure and the fuel crisis have adversely affected the dynamics of this practice. Further, crop-tree associations are site-specific and there are areas where these practices are almost absent. There is potential to improve the existing practices of tree cultivation based on the family's need and productivity to introduce new practices in areas where they are absent.

The use of cowdung and crop residues as fuel is a well- known practice. It is also known that unless fuel need are met, it is almost impossible to convince farmers to apply cowdung and compost to the soil at a level more than the present one. As more food is produced from the finite land resources, there will be more food to cook and more demand for fuel. More cowdung and crop residues will be burned for cooking while more organic manures will have to be applied to the crop field to support additional production.

It has, therefore, become very important to solve the rural fuel shortage through the production of fuelwood. As the homestead currently supplies 90 percent of the fuelwood and this role is not expected to greatly change in the near future, higher

production of tree products on the homestead is a priority. Besides, agroforestry practices may also play a great role, as in other countries, in augmenting fuelwood, food and fodder production, enhancing soil fertility directly and indirectly, and checking soil erosion. In an area like the Barind tract of Bangladesh, this may improve the tree cover to attract more rainfall.

However, further intervention in the homestead as well as in crop lands will require very careful planning. Understanding the existing systems is the first step of such a process. Except some isolated works confined to limited areas, no organized research has been done in Bangladesh as yet to understand and document the farmers' own systems of homestead utilization, agroforestry practices, and fuel management.

Therefore, this study documents the existing homestead utilization systems and the fuel issues through a survey conducted at six Farming Systems Research Sites of the Bangladesh Agricultural Research Institute located in six agro-ecologically different areas. The objectives of the survey were:

i) to understand current household fuel needs and uses,
ii) to understand farmers, traditional practices of tree cultivation on the homesteads, and
iii) to understand the dynamics relating of tree cultivation, fuel use and other production processes of the farmers.

II. Methodology

The survey was conducted at six Farming Systems Research Sites of Bangladesh Agricultural Research Institute. These were: (i) Kalikapur Farming Systems Research Site, Ishurdi, Pabna, representing the High Ganges River Floodplain Region, (ii) Saroil Farming Systems Research site, Godagari, Rajshahi, representing the High Barind Tract (iii) Bagherpara Farming Systems Research site, Jessore, representing the Low Ganges River Floodplain region (iv) Janokinathpur Farming Systems Research site, Rangpur, representing the Tista Meander Floodplain (v) Palima Farming Systems Research site, Tangail, representing the Young Brahmaputra and Jamuna Floodplain and (vi) Lebukhali Farming Systems Research site, Patuakhali, representing the Ganges Tidal Floodplain (non-saline)region of Bangladesh.

Each of the study locations included a cluster of villages within a radius of about 2 miles. Initially, a simple inventory was made to enlist all of the households in the study area and to record the gross area of each farm. The households were divided into five farm categories on the basis of ownership of cultivated land.

Farm category[1]	Land ownership[2]
Landless	0-0.20 ha
Marginal	0.21-0.50 ha
Small	0.51-1.0 ha
Medium	1.01-2.0 ha
Large	2.01 ha or more

Sixty households, 12 from each farm size category, were selected randomly for the survey in each location. Data were collected from both male and female heads of the households using a pre-tested interview schedule. The distribution of different tree species on the homestead was recorded. The agro-ecological characteristics of the study areas were recorded from secondary sources.

The data were analyzed mainly by simple tabular methods. The local units of measurements were converted to metric units before analysis.

1. This classification of farm sizes is commonly used by BARI and other Bangladesh research organizations conducting farming systems and socio- economic research (Elias et al., 1982; OFRD, 1984; Dhaka University, 1986; Sikdar and Nabi, 1988; Abedin, et. al., 1988). These 5 groups were desired through simple modification of 10 farm size groups used by the Bangladesh Bureau of Statistics (BBS, 1986).

2. Excluding homesteads and area rented in.

III. The Study Area

3.1. Agro-ecological condition

The six study areas are largely distinct in their physiography, soil characteristics and climate. The physical nature of the study areas are briefly described below.

3.1.1. Rajshahi (Saroil)

The Saroil site is located at 24^{0} 36.7'N latitude and 88^{0} 34.6'E longitude. It represents the High Barind Tract region (UNDP/FAO, 1988) occupying an area of 811 sq. km (1,800,000 acres) in the districts of Rajshahi, Nawabgonj and Naogaon. This region is characterized by extreme environmental conditions, such as low and erratic rainfall, extreme temperature (both high and low) and an undulating terraced landscape. The soils on the summits and terraced slopes are imperfectly to poorly drained, grey or mixed grey and brown in color and silty loam to silty clay loam (occasionally silty clay or clay) in texture. The soils are shallow with a unweathered or partially weathered heavy clay (Madhupur clay) substratum occurring only 60-90 cm below the surface (SRDI 1968). The soils in the valleys are relatively deeper but have similar color and texture to soils on the summits. The pH ranges from 5.5 to 6.5 on the summits and from 6.0 to 7.0 in the valleys. The organic matter content of Barind soil is very low, ranging from 0.8 to 1.2 percent. The natural fertility of the soil ranges from moderate to moderately low (Hunt 1984).

The High Barind Tract receives the lowest rainfall in Bangladesh; the mean annual rainfall is only about 1363 mm (Manalo 1976). Reliable rainfall (more than 200 mm in each month) only occurs from mid-June through mid-September. The rainfall of the pre-monsoon period from April to mid-June is very unreliable, and drought is very frequent. Excessive rainfall has also been observed during this period once in three years. The post-monsoon (mid-September to mid-November) rainfall is also erratic (Brammer 1985). Due to the short monsoon and poor water holding capacity, the soils become devoid of available soil moisture by the end of December and the drought period continues to the end of April.

The atmospheric temperature in the Barind Tract is also somewhat extreme compared to other ecological zones of the country. In the months of May, June and September the average maximum temperature remains above 34°C and, on average, there are 10 days or more in each year when the maximum temperature exceeds 40°C (Brammer 1985). In the winter, the average minimum temperature remains below 15°C for 100-125 days.

Singly transplanted 'Aman' rice is the predominant cropping pattern of the High Barind Tract. Dry-land 'Aus'rice is grown in the early 'Kharif' season only in 10-25 percent of the area before transplanted 'Aman'rice. Another 10-20% of the areas, which remains fallow in early 'Kharif' season, is sown with chickpea, barley, mustard or linseed after harvest of transplanted 'Aman' rice (OFRD 1987). The cropping intensity is about 130 percent.

3.1.2. Ishurdi (Kalikapur)

The Kalikapur site, located at 24° 08'0 N latitude and 89° 02.5'E longitude, represents the High Ganges River Floodplain (UNDP/FAO 1988) with brown and dark grey calcareous soils. The landscape has been developed in a catenary sequence. The upper part of the catena, called the 'Sara series', is above normal flood level and the soils are of sandy to silty loam texture and light olive-brown color. The soil has a low organic matter content (0.9 percent) and a pH value of 7.9. Moisture stress occurs during November through April. The upper middle portion of the catena, called the Gopalpur series, is also above the normal flood level but very shallowly flooded by rain-water during the monsoon. The soil of this zone is silty loam to clay loam in texture and olive brown in color. The soil contain, 1.4 percent organic matter and has a pH value of 7.7 (SRDI 1976).

Homesteads are mainly confined to these two phases of the catena. The lower middle portion of the catena, called the Ishurdi series, is imperfectly to poorly drained and intermittently to seasonally flooded. The soils are silty loam to silty clay loam in texture and contain 1.8 percent organic matter. Homesteads are found only on artificially raised high lands in this phase. The bottom of the catena, called Ghior series, is very poorly drained and is seasonally flooded for a period of 90-120 days in the monsoon. The soils are brown to olive-grey with silty clay or clay texture. The average pH value of the soil is 6.8 and the organic matter content is 2.1 percent (SRDI 1976). Homesteads are not usually found in this phase of the catena.

The predominant cropping pattern of the highland (Sara series) is broadcast 'Aus' rice followed by 'Rabi' crops (mustard, lentil, wheat, chickpea, linseed blackgram) or a single sugarcane crop. The cropping pattern of the Gopalpur series (medium highland) is broadcast 'Aus' rice - transplanted 'Aman' rice - lentil + mustard. The Ishurdi (medium highland) series is planted with broadcast 'Aus' rice - transplanted 'Aman' rice - chickpea + barley (OFRD 1987). The cropping intensity is quite high (230 percent).

There is no reserved forest in the area but the homesteads contain numerous tree species mainly of fruit and timber value. Some tree species are also found in the crop fields, *Acacia nilotica* being the dominant one. The other tree species, which

are less common in the crop fields, are *Acacia catechu, Borassus flabellifer,* and *Phoenixsylvestris* (Miah et al. 1989).

3.1.3. Jessore (Bagherpara)

The Bagherpara site is also situated in the Low Ganges River Floodplain region of Bangladesh (UNDP/FAO, 1988). The landscape is nearly level to gently undulating with broad highland ridges, some medium highland inter-ridge depressions, and some small, concave basins and unfilled channels. The soils are mainly calcareous, sandy loam to silty clay in texture, and pale brown to dark grayish brown in color. The pH of the soils range between 7.0 and 8.5 (SRDI, 1977). The homesteads are situated on highlands, which are above normal flood level and well drained, but the lower part of the medium highland is shallowly flooded during the rainy season.

The mean annual rainfall at Bagherpara (1652 mm) is somewhat higher than that of Kalikapur, but there are only four wet months in a year (June - September) and the dry season is droughty. The mean maximum temperature is the highest (34.71^{o}C) in the month of April and the mean minimum temperature is the lowest (11.86^{o}C) in the month of January. However, both the highest and lowest temperatures are less extreme than those at Kalikapur.

Mainly upland 'Aus' rice and jute are grown in the early 'Kharif' season, both on high and medium lands. The high lands are kept fallow in the late 'Kharif' season and then pulses (lentil or chickpea) and oil seeds (mustard or linseed) are grown either as solely or in mixture in the winter season under rainfed conditions. Sugarcane is also grown over a considerable area on the highland. In the medium highland, transplanted 'Aman' rice is grown in the late 'Kharif' season following 'Aus' rice or jute and then mostly remain fallow in the winter under rainfed conditions. Currently, chickpea and linseed (solely or in mixture) are grown in some rainfed medium highlands after harvest of transplanted 'Aman' rice. A small area is also cultivated with wheat, potato and boro rice following the transplanted 'Aman' crop under irrigated conditions. Some tree species, including, *Phoenixsylvestris, Borassus flabellifer and Artocarpus heterophyllus,* are grown in the crop fields in different combinations (Alam et al., 1988).

3.1.4. Rangpur (Janokinathpur)

The Janokinathpur site is located at 25° 35'N latitude and 89° 15'E longitude, 3.12 m above sea level. It represents the highland areas of the Tista Meander Floodplain region (UNDA/FAO, 1988) occupying 45 percent of the area of the greater Rangpur district. The landscape is nearly level to very gently undulating or

sloping, on the upper part of the ridges and is above normal flood level. The soils are mainly well drained. Developed from noncalcareous alluvium deposits of the river Tista, the soils are loamy to sandy-loam in texture with a fine sand or sandy loam substratum at a shallow depth. The soils suffer from moisture stress during the dry season. The dried samples of the topsoils are slightly acidic (pH ranging from 5.2 to 6.1), but they are nearly neutral in field capacity conditions. The organic matter content of the soils is moderately low.

The mean annual rainfall of the area is about 2169 mm, and each of the months from May through September (5 months) receive more than 200 mm (Fig. 1). Being located in the northern part of Bangladesh near the Himalayas, this area enjoys a longer winter than the other regions of the country. Sometimes in the month of January (the coldest month of the year) the minimum temperature is around 7°C; the mean minimum temperature of this month is 10.2°C.

Jute or transplanted 'Aus' rice followed by transplanted 'Aman' rice is the most predominant cropping pattern of this area. Some lands remain fallow in the early 'Kharif' season when wheat, potato or chili are grown following transplanted 'Aman' rice. A small area (9 percent) is devoted to vegetable production (pointed gourd-fallow-potato + garlic + pointed gourd) almost throughout the year. There is a substantial area (21 percent) producing three cereals, 'Aus' rice, transplanted 'Aman' rice and wheat in a year, and there is an equal area (rainfed medium highland) producing only one crop (transplanted 'Aman' rice) in a year. The cropping intensity of the area is 277 percent (BARI 1987), which is much higher than the national average of 154 percent.

3.1.5. Tangail (Palima)

The Palima site is located at about 24° 17'N latitude and 89° 54'E longitude. The site represents the Young Brahmaputra and Jamuna Floodplain region of Bangladesh (UNDP/FAO, 1988). The landscape is developed in a catenary fashion. The catena starts with a small area of high land (18 percent) and gradually slopes down to medium high (56 percent), and medium low (20 percent) lands, and ends with a small (6 percent) low land area. These four land types represent about 70 percent of the cultivated land of Tangail district. Except for the small highland portion, all of the other areas are seasonally flooded at varying depths depending on the topography. Homesteads are made on artificially raised high lands in the floodprone areas.

The mean annual rainfall in this area is 1732 mm. Though the annual rainfall is fairly low in this dry belt of the country (Manalo 1976), the on-set of the monsoon is earlier here than in the Kalikapur and Saroil sites. The winter is shorter and the

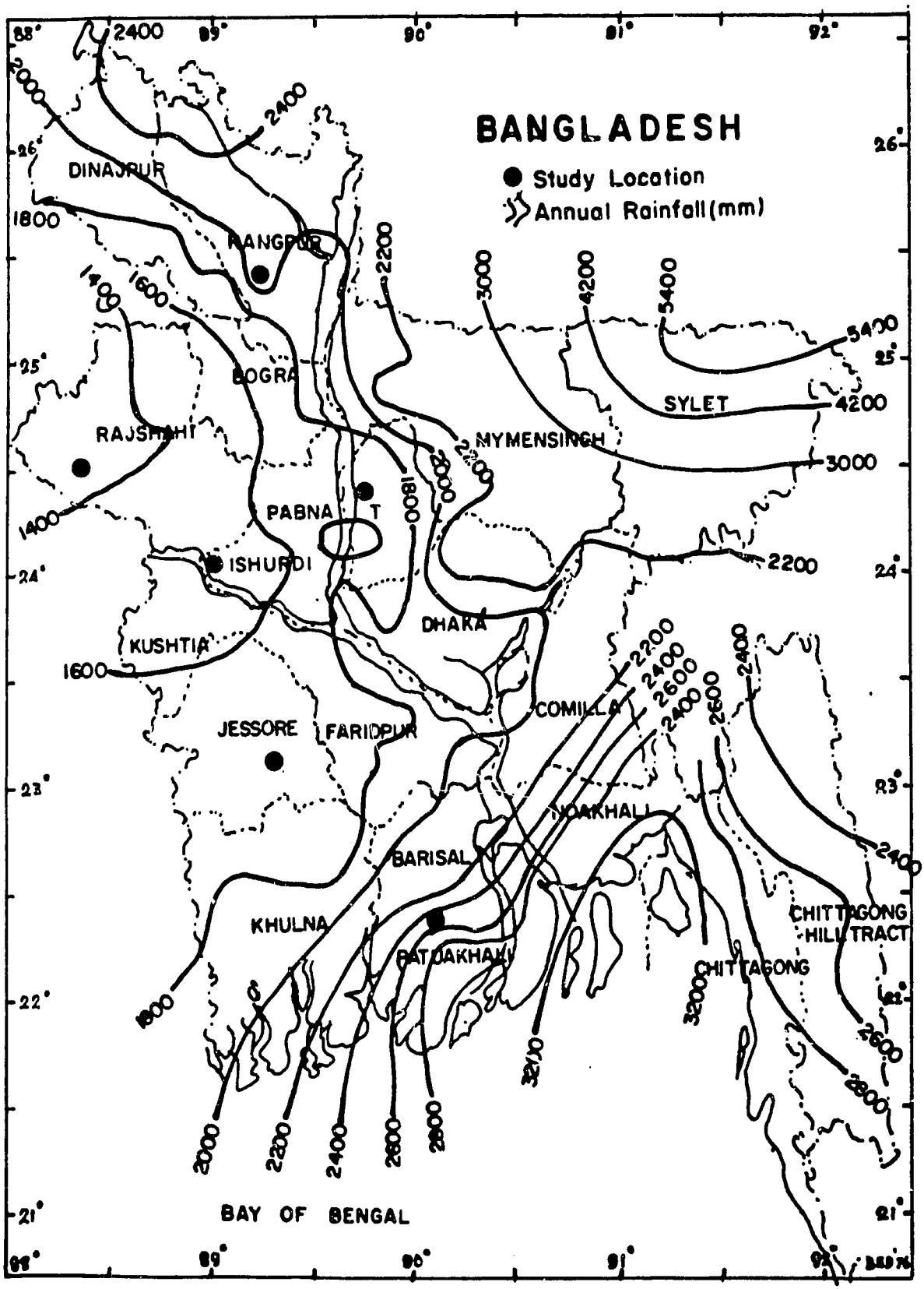

FIG. 1. MAP OF BANGLADESH SHOWING THE STUDY LOCATIONS WITH MEAN ANNUAL RAINFALL.

minimum temperature is higher in this area than in the northern parts of the country. The mean minimum temperature is about 12°C in the month of January. The temperature starts rising in February and the mean maximum temperature is highest (35.5°C) in April. Jute, broadcast 'Aus' rice, and deepwater 'Aman' rice are predominant crops during the early 'Kharif' season. Jute and broadcast 'Aus' rice is followed by transplant 'Aman' rice on the medium highlands and by a fallow period on the highlands. During the winter season, a range of winter crops, such as vegetables, lentil, chickpea, wheat, corriander, mustard, and sunhemp, are grown. The introduction of irrigation equipment has led to the replacement of pulse crops with HYV winter rice.

3.1.6. Patuakhali (Lebukhali)

The Lebukhali site is located at about 22° 22' N latitude and 90° 21' E longitude only 3.35 m above sea level. The site represents the Ganges Tidal Floodplain (non-saline) region of Bangladesh (UNDA/FAO, 1988). The soils are clay and silty clay loam in texture, poorly drained, non-calcareous, non-saline, and neutral to slightly acidic. Topographically the landscape is mostly medium high land. The soils undergo tidal flooding in the monsoon (March-October), usually up to a depth of 1-3 feet. Sometimes the basins are flooded up to a depth of 5 feet. The homesteads are made on artificially raised high lands. Therefore, perennial trees are confined in the homesteads. The Lebukhali site enjoys a fairly high annual rainfall (3067 mm) with six wet months (May-October). Being nearer to the Bay of Bengal, the temperature is milder than the northern and central parts of Bangladesh. The highest mean maximum temperature is 32.4°C (April) and the lowest mean minimum temperature is 13.8°C (January) (Khan et al., 1988).

Transplanted 'Aman' rice is the predominant crop grown by the farmers. This is usually preceded by transplanted 'Aus' rice. Since harvesting of 'Aman' rice is delayed, most of the land remains fallow during the winter ('Rabi') season. Lathyrus, cowpea and mungbean are grown in a limited area.

3.2 Socio-economic aspects

3.2.1. Farm and Family size

Though the households were broadly classified into five farm categories based on ownership of cultivated land, there were differences in the average size of holdings (owner cultivated + rented land + homeplot) within a category at different locations (Table 1). The average farm size was relatively larger at Ishurdi (1.52 ha) and Patuakhali (1.45 ha) than at the other locations. The average holding was the smallest at Tangail (1.08 ha).

Table 1. Average farm size in different farms categories at the six study locations.

Farm category	Average farm size (ha)						
	Patuakhali	Jessore	Rangpur	Rajshahi	Ishurdi	Tangail	Overall
Landless	0.21	0.12	0.17	0.07	0.12	0.09	0.13
Marginal	0.72	0.40	0.73	0.51	0.37	0.32	0.50
Small	0.79	0.80	0.88	0.95	0.79	0.66	0.81
Medium	1.54	1.42	1.52	1.85	1.54	1.44	1.55
Large	4.00	2.82	3.24	3.16	4.82	2.87	3.49
All farms	1.45	1.11	1.31	1.31	1.52	1.08	1.30

The average family size ranged from 6.4 at Rangpur to 8.2 at Ishurdi (Table 2). Family size tended to be larger with increasing farm size at each of the locations. The overall average family size in the landless category was 5.5 and in the large farm category 10.2. The percentage of joint families was higher in the larger farm categories, which might explain the larger family size in the large farm category. The percentage of joint families was, in general, lower at Rajshahi, Patuakhali and Rangpur than at the other three locations.

Table 2. Average family size (ha) in different farm categories.

Farm category	Patuakhali	Jessore	Rangpur	Rajshahi	Ishurdi	Tangail	Overall
Landless	5 (0)	5.8 (8)	4.8 (0)	5.8 (8)	5.5 (0)	5.7 (25)	5.5 (8)
Marginal	7 (0)	6.4 (8)	5.1 (0)	5.6 (0)	7.5 (25)	4.9 (8)	6.1 (8)
Small	7 (0)	7.0 (17)	7.0 (0)	5.9 (0)	7.6 (25)	7.8 (17)	7.0 (10)
Medium	6 (0)	7.8 (50)	7.3 (0)	8.7 (0)	8.2 (42)	7.9 (33)	7.7 (26)
Large	8 (17)	9.3 (75)	7.7 (25)	10.0 (8)	12.4 (42)	11.9 (58)	10.2 (36)
All farms	7 (5)	7.3 (32)	6.4 (12)	7.2 (3)	8.2 (28)	7.6 (28)	7.3 (18)

Figures in the parentheses indicate percentage of joint families.

3.2.2. Occupation and Income

Except for people in the landless category, agriculture was the major occupation at all of the locations (Table 3a). Landless farmers were mostly agricultural laborers. Though attempts were made to calculate the annual income of different categories of farmers at different locations, the data were exaggerated in some cases, while too conservative in others, and thus were not reliable. However, the total income increased with increasing farm size in all of the locations (Table 3b). In some cases landless farmers earned more from selling their labor than marginal farmers. The marginal farmers were hesitant to work as laborers, though their agricultural income was not satisfactory (Momin et al., 1988).

Table 3a. Major family occupation according to farm category.

Farm category	% of farmers				
	Agriculture	Service	Business	Agricultural labor	Non agril. labor
Landless	17	7	8	59	11
Marginal	72	9	13	20	1
Small	84	7	12	5	1
Medium	89	6	12	-	-
Large	79	16	16	-	-
All farms	69	9	12	17	3

Table 3b. Relative contribution of different farm resources to the total income of the family in each farm category.

Farm category	Total income (Tk.)	% contribution of different resources							
		Crops	Home-stead	Lives stock	Fishes	Service	Business	Labor	Others
Landless	58278	8.7	3.3	4.9	0.2	8	8.0	52.0	15.0
Marginal	76039	35.4	4.0	6.2	0.3	12	12.0	18.0	8.1
Small	114783	47.5	5.4	4.1	0.5	14	14.0	9.0	5.5
Medium	143347	66.0	5.1	5.5	0.6	10	9.0	1.0	2.8
Large	267156	68.2	4.7	6.3	1.4	4	11.0	-	4.4
All farms		46.7	4.7	6.6	0.8	9	11.0	15.0	6.2

3.3.3. Land tenure systems

The landless, marginal and small farmers were mostly tenant and/or owners-cum-tenants, while the medium and large farmers were mostly owner-operators. Fifty three percent and 40 percent of the land (average of six locations) cultivated by the landless and marginal farmers, respectively, was rented, but only 9 percent of the cultivated land in the large farm category was rented in (Table 4).

There are three different forms of tenurial arrangements: cash rental, mortgaging, and share cropping. Share cropping is predominant at all locations, though the practice of cash rental has increased gradually at Jessore, Ishurdi and Patuakhali. Mortgaging is a minor form of rental in all locations except in Rangpur. The large farmers are the lessors for both share cropping and cash rental, and the landless, marginal and small farmers are the lessees. Those with little or no land are also the most likely to mortgage their land for loans, while the large farmers are the mortgagees who hold and use the land until the loans are repaid.

In share cropping, the renter must pay a definite share of the produce. The terms for share cropping vary by location and crop. Often produce is shared equally between renter and owner. For most crops, the renter must also pay all the input costs. In the case of HYV of rice, the owners will provide some of the input costs. In Patuakhali the owners provide 67 percent of the cost of seeds, fertilizer and pesticides (Khan et al., 1988), while in Rangpur the owners provide only 50 percent of fertilizer costs for the same crop (Islam et al., 1988).

Terms of cash rental are similar, though the rates vary with location and available infrastructure. The owner rents out lands to the lessee at a fixed annual or seasonal rate. The owner has no claims to any share of the produce, nor does the owner provide any of the costs of inputs. Lands with irrigation facilities have higher rental rates than those without irrigation.

In mortgaging, the owner gives the land in lieu of a loan. The amount of land and loan varies from case to case, by agreement between the landowner (borrower) and the mortgagee (lender). Until the mortgagor repays the entire loan, the mortgagee operates the land, taking all the produce as his own. The terms of mortgages are usually indefinite. An exception was found at Rampur where loans taken in mortgage had to be repaid at a fixed annual rate.

Almost all farmers in all farm categories, including the landless, at all locations own their homesteads. The only exception was found in Rajshahi where 18 percent of the landless farmers did not even own their homestead.

Table 4. Percentage of cultivated land that is rented in different farm size categories.

Location	Rented land (% of total cultivated land)				
	Landless	Marginal	Small	Medium	Large
Patuakhali	88	49	14	9	4
Jessore	29	19	19	6	10
Ishurdi	25	4	4	21	8
Rajshahi	75	91	50	54	23
Rangpur	76	52	26	12	0.3
Tangail	25	23	38	15	10
Overall	53	40	25	20	9

IV. HOUSEHOLD FUEL SITUATION

This chapter documents the regular and casual cooking patterns by location and size of holding as indicators of the amount of fuel needed at rural households of Bangladesh; various materials used as fuel and seasonal variation in their use; relative preference of different fuel materials in various farm sized households; nature and extent of annual fuel shortage at rural households by location and size of farm along with seasonal dimension of shortage; mechanisms adopted by farmers to adjust to the fuel shortage; organic matter recycling in relation to the fuel shortage situation; and the interrelationships among the specified variables according to farm category and location.

It can easily be argued that the average quantity of fuel materials burnt per day, or the cumulative time of burning fuel materials for cooking and heating are better measures than a record of cooking and heating patterns to determine the amount of fuel needed by a family. Limits in data collection for the present study did not allow for accurate assessments of the quantity of fuel or the time of cooking and heating. The respondents were largely illiterate, and few have watches to measure time; they could not be asked to give accurate assessments of the amount of fuel or time of cooking. The quantity of fuel or the time required to cook or heat an item varies with the kind of material used. The materials used vary with farm category and season, and the quantity needed also varies with family size. Intensive monitoring of fuel use would be needed to gain an accurate picture of the quantity of fuel materials used per day, or the cumulative time of cooking and heating. Given the data collection limits of this study, the researchers decided to observe the regular and casual cooking and heating patterns as indicators of the relative fuel needs of farmers in different farm categories and at different locations.

4.1. Regular Cooking Pattern

The regular cooking pattern includes the cooking of common food items, such as rice, '<u>rooti</u>' (leavened bread made of wheat flour), curry (including '<u>dal</u>', or pulse soup), and the boiling of milk and water. The pattern of cooking is directly related to fuel use. However, it must be recognized that, at times, the cooking pattern may be dictated by fuel availability or food availability. The estimation of the frequency of regular cooking per day in different study locations is shown in Table 5. The overall cooking frequency was highest at Ishurdi (13.7), and lowest at Rajshahi (6.3).

The daily cooking frequency of each food item varied widely among the locations. For example, the cooking frequency for rice was the greatest at Rangpur, Ishurdi,

and Tangail. However, in Patuakhali, Jessore, and Rajshahi, the frequency of rice cooking was much lower. The daily cooking frequency of '<u>rooti</u>' and curry was greatest at Ishurdi, followed by Jessore and Rajshahi in the case of '<u>rooti</u>', and Rangpur and Jessore in the case of curry. This variation in regular cooking pattern, among the survey locations may have influenced the nature and extent of fuel use in each location. The nature and extent of fuel use is expected to be dependent on the homestead plantations, which are a major source of fuel materials.

Table 5. Regular cooking pattern at different study locations.

Location	Frequency of cooking per day*				
	Rice	Rooti	Curry	Others**	Row Total
Patuakhali	2.0	0.1	3.5	1.5	7.1
Jessore	2.0	0.8	4.4	0.2	7.4
Rangpur	4.5	0.1	6.3	0.8	11.7
Rajshahi	1.9	0.8	3.2	0.4	6.3
Ishurdi	3.6	1.4	7.6	1.1	13.7
Tangail	2.3	0.5	4.2	0.6	7.6
Overall	2.7	0.6	4.9	0.8	9.0

* Frequency of an item = Number of that item (i.e., no. of curries, no. of pots of rice, etc.) x times cooking/day

** Preparation of tea, boiling of water and milk, etc.

Table 6. Regular cooking pattern for different farm size households.

Size category	Frequency of cooking per day*				
	Rice	Rooti	Curry	Others	Row total
Landless	2.0	0.7	3.2	0.1	6.0
Marginal	2.4	0.8	3.6	0.2	7.0
Small	2.7	0.8	4.7	0.6	8.8
Medium	2.8	0.6	6.0	0.9	10.3
Large	3.6	0.3	7.0	1.4	12.3
Overall	2.7	0.6	4.9	0.8	9.0

In general, the regular daily cooking frequency increased with farm size (Table 6). This trend was observed for all food items, except rooti. Both food and fuel shortages compel poor families to cook less frequently. At times, particularly in the rainy season, the fuel crisis becomes more acute than food shortage. Smaller farmers cook rice less frequently, but cook 'rooti' more often. 'Rooti' usually does not require as much curry as rice requires. Therefore, a lesser amount of curry is prepared by smaller farmers. Their shortage of food and fuel is balanced in an unique way.

4.2. Casual Cooking Pattern

Culture and tradition have given rice to the practice of preparation of special foods, such as 'pitha' (homemade cakes), 'cheera' (flattened rice), 'muri' (popped rice), and 'khoi' (another type of popped rice). While 'cheera','muri', and 'khoi' are consumed usually as snacks, 'pithas' are prepared only occasionally for festivals, other social events, or visits of guests or relatives from distant places. A visiting son-in-law, especially a new one, must be entertained with 'pitha'. This has become an integral part of hospitality. Although the number of items and frequency of their preparation vary according to the different capabilities of the farm families, almost all will prepare some of these food items.

Since these foods are cooked occasionally, information on the number of days these items are cooked per year has been collected to estimate the fuel need. The daily use of fuel for preparation of 'cheera' or 'muri' is probably more than for 'pitha'. Usually 'cheera' and 'muri' are prepared in larger quantities requiring about 3-4 hours or more cooking time. Preparation of 'pitha', however, may not require as much cooking time.

Because of eating habits, rice must be parboiled and dried before husking. This is another very important activity of the households, but it is not done as frequently as normal cooking. Though many people now take their paddy to mills, about 75-80 percent of the paddy is still parboiled at home. A considerable amount of fuel is required for this purpose. The frequency of parboiling rice, like the frequency of cooking food items, is dependent mainly on the quantity of rice available for boiling and the availability of fuel.

Another fuel-consuming activity in rural households is the cleaning of clothes using washing soda. Although the use of factory-made soaps has increased, the use of soda remains predominate among rural families, especially the poorer ones, because soda is cheaper than soap. In order to clean clothes using soda, the clothes are dipped in soda-mixed water and boiled.

The number of days per year spent on casual cooking increased positively with farm size (Table 8). This patterns holds for each type of casual cooking, except for boiling water for clothes washing by medium and large sized households. On average, the number of days of casual cooking per year was highest at Jessore and Rajshahi and lower at Tangail, Ishurdi, Patuakhali and Rangpur (Table 7). Data revealed a wide range of variation in casual cooking patterns across the study locations.

Table 7. Casual cooking pattern at different study locations.

Location	Days per year				
	Rice Par-boiling	Boiling water for cloth washing	Special food pre-parathion	Others	Row total
Patuakhali	15	13	4	0	32
Jessore	17	26	18	31	92
Rangpur	7	11	10	0	28
Rajshahi	32	36	13	11	92
Ishurdi	36	12	14	1	63
Tangail	18	9	13	27	67
Overall	21	18	12	12	62

Table 8. Casual cooking pattern by different farm sizes.

Location	Days per year				
	Rice Par-boiling	Boiling water for cloth washing	Special food pre-parathion	Others	Row total
Landless	11	16	6	2	35
Marginal	13	18	7	7	45
Small	23	20	9	14	66
Medium	25	18	15	14	72
Large	32	18	22	20	92
Overall	21	18	12	12	62

4.3. Amount of Fuel Need

The family size, size of land holding, food availability, dietary habit, extent of casual labor hiring, frequency of visits of relatives, and social status of the households are likely to determine the household fuel requirement. It was not possible to directly quantify the fuel requirement of individual farm families through the survey. Therefore, an indirect method was used to assess fuel needs of different farm sizes. The regular and casual cooking patterns (Tables 5-8) were taken as indicators of household fuel needs. Thus, the total fuel requirement was directly related to the size of farm. Both regular and casual fuel consumption increased with increasing farm size. The casual fuel consumption was higher in the large farm categories mainly due to more rice parboiling and more frequent preparation of special food items. Because the family size was larger in the larger farms (Table 2), the fuel need was correspondingly higher.

4.4. Materials Used as Fuel and Seasonal Variation

Cowdung, branches of trees, leaves, husks and bran, fuelwood, crop residues, jute stick and straw were the fuel materials used by rural households in Bangladesh (Table 9). There was wide variation among locations in the relative contribution of these materials to total fuel used. Cowdung contributed most to the total fuel use at all of the location, except Rangpur and Ishurdi. Cowdung was not used as fuel at Rangpur, because there was an abundant supply of tree branches, fuelwood and jute stick. Conversely, cowdung accounted for nearly 52 percent of the total fuel used in Rajshahi, where fuelwood, branches and leaves contributed only 4, 5 and 4 percent, respectively. It is important to note that, at Patuakhali, Jessore and Rajshahi, the relative contribution of cowdung to the rural household fuel use was more than the national average of 24 percent (BBS 1984) while in Tangail (20 percent) it was close to the national average. At all of the locations, except Rangpur and Patuakhali, fuelwood contributed 10 percent or less to total fuel use.

Table 9. Relative contribution of various materials to total fuel use at different locations.

Materials	Contribution of materials to fuel use (%)						
	Patuakhali	Jessore	Rangpur	Rajshahi	Ishurdi	Tangail	Overall
Cowdung	28	30	0	52	13	20	20
Branches of trees	17	15	20	5	16	10	14
Leaves	8	18	10	4	16	18	12
Husks & bran	4	3	6	9	16	31	12
Fuelwood	22	10	20	4	8	4	11
Crop residues	8	7	5	18	9	15	10
Jute stick	0	8	20	0.2	9	16	9
Straw	4	3	7	6	9	5	6
Bamboo	0	6	11	0.9	5	6	5
Kerosene	0	0	0.7	0	0	0.2	0.1
Electricity	0	0	0.4	0	0	0	0.1
Pigeon pea plants	0	0	0	0.1	0	0	0.02
Others	9	0	0.8	0	0	0.2	2

Proportional contribution of various fuel materials to total fuel use varied substantially among different farm sizes mainly due to their differential access to the respective sources (Table 10). The contribution of rice straw and jute stick was higher in medium and large farm households than in the landless, marginal and small farm households because the medium and large farmers own more crop lands. The greater contribution of fuelwood in the large farms may be due to their larger homestead area. The relative contribution of leaves and twigs to total fuel use was higher on smaller farms than on large farms.

Table 10. Relative contribution of various materials to total fuel use in different farm size categories.

Fuel materials	% contribution in different farm categories				
	Landless	Marginal	Small	Medium	Large
Cowdung	22	21	28	28	21
Branches of trees	16	12	15	12	13
Leaves	20	17	11	8	5
Husks and bran	7	8	8	8	7
Fuelwood	5	11	8	13	19
Crop residues	18	11	9	6	7
Jute stick	4	6	9	12	13
Straw	4	5	5	7	6
Bamboo	3	5	5	6	7
Kerosene	0.2	0.04	0.2	0.3	0.1
Electricity	0.03	0	0.2	0.1	0.2
Pigeon pea plants	0	0.1	0	0	0.02
Others	2	2	2	1	1

Although the landless and marginal farmers owned very little crop land and cattle, the relative contribution of cowdung and crop residues were not lower in these farm categories than in the large farm sizes. The landless and marginal farmers had frequent access to other fields, and roadsides, for the collection of these fuel materials. Differences between farm categories in fuel materials used would be more evident if the amount as well as proportion of the materials could be determined.

There was notable seasonal variation in household fuel utilization. In general, the relative contribution of leaves (81 percent), branches and twigs (48 percent), crop residues (46 percent) and rice straw (35 percent) was greater during the dry season than during the wet season (Table 11a). During the rainy season, stored dung cakes (69 percent), jute sticks (45 percent), fuel wood (45 percent), rice husks (36 percent) and branches and twigs (28 percent) contributed more to total fuel use (Table 11b). Because dried leaves and rice straw were difficult to store, their use was restricted to the dry season.

Table 11a. Incidence of using various materials as fuel during dry season at different locations.

Materials	% of farmers using various materials for fuel						
	Patuakhali	Jessore	Rangpur	Rajshahi	Ishurdi	Tangail	Overall
Leaves	95	100	65	40	93	96	81
Branches & twigs	47	52	65	38	44	[illegible]	48
Crop residues	60	47	0	62	23	83	46
Straw	17	0	63	53	52	23	35
Cowdung	95	37	0	49	12	12	34
Husks and bran	0	17	45	52	57	27	33
Jute stick	0	20	47	0	2	20	15
Bamboo	0	28	15	5	13	18	13
Nara[1]	73	0	0	0	0	0	12
Fuel wood	0	0	8	12	8	0	5
Water hyacinth	0	0	0	0	0	2	0.3

[1]'Nara' is the submerged portion of deep water Aman rice stem left in the field at the time of harvest.

Table 11b. Incidence of using various materials as fuel during the rainy season at different locations.

Materials	% of farmers using various materials for fuel						
	Patuakhali	Jessore	Rangpur	Rajshahi	Ishurdi	Tangail	Overall
Cowdung	92	82	0	97	63	80	69
Jute stick	0	28	83	3	63	94	45
Fuel wood	54	28	68	22	38	58	45
Rice Husks	53	0	37	35	42	47	36
Branches & twigs	70	38	0	0	58	0	28
Bamboo	0	0	77	0	28	52	26
Leaves	22	15	0	0	0	0	16
Crop residues	3	0	0	3	0	17	4
Straw	0	0	0	5	17	0	4
Fire wood	0	0	0	0	0	28	5

4.5. Preference of Fuel Materials

Regardless of the study location and the size of holding, fuelwood (44 percent), cowdung (44 percent), jute stick (39 percent), bamboo (27 percent) and branches of trees (20 percent) were the more preferred fuel materials (Table 12). Cowdung and fuelwood were the most preferred fuel material by landless and marginal households. Fuelwood and cowdung were preferred by small and medium farmers and jute stick and fuelwood were preferred by large farmers.

Table 12. Relative preference of fuel materials in different farm categories.

Materials preferr	% farmers preferred					
	Landless	Marginal	Small	Medium	Large	Overall
Fuelwood	39	40	53	50	42	44
Cowdung	50	43	45	43	41	44
Jute stick	22	40	41	42	45	39
Branches of trees	24	25	24	17	17	20
Bamboo	26	18	30	28	35	27
Husk and bran	24	22	11	12	17	17
Rice straw	11	10	13	8	11	10
'Babla' wood	11	8	10	11	10	10
Mango wood	1	10	11	11	14	9
Dung stick	4	7	11	6	6	7
Tamarind wood	4	10	4	8	10	7
Leaves	10	1	8	6	3	6
Crop residues	10	3	10	3	1	5
Raintree wood	0	0	1	11	13	5
Pigeon pea	0	1	0	0	1	0.4
Pulse straw	1	0	0	0	0	0.3
Others	0	3	0	6	0	2

4.6. Sources of Fuel Materials

In general, 67 percent of the total fuel was owned by the households, 18 percent was collected and 15 percent was purchased (Table 13).

Table 13. Percent of fuel owned, collected, and purchased by households at different locations.

Location	Percentage distribution of fuel use by source of fuel management		
	Owned	Collected	Purchased
Patuakhali	70	19	11
Jessore	57	31	12
Rangpur	65	9	26
Rajshahi	71	12	17
Ishurdi	70	24	6
Tangail	72	12	16
Overall	67	18	15

In all locations, except Rangpur and Jessore, 70 percent or more of the total fuel was owned by the households. The proportion of collected fuel materials was lowest at Rangpur (9 percent) and highest at Jessore (31 percent), while the proportion of purchased fuel materials was lowest at Ishurdi (6 percent) and the highest at Rangpur (26 percent).

Most of the household fuel used by the landless families was collected while large farm families did not collect any fuel material (Table 14 and Figure 2). As the size of holding increases, the proportion of collected fuel decreases ($r = -0.87$, P 0.01). Conversely, the proportion of fuel owned by the family increases as the size of holding increases ($r = +0.81$, P 0.01).

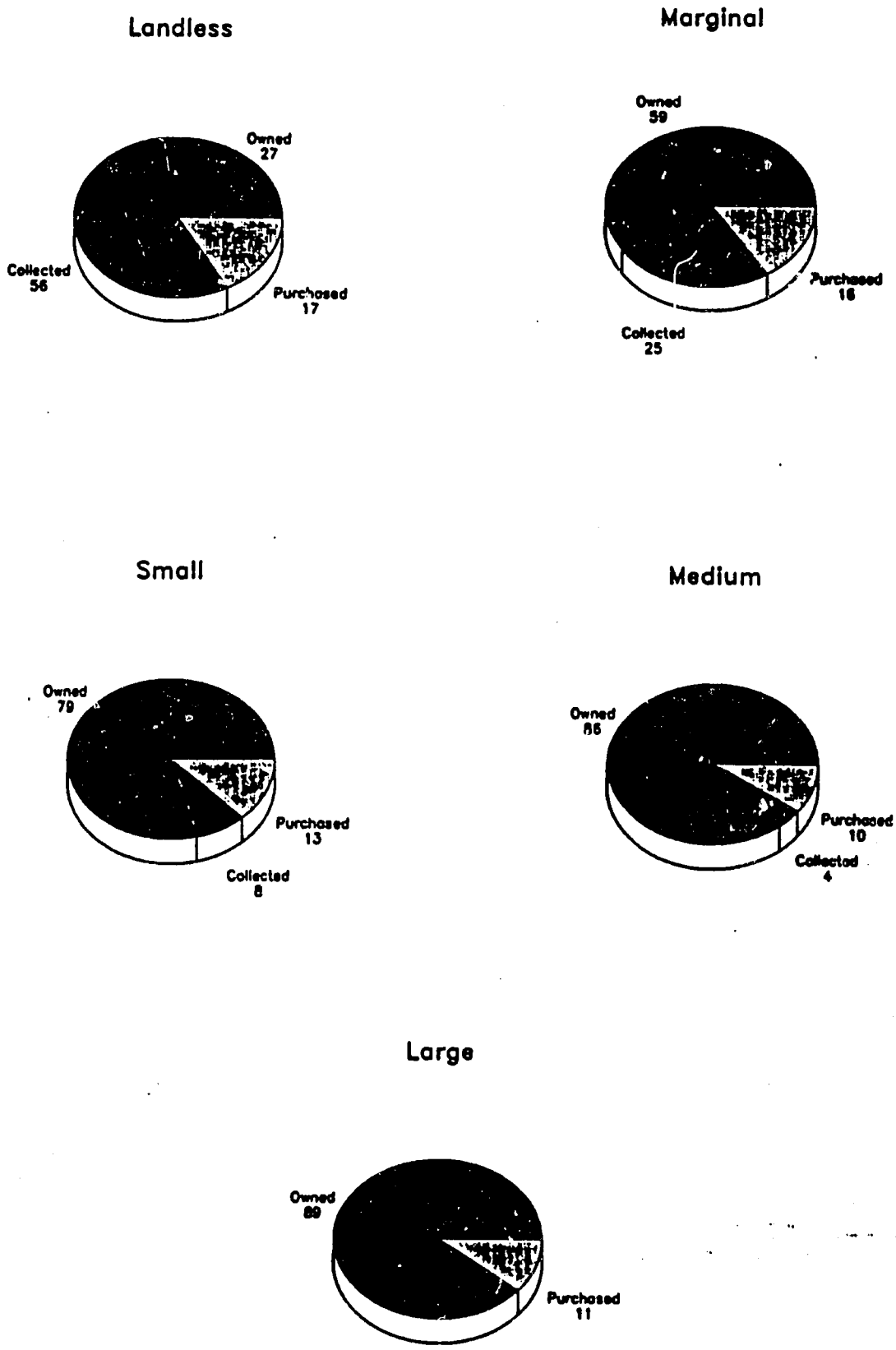

Figure 2. Graph showing relative contribution of different sources total household fuel-use in different farm categories.

Table 14. Percent of fuel owned, collected, and purchased by different farm sizes.

Size category (x)	% of fuel		
	Owned (Y1)	Collected (Y2)	Purchased (Y3)
Landless	27	56	17
Marginal	59	25	16
Small	79	8	13
Medium	86	4	10
Large	89	0	11
Overall	67	18	15

r (x, y1) = 0.81, Significant at P = 0.01 +
r (x, y2) = 0.87, Significant at P = 0.01 -
r (x, y3) = 0.33, Not significant at P = 0.10 -

The proportion of purchased fuel materials was highest for landless and marginal farm families due to their lack of resources (crop field, livestock, etc). However, the negative association between size of farm and the proportion of purchased fuel materials was not significant.

Distinct differences were found among farm categories in sources of fuel by type of fuel. for the landless farms, most fuelwood was purchased while tree leaves, crop residues and cowdung were collected. In contrast, the large farmers obtained almost all their fuel materials from their own resources. The need to collect or purchase fuel materials diminished as farm size increased. For marginal farms, most of the cowdung, rice straw and other crop residues came from their own sources. Still, marginal farmers had to purchase most of their fuelwood and collect most of the leaves just like the landless households. For small and medium farm households, most of the fuel materials came from their own resources, even though a considerable portion of fuelwood was purchased and cowdung, leaves and crop residues collected.

4.7. Fuel Shortage of Rural Households

It is difficult to quantify the actual shortage of fuel, because this is determined by various factors, such as the amount of food available to cook, decisions to change cooking patterns due to anticipated or existing fuel shortage, and the demand of food at a particular period. For the purpose of this study, it was assumed that farmers resorted to purchasing or collecting fuel materials when there was a shortage of it. Therefore, the sum of the amount collected and the amount purchased was considered as the amount of fuel shortage and has been expressed as a percent of the total fuel use. It does not include the "hidden" shortage of fuel due to the non-availability of food to cook or other reasons.

Farmers in all of the farm categories at all of the locations suffered from fuel shortages (Table 15). In general, 100 percent of the landless, 78 percent of the marginal and 61 percent of the small farmers bought or collected fuel material to meet the household needs. A small proportion of larger farmers suffered fuel shortages. The difference between fuel shortages for landless and large farmers was smallest in Patuakhali and Rajshahi and largest at Ishurdi. In the Barind area of Rajshahi, 100 percent of the landless and marginal farmers and 75 percent of the small, medium and large farmers suffer from fuel shortage though the durations of the shortages were different (Table 16).

In general, there is a shortage of household fuel at all the study locations for 16-42 percent of the year (Table 16). Shortages were most acute in the Barind area of Rajshahi district, where farmers suffered from fuel shortages for about two-thirds of the year. Farmers in Rangpur, Jessore, Patuakhali and Tangail suffered fuel shortages between 87 and 114 days per year.

The fuel shortage period tends to decrease as farm size increases. Landless and marginal farmers face fuel shortages for almost half of the year. Regardless of location and size of holding, the overall fuel shortage period was 113 days in a year (Table 16).

The rainy season (June - October) is the most critical period of fuel shortage. The inability to store a sufficient quantity of fuel materials because of inadequate storage space was one of the important reasons why the resource poor farmers suffered greater fuel shortage problems than the medium and large farmers, particularly in the rainy season. The collected materials were almost exhausted in the dry season and, thus, the landless and marginal farmers were compelled to purchase fuel materials during the rainy season, even when facing considerable economic hardship.

Table 15. Farmers deficit of fuel according to location and farm category.

Farm category	% farmer who experience deficit of fuel						
	Patuakhali	Jessore	Rangpur	Rajshahi	Ishurdi	Tangail	Overall
Landless	100	100	100	100	100	100	100
Marginal	66	92	58	100	75	75	78
Small	58	92	50	75	33	58	61
Medium	50	75	25	75	17	33	40
Large	58	25	25	75	8	33	38
All farm	67	77	52	85	47	60	65

Table 16. Annual fuel shortage in different farm categories in each study location.

Farm category	Shortage period (no. of days/year)						
	Patuakhali	Jessore	Rangpur	Rajshahi	Ishurdi	Tangail	Overall
Landless	190	120	150	240	105	127	155
Marginal	70	120	180	270	75	78	132
Small	68	120	90	240	25	46	91
Medium	50	90	150	270	20	64	107
Large	90	90	0	150	11	12	59
All farms	95	108	114	234	47	87	113

4.8. Mechanisms to Adjust to the Fuel Shortage

The collection of different fuel materials, such as cowdung, leaves, twigs, and crop residues was be the most common practice to compensate for fuel shortages, in landless, marginal and small farm categories at all of the locations (Table 17).

In addition, they reduced cooking frequencies during the crisis period, especially in the landless and marginal farm categories. Sometimes, food was cooked once during the day. The number of curries was also reduced. Many people resorted to cooking 'Khichuri' (rice and pulses cooked together) or boiling vegetables with the rice. These changes in cooking habits may have negatively affected the families' nutrition.

The fuel shortage was less acute in the medium and large farm families and they usually bought fuel materials when the stored materials were exhausted. Only at Rajshahi and Jessore did a considerable number of large farmers (33 and 25 percent, respectively) collect fuel materials. Seventeen percent of the large farmers at Rajshahi also reduced the cooking frequency during periods of the fuel shortage.

Some people purchased fuel materials. Many people burned fences, poles, and rafts during the crisis period. Farmers cut branches of homestead trees during fuel shortages, but no definite pattern and class specificity could be identified in this case. The fuel crisis adjustment mechanisms identified in the present investigation are similar to those reported in a previous study conducted at a deeply flooded site (Quddus and Abedin 1988).

Many farmers used methods to increase fuel efficiency. Most of the farmers at Rangpur (71 percent) and Ishurdi (69 percent) used husks and brans along with wood or bamboo to increase fuel use efficiency. A similar method was also used by some farmers in Tangail (8 percent). Almost all of the farmers of Patuakhali used double burner earthen 'Chulas' (cook stoves) in the dry and rainy seasons for efficient consumption of fuel, particularly when more items were cooked. A similar practice was used during the dry season by 50, 50 and 30 percent of the farmers of Jessore, Ishurdi and Rajshahi, respectively. The double burner 'chulas' were more common in the large and medium farm size categories than in the lower categories. The use of these 'chulas' was very limited (17, 25 and 10 percent of the households in the respective areas) during the wet season, because they are usually located in the courtyard. These double burner 'chulas' are particularly suitable for dried leaves, because the leaves burn quickly and produce a large quantity of ash within a short time. The single burner 'chula' needs frequent cleaning if leaves are used for fuel.

Table 17. Percent of farmers who collect of fuel materials by different farm categories at the study locations.

Farm category	% farmers who collect fuel materials					
	Patuakhali	Jessore	Rangpur	Rajshahi	Ishurdi	Tangail
Landless	100	83	92	90	100	92
Marginal	92	67	83	84	100	67
Small	75	85	58	56	84	25
Medium	50	42	0	2	25	0
Large	50	25	0	33	0	0
All	73	60	47	53	62	37

The use of the double burner 'chula' to increase fuel use efficiency (saves at least 25 percent fuel) has been reported earlier. In addition, some farmers of Tangail (35 percent) and Ishurdi (20 percent) reported the use of smaller 'chulas' for increasing fuel use efficiency. Large farm families seldom used smaller 'chulas' for regular cooking.

Table 18. Techniques followed to increase fuel-use efficiency

Techniques followed	% farmers responded					
	Patuakhali	Jessore	Rangpur	Rajshahi	Ishurdi	Tangail
1. Use of double burner 'Chula'						
a) Dry season	100	50	0	33	50	0
b) Wet season	98	17	0	10	25	0
2. Use of moveable/ small 'Chula'						
a) Dry season	7	50	3	0	0	17
b) Wet season	30	2	7	0	8	17
3. Low-depth 'Chula'	-	-	-	-	-	12
4. Mixing husks & brans with wood or bamboo	-	-	71	-	69	8
5. Pouring small amount of fuel at a time in the 'Chula'	-	-	-	-	-	8
6. Storing of the fuel material in the 'Chula'	-	-	-	-	-	10
7. Use of small 'Chula'	-	-	-	-	30	35

4.9. Fuel Shortage and Organic Matter Recycling

The use of cowdung and rice straw as fuel materials is the manifestation a of a serious fuel shortage for rural households in Bangladesh. Their use as fuel has a long-run detrimental effect on the economy in terms of reduced crop yield and cattle production. As more of these materials are used for fuel, less are available for organic matter in crop lands and for feed for cattle. The reduced crop yield would result in even less straw, less cattle feed, and, thus, lower cattle production. As a result, the supply of cowdung to be used as manures in crop fields would be reduced even more, creating a treadmill of lower food production and lower fuel availability.

Most of the cowdung was used for fuel instead of manure at all of the locations, except Rangpur and Ishurdi. On average, only 9 percent of the cowdung was used as manure at Patuakhali, 36 percent at Jessore, 27 percent at Rajshahi and 38 percent at Tangail. Farmers at Rangpur, on the other hand, used almost all of the cowdung (98 percent) as manure and farmers at Ishurdi used 58 percent of the cowdung as manure. Regardless of the locations, the share of cowdung used as manure increased with the increase in farm size (Table 19). Most of the farmers responded that a reduced crop yield resulted from using cowdung as fuel (Table 20).

Thirty seven percent of the respondents from Ishurdi reported that using rice straw as fuel created a shortage of cattle feed, but only 13 percent of the respondents from Tangail reported this problem . A shortage of cattle feed because of using rice straw as fuel was most intense in small farms and least intense in large farms (Table 21).

Table 19. Utilization pattern of cowdung in different farm categories at the various locations.

Farm category	% cowdung (own + collected) used as fuel and manure											
	Patuakhali		Jessore		Rangpur		Rajshahi		Ishurdi		Tangail	
	Fuel	Manure	Fuel	Manure	Fuel	Manure	Fuel	Manure	Fuel	Manure	Fuel	Manure
Landless	96	1	72	7	0	100	99	1	93	4	85	7
Marginal	91	2	72	24	8	92	53	46	30	66	58	33
Small	80	11	56	38	0	100	76	23	28	69	37	43
Medium	81	11	52	44	0	100	71	28	20	75	56	44
Large	70	20	36	60	0	100	61	35	19	76	67	36
All farms	84	9	58	36	1.7	98	72	27	38	58	54	38

Note: A small quantity of cowdung was also used for other purpose like smearing in addition to fuel and manure.

Table 20. Farmers' opinion about reduction of crop yields as a consequence of using cowdung as fuel.

Farm category	% farmers who responded that using cowdung as fuel reduces crop yields					
	Patuakhali	Jessore	Rangpur	Rajshahi	Ishurdi	Tangail
Landless	17	25	92	42	25	42
Marginal	33	50	90	100	33	42
Small	42	75	91	75	58	50
Medium	25	100	94	91	83	92
Large	25	83	98	75	100	58
All farms	28	67	93	76	60	57

Table 21. Farmers' opinion regarding whether shortage of cattle feed occurred as a consequence of using rice straw as fuel.

Farm category	% farmers who responded that using rice straw as fuel causes shortage of cattle feed					
	Patuakhali	Jessore	Rangpur	Rajshahi	Ishurdi	Tangail
Landless	8	0	85	25	33	25
Marginal	25	28	13	92	42	8
Small	42	42	25	58	58	17
Medium	8	17	13	45	33	17
Large	25	17	10	25	17	0
All farms	22	17	29	49	37	13

V. The Home Gardens

5.1. The Trees Grown

The homesteads were, in general, small in size (Table 22). Although open space is required for various household tasks, many species trees were grown on the homestead. As many as fifty-two species were recorded at the homesteads of the Tangail site. The total number of tree species at the other locations was 34, 28, 20, 28 and 21 at Ishurdi, Jessore, Patuakhali, Rajshahi and Rangpur, respectively. On average, there was 1.1 tree per $10m^2$ area in the homestead (excluding the area occupied by houses and ponds). However, there was remarkable variation in the density of trees in the homesteads of different locations and farm sizes. The average density was highest at Patuakhali and Rangpur (1.5 and 1.4 trees/$10m^2$ respectively) and lowest at Rajshahi (0.7 trees/$10m^2$) and Ishurdi (0.8 trees/$10m^2$). The abundance of trees in the homesteads might be affected by climatic factors, especially by rainfall. The rainfall at Rajshahi and Ishurdi was lowest among the six locations and at Patuakhali and Rangpur it was highest (Fig. 1).

The homesteads of the landless and marginal farmers had a higher density of trees than the homesteads of the larger farmers (Table 23). The data suggest that the poorer families were under more pressure to use their homesteads intensively to satisfy the various needs of the family.

Table 22. Average size of homestead area in different farm categories at the study locations.

Farm category	Average homestead area (ha)						
	Patuakhali	Jessore	Rangpur	Rajshahi	Ishurdi	Tangail	Overall
Landless	0.04	0.05	0.02	0.03	0.06	0.05	0.04
Marginal	0.07	0.08	0.05	0.07	0.11	0.06	0.07
Small	0.07	0.13	0.11	0.08	0.14	0.16	0.11
Medium	0.11	0.16	0.11	0.12	0.22	0.20	0.15
Large	0.20	0.22	0.30	0.35	0.34	0.30	0.28
All farms	0.10	0.13	0.12	0.13	0.18	0.15	0.14

Table 23. Average number of trees per 10m2 area of homestead according to location and farm category.

Location	Average number of trees per 10m2 of homestead*					
	Landless	Marginal	Small	Medium	Large	All farm
Patuakhali	1.3	1.9	1.6	1.4	1.1	1.5
Jessore	3.0	1.1	0.4	0.7	0.3	1.1
Ishurdi	0.9	1.2	0.7	0.5	0.6	0.8
Rajshahi	1.6	0.7	0.5	0.8	0.1	0.7
Rangpur	3.8	1.9	0.3	0.7	0.2	1.4
Tangail	1.1	1.5	0.7	1.0	0.8	1.0
Overall	2.0	1.4	0.7	0.9	0.5	1.1

* Part occupied by houses and ponds have been excluded

The Species Composition

Almost all of the homesteads had a mixed vegetation of perennial trees and annual vegetable crops, determined by the macro- and micro-environment at the homestead, and the needs and choices of the family. Thus, the species composition varied among locations and among farm categories. Although jackfruit was an important tree species at all other locations and had the most diverse utility among the tree species grown on the homesteads, it was only of minor importance at the Patuakhali site. The poorly drained soil and high water table throughout the year might be the obvious ecological limitation for growing jackfruit in this non-saline Tidal Floodplain area of Bangladesh (UNDP/FAO, 1982). Betelnut was the most important species at the Patuakhali site, but it was only a minor species in the low rainfall areas, such as Ishurdi. Date palm and 'Babla' were more common in the low rainfall areas of Jessore, Ishurdi and Rajshahi. Abedin et al. (1988) described how minor ecological variations (rainfall, soil characteristics) within the same physiographic unit (Ganges flood-plain) affect the distribution of Phoenix sylvestris and Acacia nilotica. It is important to note that some important fruit species of Bangladesh, notably mango and coconut, have wider adaptability and were important species at all of the study locations. The dominant tree species on the

homesteads at different locations are presented in Table 24. The species of minor importance at different sites are listed in Appendix 1.

Table 24. Major tree species grown on the homesteads at different locations of Bangladesh.

Location	Major Species	Average number per household	% household contained
Rajshahi	Palmyra palm (*Borassus flabellifer*)	4.48	58
	Babla (*Acacia nilotica*)	2.37	55
	Mango (*Mangifera indica*)	0.70	45
	Date palm (*Phoenix sylvestris*)	3.36	40
	Neem (*Azadirachta indica*)	0.50	33
	Bamboo (*Bambusa* spp.)	0.67	32
Tangail	Mango (*Mangifera indica*)	9.93	95
	Jackfruit (*Artocarpus heterophyllus*)	5.56	90
	Bamboo (*Bambusa* spp.)	2.65	89
	Betel nut (*Areca catechu*)	16.80	65
	Pituraj (*Amoora rohituca*)	1.02	48
	'Jiga' (*Odina woodier*)	2.05	43
	Coconut (*Cocos nucifera*)	0.96	40
	Lemon (*Citrus lemon*)	1.47	40
	Banana (*Musa* spp.)	1.01	38
Ishurdi	Mango (*Mangifera indica*)	4.54	87
	Jackfruit (*Artocarpus heterophyllus*)	2.18	60
	Date palm (*Phoenix sylvestris*)	3.19	58
	Coconut (*Cocos nucifera*)	3.25	53
	Banana (*Musa* spp.)	9.50	
	Black berry (*Eugenia jambolana*)	1.28	48
	Betelnut (*Areca catechu*)	4.90	38
	Palmyra palm (*Borassus flabellifer*)	0.78	32
	Bamboo(nos.) (*Bambusa* spp.)	22.43	23

Table 24. (Continued)

Location	Major Species	Average number per household	% household contained
Jessore	Coconut (*Cocos nucifera*)	5.12	78
	Mango (*Mangifera indica*)	1.99	67
	Jackfruit (*Artocarpus heterophyllus*)	3.35	67
	Banana (*Musa* spp.)	3.43	65
	Date palm (*Phoenix sylvestris*)	2.73	37
	Bamboo(clumps) (*Bambusa* spp.)	1.52	37
	Betelnut (*Areca catechu*)	3.98	
Rangpur	Jackfruit (*Artocarpus heterophyllus*)	2.75	73
	Mango (*Mangifera indica*)	3.25	72
	Bamboo(clumps) (*Bambusa* spp.)	0.05	60
	Betelnut (*Areca catechu*)	11.92	55
	Pitraj (*Amoora rohituca*)	2.20	38
	Coconut (*Cocos nucifera*)	0.46	37
	Neem (*Azadirachta indica*)	6.00	35
	'Poa'	0.85	34
Patuakhali	Betelnut (*Areca catechu*)	5.0	25
	Mango (*Mangifera indica*)	1.65	15
	Banana (*Musa* spp.)	1.3	13
	Coconut (*Cocos nucifera*)	0.42	7
	Raintree (*Samanea saman*)	0.42	7

*Average of 60 households

In addition to the ecological reasons, the socio-economic condition of the households was also a major determinant of the species composition in a homestead. The percentage of landless, marginal and small farmers having bamboo in their homestead was lower than for medium and large farmers (Table 25). But the frequency of banana in the poorer households was higher than in the larger farm categories. The smaller farmers may prefer those species which give a quick and regular cash return, require little space and do not cast much shade that might cause conflict with neighbors. While larger farmers may look for fruits and long term economic benefit, they were not concerned with the neighbors' inconvenience resulting from shade. A rapid rural appraisal indicated that poor farmers did not

raise bamboo which could shade the homestead of richer neighbors, but poor farmers' homesteads were shaded by large bamboo bushes owned by rich neighbors (Quddus and Abedin 1988).

Table 25. Average number of major tree species in different farm size categories.

Tree species	Location	Landless	Marginal	Small	Medium	Large
Fruit species						
M. indica	Rj/I/J/R/T/P	1.6	3.4	5.8	6.1	8.6
A. heterophyllus	Rj/I/J/R/T/P	1.4	2.2	2.3	3.6	3.9
C. nucifera	Rj/I/J/R/T/P	0.7	1.7	2.3	3.5	4.6
A. catechu	Rj/J/R/T/P	5.2	6.0	10.6	12.6	17.8
P. sylvestris	Rj/I/J/R/T/P	0.5	1.6	1.8	2.5	4.9
B. flabellifer	Rj/I/J/R/T/P	0.2	0.4	0.9	1.5	3.4
Zizyphus zuzuba	Rj/I/J	0.3	1.3	0.2	0.3	0.3
Citrus spp.	Rj/I/J/R/T/P	0.4	0.5	0.4	0.3	0.7
Psidium guajava	j/I/J/R/T	0.3	0.2	0.4	0.7	0.5
Carica papaya	Rj/I/J/R/P	0.7	0.5	0.7	0.6	1.3
Musa spp.	Rj/I/J/R/T/P	4.2	3.8	3.9	4.6	4.7
Forest species						
S. saman	I/R/P	1.2	3.5	2.2	2.6	2.6
A. indica	Rj/I/J/R/T	1.1	2.5	0.5	1.5	0.7
A. nilotica	Rj/I/J/R	0.2	0.9	0.3	2.1	0.6
Bambusa spp.	Rj/I/J/R/T/P	0.6	6.1	6.9	2.9	10.4
O. woodier	Rj/I/J/P	0.1	1.5	0.5	0.8	2.1
B. malaboricum	Rj/I/R/P	0	-	0.1	0.1	0.3
Albizzia procera	J/R/P	0.3	0.1	2.1	0.4	0.1
Moringa olifera	Rj/J/R	0.2	0.1	-	0.2	0.2
Anthocephallus cadamba	Rj	0	-	0.1	0.1	0.1

*Rj = Rajshahi I = Ishurdi J = Jessore
R = Rangpur T = Tangail P = Patuakhali

5.2. Vegetables in the Homegardens

In additional to perennial trees, different vegetables and spices were grown on the homestead. At almost all of the locations, farmers used the trees to support climbing vegetables (Table 26). This practice was most frequent at Tangail, Patuakhali and Ishurdi. Country bean was the most common climbing vegetable. The other common species growing on the homestead trees were bottle gourd, sponge gourd, ash gourd, sweet gourd, and ribbed gourd (Table 26). Almost all of the shrub and tree species were associated with climbing vegetables. However, *Odina woodier, Amoora rohituca, Acacia nilotica, Mangifera indica, Artocarpus heterophyllus, Anthocephallus cadamba* and *Diospyros cardifolia* were the most common trees associated with vegetables. Most respondents reported that the tree - creeper association adversely affected the growth and fruit yield of the host trees.

Many vegetables and spices were also grown under the shade of the trees. Turmeric, ginger, elephants foot ('01 kochu'), chilli, stem amaranth, Indian spinach, brinjal and lalsak were the most common vegetables and spices. Although most of the shrubs and tree species were associated with these vegetables and spices, the tree species casting little shade, such as Musa spp., Areca catechu, Cocos nucifera and Phoenix sylvestris were more commonly associated with these vegetables and spices than other tree species. Some of the vegetables and spices grow well only under shade and, therefore, these were not usually grown in sunny places. Turmeric, ginger, aroid, giant taro and elephants foot were among those grown in the shade. On the other hand, most of the exotic winter vegetables, such as potato, tomato, spinach, cabbage, and radish, were grown only in sunny places. Most of the respondents reported that the yield of these vegetables were reduced by the shade of trees.

Table 26. Vegetables grown in the home gardens at different locations.

Type	% farmer grew							Common associated tree species
	Rajshahi	Ishurdi	Jessore	Rangpur	Tangail	Patuakhali	All	
A. Climbing on trees								
1. Country bean (*Dolichos lablab*)	17	30	5	12	48	95	35	Jiga, Neem Pitraj,
2. Ash gourd (*Benincasa hispida*)	2	8	-	-	18	-	5	Babla, Mango,
3. Sponge gourd (*Luffa cyclindrica*)	-	10	3	-	15	57	14	Jackfruit Kadam, Gab
4. Bottle gourd (*Lagenariavulgaris*)	11	15	-	5	47	-	13	Woodapple
5. Sweet gourd (*Cucurbita moschata*)	6	18	-	-	13	-	6	
6. Ribbed gourd (*Luffa acutangula*)	-	-	-	-	5	22	5	
7. Yam (*Dioscorea bulbifera*)	-	-	8	20	25	15	11	
8. Snake gourd (*Trichosanthes anguina*)	-	7	-	-	7	-	2	
9. Indian spinach (*Basella alba*)	-	5	-	-	7	-	2	
10.Kakrol (*Momordica dioica*)	-	-	-	-	-	5	< 1	
11.Cow pea (*Vigna unguiculata*)	-	-	-	-	-	37	6	
B. Grown under shade								
1. Turmeric (*Curcuma domestica*)	-	-	10	-	8	-	3	Banana Betel nut
2. Ginger (*Zingiber officinale*)	-	-	-	-	13	-	2	Date palm Coconut
3. Giant taro (*Alocasia macrorrhiza*)	7	-	5	8	5	-	4	Mango Jackfruit

Table 26. (Continued)

Type	% farmer grew							Common associated tree species
	Rajshahi	Ishurdi	Jessore	Rangpur	Tangail	Patuakhali	All	
4. Elephants foot ('O1') (*Amorphophallus campanulatus*)	8	-	-	-	-	-	1	Jujube Babla Neem Guava
5. Aroid (*Calocasia esculenta*)	-	-	-	-	-	-	5	Tamarind
6. Chili (*Capsicum annum*)	-	8	-	-	8	-	3	
7. Data sak (*Amaranthus lividus*)	-	16	-	-	-	-	3	
8. Bottle gourd (*L. vulgaris*)	-	5	-	-	-	-	< 1	
9. Country bean (*D. lablab*)	-	8	-	-	-	-	1	
10.Indian spinach (*B. alba*)	-	15		-	-	-	3	
11.Sponge gourd (*L. cylindrica*)	-	-	7	-	-	-	1	
12.Brinjal (*Solanum melongena*)	-	-	-	-	15	-	3	
13.Garlic (*Allium sativum*)	-	-	-	3	-	-	< 1	
14.Lal sak (*Amaranthus gangeticus*)	-	25	-	-	-	-	4	
C. Grown in sunny place								
1. Bottle gourd (*L. vulgaris*)	33	28	28	80	60	50	47	
2. Data sak (*A. lividus*)	30	55	35	-	23	53	33	

Table 26. (Continued)

Type	% farmer grew							Common associated tree species
	Rajshahi	Ishurdi	Jessore	Rangpur	Tangail	Patuakhali	All	
3. Country bean (*D. lablab*)	23	23	17	76	38	-	30	
4. Lal sak (*A. gangeticus*)	12	62	-	-	-	73	25	
5. Ash gourd (*B. hispida*)	22	7	-	-	8	-	6	
6. Radish (*Raphanus sativus*)	22	43	20	1	8	35	22	
7. Brinjal (*S. melongena*)	-	30	-	1	27	68	21	
8. Tomato (*Lycopersicon esculentum*)	-	-	13	-	8	41	10	
9. Lady's finger (*Hibiscus esculentus*)	13	40	-	-	-	-	9	
10. Sweet gourd (*C. moschata*)	20	10	-	-	25	18	12	
11. Indian spinach (*B. alba*)	30	-	-	-	-	-	-	
12. Potato (*Solanum tuberosum*)	10	-	-	-	-	-	-	
13. Spinach (*Spinacia oleracea*)	-	-	23	-	7	-	5	
14. Chili (*C. annum*)	25	-	-	-	8	-	6	
15. Bitter gourd (*Momordica charantia*)	-	12	-	-	-	3	3	
16. Cabbage (*Brassica oleracea*)	-	32	-	-	-	-	5	
17. Ribbed gourd (*L. acutangula*)	-	-	-	-	8	5	2	

5.3. Management of Homestead Trees

Farmers invest little in the management of trees grown on homesteads. The management of homestead trees by farmers in different farm categories at the study locations was assessed by collecting data on fertilizer application and pruning practices.

Most of the farmers did not apply manures and fertilizers to the trees grown in the homestead. Only 32 percent of the farmers used manure and/or fertilizer (Table 27a). The use of chemical fertilizers for the trees was much less common than the application of organic manure (cowdung and compost). Three percent of the farmers used chemical fertilizer alone and another 7 percent used both organic manure and chemical fertilizers, while 22 percent used organic manure alone.

The farmers of Ishurdi and Rangpur were more aware of manuring homestead trees than farmers of other locations. Fifty-seven and 43 percent farmers of the farmers in Ishurdi and Tangail, respectively, applied manure and/or fertilizer to their trees.

The percentage of farmers who manured or fertilized their trees increased as farm size increased (Table 27b). Forty-two percent of large farmers and 38 percent of medium farmers applied manure and/or fertilizer and only 26 percent of the landless and 23 percent of the marginal farmers applied manure and/or fertilizer.

Table 27a. Status of fertilizer management for the homestead trees at different locations.

Location	% of farmers applying manure and/or fertilizer			
	Organic Manure	Chemical Fertilizer	Manure + Fertilizer	Total
Rajshahi	8	0	5	13
Ishurdi	37	13	7	57
Jessore	37	0	0	37
Rangpur	28	5	10	43
Tangail	18	0	20	38
Patuakhali	3	0	0	3
Overall	22	3	7	32

Table 27b. Fertilizer management for the homestead trees according tofarm category.

Location	% of farmers applying manure and/or fertilizer			
	Organic Manure	Chemical Fertilizer	Manure + Fertilizer	Total
Landless	18	1	7	26
Marginal	18	1	4	23
Small	22	1	8	31
Medium	24	6	8	38
Large	28	6	8	42
All farms	22	3	7	32

Most of the trees were pruned for various purposes and many tree species, such as Mango,jackfruit, coconut, date palm, palmyra palm, jujube, babla, pitraj, koroi, raintree and mandar, were pruned at a particular time of the year (Table 28. In a strict sense, the practices could not be called pruning, because the farmers cut the branches of trees as required for fuelwood, fencing, and poles, rather than considering the growth and productivity of the trees. Forty-one percent of the farmers cut the branches or leaves to meet their fuel needs, and 37 percent pruned the trees for increased fruit or juice yield (Table 29).

Only five of the commonly pruned species, jackfruit, jujube, coconut, date palm and palmyra palm, were pruned or cleaned to increase the productivity of the trees. The small, thin branches of jackfruit were removed during mid September to mid October before the trees blossom, to enhance flowering and fruiting. The old branches of jujube were cut during mid February to April to enhance new branching for better fruiting. Some other less common tree species, such as litchi and lemon, were also pruned. Usually the branches of lemon affected by die-back were removed, and the top of the young branches of litchi were cut prior to the monsoon to enhance vegetative growth. The lower leaves of coconut removed twice per year, first during April to May and then in September to October, mainly for cleaning and increased fruiting. Palmyra palm was cleaned in the same way, but usually once per year in April to May. The date palm was cleaned during mid October to mid December for extracting juice from which molasses ('Gur') is made. The branches of other species were cut usually for fuel and other needs for the family. A considerable

number of households in the large farm category (24 percent) reported that they cut the branches of the trees to increase sunlight availability in the homestead.

Table 28. Pruning practices in different tree species grown in the homesteads

Tree species pruned	Sites of observation	% farmer pruned	Plant part pruned	Time of pruning
Mango (Mangifera indica)	J/I/R/T/P	25	Small than branches	September-mid June
Jackfruit (*Artocarpus heterophyllus*)	J/I/R/T/P	21	"	Mid Sep-Mid Oct. and June
Coconut (*Cocos nucifera*)	J/I/R/T/P	22	Lower leaves	April-May & Sept-Oct.
Date palm (*Phoenix sylvestris*)	J/I/R/T/P	18	"	Mid Oct-Mid Dec.
Palmyra palm (*Borassus flabellifer*)	Rj/J/J/P	10	"	Mid April-Mid May
Jujube (*Zizyphus zuzuba*)	Rj/J/I/R/T	10	Branches	Mid Feb-April
Lemon (*Citrus lemon*)	T	2	Dead & diseased branches	October
Wood apple (*Aegle marmelos*)	T	2	Dead and diseased branches	Mid Sept-Mid Nov.
Pomello (*Citrus grandis*)	P	2	"	Mid Oct-Mid Nov.
Tamarind (*Tamarindus indica*)	J/I/P	3	Dried branches & twigs	Mid Feb-Mid April
Litchi (*Litchi sinensis*)	T	2	Tip of young branches	May
Babla (*Acacia nilotica*)	Rj/S/T	24	Branches & twigs	March-April & Dec-Jan

Table 28. (Continued)

Tree species pruned	Sites of observation	% farmer pruned	Plant part pruned	Time of pruning
Pitraj (*Amoora rohituca*)	T/R	18	"	April-June & Aug-Sept
Koroi (*Albizzia procera*)	T/P	45	"	April-May & Sept-Nov
Raintree (*Samanea saman*)	P	45	"	April-May & Sept-Nov
Mandar (*Erythrina indica*)	P	13	"	Sept-Nov

Table 29. Reasons for pruning homestead trees by different categories of farms.

Reason for pruning or cutting branches	% of farmers*					
	Landless	Marginal	Small	Medium	Large	All farm
1. To meet fuel needs	25	28	46	45	55	41
2. To increase fruit yield	20	30	36	45	52	37
3. To increase juice yield (where applicable)	6	14	14	22	30	17
4. To enhance growth of the tree	5	8	25	21	25	17
5. To remove shade	8	4	4	9	24	10

*Average of five locations viz, Jessore, Ishurdi, Rajshahi, Rangpur and Tangail

5.4. Sources of Seeds and Seedlings

In general, the local market, the household and the neighbors were the main sources of seeds and seedlings of trees and vegetables for the homesteads. Government horticulture nurseries and forest nurseries were not important sources of seed and seedlings, though private traders might have purchased the seedlings from these nurseries. However, the relative contribution of different sources varies among locations and among farm categories. At Rangpur and Tangail the household was the main source of seeds and seedlings, while at the other four locations local markets were the main sources (Table 30a). Within farm categories, the neighbors were the most important source of seed and seedlings for the landless farmers, the local market was most important to marginal and small farmers, and the household was the most important to medium and large farmers (Table 30b).

Table 30a. Sources of seeds/seedlings at different locations.

Sources	% of farmers getting seed from various sources						
	Rajshahi	Ishurdi	Jessore	Rangpur	Tangail	Patuakhali	Average
1. Own	29	53	53	67	82	37	54
2. Neighbors	27	35	70	35	42	34	41
3. Market	32	60	76	33	43	83	55
4. Agriculture office	20	15	12	3	17	0	11
5. Forest office	3	5	-	6	17	5	6
6. Relatives	17	20	30	15	35	10	21
7. Others	3	-	-	-	3*	0	1

Table 30b. Sources of seeds/seedlings in different farm categories.

Sources	% of farmers getting seed from various sources					
	Landless	Marginal	Small	Medium	Large	All farm
1. Own	36	43	50	61	68	54
2. Neighbors	57	36	39	42	28	41
3. Market	36	56	62	56	64	55
4. Agriculture office	15	7	7	11	15	11
5. Forest office	1	4	7	11	7	6
6. Relatives	29	17	21	22	17	21
7. Others	0	0	1	3	1	1

5.5. Change in Species Dominance over Time

The changing needs have compelled rural people to replace some of the earlier tree species with new ones. Ten years ago mango was a dominant species on the homesteads at all of the locations, but now betel nut has become more dominant than mango at Rangpur, Tangail and Patuakhali. Acacia nilotica is more dominant than mango at Jessore, Ishurdi and Rajshahi. These distributions are mainly

determined by ecological factors. Class specificity is only reflected in the diversity and abundance of species within a homestead. Raintree and 'Koroi' have been planted at a higher rate within the last ten years at Patuakhali and Rajshahi, perhaps because of their multiple uses. Date palm plantings have also increased at Patuakhali, Ishurdi and Rajshahi in recent years. Date palm also remains dominant at Jessore. The cash income from 'Gur', prepared from the juice of the tree is the main attraction of this species. Although it used to be a good source of cash income to farmers, the population of khayer trees (Acacia catechu) at Ishurdi and Rajshahi declined drastically because of the difficult extraction process.

5.6. Choice of Species for Homesteads in Different Farm Categories.

Survey data reveal that species were considered for their use for fruit and timber by a majority of the farmers regardless of location and farm category. However, a variety of other uses as well as the possible effect of the species on other homestead-based enterprises were also considered by the farmers.

Despite the fuel crisis, very few farmers grew trees primarily for fuel. Farmers preferred fruit trees from which they could derive fruit as well as fuel (and also fodder in some cases) from the same tree. There is a growing trend to choose species which ensure more regular income than from mango, traditionally the most popular species. Less shady species are preferred as they do not hamper vegetable production, seedling raising, and other homestead-based activities.

5.7. Farmers Plan of Future Homestead Plantation

A majority of the farmers planned to plant new trees on their homestead, though the choice of the species varied according to the need and existing situation of the individual farmers, and environmental (macro and micro) factors. Almost all of the farmers, regardless of farm category and location, were eager to plant fruit trees if good varieties were available.

5.8. The Decision Making Process in the Family Regarding Homestead Planting.

In most cases, the family head (farmer himself) made decisions about tree planting on the homestead (Table 31). The role of the wives of the farmers was also important, particularly in small and medium farm categories. The old members of the family (aged parents) made decisions about tree planting only in a few cases, regardless of the farm category. The children also participated in decisions, particularly in the medium farm category. Unfortunately, the joint role of the family head and his wife was not assessed at most of the study locations. The evidence from Tangail indicated that the joint decision of the farmer and his wife was very

significant in landless and marginal farm categories (33 percent and 25 percent of the respondents, respectively). In landless households, the joint decision was more frequent than the independent decision by the farmer. The joint role of the husband and wife in the decision making process regarding production of trees and vegetables in the homestead was very important in a survey conducted by Hossaian et.al (1988).

Table 31. The role of different family members in making decisions about homestead plantings.

Family member making the decision	% of farmers who responded					
	Landless	Marginal	Small	Medium	Large	All farm
Farmer	63	81	63	77	76	72
Housewife	13	22	27	30	23	23
Father	6	8	5	5	2	5
Mother	4	8	13	5	2	7
Children	7	8	17	12	22	12

5.9. The Use of Homestead Trees

Every tree species on the homestead had multiple end uses, though not all of the uses were considered when planting the species. The major fruit species, mango and jackfruit, are planted primarily for fruit and timber, but eventually they provide fuel and fodder. Similarly, all of the other tree species had some utility in addition to their primary use. These additional uses were by no means less important to the families. For example, household fuel was the most common use of the homestead trees, though very few farmers planted trees primarily for fuel. The primary uses of the trees grown on the homesteads were fruit, juice, timber and building materials (poles, rafts) and the secondary uses were fuel, fodder, manure, handicrafts, fencing, and windbreak. The major and minor utilities of the common tree species on the homestead are listed in Table 32.

Table 32. Relative importance of the different uses of homestead trees.

Species	Uses											
	Fruit	Timber	Poles & rafts	Juice	Agril. imple-ment	Fuel	Fodder	Trellis & fenc-ing	Insct. & Medic	Handi-craft	Support to cree-per veg	Others 1/
Mango	***	**				**	*				*	
Jackfruit	***	***				*	*				*	
Coconut	***		**		*	**		*			*	
Betel nut	***		**								*	
Date palm	*		**	***		*		*		*	*	
Palmyra palm	**		**	**		**		*		*		*
Blackberry	**	**			*	*					*	
Jujube	***	*			*	*	*	*			**	
Guava	***					*	*				*	
Pomelo	***										*	
Lemon	***					*					*	
Custard apple	**		*			**	*	*			*	
Bullocks Heart	***					*		*			*	
Woodaple	***					**			*		*	
Hog plum	***					*		*				
Tamarind	*					**						
Papaya	***					*	*		*			
Banana	***					*	*	*	*		*	
Litchi	***		*			**		*			*	
Pomegranate	***					*						
Gab	*					*		*			*	
Fig	*					*		*			*	
Sajina	***					*	*	*			*	
Bamboo			***		**	**	*	***		**		
Babla		**	*		***	**	**	**			**	
Koroi		***	**			**						
Raintree		***	**			**						
Meghogoni		***				*						
Debdaru		*				*	*					*
Sissu		***	*		*	**						
Segun		***			*	**						
Neem		***	***		**	**		*			**	*
Ghoranim		**			*	*		*				
Pitraj								*			**	
Silk cotton						**	**	*				
Jiga			*			**		*			**	
Kadam						*	*					
Mandar	**					*	*					
Gamar						*						
Poa						*						
Krishnachura						*						*
Nishinda						*		**				

*** = Most important use ** = Moderate importance * = Minor importance
1/ = Wind break, shade, manure, beauty, etc.

5.10. The disposal of homestead trees

Attempts were made to understand the disposal pattern of the homestead trees in different farm categories and at different locations. About 36 percent of the households felled at least one tree during a year. The felling of trees was more common among the large farmers. About 49 percent of the large farmers reported felling at least one tree during a year. The rate of felling was the lowest among the marginal farmers (28 percent of farmers). The overall rate of felling was the highest at Rangpur, where 50% of the households felled at least one tree during a year (Table 33). About 45% and 42% households at Tangail and Patuakhali, respectively felled trees during a year. A lower percentage of households cut their homestead trees at Rajshahi and Jessore (only 8 percent and 25 percent, respectively).

Table 33. Percentage of households felling trees in different farm categories.

Location	% farmers who felled homestead trees during a year					
	Landless	Marginal	Small	Medium	Large	All farm
Rajshahi	8	0	8	8	17	8
Ishurdi	NR	NR	NR	NR	NR	NR
Jessore	17	25	58	8	18	25
Rangpur	67	42	8	58	78	50
Tangail	8	42	50	42	67	42
Patuakhali	8	42	50	42	67	42

NR = Not recorded

Table 34. Percentage of farmers felling different types of trees according to farm category.

Type of species felled	% farmers					
	Landless	Marginal	Small	Medium	Large	All farm
Woody fruit trees	18	17	25	17	23	20
Timber yielding trees	8	13	5	13	23	12
Multipurpose trees	4	7	18	7	8	9
Palms	2	3	7	2	8	4

The percentage of households felling homestead trees during a year was proportional to the population of trees on a homestead. It was most common to fell woody fruit trees, such as mango, jackfruit, and blackberry, in all of the farm categories (Table 34). Overall, 20 percent of the households felled woody fruit trees, 12 percent felled timber species, 4 percent felled palms and 9 percent felled other types, including multipurpose species, like Babla, and woody shrubs of fruit and fuel value. The felling of timber yielding trees was most common among the large farmers (23 percent) only 13 percent of both marginal and medium farmers felled timber yielding trees, while the percentage of landless and small farmers who felled timber yielding trees was even lower (8 percent and 5 percent of the households, respectively).

The reasons for felling homestead trees are presented in Table 35. Most landless, marginal and small farmers cut the trees to earn cash to meet their daily needs. They used the cash earned from selling the tree to pay for food, clothes and other necessities, or to repay loans. While 55 percent of the medium farmers and 32 percent of the large farmers also reported felling trees to earn money, their perspectives were different from the smaller farm categories. Most medium and large farmers used their cash earnings to buy land, irrigation equipment, or to repay bank loans. Many of the farmers in all categories reported selling trees to earn cash needed for their children's marriage ceremony.

Among large farmers, the need for both household fuel and buiding materials were equally important reasons to cut down homestead trees. For small and medium farmers the need for fuel and building materials were also significant reasons to fell homestead trees, though not nearly as important as the need to earn cash income.

Table 35. Reasons for felling trees, by farm categories

Farm category	% Farmers felling trees for different reasons					
	Cash Income	Fuel Wood	Building Material	Furniture	Unpro-ductive	Other
Landless	64	21	19	6	7	3
Marginal	62	4	23	6	0	8
Small	56	30	20	3	12	11
Medium	55	22	32	20	5	12
Large	32	30	34	22	12	15
All Farms	54	21	26	11	7	10

It is important to recognize that most of the farmers are felling trees for cash generation. Some farmers use some of these tree products for fuel and other household needs. However, most of the wood is sold to generate cash, despite the fact that almost all of the farmers suffer from fuel shortages. Due to economic hardships, the farmers' products are being used to supply the city dwellers directly or indirectly. Therefore, the solution to the rural fuel shortage lies in addressing the economic hardships of the villages while at the same time addressing the fuel needs of the city dwellers.

5.11. Income from the Homegardens

The contribution of the homegarden to the total annual income of the rural households in all of the farm categories was not significant. On average, it provided only 4.68 percent of the annual income (Table 36). However, the income from the homegarden varied significantly among locations (due to incomplete data, the income from the home gardens at Rajshahi and Rangpur could not be computed). Among the other four locations, the income from the homegarden was the highest at Jessore (Tk. 11,026/year) and Tangail (Tk. 3,708). The income from the homegarden at Patuakhali was almost negligible (Tk. 67). The income from fruits and trees was much higher than from vegetables. However, the contribution of trees, fruits, and vegetables to the annual income varied among locations. Vegetables provided significant income only at Ishurdi.

Annual income from the home garden increases as farm size increases (Table 37). The income from the home gardens ranged from Tk 1,597/year in the landless households to Tk 5530/year in the large farm category. The largest share of large farm income (59 percent) came from the sale of the trees, while fruit provided the maximum share of income (55 percent) in medium farms, and vegetables provided the maximum share of income (41 percent) in marginal farms. In landless and small farms the contributions of both trees and fruits were almost equal. The relative contribution of different components of the home garden was more influenced by the ecological variations than by the class specificity.

Table 36. Average annual income from home gardens and relative contribution of different resources at different locations.

Location	Annual income from home garden (Tk)	% Contribution of different resources		
		Trees	Fruits	Vegetables
Patuakhali	67	100	0	0
Jessore	11,026	28	54	18
Ishurdi	1,590	32	25	43
Tangail	3,708	40	38	22
Average	4,098	31	47	22

Table 37. Average annual income and relative income from different homestead resources according to farm category.

Farm size	Annual income from home garden (Tk)	% Contribution of different resources		
		Trees	Fruits	Vegetables
Landless	1,597	36	36	28
Marginal	2,640	26	33	41
Small	3,243	36	36	28
Medium	4,142	24	55	21
Large	5,530	59	27	14
All farms	3,430	39	37	34

VI. CONSTRAINTS OF TREE GROWING ON THE HOMESTEAD

The need for growing more trees is felt by almost all of the farmers. But they are constrained by physical, technical and socio-economic factors (Table 38). The physical problems are related to environmental factors and are common to all of the farms of a particular location. The socio-economic problems vary with farm category and also within a farm category due to differential needs and resource bases.

6.1. Physical

There were physical problems with growing trees at each of the locations.

Rangpur:

Most of Rangpur district is either flood free or only shallowly flooded. However, occasional flooding during the rainy season is often a limitation for raising seedlings. Low organic matter content of the soil, a sandy substratum at a shallow depth and winter drought (Abedin et al. 1983) may also be constraints to planting trees.

Rajshahi (Barind):

The environment of the Barind Tract is the most challenging for agriculture. The extremely low rainfall, high temperature and consequent higher rate of evaporation have made the Barind Tract highly vulnerable to drought. The low water holding capacity and low organic matter content of the soil and the low ground water table (Shahidullah et al. 1983) worsen the situation.

Tangail:

The deep flooding of this area is the most important limitation for growing trees, particularly in crop lands. Flooding indirectly limits homestead tree growing because the homesteads in Tangail are usually located on artificially raised lands, which are small and already intensively used.

Ishurdi:

Like Rajshahi, Ishurdi is located in one of the lowest rainfall areas of Bangladesh and, thus, soil moisture is a limiting factor for tree seedlings during the dry months. High temperatures and dry weather may be highly detrimental to some species from February through May.

Jessore:

Although the annual rainfall at Jessore is somewhat higher than that at Rajshahi and Ishurdi, it belongs to the dry zone (Manalo 1976). However, the climatic and edaphic factors are not serious constraints for tree growing at Jessore.

Patuakhali:

High rainfall and a high water table in Patuakhali may be limiting factors for some tree species. The soils remain water saturated for about half of the year, which is not suitable for tree species requiring well drained soils. This constraint explains the absence of jackfruit at Patuakhali.

A number of other factors limit tree growing by the farmers. The space constraint was the most common among and within different farm categories. Even the farmers with large homesteads are constrained by space scarcity due to the requirement of open space for different household needs, such as drying crop products and clothes, and threshing crops.

6.2. Socio-economic Constraints

Among the socio-economic problems, conflict with neighbors was the most notable and common to all farm categories. Free grazing of cattle was a major constraint to planting trees either on crop fields or on homesteads. The authors noted from a rapid rural appraisal that richer neighbors impose on the resources of the landless and marginal farmers. Due to their inferior social status, poor farmers could not protest when a richer neighbor raised bamboo near the south of the poor farmers' homesteads, restricting the availability of sunlight for raising trees and other household tasks.

6.3. Technology related problems

The common technologically related problems were the lack of good seeds/seedlings at almost all of the locations and in all of the farm categories and the lack of knowledge regarding the modern management of trees.

The conflict between different components of a farm was also an important problem for the farmers. Many farmers reported that vegetable production and rearing household animals would be hampered by increased tree plantings. These concerns were more common among the landless and marginal farmers.

Table 38. Constraints to planting new trees on the homesteads of different farm categories.

Constraints	% Farmer responded (average of 6 locations)					
	Landless	Marginal	Small	Medium	Large	All farmers
Technological						
1. Lack of good seed/seedling	57	57	78	67	53	62
2. Lack of technical know-how	39	39	32	43	29	37
3. Problem in poultry and duck rearing	7	3	5	8	5	6
4. Limits vegetable production	17	22	21	16	12	17
5. Presence of insects and diseases	-	8	4	4	10	4
6. Creates problem in livestock rearing	14	10	15	17	15	15
Social						
1. Conflict with neighbors	22	7	7	12	10	13
2. Other members of the family do not like	5	-	3	6	3	4
3. Creates problem in household activities	11	20	7	12	30	16

Table 38 (Continued)

Constraints	% Farmer responded (average of 6 locations)					
	Landless	Marginal	Small	Medium	Large	All farmers
Physical						
1. Restricts sunshine and air	22	22	21	36	31	29
2. Unsuitable soil	20	6	21	18	17	16
3. No more space	65	54	44	42	46	50
Others	17	10	17	9	10	12

VII. CONCLUSIONS AND RECOMMENDATIONS

Fuel, an item as important as food, is in short supply in the rural households of Bangladesh. The poor suffer the most from fuel shortages. As a result, cooking patterns are frequently changed, which might have a negative effect on human health. Further, the shortage of fuel has led to the widespread burning of cowdung and crop residues, which negatively affects soil productivity. This, in turn, limits crop production.

The role of trees in farming systems deserves priority as part of a solution of the fuel crisis. Unfortunately, very little work has been done on the role of trees in farming systems in Bangladesh. In fact, the problems related to tree production in various situations in Bangladesh have not been studied in sufficient detail. Several research and development issues were raised by Abedin et al. (1988). Subsequently, the present studies were conducted to understand details regarding tree growing and its relationship to fuel use, and to identify the areas for improvement in existing farming systems. The following research and development issues are suggested by the present studies.

1. Since the fuel shortage is acute, production of fuelwood at the household level should receive high priority. This would save crop residues and cowdung for recycling as organic manure.

2. Methods to improve fuel use efficiency should be devised for rural households. This must involve the evaluation of the materials being used as fuel.

3. In order to solve the rural fuel crisis, the fuel problem of city dwellers must be solved so that the export of fuel from villages to cities is reduced. The use of wood fuel in a brick-kiln should be reduced.

4. More multi-purpose and quick growing trees must be planted. Fruits trees should be emphasized for home garden plantations because farmers prefer fruit trees.

5. Detailed analyses of the existing tree-crop and tree-vegetable interactions in different agro-ecological zones are needed for the selection of appropriate species.

6. The indigenous tree species should be evaluated for the desired functions.

7. Improved management practices for both trees and crops/vegetables need to be developed.

8. The economics of growing different tree species under agroforestry/homestead plantation systems should be studied.

9. The prospect and feasibility of introducing quick growing multi-purpose tree species on crop fields and homesteads should be studied.

10. Proper techniques for the establishment of seedlings/saplings on marginal soils such as Barind soils, need to be developed.

11. Seeds/seedlings of proven species should be made available to the farmers.

12. The farmers and extension workers should be trained on improved management practices of trees, particularly under homestead plantations and agroforestry systems.

SUMMARY

A survey of six study locations revealed severe shortage of household fuel. On average 65 percent of households surveyed had insufficient fuel materials. Landless, marginal and small farmers suffered worst, with 100 percent, 78 percent and 61 percent respectively, reporting regular fuel shortages. These groups own only a few of the resources required to meet their daily fuel needs. The crisis was the most acute in the Barind tract (Rajshahi) where 85 percent of all households were fuel deficient. The crisis was least severe in Ishurdi and Rangpur where 47 percent and 52 percent of the respondents, respectively, reported shortages.

On average, about one-third of total fuel materials were either collected or purchased. Among landless farmers, 56 percent of their fuel materials were collected and another 17 percent purchased, while only 27 percent came from resources they owned. For marginal farms 25 percent of total fuel materials used were collected and another 16 percent purchased. Fifty nine percent came from resources they owned.

Cowdung was the major household fuel material (20 percent of total fuel used). It made up 52 percent of the total household fuel at Rajshahi, 30 percent at Jessore, 28 percent at Patuakhali, 20 percent at Tangail and 3 percent at Ishurdi. Cowdung was not used for fuel at Rangpur. The contribution of fuelwood to total household fuel supply was only 11 percent on average at the six locations. Branches and tree leaves contributed another 14 percent and 12 percent respectively. The contribution of fuel wood at Rajshahi, Tangail and Ishurdi was lowest at 4, 4 and 8 percent respectively, and much higher at Patuakhali (22 percent) and Rangpur (20 percent). Use of leaves was confined to the dry season only. Use of branches and twigs also declined during the rainy season. Except at Rangpur, most farmers depended on cowdung fuel during rainy season.

Most farmers reported the use of cowdung as fuel rather than fertilizer adversely affected soil fertility, thus limiting crop production. Use of paddy straw as fuel due to scarcity of other materials also has adversely affected availability of cattle feed and thatching materials.

The fuel crisis, particularly during the rainy season, often compels the poor farmers to cook only once a day, though they eat two or three times daily. This practice may contribute to health problems, particularly diarrhea, a common disease among the rural poor during the rainy season.

Augmenting the production of fuel wood is essential. Under the present land

ownership pattern, land use system and tenurial arrangements, the homestead is the most dependable area for improvement in fuel production. Most of the rural population belong to the landless and marginal farm groups who have little or no crop land, but who have their own homesteads. Homesteads are more reliable for tree growing for ecological and management reasons as well. The homesteads are mainly on highlands not affected severely by annual floods. Managing and harvesting the trees are also more convenient at the homestead.

Apart from meeting the fuel need, additional tree plantation on the homestead can help meet other needs such as fruit, timber, building materials, fodder, and wind break. The trees, however, have to fit with other uses of the homestead areas including vegetable production.

Selection of appropriate species is crucial for homestead plantation. The homestead plantation must satisfy the multiple needs of farmers to the extent possible without limiting vegetable production, threshing and drying of crops, livestock and poultry rearing, and other homestead activities. Fruit and timber were the most important uses when farmers considered what trees to plant on their homesteads.

The scope of fuelwood plantation on the homestead is thus somewhat limited by the needs and choices of the farmers. After planting fruit and timber trees, very little additional space may be available for fuelwood plantation, particularly in the landless and marginal farms. Already, there are about 2.0 and 1.4 trees per $10m^2$ area of homesteads in landless and marginal farms respectively. However, a judiciously planned multistory plantation may accommodate more trees in the homesteads even under existing conditions.

Given the existing homestead utilization system and the socio-economic condition, of the farmers, quick-growing multipurpose species with good fuel value may be most useful for homestead plantation. Furthermore, old and unproductive fruit trees may be replaced, with considerable scope for improved management.

There is urgent need to undertake a comprehensive action plan to develop multistory plantations on the rural homesteads of Bangladesh, in order to augment the supply of household fuel, fruit, timber, etc. For this purpose, research efforts are needed immediately to select suitable species for different agro-ecological conditions. Planting modules need to be developed for different homestead sizes and target groups. Farmers need to be motivated to grow more trees and trained in modern management practices for trees. Efforts are also needed to develop simple techniques to increase fuel use efficiency in rural households. Finally, an adequate supply of seeds/seedlings of trees to the farmers must be ensured.

Appendix 1
Trees on Homesteads at different locations

Sl. No. Species	Average number/homestead (and % homesteads w/species)					
	Patuakhali	Ishurdi	Rajshahi	Tangail	Jessore	Rangpur
1. Coconut (*Cocos nucifera*)	0.42 (7)	5.25 (53)	0.08 (8)	0.96 (40)	5.12 (78)	0.46 (37)
2. Betel nut (*Areca catechu*)	5.00 (25)	4.90 (38)	- -	16.80 (65)	3.98 (35)	11.92 (55)
3. Mango (*Mangifera indica*)	1.65 (15)	4.54 (87)	0.7 (45)	9.93 (95)	1.99 (67)	3.25 (72)
4. Jackfruit (*Artocurpus heterophyllous*)	0.12 (4)	2.18 (60)	0.25 (23)	5.56 (90)	3.35 (67)	2.75 (73)
5. Rain tree (*Samanea saman*)	0.42 (7)	- -	0.35 (21)	- -	0.12 (8)	- -
6. 'Karoi' (*Albizzia procera*)	0.04 (7)	0.23 (23)	- -	- -	0.13 (10)	- -
7. Date palm (*Phoenix sylvestris*)	0.24 (6)	5.19 (58)	3.36 (40)	0.60 (28)	2.73 (37)	0.04 -
8. Hog plum (*Spondias dulchis*)	0.01 (1)	- -	0.08 (8)	- -	0.25 (20)	- -
9. 'Mandar' (*Erythrina indica*)	- -	0.11 (10)	- -	- -	- -	- -
10. Banana (*Musa spp.*)	1.30* (13)	9.50* (50)	0.59* (17)	1.01* (38)	3.43* (65)	0.14* -

*No. of bushes/clumps

Sl. No.	Species	Average number/homestead (and % homesteads w/species)					
		Patuakhali	Ishurdi	Rajshahi	Tangail	Jessore	Rangpur
11.	Guava	-	0.46	0.18	0.59	0.48	0.18
	(*Psidium guajava*)	-	(43)	(10)	(47)	(30)	-
12.	Papaya	1.01	1.70	0.12	1.03	0.82	-
	(*Carica papaya*)	(1)	(42)	(10)	(35)	(23)	-
13.	'Jamrul'	-	-	-	-	0.10	-
	(*Eugenia jambos*)	-	-	-	-	(10)	-
14.	Bamboo	0.01*	22.43	0.67*	2.65*	1.52*	0.05*
	(*Bambusa spp.*)	(1)	(23)	(32)	(89)	(37)	(60)
15.	Bullocks heart	-	0.02	0.17	0.57	-	0.09
	(*Annona squamosa*)	-	-	(17)	(40)	-	-
16.	Lemon	0.01	0.48	0.09	1.47	0.55	0.01
	(*Citrus spp.*)	(1)	(23)	(17)	(40)	(38)	-
17.	Mahogany	0.01	0.18	-	0.23	-	0.28
	(*Swietenia mahogany*)	(1)	(13)	-	(37)	-	-
18.	Jujube	-	1.13	0.38	0.47	-	-
	(*Zizyphus zuzuba*)	-	(33)	(35)	(47)	-	-
19.	Palmyra Palm	0.04	0.78	4.48	0.08	0.85	0.02
	(*Borassus flabellifer*)	(2)	(32)	(58)	(7)	27)	-
20.	Pome granet	-	0.16	0.19	0.08	-	-
	(*Punica granatum*)	-	(15)	(17)	(7)	-	-
21.	'Babla'	-	0.43	2.37	-	0.41	-
	(*Acacia nilotica*)	-	(22)	(55)	-	(17)	-

* No. of bushes/clumps

Sl. No.	Species	Average number/homestead (and % homesteads w/species)					
		Patuakhali	Ishurdi	Rajshahi	Tangail	Jessore	Rangpur
22.	Silk cotton	-	0.13	0.21	0.28	0.08	0.41
	(*Bombox malabaricum*)	-	(12)	(8)	(18)	(10)	(25)
23.	'Neem'	-	0.20	0.50	0.20	0.05	0.60
	(*Azadirachta indica*)	-	(17)	(33)	(18)	(12)	(35)
24.	Wood apple	-	0.21	-	-	0.41	-
	(*Aegle marmelos*)	-	(22)	-	-	(22)	-
25.	'Kadam'	-	0.07	0.12	0.13	-	0.13
	(*Anthocephallus cadamba*)	-	(7)	(8)	(13)	-	(9)
26.	'Jiga'	0.20	0.31	0.08	2.05	-	-
	(*Odina woodier*)	(5)	(8)	(13)	(43)	-	-
27.	'Krishnachura'	-	0.03	0.17	0.08	-	-
	(*Delonix regia*)	-	(3)	(17)	(7)	-	-
28.	Custard apple	-	0.28	0.08	0.69	3.37	-
	(*Annona reticulata*)	-	(18)	(8)	(40)	(15)	-
29.	Tamarind	-	0.13	0.10	0.31	0.11	-
	(*Tamarindus indica*)	-	(13)	(8)	(23)	(10)	-
30.	Pomelo	-	0.15	-	0.72	-	-
	(*Citrus grandis*)	-	(10)	-	(39)	-	-
31.	Blackberry	-	1.28	-	0.68	0.25	0.01
	(*Eugenia jambolana*)	-	(48)	-	(40)	(13)	-
32.	'Shajna'	-	0.33	-	0.58	0.62	-
	(*Moringa olifera*)	-	(22)	-	(32)	(18)	-

Sl. No. Species	Average number/homestead (and % homesteads w/species)					
	Patuakhali	Ishurdi	Rajshahi	Tangail	Jessore	Rangpur
33. 'Painka'	-	0.38	-	0.33	0.10	0.85
(*Toona ciliata*)	-	(22)	-	(23)	(5)	(34)
34. 'Kamranga'	-	-	-	0.12	-	-
(*Averrhon carambola*)	-	-	-	(18)	-	-
35. 'Shara'	-	-	-	0.32	-	-
(*Streblus asper*)	-	-	-	(15)	-	-
36. 'Bilati Gub'	-	-	-	1.30	-	-
(*Diospyros peregrina*)	-	-	-	(30)	-	-
37. 'Pituli'	-	-	0.23	0.38	-	-
(*Trewia nudiflora*)	-	-	(13)	(67)	-	-
38. Banyan	-	-	0.15	-	-	-
(*Ficus bengalensis*)	-	-	(12)	-	-	-
39. 'Bohla'	-	-	0.75	0.02	-	-
	-	-	(25)	(2)	-	-
40. 'Ziala'	-	-	0.08	-	-	-
	-	-	(8)	-	-	-
41. 'Bay leaf'	-	-	-	0.02	-	-
(*Cinamonum tamala*)	-	-	-	(2)	-	-
42. 'Gub'	0.20	-	-	-	-	-
(*Diospyros cardifolia*)	(2)	-	-	-	-	-
43. 'Kharajora'	-	-	-	0.50	-	-
(*Litsaca monopetala*)	-	-	-	(25)	-	-

Sl. No.	Species	Average number/homestead (and % homesteads w/species)					
		Patuakhali	Ishurdi	Rajshahi	Tangail	Jessore	Rangpur
44.	'Huira'	-	-	-	0.18	-	-
		-	-	-	(17)	-	-
45.	Pitraj	-	-	-	1.02	-	2.2
	(*Amoora rohituca*)	-	-	-	(48)	-	(38)
46.	'Kender'	-	-	-	0.40	-	-
		-	-	-	(10)	-	-
47.	'Mehdi'	-	-	-	0.02	-	-
	(*Lawsonia laba L.*)	-	-	-	(2)	-	-
48.	'Fig'	-	-	-	0.22	-	-
	(*Ficus glomerala*)	-	-	-	(18)	-	-
49.	Olive	-	-	-	0.10	-	-
	(*Olea europaea*)	-	-	-	(8)	-	-
50.	Teak	-	-	-	0.03	-	-
	(*Tectona grandis*)	-	-	-	(3)	-	-
51.	Caranda	-	-	-	0.12	-	-
	(*Carissa carandas*)	-	-	-	(2)	-	-
52.	Litchi	-	-	-	0.08	0.12	0.08
	(*Litchi sinensis*)	-	-	-	(3)	(3)	-
53.	'Zarul'	-	-	-	0.10	-	-
	(*Lagerstroemea flosreginae*)	-	-	-	(5)	-	-
54.	'Debdaru'	-	-	-	1.06	0.07	-
	(*Polyalthia longifolia*)	-	-	-	(12)	(8)	-

Sl. No.	Species	Average number/homestead (and % homesteads w/species)					
		Patuakhali	Ishurdi	Rajshahi	Tangail	Jessore	Rangpur
55.	'Bainna'	-	-	-	0.13	-	-
		-	-	-	(8)	-	-
56.	'Nishinda'	-	-	-	0.16	-	-
	(*Vitex negundo L.*)	-	-	-	(2)	-	-
57.	'Dewa'	-	-	-	0.16	-	-
		-	-	-	-	-	-
58.	Eucalyptus	-	-	-	0.12	-	-
	(*Eucalyptus sp.*)	-	-	-	-	-	-
59.	'Raktachandan'	-	-	-	0.16	-	-
		-	-	-	(2)	-	-
60.	Sissu	-	0.03	-	-	-	-
	(*Dalbergia sissoo*)	-	(3)	-	-	-	-
61.	'Khair'	-	0.02	-	-	-	-
	(*Acacia catechu*)	-	(2)	-	-	-	-
62.	'Safada'	-	0.03	-	-	-	-
	(*Manilkara acras*)	-	(3)	-	-	-	-
63.	Ipil-Ipil	-	0.05	-	-	-	-
	(*Leucaena leucocephala*)	-	(2)	-	-	-	-
64.	Indian plum	-	-	0.15	-	0.30	-
	(*Zizyphus mauritiana*)	-	-	(12)	-	(28)	-

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