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Financial prospect of monoculture of exotic tree species in private land of Tangail District, Bangladesh

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ABSTRACT

Acacia auriculiformis A. Cunn. ex Benth. is a popular choice while selecting exotic species for plantations in private and public lands in Bangladesh. Fast-growing nature and quick economic return are the major reasons for private landowners to prefer exotic tree species over the indigenous. This study, carried out in 2010-11, aims at analyzing financial prospects of exotic tree species plantations in Bangladesh. We evaluated 30 private woodlots plantations of *Acacia auriculiformis*, *Eucalyptus camaldulensis* Dehnh. and *Swietenia macrophylla* King in Sakhipur Upazila of Tangail District, Bangladesh. We employed Benefit-Cost Analysis (BCA) framework to calculate Benefit-Cost Ratio (BCR), Net Present Value (NPV), and Internal Rate of Return (IRR) for the plantations. For a 10-year rotation period, the BCR was 1.15. The NPV was BDT 84,074, whereas the IRR was 14.55%. The sensitivity analysis shows that the tree growers can withstand a maximum of 10% of damages of the final crops to keep the investments financially promising. The local people in the region are enthusiastic in such investment since such plantations were rewarding over time.

Keywords: Sakhipur, monoculture, exotic, woodlot, *Acacia*, economic

1. INTRODUCTION

Since the 1980s, scientific interest has increasingly focused on monoculture of exotic tree species for meeting the economical demand for high timber productivity in Bangladesh. The country has been facing an acute demand for timber and associated produces since the 1970s because of the increasing gap between the supply and demand of timber and fuel wood. To bridge this gap, a number of tree plantation programs were launched by the government of Bangladesh and development agencies (FAO/UNDP, 1981) including introduction of fast-growing exotic tree species both in private and public lands (Ridenour and Callaway, 2001; Dogra *et al.*, 2010). Tangail is one of the districts in Bangladesh where the community people, farmers, and Non-Government Organizations (NGOs) raised large scale plantations of *Acacia auriculiformis*, *Eucalyptus camaldulensis*, and *Swietenia macrophylla* in homesteads, marginal lands, fallow lands and farm lands. These plantations most commonly chose *A. auriculiformis* and *E. camaldulensis* over other species in private lands because of

their fast-growing characteristics, high production of biomass within a short period of time and thus quick economic return. Due to the same reason *A. auriculiformis* and *E. camaldulensis* are being widely considered as the most common species for monoculture as well as community forestry (Jagger and Pender, 2003).

Evans and Turnbull (2004) chalked out nexus among fast growing species plantations, exotic monocultures and their biomass production and economic impact. They opined that development of planted forests in tropical countries is accelerating to satisfy the ever-growing global demands for wood products as well as to improve the livelihoods of poor people. A number of studies have also been done on plantations of exotic species in Bangladesh (Davidson and Das, 1985; Ara *et al.*, 1989; Islam *et al.*, 2003). Kabir and Webb (2005) and Ali (2009) which carried out research on government owned social forestry program which revealed that tree productivity and gross revenue earned from monoculture of exotic tree plantation was higher than that of indigenous species and these sorts of plantation programs have improved the economic condition of the participants. A number of studies (Green, 1981; Ahmed, 1996; Rahman, 2001, 2009; Al-Amin *et al.*, 2004; Kabir and Ahmed, 2005; Motiur, 2006; Haque, 2007; Khan *et al.*, 2007; Alam *et al.*, 2008; Malaker *et al.*, 2010; Rahman & Khan, 2022) conducted in different parts of Bangladesh reported that most of the plantation forestry programs in private land rely on monoculture of exotic species for their short rotation period, high yields, and economic returns.

Sakhipur Upazila of Tangail District is one of the pioneer rural areas of Bangladesh where the private lands - both agricultural and non-agricultural- are being converted in to exotic woodlot plantations and the landowners don't have a clear estimation of how profitable their investments in exotic woodlot plantation projects are, though they are interested on such plantation projects with the expectation of quick financial return. There is clearly a lack of scientific investigations on this issue too. Thus, a study on the financial prospect of the exotic woodlot plantations would enable the tree growers in Sakhipur area to get a clear perception on how much their investments in exotic species plantations are worth, how much they should invest in such plantations projects, and whether they should be more aware of their decision to convert agricultural land to woodlot monoculture. Therefore, this study was conducted to understand and estimate the extent of financial returns of the monoculture plantations of fast-growing exotic species *A. auriculiformis, E. camadulensis* and moderate fast-growing *S. macrphylla* in the private lands in the study area.

2. MATERIALS AND METHODS

2.1. Description of the study area

The Sakhipur Upazila of the Tangail District, Bangladesh occupies an area of 435 km². (BBS, 2012; Figure 1). It is located between 24°11′ and 24°26′ N latitudes and between 90°04′ and 90°18′ E longitudes. This area experiences a sub-tropical monsoon climate with three distinct seasons, *viz*. summer (March to mid-June), monsoon (mid-June to mid-October) and winter (mid-October to February). The mean annual rainfall 1937 mm (ranges from 1126 to 2748 mm) and the mean annual temperature 25.7 °C (ranges from 20.3 °C to 31.5 °C). The relative humidity varies between 69% and 86%, the duration of sunshine ranges between 5-9 hours and average maximum wind speed is 87 km/hour (NWRD/CEGIS, 2015). Among the climatic factors, rainfall, humidity, sunshine penetration, evaporation and evapo-transpiration, canopy structure etc. affect the growth and development of vegetation and woodlot plantations as well as the associated undergrowth species to varying extents. Sakhipur Upazila belongs to the bio-ecological zone of Madhupur Sal (*Shorea robusta* Gaertn.) tract (Nishat *et al.* 2002). The topography of this area is characterized by plain land or low hills rising 3.0-4.5 m above the surrounding paddy fields, locally known as *'Chalas'*, intercepted by numerous depressions or '*Baids*' (Ismail and Miah, 1973). There are three major soil types in Sakhipur area *viz*., deep red brown terrace soil, shallow red brown terrace soil, and brown mottled terrace soils (Richards and Hassan, 1988). Livelihoods in this area depend greatly on Sal forest for timber, fuel wood, herbal medicines.

2.2. Sampling and Data collection

Between 2010 and 2011, we consulted the local Forest Department officials, NGOs and local people to find out appropriate areas or villages representing enough woodlots for sampling and data collection in relation to the objectives. As a result, Sakhipur was detected as suitable for conducting this study. We randomly selected the sampling plots within each village representing the woodlots. A purposive random sampling framework was employed to make the final selection of sample plots and data collection. A total of 20 plots of *A. auriculiformis*, eight plots of *E. camaldulenis*, and two plots of *S. macrophylla* were selected from different villages of Sakhipur area. Each sample plot was of 36 m x 36 m size. For each of the tree plots selected, we counted the number of trees, and measured tree height, and DBH. Related data were also collected like respondents' household status, specification of land, characteristics of private woodlot plantation, causes of plantation damaging factors, expenditure and future valuation of woodlot/block plantation, social and environmental benefits/losses from plantation and potential timber tree species for

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monoculture etc. Additionally, we arranged a number of focus group discussions (FDGs) and Key Informant Interviews (KII) to know about the nature of private woodlot plantation, plantation damaging factors, social and environmental benefits/losses, financial prospects of woodlot plantations, and potential timber tree species for monoculture.

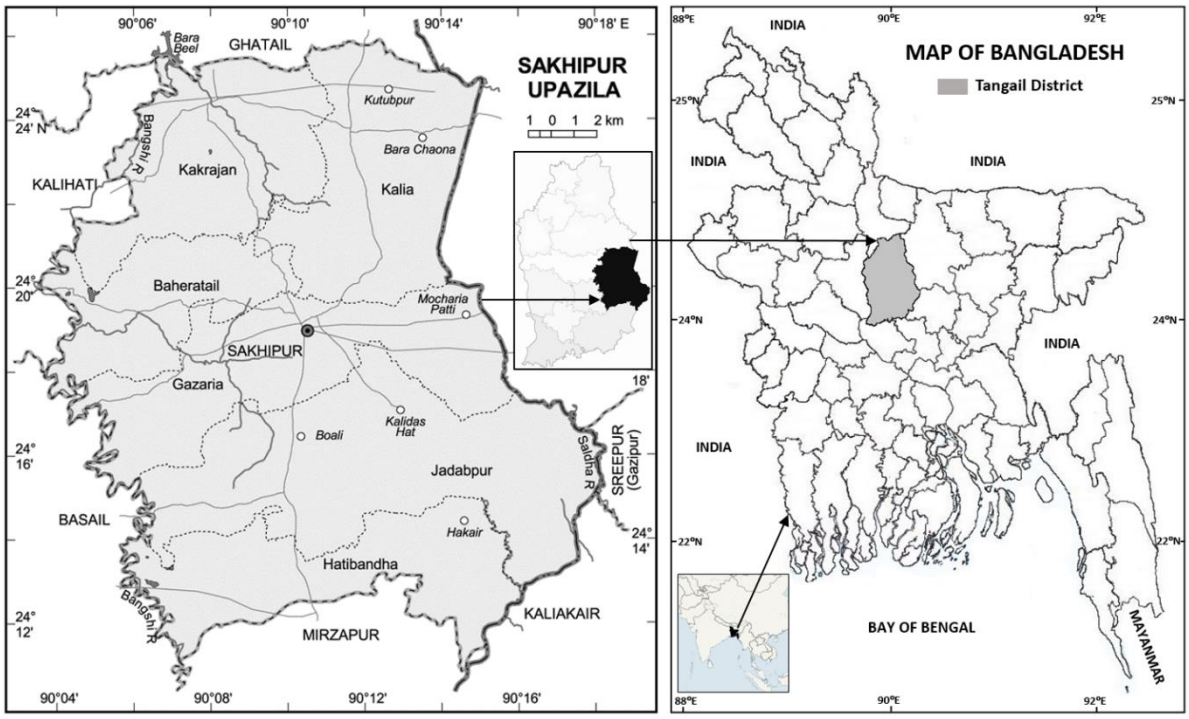

Figure 1. Location of the study area, Sakhipur, Tangail.

2.3. Quantitative Framework

Discounting rate

In order to estimate a reasonable and realistic discounting rate, the current lending rate of Bangladesh Bank was used. The lending rate remained constant at 13% since 2012 (Trading economics, 2015). This has been taken as the discounting rate in this study to discount all future costs and benefits to the present.

Estimating benefit-cost ratio

Benefit-Cost Ratio (BCR) was calculated for each of the possible scenarios over varying lengths of time horizons (three phases) following the steps as outlined in the ADB guidelines (ADB, 1997). The steps are: (i) Identification of the economic (and financial) benefits and costs, (ii) Quantification of the benefits and costs, (iii) Valuation of the benefits and costs over the life or time horizon of the analysis, and finally, (iv) Comparing the benefits with the costs using the BCRs.

Let the benefit derived at present (time $t = 0$) be $B0$ and after $t = T$ years be BT. If the discounting rate for all future benefits remains constant at i %, the sum of the present values of all the future benefits can be summarized as follows:

Present value of benefits, $$B = \frac{B_0}{(1+i)^0} + \frac{B_1}{(1+i)^1} + \frac{B_2}{(1+i)^2} + \ldots\ldots + \frac{B_T}{(1+i)^T} = \sum_{t=0}^{t=T} \frac{B_t}{(1+i)^t}$$

where B is Benefit and i is Discount Rate or Interest Rate

Similarly, the present value of all the costs, $C = \sum_{t=0}^{t=T} \frac{C_t}{(1+i)^t}$, where C is Cost

The net present value, NPV, can be estimated as,

$$NPV = \sum_{t=0}^{t=T} \frac{B_t}{(1+i)^t} - \sum_{t=0}^{t=T} \frac{C_t}{(1+i)^t}$$

The BCR is defined as follows:

$$BCR = \frac{\sum_{t=0}^{t=T} \frac{Bt}{(1+i)^t}}{\sum_{t+0}^{t=T} \frac{Ct}{(1+i)^t}}$$

Internal rate of return (IRR) is defined as an interest rate of *i* %, for which the discounted total benefit is equal to the discounted total cost of a potential investment decision. That is, *i* = IRR when *NPV = 0* or *BCR = 1*. In this study, IRR has been calculated for increasing return and stable return phases of the project. The BCRs were calculated both from financial and economic perspectives. The concept of financial profit is different from economic profit. The financial analysis of a project estimates the profit accruing to the project-operating entity or to the project participants. In financial analysis, all direct costs incurred under the plantation activities and the associated direct benefits were considered. On the contrary, economic analysis measures the effect of a project on the society. For a project to be economically viable, it must be financially sustainable, as well as economically efficient. Thus, financial and economic analyses are complementary to each other (ADB, 1997).

2.4. Sensitivity analysis

Sensitivity analysis became imperative to examine the response of the BCR within the range of a number of stochastic variables. Sensitivity analysis is the study of how the uncertainty in the output of a mathematical model or system can be apportioned to different sources of uncertainty in its inputs (Saltelli *et al*., 2008; Saltelli, 2002). According to Pannell (1997), sensitivity analysis is useful in testing the robustness of the results of a model or system in the face of uncertainty and understanding the relationships between input and output variables in a system or model. Sensitivity analysis can also be used to test the robustness of composite indicators (Saisana *et al*., 2005). As per the 1997 ADB guidelines, the BCR has been calculated using most likely forecast values of economic benefits and costs. The stream of benefits and costs are influenced by a wide variety of factors that may vary from the current scenario. However, the sensitivity analysis consists of the following sequential steps: (i) Selection of the variables for which BCR is subject to change, (ii) Determination of the extent of variation (upper and lower bounds) of the value of such variables, (iii) Calculation of the sensitivity of BCRs using the upper and lower bounds of the variables, and (iv) Interpretation of the extent of impacts using tabulated outputs.

3 RESULTS

This study revealed that the tree growers of the study area were used to plant the seedlings of 1.1±0.2 years old and 1.3±0.2 m average height (Table 1) and to maintain 1.5 m x 1.5 m (4,444 seedlings per ha) to 2 m x 2 m spacing (2,500 seedlings per ha) to raise woodlot plantations. The highest average number of saplings/seedlings planted initially per hectare ranged between 1,894 and 4,318. The fluctuations in number of seedlings planted by the tree growers varied due to the spacing issue in term of land size. During the survey, the average age of the privately-owned woodlot of exotic trees was 6.4±2.5 years, and on average, one hectare of woodlot plots was comprised of 1,923±974 trees, of which the average tree height was 9.52±2.13 m and average DBH 11.57±4.73 cm (Table 1). The tree growers did the first thinning oin the fourth year of woodlot plantation and they thinned out 34% trees on average from the woodlot plantation sites as a part of tending operation. A second thinning was conducted on the seventh year of woodlot plantation, the tree growers thinned out on average 50% trees out of the survived trees in the plots. The thinned-out trees, usually used as fuel, stick, pole, generated the additional income with the total revenue of the woodlot. The elimination rate (thinning percentage) of saplings or trees of woodlot varied based on edaphic factor, natural disaster, insect attack, tending or cultural operation and overall tree growth.

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3.1. Expenditure

Expenditure statements collected from the tree growers depicted that, more than 80% expense were incurred from seedlings purchase and labour hiring and the rest was expended for staking, fencing, manuring and transport of seedlings (Table 2). In contrast, a minimum amount of the expenditure was used for thinning, pruning and irrigation purposes (Table 2). Pest attack in exotic woodlot plantation was negligible.

Table 1. Characteristics of private woodlot plantations in Sakhipur Upazila of Tangail District, Bangladesh

Type of woodlot	Age of trees (yr.)	Trees per ha. while survey	Average height seedlings (m)	Average age seedlings (yr.)	Plantation year	Average height (m) of trees	Average DBH (cm) of trees	Tree growth pattern	Previous land use
A. auriculiformis	4	(1515-) 1894-3553	(0.91-)1.22-1.52	1.0-1.5	2007-8	(6.71-)8.23-10.67	(6.37-)7.96-11.94	Fast	Agriculture/ Fallow land
A. auriculiformis	5-6	(1515-) 1538-3030	(0.91-)1.22-1.52	1.0-1.5	2005-7	(5.18-)8.23-10.67	(1.60-)8.76-23.89	Fast/ Medium	Agriculture/ Fallow land
A. auriculiformis	7	1818-2273	0.91-1.22	1	2004	7.93-9.15	10.35-11.15	Fast	Agriculture/ Sal forest
A. auriculiformis	9	606-1371	1.22-1.52	1	2002	8.23-14.02	14.33-16.72	Fast	Sal forest
E. camadulensis	4-5	1742-3788	1.22-1.52	1	2006-7	6.71-10.67	6.37-11.15	Fast/Medium	Agriculture

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Type of woodlot	Age of trees (yr.)	Trees per ha. while survey	Average height seedlings (m)	Average age seedlings (yr.)	Plantation year	Average height (m) of trees	Average DBH (cm) of trees	Tree growth pattern	Previous land use
E. camadulensis	6-7	515-674	1.52	1	2004-5	6.10-7.32	5.57-6.37	Fast	Agriculture
S. macrophylla	10-15	1515-1894	0.91-1.52	0.8-1.5	1997-2001	9.15-10.67	13.54-18.31	Medium	Agriculture
Average± SD	6.37±2.46	1923±974	1.33±0.23	1.08±0.20		9.52±2.13	11.57±4.73		

Table 2. Expenditure details in BDT of tree growers for raising woodlot plantations on one hectare land in Sakhipur Upazila of Tangail district.

	Age of Plantation (yr.)	Seedling purchase	Transport/ carrying	Labour/ watcher	Fencing	Staking	Manuring	Pesticide	Irrigation/ watering	Thinning	Pruning	Total projected expenditure/ cost upto rotation
A. auriculiformis	4	11364-22727	758-3788	130303-199159	3788-15152	7576-11364	4273-15152	0	1370-6580	9840-15152	8680-13576	194726-273210
A. auriculiformis	5-6	8523-22727	2273-15152	116606-177424	3400-18939	5303-15152	3788-18939	0-1300	0-6800	7000-15000	5600-14350	177072-258099

	S. macrophylla	E. camadulensis	E. camadulensis	A. auriculiformis	A. auriculiformis	Average ± SD	%
Age of Plantation (yr.)	10-15	6-7	4-5	9	7	6.37±2.46	
Seedling purchase	9091-15152	4545	6439-22727	7576-15152	9091-15152	13600±5283	6.5%
Transport/ carrying	3030-6061	1515-2273	758-18182	4000-11364	10001-12121	5404±4288	2.6%
Labour/ watcher	141818-170833	71983-79980	122242-200212	79818-120735	122727-186364	136776±37077	65.5%
Fencing	6818-7800	4410-11364	3500-45455	3500-7500	7600-9091	10652±10183	5.1%
Staking	7361-9061	7576-8788	8500-15152	7701-13636	12121-13636	9631±3004	4.6%
Manuring	4188-8990	4273-5788	4471-15152	3991-7576	6545-9848	8283±4217	4.0%
Pesticide	0	0	0-3788	0-1370	0	327±926	0.2%
Irrigation/ watering	0-6545	0-5871	0-7576	0-4041	0-4261	2260±2843	1.1%
Thinning	7800-8900	10890-14780	9900-13670	8500-13250	9890-14000	11861±2358	5.7%
Pruning	6590-12300	9300-13633	5500-15190	6000-15300	7900-11700	9960±2856	4.8%
Total projected expenditure/ cost upto rotation	196188-236150	123701-137813	184794-302958	134545-194688	199371-262676	208753±48057	100%

3.2. Benefit cost analysis

The results show that a tree grower spent 208753±48057 BDT (2817±648 USD) on average for woodlot plantation in one hectare of land. On the other hand, they were expecting to sale the timber/wood by 1951869±943607 BDT (26341± 12734USD) and to get net profit of 1806726±897146 BDT (24382±12107USD) in ten years of rotation period (Table 7). The results of benefit cost analysis on the woodlots have been presented in Table 8.

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3.3. Net Present Value (NPV), Internal Rate of Return (IRR), and Benefit Cost Ratio (BCR)

All costs incurred and revenues gained from the project are discounted to present the value for both NPV and IRR. Hence, a discounted rate (base) of 12% has been used as the proximity rate of capital loan in Bangladesh. Benefit cost analysis for one hectare (average made from 30 woodlots) private woodlot plantations showed that, the BCR was 1.15 on a ten-year rotation and the NPV was 84074 BDT, whereas, the IRR was 15% (Table 3 and Table 4). From NPV point of view, the net present return from this woodlot was 84074 BDT per ha, which is financially a viable option for investment into woodlot forestry.

Table 3. Calculation of Internal Rate of Return (IRR) (in BDT)

Years (t)	Total Annual Costs (C)	Discounted Cost C*(1+r)^(-t)	Total Annual Benefits (B)	Discounted Benefits B*(1+r)^(-t)
1	157648	137618	0	0
2	125038	95284	0	0
3	120596	80222	0	0
4	78527	45600	8379	4866
5	72872	36940	3200	1622
6	73420	32489	4080	1805
7	81000	31290	28852	11145
8	75220	25365	5540	1868
9	75240	22148	6230	1834
10	76393	19630	1959189	503446
Total		526,587		526,587
		Sum = Total Discounted Cost (TDC)		Sum=Total Discounted Benefits (TDB)
NPV = TDB – TDC			IRR	15%
BCR = TDB/TDC			NPV	0.0
IRR = r when NPV =0, that is, TDB = TDC			BCR	1.0
C = Cost				
B = Benefit				
t = time (year)				

Net Present Value (NPV), Benefit Cost Ratio (BCR), Internal Rate of Return (IRR)

Table 4. Calculation of Net Present Value (NPV) and Benefit Cost Ratio (BCR) (in BDT)

Years (t)	Total Annual Costs (C)	Discounted Cost C*(1+r)^(-t)	Total Annual Benefits (B)	Discounted Benefits B*(1+r)^(-t)
1	157648	140757	0	0
2	125038	99680	0	0
3	120596	85838	0	0
4	78527	49905	8379	5325
5	72872	41349	3200	1816
6	73420	37197	4080	2067
7	81000	36640	28852	13051
8	75220	30380	5540	2238
9	75240	27132	6230	2247
10	76393	24596	1959189	630806
Total		573,475		657,549
		Sum = Total Discounted Cost (TDC)		Sum=Total Discounted Benefits (TDB)
NPV = TDB – TDC			NPV	84074
BCR = TDB/TDC			BCR	1.15

Net Present Value (NPV), Benefit Cost Ratio (BCR), Internal Rate of Return (IRR)

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3.4. Sensitivity analysis

Sensitivity of BCR and NPV with reference to changes in the interest rate for one hectare woodlot monoculture plantation has been analyzed. In absence of any risk of crop destroy, the 5%, 10%, 12% (base case scenario), 15% and 20% changes in interest rate showed BCR 1.66, 1.28, 1.15 (base case scenario), 0.98 and 0.75 and NPV 495394, 169794, 84074, -12251 and -113096 BDT respectively (Table 5).

Table 5. Sensitivity of BCR and NPV with reference to changes in the interest rate for one hectare woodlot monoculture plantation in Sakhipur, Tangail

Interest Rate	Benefit Cost Ratio (BCR)	Net Present Value (NPV) in BDT
5%	1.66	495394
10%	1.28	169794
12% (Base Case)	1.15	84074
15%	0.98	-12251
20%	0.75	-113096

To test the woodlot plantation project viability with respect to changes in risk of crop destroy in the final harvest, a sensitivity analysis was carried out. In this study, variation of sensitivity based on negative decreases for benefit of 10%, 20%, 30%, 40% and 50% due to damage of final harvest showed BCR 1.04, 0.93, 0.82, 0.71 and 0.60 respectively; and NPV 20994, -42087, -105167, -168248 and -231329 BDT and IRR 12.68%, 10.56%, 8.16%, 5.36% and 2.02% respectively (Table 6).

Table 6. Sensitivity of BCR, NPV, and IRR with reference to potential risk of damages of the final crops for one hectare woodlot plantation in Sakhipur, Tangail

Damage thresholds	Benefit Cost Ratio (BCR)	Net Present Value (NPV) in BDT	Internal Rate of Return (IRR)
10%	1.04	20994	12.68%
20%	0.93	-42087	10.56%
30%	0.82	-105167	8.16%
40%	0.71	-168248	5.36%
50%	0.60	-231329	2.02%

Table 7. Future valuation and expected profit of woodlot trees in BDT per ha raised in the private land in Sakhipur, Tangail.

Name of tree species	Age of trees (yr.)	No. of saplings planted initially per ha.	No. of trees encountered while survey per ha. (after 1st thinning)	Expected no. trees will remain per hectare upto ±10 years rotation (after 2nd thinning)	Expected price per tree upto rotation	Projected benefit from tree sale	Average benefit from thinning	Average benefit from pruning	Projected benefit including thinning and pruning	Average expenditure/ cost	Average expected Profit
A. auriculiformis	4	2652-4242	1515-3788	758-1894	2000-2600	1969697-4166667	34091-61364	26691-36818	2031788-4254173	194726-273210	1826555-3980963

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S. macrophylla	*E. camadulensis*	*E. camadulensis*	*A. auriculiformis*	*A. auriculiformis*	*A. auriculiformis*	Name of tree species
10-15	6-7	4-5	9	7	5-6	Age of trees (yr.)
2500-2652	1894-1932	2576-4318	1894-2727	2652-2689	2424-3258	No. of saplings planted initially per ha.
1515-1894	515-674	1591-3788	606-1371	1818-2273	1515-3030	No. of trees encountered while survey per ha. (after 1st thinning)
758-947	258-337	795-1894	303-686	909-1136	758-1515	Expected no. trees will remain per hectare upto ±10 years rotation (after 2nd thinning)
2500-2800	2000	1500-1900	1900-2600	1800-2000	1500-2600	Expected price per tree upto rotation
2121212-2367424	515152-674242	1306818-2840909	575758-1439773	1636364-2272727	1238636-3030303	Projected benefit from tree sale
34091-34470	21515-22689	33712-62121	22424-34129	35985-37879	31818-47727	Average benefit from thinning
13400-28409	25390-37881	19500-29800	17971-34890	19900-38500	16900-31601	Average benefit from pruning
2168703-2430303	562057-734813	1368182-2932830	630648-1491872	1710848-2330506	1297424-3103530	Projected benefit including thinning and pruning
196188-236150	123701-137813	184794-302958	134545-194688	199371-262676	177072-258099	Average expenditure/ cost
1972515-2194153	438355-597000	1111591-2631528	496103-1297184	1511477-2067830	1097382-2908188	Average expected Profit

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Name of tree species	Mean±SD
Age of trees (yr.)	6.37±2.46
No. of saplings planted initially per ha.	2761±658
No. of trees encountered while survey per ha. (after 1st thinning)	1923±974
Expected no. trees will remain per hectare upto ±10 years rotation (after 2nd thinning)	962±487
Expected price per tree upto rotation	2077±357
Projected benefit from tree sale	1951869±943607
Average benefit from thinning	37231±11330
Average benefit from pruning	26370±6082
Projected benefit including thinning and pruning	2015470±954632
Average expenditure/ cost	208753±48057
Average expected Profit	1806727±919144

Table 8. Average benefit cost analysis for one hectare woodlot monoculture plantation in Sakhipur, Tangail

	Investment and Maintenance Cost (BDT)												Benefits (BDT)			
Year	Seedling purchase	Transport / carrying	Labour/ watcher	Fencing	Staking	Manuring	Pesticide	Irrigation/ watering	Thinning	Pruning	Opportunity Cost *	Total Cost (BDT)	Thinning	Pruning	Tree sale	Total Benefits (BDT)
1st	12847	3939	53343	4848	5303	4116		530			72720	157648				
2nd	753	682	43232	2803	2753	1667		429			72720	125038				
3rd			40200	3000	1576	2500		600			72720	120596				
4th							176	700	5631		72720	79227	8379			8379
5th							152				72720	72872		3200		3200
6th											72720	72720		4080		4080
7th									6230	2050	72720	81000	28852			28852
8th										2500	72720	75220		5540		5540

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9th										2520	72720	75240		6230		6230
10th		783								2890	72720	76393		7320	1951869	1959189
Total	13600	5404	136776	10652	9631	8283	327	2260	11861	9960	727200	935953	37231	26370	1951869	2015470

*Opportunity Cost: It was discussed with the respondents (tree grower) of Sakhipur, Tangail. The average paddy production (yield) rate for Boro and Aman categories was 4848 kg per hectare in 2010-11. Whereas, the average paddy price was 15 BDT per kg, based on which the paddy price calculated for one year was 72,720 BDT per hectare.

4. DISCUSSION

In the private sector, woodlot plantation got momentum in the last two decades which helps in improving the economic condition of the rural people by generating employments related to plantation programs, including nurseries and timber business operations. Plantations of *A. auriculiformis* and sporadic plantations of *E. camaldulensis* and *S. macrophylla* species were found to be established in the farmlands in Sakhipur, Tangail. The data collected under this study revealed that all the farmers were used to plant the seedlings of ±1.33 m height and even more in the monoculture woodlots or block plantations which were one year old and even more because they preferred to plant larger seedlings to get the benefit of nursing cost and protection from small cattle's or goats (Table 1). The variations in number of seedlings planted by the tree growers were mainly due to the spacing issue in terms of land size. Woodlot plantation and its maintenance is a labour-intensive work (~65% expenditure). The most of the expenditure were incurred from seedlings purchase, labour and watcher hiring followed by staking, fencing, manuring and transport cost (Table 2).

In Bangladesh, the afforestation activities attempt to promote the income generation as well as employment opportunities to disadvantaged sections of the society and to create a self-reliant system to cater to a community's basic needs (Shiva *et al*. 1981). In the study area, the seedling production and transportation in the beginning stages of the plantations offers a lot of employment opportunities to the people. Moreover, seedlings plantation and tending operations and harvesting of trees generated earning opportunities among the local communities. The majority of households thought that the greatest benefits of forestry to their families and the community were the creation of employment and income, both directly and indirectly. However, the generation of employment and income might create positive cultural and social impacts (Forestal Oriental, 2006).

However, the profitability of the woodlot plantation was found to be changing and the identified reasons were species selection, negligence in plantation care and maintenance, and illegal tree felling in the plots. It is depicted that, the proper maintenance of plantation (Silvicultural operation) such as fencing, weeding, cleaning, fertilizing, watering is required after planting of seedlings. Damage of trees by the cattle cannot be avoided without continued fencing or watcher physical presence at the plantation site. Nevertheless, over exploitation of plant resources, especially by illegal tree cutting, fuel wood collection, branch cutting and cattle grazing etc. were observed as functioning in the exotic tree plots that could loss tree productivity and profitability. This study indicated that, there was a variation in between the poor and rich household tree growers in ranking the above reasons and perceptions.

In this study, the sale valuation of *A. auriculiformis, E. camaldulensis* and *S. macrophylla* plot were calculated considering about ten (±10) year rotation, number of tree exist in the plot, thinning, growth performance of the trees. In this connection, the future valuation of twenty *A. auriculiformis*, eight *E. camaldulensis* and two *S. macrophylla* woodlot plots were carried out and species-wise average values of woodlot plot were calculated per hectare accordingly (Table 7). The net sale value in term of the cost for generating a ten year's old *A. auriculiformis* woodlot, recorded during the present study, are higher than that reported by Muhammed and Koike (2005), but the sale value recorded by this study for raising a six-year-old monoculture of *E. camaldulensis* plantations was much less than that reported by Jalota and Sangha (2000). Data of this study showed that, most of the tree growers were able to earn handsome cash through fast growing exotic tree production investing minimum cost, which is in conformity with the statement of Ahmed *et al.* (2007) and Ali (2009). This financial benefit from tree selling was reported to be useful for the tree growers in different purposes, especially for education, marriage, treatment, festivals, construct houses, furniture making, land purchase and livelihoods activities which is consistent with the study conducted by Safa (2004).

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This study examined the costs and benefits of fast-growing exotic woodlot plantation. The financial analysis carried out in this study indicates that, the monoculture of selected exotic tree species might provide a consistent return to the tree growers. Net Present Value (NPV), Internal Rate of Return (IRR) and Benefit Cost Ratio (BCR) are used to evaluate the financial feasibility of a plantation project (FAO/UNHCR, 2018). The benefit cost analysis for the woodlot of exotic tree plantation on one hectare land (based on the average data from 30 woodlots) showed the generation of the NPV of 84,074 BDT, BCR 1.15 and IRR 15% on ten-year rotation that are positive and comparatively higher (Table 3 and Table 4). It means the woodlots plantation project is a financially viable option in the study area, though some studies (e.g. Ahmed *et al.*, 2007; Safa, 2004; Muhammed *et al.*2008) have indicated that agroforestry is financially more viable than woodlot management. The estimated NPV reported by Islam *et al.* (2013) studying six years old *A. auriculiformis* plantation in Tangail and that reported by Yunus *et al.* (2014) based on the plantation of seven and eight years old 'Sissoo' (*Dalbergia sissoo* DC.) in Mymensingh are lower while those recorded by Yunus *et al.* (2014) are comparatively higher than the results of this study. The BCR and IRR at 10% discount rate estimated by Terwari (1994) are higher, but that recorded by Goswami (1976) and Islam *et al.* (2013) are consistent with the records of this study. The IRR reported by Trivedi (1986) based on 10 and 20 year rotation of exotic trees was higher, but that reported by Terwari (1994) was consistent with the records of this study.

The sensitivity analysis based on the results derived from NPV, BCR and IRR showed that, 10% potential risk of damages of the final crops could be managed by the tree growers but the crop damage more than that level would be the loss project for them (Table 6). If there is no risk of final crop harvesting, the base case scenario in 12% lending interest rate might be with BCR 1.15 and NPV 84074 BDT, indicating profit in plantation business. If the trend of less interest rate on lending continues in future, it will generate more BCR and NPV, and thus better profit as well (Table 5). The maintenance cost of woodlot plantation is assumed low by the tree grower's family in term of their expected benefits from the plantation. The BCR, NPV and IRR results depicted that the investments for monoculture woodlot with exotic species were feasible. The woodlots grown in private land possessed high survival rate, excellent growth and required low expenditure in forming the plantation. These data indicated that the woodlot tree plantations are profitable and feasible in the study area, so the establishment of woodlot plantation is increasing day by day. The data analysis showed that, the tree productivity or woodlot of exotic tree species provides more cash benefits than that of indigenous tree species. The tree growers emphasized on the importance of fuel wood but their main interest was to get immediate return from the plantation over timber production. In the study area, *A. auriculiformis* was the most popular species, followed by *E. camaldulensis* and *S. macrophylla*. The two most frequently cited reasons of why local people preferred *A. auriculiformis* over *E. camaldulensis* and *S. macrophylla* for their woodlot plantation were firstly that *A. auriculiformis* was the only tree species that produced small-dimension timber suitable for furniture making and secondly that they felt *A. auriculiformis* produced fuel wood of high fuel value. Kabir and Webb (2005) mentioned that, the *A. auriculiformis* timber grain direction and texture are similar with Teak (*Tectona grandis* L.f.) timber and often wood carpenter fraud the customer through replacing the *A. auriculiformis* timber in the furniture by the name of Teak. However, data from saw mills and furniture making shops also revealed that *A. auriculiformis* timber was preferable to them as the timber grain of *A. auriculiformis* is similar to Teak timber. The tree growers opined that, they were interested in preferring the fast growing tree species, especially *A. auriculiformis*, for future woodlot block plantation due to its wide range of adaptive capacity and excellent timber and fuel wood productivity, supported by NAS (1980), Akkasaeng*et al.* (1989), Duguma and Tonye (1994), Kamara and Maghembe (1994), Rahman (2003), Kabir and Webb (2005) and Das (2008). The other reasons for preferring *A. auriculiformis* were the non-palatable, excellent timber and fuel wood productivity, ornamental and less shade casting characteristics of the plant. Due to the above reasons, the value and market demand of *A. auriculiformis* was more than that of *E. camaldulensis* and *S. macrophylla.* It is noted that, the age of trees of the *S. macrophylla* plot was higher than that of *A. auriculiformis* and *E. camaldulensis* plots, so the tree height and DBH were found comparatively higher, though *S. macrophylla* is a moderate fast growing species.

In Sakhipur area, wood productions of *A. auriculiformis* plots were always faster than any other fast growing exotic tree species. Within a short time (*i.e.* after about two or three years) after plantation the farmers usually get twigs, branches and grows crops and other vegetables as intermediate products. Managing plantation forests at private level should be with the aims that it will earn money, save the land from encroachment, ensure a scope of employment and income generation, and it will be a model of sustainable land management practice in Bangladesh (Alam *et al.*, 2008). Previously no attention was given to find out any detail on economic prospect of plantation forestry in Bangladesh, especieally in the remote areas like Sakhipur of Tangail. The economic impacts of monoculture of exotic tree species were not also assessed thoroughly.

It can be concluded that the fast-growing exotic tree species woodlot has direct and short term positive financial impacts on the local economy and livelihoods of the beneficiaries as well as in local community. During the survey, most of the farmers were found enthusiastic to raise monoculture plantations of exotic tree species, even in their agricultural lands, because such plantations

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offer quick return for them from low investment, and meet their immediate demand within a short period. Most of the tree growers opined that they go for woodlot block plantation in practice in the near future leaving regular agricultural practices. Monoculture of exotic trees has a promising prospect in the study area as well as in similar adjacent areas. The result of this study gives an insight into the scope of economic return from monoculture of exotic tree species and its impacts on the local economy and community people.

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Conflicts of interests

The authors declare that there are no conflicts of interests.

Data and materials availability

All data associated with this study are present in the paper.

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