Economics of the plant species used in homestead agroforestry on an offshore Sandwip Island of Chittagong District, Bangladesh

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Abstract: This study was performed in five villages of Sandwip Upazila, Chittagong district 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 60 households ranging from marginal, small, medium and large categories. Number of plant species increased with the increase of homestead area. A total of 33 plant species were recorded from the homegarden, of which 19 were fruit and 14 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 *Artocarpus heterophyllus*, *Cocos nucifera*, *Tectona grandis* and *Swietenia macrophylla* are planted.

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Introduction

Bangladesh is a land hunger country having about 14.4 million hectares of land with a population of 133 million (BBS 2003). Of the total land area, about 1.48 $\times 10^6$ hm^2 are designated as government forest land, 0.72 million hectares are of Unclassified State Forests and 0.27$\times 10^6$ hm^2 are homegardens (FMP 1992). Because of the rapid destruction of forest cover, it is difficult to meet the country's huge demand for timber, fuel, food and fodder and maintaining ecological balance. In such a situation, homestead agroforestry plays a vital role in providing firewood, fodder, fruit and timber). Estimation is that about 70% of timber, 90% of fuel wood, 48% of sawn and veener logs and almost 90% of bamboo requirements are met from homegardens of Bangladesh (Khondakar 1991; Uddin *et al.* 2001).

Homegardens represents a landuse system involving deliberate management of multipurpose trees and shrubs in close association with seasonal vegetables (Fernandes *et al.* 1986). 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 Sandwip Upazila in Chittagong district, Bangladesh.

Materials and methods

The study was conducted in Sandwip Upazila, the biggest offshore Island in Chittagong district during October 2004 to January 2005. The climate of the area is tropical with a mean annual rainfall of 3600 mm and average maximum temperatures from 25.4°C to 31.6°C. Among the 19 Unions of the Upazila, 5 Unions (Maitbhanga, Harishpur, Haramia, Mogdhara and Santuspur) 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). Sixty households for socio-economic survey were selected randomly and interviewed with the help of semi-structured questionnaire. Out of these samples, 15 households were surveyed for marginal household category, 20 for small, 15 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)

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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 0.312 hm2 with minimum size (0.043 hm2) for marginal and maximum size (0.892 hm2) for large farmers (Table 1). Large households were observed to have land property much greater than the medium, small and marginal households during the study period. Among the different uses, ponds occupied the largest space (0.102 hm2) of the homesteads followed by housing (0.049 hm2) and vegetation (0.07 hm2) 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). Yard is also the case.

Homestead tree species

There were 19 fruit (Table 2) and 14 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 (4.72 stems per household) followed by Cocos nucifera (2.85 per household) and P. guajava (2.02 per household). It was also observed that 98.5% of households possessed A. catechu followed by C. nucifera (96.3%) and Citrus spp (93.3%), (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). Among the timber species, the mean number of Albizia saman per household was the highest (3.57 per household) followed by A. lebbeck (2.07 per household) and A. procera (1.62 per household). 92.1% of household contained A. saman followed by A. lebbeck (91.3%) and A. procera (90.1%), (Table 3). Nath et al. (2004) also found that A. saman was the most dominant timber tree species grown in the homesteads of Sitakunda Upazilla.

Table 1. Homestead utilization pattern in different household categories (N=60) in Sandwip Upazila

Household category	Homestead area under different uses(hm^2)						
	Housing	Cattle shed	Pond	Vegetation	Yard	Others/ fallow	Total size (hm^2)
Marginal	0.022	0.001	0.005	0.009	0.006	-	0.043
Small	0.034	0.005	0.05	0.031	0.01	-	0.13
Medium	0.05	0.017	0.043	0.055	0.019	-	0.184
Large	0.093	0.029	0.31	0.25	0.11	0.1	0.892
All sizes	0.049	0.013	0.102	0.07	0.04	0.025	0.312

Table 2. Fruit species found in different homesteads in Sandwip Upazila

Scientific Name	Common Name	Trees (No./household)					Percentage of household contained
		Marginal	Small	Medium	Large	All sizes	
Annona muricata	Ata	0.1	-	0.3	0.9	0.32	25.3
Areca catechu	Betel nut	1.3	2.3	5.8	9.5	4.72	98.5
Artocarpus heterophyllus	Jackfruit	0.5	0.5	1.4	3.3	1.42	80.0
A. lakoocha	Barta	-	-	-	0.5	0.12	5.50
Borassus flabellifer	Palmyra palm	0.2	0.1	0.7	1.1	0.52	75.0
Citrus spp.	Lemon	0.3	0.3	1.7	2.5	1.20	93.3
Cocos nucifera	Coconut	1.7	2.3	2.9	4.5	2.85	96.3
Diospyros peregrine	Gab	0.1	0.7	0.7	0.5	0.5	75.1
Litchi chinensis	Litchi	-	0.1	0.2	0.9	0.30	25.0
Mangifera indica	Mango	0.9	0.9	1.1	2.1	1.25	91.3
Musa spp.	Banana	0.3	-	0.7	2.6	0.90	54.0
Phoenix sylvestris	Date palm	0.4	0.3	1.9	2.7	1.32	70.0
Psidium guajava	Guava	1.4	1.7	2.2	2.8	2.02	77.0
Punica granatum	Dalim	0.1	-	0.3	2.1	0.62	69.5
Spondias pinnata	Amra	0.1	0.1	0.3	0.5	0.25	45.0
Syzygium cumini	Black berry	0.1	-	0.7	2.1	0.72	25.0
S. samarengense	Zamrul	-	-	0.3	-	0.07	5.70
Tamarindus indica	Tamarind	-	0.1	0.3	0.5	0.22	30.5
Zizyphus jujube	Kul /Ber	0.5	1.1	1.5	1.7	1.20	68.5

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 14 vegetable species were recorded from the homegarden, of which 7 were grown in summer, 4 in winter and 3 all year round. Spices, e.g. Capsicum annum, Curcuma do-

mestica, Zingiber officinalis, 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 (BCR), net present value (NPV) and internal rate of return (IRR). The average BCR, NPV and IRR for the fruit species were 35.28, US$ 48.62 and 15.19%, respectively (Table 5). Among the fruit species, *Artocarpus heterophyllus* and *Cocos nucifera* were found most profitable because of their high BCR, NPV and IRR (63.00, US$ 85.40, 18.02% and 50.78, US$ 87.77, 17.01% respectively).

The average BCR, NPV and IRR for timber species were 46.49, US$ 46.01 and 16.27% respectively, which is much greater than those of fruit species. Among the timber trees, *Swietenia macrophylla* and *Tectona grandis* were more profitable because of their high BCR, NPV and IRR (76.34, US$ 96.52, 18.93%, and 80.00, US$ 108.28, 19.15%, respectively). The lowest return (IRR 11.79%) was with *Zizyphus jujube* followed by *Borassus flabellifer* (IRR 13.30%).

Table 3. Timber tree species and bamboo recorded in the homesteads in Sandwip Upazila

Scientific Name	Common Name	Trees (No./household)					Percentage of household contained
		Marginal	Small	Medium	Large	All sizes	
Albizia procera	Sil koroi	0.3	1.2	1.9	3.1	1.62	90.1
A. lebbeck	Kala koroi	0.4	1.7	2.1	4.1	2.07	91.3
A. saman	Rain tree	0.9	1.9	4.8	6.7	3.57	92.1
Bambusa vulgaris	Bamboo	0.1	0.2	0.3	0.9	0.38	60.0
Bombax ceiba	Simul	-	-	0.1	-	0.02	4.50
Cassia fistula	Bandarlathi	-	-	0.3	0.5	0.20	5.00
Dalbergia sissoo	Sissoo	-	-	0.1	0.3	0.10	5.70
Erythrina indica	Mandar	-	0.3	0.7	0.3	0.32	73.1
Eucalyptus camaldulensis	Eucalyptus	-	-	0.9	1.7	0.65	35.3
Gmelina arborea	Gamar	0.2	0.1	0.8	1.9	0.75	75.0
Lannea coromandelica	Bhadi	-	0.2	0.9	0.8	0.47	65.7
Leucaena leucocephala	Ipil ipil	-	-		0.3	0.07	27.0
Swietenia macrophylla	Mahagoni	0.1	0.3	1.7	1.1	0.80	75.3
Tectona grandis	Teak	-	0.9	0.9	1.7	0.87	65.4

Table 4. Vegetable and spices found in the homesteads of Sandwip Upazila

All Year	Summer Vegetable	Winter Vegetable	Spices	Shade Trees
Carica papaya	*Trichosanthes anguina*	*Dolichos lablab*	*Capsicum annum*	*Cocos nucifera*
Colocasia esculenta	*Basella rubra*	*Vigna sinensis*	*Curcuma domestica*	*Areca catechu*
Alocasia indica	*Abelmoschus esculentus*	*Legenaria siceraria*	*Zingiber officinalis*	*Albizia saman*
	Luffa acutangula	*Cucurbita maxima*		*Psidium guajava*
	Cucumis sativus			*Mangifera indica*
	Momordica charantea			*Artocarpus heterophyllus*
	M. cochinchinensis			*Zizyphus jujube*

Table 5. Investment analysis of horticultural and timber trees in the Sandwip Upazila

Species	TC* (US$/tree)	TR (US$/tree)	NB (US$/tree)	BCR	NPV (US$/tree)	IRR (%)
Horticultural species						
Annona muricata	1.53	45.45	43.92	29.70	39.93	14.52
Areca catechu	1.24	51.09	49.85	41.12	45.32	16.03
Artocarpus heterophyllus	1.51	95.45	93.94	63.00	85.40	18.02
A. lakoocha	1.95	65.75	63.8	33.64	58.00	15.10
Borassus flabellifer	1.66	37.87	36.21	22.72	32.92	13.30
Citrus spp.	0.57	14.39	13.82	25.00	12.56	13.74
Cocos nucifera	1.94	98.48	96.54	50.78	87.77	17.01
Diospyros peregrine	1.32	43.78	42.46	33.21	38.61	15.04
Litchi chinensis	2.23	91.13	88.9	40.91	80.83	16.00
Mangifera indica	2.44	83.03	80.59	34.00	73.26	15.15
Musa spp.	0.15	3.86	3.71	25.50	3.07	14.44
Phoenix sylvestris	2.12	72.15	70.03	34.01	63.66	15.15
Psidium guajava	1.06	40.15	39.09	37.85	35.54	15.64
Punica granatum	0.76	21.84	21.08	28.84	19.17	14.39
Spondias pinnata	0.83	32.42	31.59	38.90	28.72	15.77
Syzygium cumini	1.74	78.78	77.04	45.21	70.04	16.46
S. samarengense	0.83	32.34	31.51	38.81	28.65	15.76

Continue Table 5

Species	TC* (US$/tree)	TR (US$/tree)	NB (US$/tree)	BCR	NPV (US$/tree)	IRR (%)
Tamarindus indica	3.03	93.71	90.68	30.92	74.94	15.37
Zizyphus jujube	3.27	53.19	49.92	16.25	45.39	11.79
Average	1.59	55.52	53.93	35.28	48.62	15.19
Timber species						
Albizia procera	1.32	81.52	80.2	61.83	72.91	17.93
A. lebbeck	1.36	84.55	83.19	62.00	75.62	17.94
A. saman	0.64	32.65	32.01	51.30	29.10	17.05
Bambusa vulgaris	1.26	61.24	59.98	48.81	54.67	16.82
Bombax ceiba	0.80	30.86	30.06	38.43	27.33	15.71
Cassia fistula	0.73	16.47	15.74	22.64	14.31	13.29
Dalbergia sissoo	0.95	24.08	23.13	25.22	21.02	13.78
Erythrina indica	0.62	17.21	16.59	27.70	15.08	14.20
Eucalyptus camaldulensis	0.89	38.44	37.55	43.00	34.13	16.23
Gmelina arborea	1.14	46.67	45.53	41.06	41.39	16.02
Lannea coromandelica	0.91	27.85	26.94	30.63	24.49	14.66
Leucaena leucocephala	0.77	32.38	31.61	41.90	28.73	16.11
Swietenia macrophylla	1.41	107.58	106.17	76.34	96.52	18.93
Tectona grandis	1.52	121.21	119.69	80.00	108.82	19.15
Average	1.02	51.62	50.6	46.49	46.01	16.27
All type	1.31	53.57	52.26	40.88	47.31	15.73

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$=66 Tk. approximately).

Conclusions

Homestead vegetation of Sandwip area typically exhibits in a layered vertical structure of diversified economic crops of immense value and domestic usage. The upper stratum comprises of timber and some fruit trees, middle stratum is usually occupied by fruit trees and bamboo clumps and the lower stratum is occupied by seasonal vegetable and small bushes. 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 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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