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Economics of the Plant Species Used in Homestead Agroforestry of Southern Bangladesh

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ABSTRACT : Agroforestry combines agriculture and forestry technologies to create more integrated, diverse, productive, profitable, healthy and sustainable land-use systems. This study was performed in three union of Chhagalnaiya *Upazila* (Sub-district; administrative entity) under Feni district, Southern Bangladesh with a view to identify the tree resources, utilization pattern and economic return of major fruit and timber tree species. Information collected from a total of 45 households ranging from marginal, small, medium and large categories. Number of plant species increased with the increase of homestead area. A total of 39 plant species were recorded from the homegarden, of which 23 were fruit and 16 were timber tree species. Considerable number of vegetables was also planted under the shade of the homestead trees. The investment analysis showed that average benefit-cost ratios were greater than one, net present values were positive and internal rate of returns were more than 10%. Long term investment on horticulture and timber tree species is highly profitable if species like *Swietenia mahagoni* and *Tectona grandis*, *Spondias pinnata*, *Syzygium cumini* and *Areca catechu* were planted.

Keywords : Agroforestry, Bangladesh, Fruit tree, Homegarden, Timber tree

INTRODUCTION

Once heavily forested Bangladesh is now almost devoid of forest vegetation, resulting from high population pressure, extensive agricultural development, urbanization, and industrialization. Forest cover was reduced from 15% in 1971 to 9% in 1996 (FAO, 2000) and created a major gap between demand and supply of forest products and services. In such a situation, homestead agroforestry plays a vital role in providing firewood, fodder, fruit and timber. More than 20 million homegardens (Salam et al., 2000) covering 270,000 ha or 2% of the country's total land area (FAO, 2000) have been providing approximately 70-90% of round wood (Hammermaster, 1981; Khan, 2001), 65-75% saw logs, 85-90% fuelwood (Leuschner and Khaleque, 1987) and 73% of bamboo (FMP, 1992). In rural and semi-urban settings, homegardens are an alternative for households to meet resource needs (Hammermaster, 1981; Kabir and Webb, 2008a, b).

A homegarden is a mixture of deliberately planted vegetation, usually with a complex structure and designed to produce natural products for the household or market. Homegardens around the world often exhibit remarkable variability in composition and structure (Kumar and Nair, 2006). Species diversity in a homegarden can range from less than 5 to more than 100 (e.g., Vogl and Vogl-Lukasser, 2003; Kabir and Webb, 2008a, b). Furthermore, a homegarden can act as a safety net in providing alternative livelihood opportunities for the people during periods of stress, such as a bad crop year. Homegardens are a vital source for subsistence economy and self-sufficiency of many Bangladeshi households, owing to their diverse products (Millat-e- Mustafa et al., 2000; Salam et al., 2000; Ahmed and Rahman, 2004; Ali, 2005). This also is true for many other tropical regions (Soemarwoto and Conway, 1992; Torquebiau, 1992; Kumar and Nair, 2004; Das and Das, 2005; Peyre et al., 2006). The role of homegarden to household economy may vary depending on the com-

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ponent products and nature of the products utilization.

From the conservation point of view, homesteads are the *in situ* conservation sites of a wide range of plant biodiversity (Uddin et al., 2001). Homestead agroforestry practices are appropriate for the poor farmers as they can earn immediate benefits from agri-crops while waiting for long term benefits from trees. The present work was an initiative to identify the plant diversity, utilization pattern and to evaluate the relative profitability of homestead trees through investment analysis at Chhagalnaiya *Upazila* in Feni district, Southern Bangladesh.

MATERIALS AND METHODS

Study area

Chhagalnaiya *Upazila* (Sub-district; administrative entity) under Feni district, Southern Bangladesh with an area of 133.49 sq km and important strategic focal point between 22°56'-23°04' N and 91°28'-91°34' E and is bounded by Parshuram *Upazila* on the north, Mirsharai *Upazila* on the south, Indian State of Tripura on the east, Feni sadar *Upazila* on the west (Fig. 1). The climate of the area is warm and moderate at the same time. The summer stats at middle April and lasts till middle June. The yearly temperature ranges from 22.20℃ to 30.50℃. Humidity is generally 79% in January and 90% in July. There is heavy rainfall from June to September. The average rainfall is about more than 80% (Banglapedia, 2006).

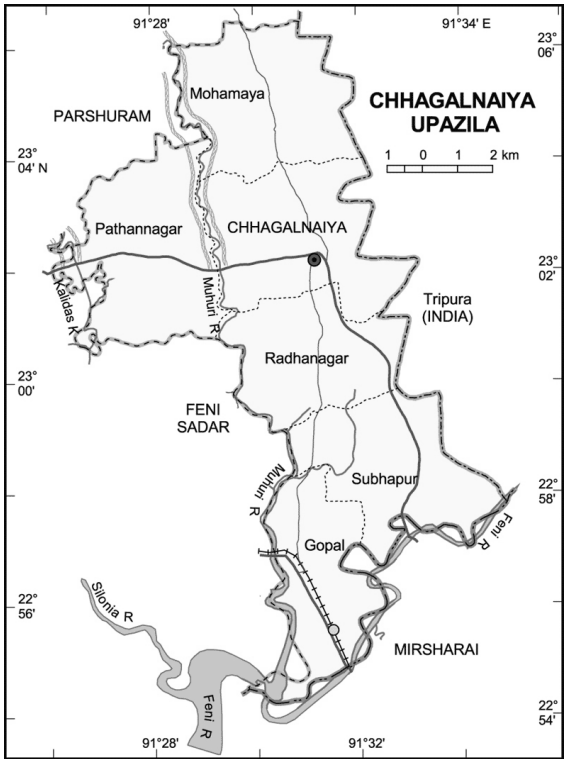

Fig. 1. Location map of the study area.

Methods

The study was conducted in Chhagalnaiya *Upazila* (Sub-district) of Feni district, Southern Bangladesh during March-May, 2008. Among the 6 unions of the *Upazila*, 3 unions (Gopal, Subhapur, and Radhanagar) were selected randomly for the study. Socio-economic survey was carried out for categorizing the households. All the households were stratified into marginal (>0.02-0.08 hm^2), small (>0.08-0.14 hm^2), medium (>0.14-0.20 hm^2) and large (>0.2 hm^2) based on homestead areas (Millat-e-Mustafa, 1997). Forty five households for socio-economic survey were selected randomly and interviewed with the help of semi-structured questionnaire. Out of these samples, 10 households were surveyed for marginal household category, 15 for small, 10 for medium and 10 for large household category. Data were also collected through both direct observations and interviews with rural household members, Union Parisad (local government unit) personnel and village leaders. In order to evaluate the profitability of fruit and timber trees, financial analysis were carried out considering the timing of benefit and costs throughout the rotation period of specific trees. Three discounted measures were used in the present study.

$$B_{CR} = \sum_{t=1}^{n} [B_t/(1+i)^t]/[C/(1+i)^t] \quad (1)$$

$$N_{PV} = \sum_{t=1}^{n} [B_t - C_t]/(1+i)^t \quad (2)$$

$$I_{RR} = \sum_{t=1}^{n} [B_t - C_t]/(1+i)^t = 0 \quad (3)$$

Where, B_{CR} is the benefit cost ratio, N_{PV} the net present value, I_{RR} the internal rate of return, B_t the benefit in each year. C_t the cost in each year, t = 1, 2··· n, n the number of years, and I the interest (discount) rate (assuming 0.10).

The B_{CR} is a relative measure, which is used to compare benefit per unit of cost. The N_{PV} is an absolute measure, which estimates the net worth of trees. N_{PV} depends mainly on the period of investment and the discount rate. The I_{RR} is defined as the average earning power of investment over the rotation period of the perennial fruit and timber (Uddin et al., 2001). In investment analysis, total cost and total return per tree was calculated by visual assessment of trees and farmer's idea about the year of planting. Total cost of fruit and timber trees involves purchase of seeds, seedlings, manure, fertilizer, pesticides and labour wage. All fruit and timber trees were estimated for 25 years rotation whereas *Psidium guajava* and *Citrus* spp. were estimated for 15 years and *Musa* spp. for one year.

RESULTS AND DISCUSSION

Homestead utilization pattern

Average homestead size was 0.351 hm^2 with minimum size (0.045 hm^2) for marginal and maximum size (1.017 hm^2) for large farmers (Table 1). Large households were observed to have land property much greater than the medium, small and marginal households. Among the different uses, ponds occupied the largest space (0.1125 hm^2) of the homesteads followed by cattle shed (0.01375 hm^2), yard (0.04375 hm^2), housing (0.0525 hm^2), vegetation (0.0985 hm^2) consisting of trees and vegetable garden. Areas under vegetation and cattle shed as well as housing increased with the increase in household size (Table 1).

Homestead tree species

There were 23 fruit (Table 2) and 16 timber (Table 3) species grown in the homesteads of the study area. Among the horticultural species, *Areca catechu*, was found to be the highest in number (5.1 stems per household) followed by *Mangifera indica* (2.9 per household) and *Cocos nucifera* (2.73 per household). It was also observed that 89% of households possessed *M. indica* followed by *Syzygium cumini* (84.5%) and *Spondias pinnata* (83.9%) (Table 2). Number of fruit species increased with the increase in household size. Similar results were also recorded in coastal areas at Noakhali district (Uddin et al., 2001). Farmers prefer fruit trees because of their multiple uses and consumption. Miah et al. (1990) and Bashar, (1999) also reported that farmers generally prefer fruit trees in their homesteads. They are interested to grow multipurpose tree species to meet the demand of fruit, fuel, timber and fodder not only for household consumption but also for commercial purposes. Multiple uses and commercial values determine species dominance in the homegardens (Millat-e-Mustafa, 1997). The study revealed that 16 timber species were found in the study area. Among the timber species, the mean number of *Albizia saman* per household

Table 1. Homestead utilization pattern in different household categories (N=45) in Chhagalnaiya *Upazila*, Feni District, Southern Bangladesh.

Homestead category	Homestead area under different uses (hm^2)						
	Housing	Cattle shed	Pond	Vegetation	Yard	Others/fallow	Total size (hm^2)
Marginal	0.024	0.001	0.006	0.010	0.004	-	0.045
Small	0.037	0.006	0.043	0.034	0.010	-	0.130
Medium	0.052	0.018	0.051	0.060	0.021	0.010	0.212
Large	0.097	0.030	0.350	0.290	0.140	0.110	1.017
All sizes	0.0525	0.01375	0.1125	0.0985	0.04375	0.06	0.351

Source: Field survey, 2008

Table 2. Fruit species found in different homesteads in Chhagalnaiya *Upazila*, Feni District, Southern Bangladesh.

Scientific Name	Common Name	Trees (No./household)					Percentage of household contained
		Marginal	Small	Medium	Large	All sizes	
Annona muricata	Ata	0.1	0.1	0.2	0.8	0.3	22.5
Areca catechu	Betel nut	1.5	1.9	6.5	10.5	5.1	81.5
Artocarpus heterophyllus	Jackfruit	0.7	0.8	1.5	4.5	1.88	80.5
A. lakoocha	Barta/Dewoa	-	0.1	-	0.4	0.25	10.0
Averrhoa carambola	Camranga	0.4	0.5	1.9	4.2	1.75	40.0
Borassus flabellifer	Palmyra palm	0.1	0.2	0.9	1.4	0.65	70.5
Calamus spp.	Bet fruit	-	-	0.1	1.5	0.8	15.5
Carica papaya	Papaya	0.4	0.5	2.2	4.6	1.93	80.5
Citrus spp.	Lemon	0.3	0.4	2.0	3.1	1.45	80.0
Cocos nucifera	Coconut	1.4	1.9	3.1	4.5	2.73	81.5
Diospyros peregrine	Gab	0.1	0.4	0.8	0.5	0.45	79.3
Elaeocarpus floribundus	Galpai	0.1	0.2	0.9	1.5	0.675	55.5
Ficus roxburghii	Dumur	0.2	0.3	1.5	3.5	1.38	60.3
Garcinia cowa	Cowa fruit	0.1	-	0.1	0.4	0.2	5.50
Mangifera indica	Mango	1.0	1.5	3.5	5.6	2.9	89.0
Musa spp.	Banana	0.4	0.6	1.2	3.8	1.5	64.3
Phoenix sylvestris	Date palm	0.3	0.2	1.5	2.9	1.23	76.0
Psidium guajava	Guava	1.6	1.8	3.1	2.9	2.35	81.5
Punica granatum	Dalim	0.1	0.2	-	2.1	0.8	45.9
Spondias pinnata	Amra	0.3	0.5	0.8	2.8	1.1	83.9
Syzygium cumini	Black berry	0.4	0.5	0.9	2.5	1.08	84.5
Tamarindus indica	Tamarind	0.1	0.2	-	1.5	0.6	41.0
Zizyphus mauritiana	Kul	0.1	0.1	1.1	1.5	0.7	58.3

Source: Field survey, 2008

Table 3. Timber tree species and bamboo recorded in the homesteads in Chhagalnaiya *Upazila*, Feni District, Southern Bangladesh.

Scientific name	Common name	Trees (No/household)					Percentage of household contained
		Marginal	Small	Medium	Large	All sizes	
Acacia auriculiformis	Akashmoni	0.2	0.5	1.5	3.0	1.3	91.2
A. mangium	Mangium	0.2	0.4	1.1	2.2	0.98	75.0
Albizia procera	Sil koroi	0.1	0.6	1.2	2.5	1.1	70.5
A. lebbeck	Kala koroi	0.2	0.5	1.5	2.1	1.1	74.2
A. saman	Rain tree	0.8	1.5	4.0	4.5	2.7	89.5
Anthocephalus chinensis	Kadam	0.1	0.5	1.4	1.9	0.98	35.2
Azadiracta Indica	Neem	-	0.2	0.8	1	0.67	10.2
Bambusa vulgaris	Jai bamboo	0.5	0.9	1.2	2.1	1.18	29.5
Delonix regia	Krisnochura	0.1	0.4	1	1.1	0.65	15.50
Ficus benghalensis	Bot	-	-	-	0.8	0.8	4.50
Melocanna baccifera	Muli bamboo	0.6	0.8	1.5	1.9	1.2	33.5
Bombax ceiba	Simul	0.1	0.5	0.9	1.1	0.65	14.50
Erythrina indica	Mandar	0.4	0.5	1.9	2.1	1.23	15.5
Eucalyptus camaldulensis	Eucalyptus	0.2	0.4	1.1	1.9	0.9	48.5
Swietenia mahagoni	Mahagoni	0.9	1.5	2.8	4.1	2.33	92.5
Tectona grandis	Teak	0.1	0.4	0.9	1.5	0.73	61.9

Source: Field survey, 2008

was the highest (2.7 per household) followed by *Swietenia mahagoni* (2.33 per household) and *Acacia auriculiformis* (1.3 per household). 92.5% of household contained *S. mahagoni* followed by *A. auriculiformis* (91.2%) and *A. saman* (89.5%), (Table 3). Nath et al. (2004) also found that *A. saman* was the most dominant timber tree species grown in the homesteads of Sitakunda *Upazila*, Chittagong district, Bangladesh.

Vegetables grown around the homesteads

A large number of seasonal vegetables were planted in and around the spaces of homestead tree species in the study area (Table 4). A total of 20 vegetable species were recorded from the homegarden, of which 8 were grown in summer, 10 in winter and 2 all year round. Spices, e.g. *Zinziger officinale*, *Curcuma domestica*, *Alliuma capa*, *Piper nigarum*, *Capsicum annum*, were also planted under the shade of trees in the homegarden.

Profit of growing fruit and timber tree species

Fruit and timber trees were found profitable because of high benefit-cost ratio (B_{CR}), net present value (N_{PV}) and internal rate of return (I_{RR}). The average B_{CR}, N_{PV} and I_{RR} for the fruit species were 33.27, US$ 38.38 and 15.04%, respectively (Table 5). Among the fruit species, *Spondias pinnata*, *Syzygium cumini* and *Areca catechu* were found most profitable because of their B_{CR}, N_{PV} and I_{RR} (53.40, US$ 36.68, 17.24%; 48.17, US$ 62.17, 16.76% and 47.54, US$ 47.39, 16.70% respectively).

The average B_{CR}, N_{PV} and I_{RR} for timber species were 54.74, US$ 53.83 and 17.36% respectively, which is much greater than those of fruit species. Among the timber trees, *Swietenia mahagoni* and *Tectona grandis* were more profitable because of their high B_{CR}, N_{PV} and I_{RR} (85.34, US$ 108.92, 19.46%, and 77.52, US$ 123.35, 19.00%, respectively). The lowest return (I_{RR} 12.41%) was with *Ficus roxburghii* followed by *Punica granatum* (I_{RR} 13.29%).

CONCLUSIONS

The homegarden is an integral part of a rural household in Bangladesh. This small but intensively cultivated farming space within the rural homestead compound plays a vital role in household production. The use of a wide range of species with different cropping schedules makes the homegarden a year-round production unit that provides cash, food, and firewood for the household. The distribution of land among the farmers was highly unequal causing poverty to a group of landless peoples. But the poor farmers tried to use their small land very effectively. Financial analysis of horticultural and timber trees showed that, average BCRs were greater than one, average NPVs

Table 4. Vegetable and spices found in the homesteads of Chhagalnaiya *Upazila*, Feni District, Southern Bangladesh.

All year	Summer vegetable	Winter vegetable	Spices	Shade trees
Amanarthus gangeticus	*Trichosanthes anguina*	*Brassica oleracea*	*Zinziger officinale*	*Albizia saman*
Colocasia esculenta	*Abelmoschus esculentus*	*Basella alba*	*Curcuma domestica*	*Artocarpus heterophyllus*
	Luffa acutangula	*Dolichos purpureus*	*Alliuma capa*	*Areca catechu*
	Cucumis sativus	*Vigna sinensis*	*Piper nigarum*	*Cocos nucifera*
	Momordica charantea	*Cucurbita maxima*	*Capsicum annum*	*Mangifera indica*
	M. cochinchinensis	*Benincasa hispida*		*Psidium guajava*
	Trichosanthes diocica	*Lagenaria vulgaris*		
	Solanum tubersum	*Raphanus sativus*		
		Ipomcca balatus		
		solanum melongena		

Source: Field survey, 2008

Table 5. Investment analysis of horticultural and timber trees in the Chhagalnaiya *Upazila*, Feni District, Southern Bangladesh.

Species	TC* (US$/tree)	TR (US$/tree)	NB (US$/tree)	BCR	NPV (US$/tree)	IRR (%)
Horticultural species						
Annona muricata	1.41	47.40	45.99	33.62	41.81	15.09
Areca catechu	1.12	53.25	52.13	47.54	47.39	16.70
Artocarpus heterophyllus	1.60	69.89	68.29	43.68	62.08	16.30
A. lakoocha	1.71	61.29	59.58	35.84	54.16	15.40
Averrhoa carambola	1.44	49.42	47.98	34.32	43.62	15.19
Borassus flabellifer	1.59	41.42	39.83	26.05	36.21	13.92
Calamus spp.	0.72	16.96	16.24	23.56	14.76	13.47
Carica papaya	0.79	28.69	27.9	36.32	25.36	15.45
Citrus spp.	0.57	14.39	13.82	25.00	12.56	13.74
Cocos nucifera	1.80	64.89	63.09	36.05	57.35	15.40
Diospyros peregrine	1.21	39.87	38.66	32.95	35.15	15.00
Elaeocarpus floribundus	1.41	45.65	44.24	32.38	40.22	14.92
Ficus roxburghii	0.89	16.59	15.7	18.64	14.27	12.41
Garcinia cowa	1.14	28.10	26.96	24.65	24.51	13.67
Mangifera indica	1.89	70.10	68.21	37.09	62.01	15.55
Musa spp.	0.15	3.86	3.71	25.50	3.07	14.44
Phoenix sylvestris	1.89	56.71	54.82	30.01	49.84	14.57
Psidium guajava	1.06	40.15	39.09	37.85	35.54	15.64
Punica granatum	1.01	22.87	21.86	22.64	19.87	13.29
Spondias pinnata	0.77	41.12	40.35	53.40	36.68	17.24
Syzygium cumini	1.45	69.84	68.39	48.17	62.17	16.76
Tamarindus indica	2.59	68.91	66.32	26.61	60.29	14.02
Zizyphus mauritiana	1.99	49.82	47.83	25.04	43.48	13.74
Average	1.31	43.53	42.22	33.27	38.38	15.04
Timber species						
Acacia auriculiformis	1.56	82.42	80.86	52.83	81.00	17.19
A. mangium	1.38	74.21	72.83	53.78	72.96	17.27
Albizia procera	1.30	71.02	69.72	54.63	69.84	17.35
A. lebbeck	1.25	69.81	68.56	55.85	68.67	17.45
A. saman	0.66	30.89	30.23	46.80	30.29	16.63
Anthocephalus chinensis	0.38	15.96	15.58	42.00	15.61	16.12
Azadiracta Indica	1.14	50.59	49.45	44.38	49.55	16.38
Bambusa vulgaris	1.09	60.84	59.75	55.82	59.85	17.45
Delonix regia	0.59	19.94	19.35	33.80	19.40	15.12
Ficus benghalensis	0.49	18.21	17.72	37.16	17.76	15.55
Melocanna baccifera	1.18	61.74	60.56	52.32	60.67	17.15
Bombax ceiba	0.81	34.16	33.35	42.17	33.42	16.14
Erythrina indica	0.29	11.25	10.96	38.79	10.99	15.75
Eucalyptus camaldulensis	0.94	39.89	38.95	42.44	39.04	16.17
Swietenia mahagoni	1.29	110.09	108.8	85.34	108.92	19.46
Tectona grandis	1.61	124.81	123.2	77.52	123.35	19.00
Average	1.00	54.74	53.74	54.74	53.83	17.36
All type	1.16	49.14	47.98	44.01	46.11	16.20

Notes: *TC=Total Cost, TR=Total Return, NB=Net Benefit, NPV=Net Present Value, BCR= Benefit-Cost Ratio, IRR=Internal Rate of Return, Tk= Bangladeshi currency unit, Taka (1 US$=70 Tk. approximately).

were positive and average IRRs were more than 10%. This indicates that long term investment on fruit and timber trees is profitable. Though it was revealed from the study that timber species yield more economic return than the horticultural species, farmers show a particular preference to horticultural species because fruit trees provide immediate cash return and contribute to household food and nutrition requirement. Whereas Large and medium households preferred timber trees for greater economic return despite of the longer rotation.

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