Economic Rotation of Sissoo Tree Plantations (Strip) in Bangladesh

Mohammad Yunus
Associate Professor; Department of Business Administration, IIUC, Bangladesh
M. A. T. Hossain
Research Officer; Bangladesh Forest Research Institute, Chittagong, Bangladesh
Farzana Yasmin
Research Assistant; Bangladesh Forest Research Institute, Chittagong, Bangladesh
MD. Milon
Field Investigator, Bangladesh Forest Research Institute, Chittagong, Bangladesh

Abstract

The paper elaborately discusses the various economic rotation methods of sissoo (Dalbergia sissoo) plantations in Bangladesh. Under the present management system, mode of marketing, market mechanism and all the economic criteria for Bangladesh as a whole, the economic rotation of sissoo tree may be fixed at 8 year for fuel wood and 12 or 13 year for timber. But if the Mean Annual Increment (MAI) is considered as rotation criterion, rotation age as 6 year for fuel wood and 11 to 13 year for timber may be suggested. The elimination rates varied from 10% to 72% depending on plantation year and location. It was found 10% in the area of Jessore and more than 50% in Rajshahi, Jessore and Dinajpur. For 6th year plantation the IRR was found highest (39%) in Mymensingh. The 14th year plantation of Rajshahi and 13th year plantation of Jessore showed the highest NPVs, IRRs, B/C ratios, Le, EI and EAEnpv. From these, it can be inferred that the economic rotation may be fixed at 13 or 14 year for timber and 6 year for fuel wood.

Keywords: Rotation, net present value, internal rate of return, land expectation value

Introduction

Sissoo (*Dalbergia sissoo*) is regarded as the most dependable ideal species for afforesting land along the banks of rivers, roads and highways, shade tree in tea gardens and rehabilitation of degraded woodland (Gupta and Karnik, 1983). It is a multipurpose tree and is extensively grown by farmers on agriculture field, homestead and community land for meeting their biomass and timber need (Terwari 1994). In the report to Terwari, at 10% discount rate Net Present Value (NPV), Gross Benefit Cost Ratio (GBCR) and Internal Rate of Return (IRR)

were found to be Rs 2705/ha. 5.07 and 18.36% respectively. The measures of economic efficiency such as the Internal Rate of Return (IRR), Benefit-Cost Ratio (B/C) and Pay- back period (PB) of sissoo were found to be 20%. 2.90 and 10 years respectively (Goswami, 1976).

In the report of Trivedi (1986) at 10 year rotation, the IRR was found to be 22.57 and number of trees per hectare 2595 with an average diameter 5.1 cm and height 7.6 meter and at 20 year, the IRR was found to be 20.06 having number of trees per hectare 865 with an average diameter 12.2 cm and height 13.7 meter. At rotation 20 year with intermediate thinning and without thinning the IRRs were found to be 22.06 and 14.38 respectively (Trivedi, 1986). In the report of

Corresponding author's
Name: Mohammad Yunus
Email address: *yunusiiuc48@gmail.com*

Gupta (1973), the average market prices (1986-91) were found Tk. 3719/m3 for round timber and Tk. 77/md for fuel wood (Bangladesh Tk. 1= India Rs. 0.80).

There is no information about the economic rotation of sissoo plantations in Bangladesh. To find out the economic rotation of sissoo plantations various economic criterea namely; Net Present Value (NPV), Internal Rate of Return (IRR), Benefit-Cost ratio (B/C), Efficiency Index (EI), Land Expectation Value (Le) and Equal Annual Equivalent (EAE) were applied.

Materials and methods

Survey method

The survey was conducted in the year 2006-2007. Five forest divisions namely, Rajshahi, Mymenshingh, Dinajpur, Chittagong and Jessore were selected subjectively. From each Forest Division, 3 to 8 plantation years, starting from 5th year to onward plantations were selected subjectively. From each plantation year, 3 sample plots of 0.01 ha each (5m× 20m, 3m×33.3m, 2m × 50m and 1m×100m) randomly selected for collecting data on diameter at breast height (DBH) and total height. The costs of nursery raising, plantation establishment, weeding, thinning, vacancy filling and maintenance were collected from respective Divisional Forest Office. The mode of marketing and market prices of sawn wood, round wood and fuel wood of sissoo were collected from nearest market places of selected areas in a designed questionnaire. The market prices of round wood and fuel wood were used in the analysis. The nature of plantations was wood lot.

Community forestry and strip plantations. The plantation areas were recorded in kilometers, acres and hectare. All the planted areas were converted into hectare. The sissoo planted areas were proportionately derived from the total planted seedlings of sissoo and other species. The yield per hectare was estimated by multiplying existing number of trees with volume per tree. As regard the planting methods different spacing ranges from (1.3m×1.3m) to 3.3m×3.3m) were found. In the report, the term 'elimination' means unauthorized felling. To estimate the elimination rate (Er), the present stock (Ps) of the standing trees, number of trees thinned (Tt) and number of trees naturally disappeared (Nd) were deducted from the initial planted number of seedlings (Is) and expressed in percentage.

Analysis method

To find out the economic rotation and economics of sissoo tree plantation the following formulae were used in the analyses:

IRR is the rete at which

$$\sum \frac{R_n}{(1+i)} - \sum \frac{C_n}{(1+i)^n} = 0$$

NPV (Net Present Value)

$$= \sum \frac{R_n}{(1+i)} - \sum \frac{C_n}{(1+i)^n}$$

$$\text{B/C Ratio} = \frac{\sum \frac{R_n}{(1+i)}}{\sum \frac{C_n}{(1+i)^n}}$$

$$\text{EI} = \frac{\sum \frac{R_n}{(1+i)} - \sum \frac{C_n}{(1+i)^n}}{\sum \frac{C_n}{(1+i)^n}}$$

(Gittinger, 1974)

Where,

Irr = Internal Rate of Return
B/C =benefit Cost ratio
EI = Efficienc y Index
R_n = Benefits at every n year
C_n = Costs of every n year
N = Number of Year
I = interest rate

$$EAE = NPV \left[\frac{i\,(1+i)^t}{(1+i)^t - 1} \right]$$

(Gunter, 1984)

Where,

      EAE = Equal Annual Equivalent
      NPV = Net Present Value
      I   = Interest Rate
      T   = Rotation Period (1 ....n)

Le =

$$\frac{Yr + T_b\,(1+i)^{r-b} + 1\left[\frac{(1+i)^r - 1}{i}\right] - Cc(1+i)^{r-c}\,e\left[\frac{(1+i)^r - 1}{i}\right]}{(1+i)^r - 1}$$

(Gunter, 1984)

Where,

    Le = Land expectation value
    Y = net yield at rotation age
    T = net value of intermediate cuttings
    b = age at which revenue is received
    1 = annual income
    C = net value of intermediate cost items
    c = age at which cost is incurred
    e = annual expenses
    r = rotation
    i = interest rate

Equation for estimating volume under bark (Vub):

Log (Vub) = -12.5189939 + 1.980535*Log (D) + 1.0775148*Log (H)   (Latif, 1995)

Where,

  Vub = Volume under bark (m3)
  D   = Diameter (cm)
  H   = Total Height (m)

Assumptions
Interest rate 10%
Cost of harvesting 10% of the total value
Cost of processing 5% of the total value
Number of trees per hectare 1000 (for MAI)
Conversion factor 1 m3=7md
1 mile= 1.609 km= 0.8923 acres=0.35692 hectares (Source: FD Plantation Journal)

Results and discussion

Two types of plantations- mixed and mono were considered. In mixed plantations, the number of planted sissoo seedlings varied from 10% to 85% of the total plants. The plantation age up to 9 year was considered as fuel wood and above 9 year as timber.

Table 1: Market survey

Locations	Fuel wood (Tk/md)	Timber price (Tk/m3)	
		Round	Sawn
Rajshahi	55	9534	17302
Chittagong	50	6797	14389
Mymensingh	45	4061	11476
Dinajpur	50	7062	15890
Jessore	50	9534	13771
Mean	50	7397	14565
SD	4	2277	2205
CV	7%	31%	15%

Market prices of timber and fuel wood of sissoo was shown in the table 1. The market survey was conducted in the year 2006-2007. The average market prices of sawn wood, round wood and fuel wood were found to be Tk 14565/m3, Tk 7397m3 and Tk 50/md respectively. In the report of Gupta (1973), the average market prices (1986-91) were found Rs. 7319/m3 for round timber and Rs.77/md for fuel wood (Bangladeshi Tk. 1= Indian Rs. 0.80).

Table 2: Basic information of sissoo plantations in Bangladesh

Variables	Rajshahi								
Plantation year	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1989-90	1990-91	1992-93
Total seedling(Nos)	1761	6300	11985	7671	11021	10560	1998	3996	22500
Sissoo seedling	50%	38%	60%	65%	50%	60%	50%	50%	50%
Sissoo seedling(Nos)	881	2394	7191	4986	5511	6336	999	1998	11250
Total area (ha)	1.15	1.72	2.58	2.30	2.30	1.72	0.29	0.57	3.21
Sissoo area (ha)	0.57	0.65	1.55	1.49	1.15	1.03	0.14	0.29	1.61
Elimination	26%	72%	55%	28%	49%	39%	20%	20%	20%
Existing sissoo (Nos)	652	670	3236	3590	2810	3865	799	1598	9000
Existing sissoo (Nos/ha)	1135	1024	2087	2404	2447	3739	5567	5567	5603
Volume ub (m3/tree)	2.218	0.655	1.024	0.793	1.077	1.274	0.213	0.069	0.132
Total yield(m3)	1445	439	3313	2847	3027	4926	171	110	1188
Yield (m3/ha)	2517	670	2137	1907	2636	4765	1188	384	740
Sissoo seedling (Nos/ha)	1533	3657	4638	3339	4798	6129	6958	6958	7004

Variables	Mymensingh			Dinajpur			
Plantation Year	1992-93	1993-94	1994-95	1985-86	1992-93	1993-94	1994-95
Total seedling(Nos)	5600	8800	5067	24750	4800	12400	4800
Sissoo seedling	48%	40%	29%	85%	42%	43%	52%
Sissoo seedling (Nos)	2688	3520	1469	21038	2016	5332	2496
Total area (ha)	1.55	2.14	1.38	10.00	2.14	4.10	1.07
Sissoo area (ha)	0.74	0.90	0.41	8.50	0.90	1.71	0.56
Elimination	39%	27%	36%	49%	50%	35%	40%
Existing sissoo (Nos)	1640	2570	940	10729	1008	3466	1498
Existing sissoo (Nos/ha)	2219	2861	2281	1262	1121	2023	2690
Volume ub (m3/tree)	0.116	0.140	0.068	0.171	0.095	0.116	0.090
Total yield(m3)	190	359	64	1835	96	402	135
Yield (m3/ha)	257	400	154	216	106	235	243
Sissoo seedling (Nos/ha)	3638	3919	3565	2475	2241	3112	4483

Variables	Chittagong			Jessore				
Plantation Year	1995-96	1995-96	1995-96	1985-86	1986-87	1992-93	1993-94	1994-95
Total seedling(Nos)	27350	82050	10940	10496	10660	6867	12800	10133
Sissoo seedling	10%	10%	23%	36%	36%	62%	40%	26%
Sissoo seedling (Nos)	2735	8205	2516	3779	3838	4257	5152	2635
Total area (ha)	1.78	5.35	1.78	2.28	2.32	1.73	2.86	2.14
Sissoo area (ha)	0.18	0.54	0.41	0.82	0.84	0.73	1.14	0.60
Elimination	20%	20%	20%	19%	19%	54%	10%	66%
Existing sissoo (Nos)	2188	6564	2013	3061	3108	1113	4608	724
Existing sissoo (Nos/ha)	12260	12260	4904	3722	3722	1515	4035	1213
Volume ub (m3/tree)	0.054	0.028	0.054	0.39	0.73	0.14	0.11	0.07
Total yield(m3)	117	182	108	1178	2282	158	486	48
Yield (m3/ha)	657	339	263	1433	2732	215	426	81
Sissoo seedling (Nos/ha)	15326	15326	6130	4595	4595	5795	4483	4411

Basic information of the different plantation years has been shown in the table-2. In the table, the planted seedlings per hectare was found maximum (15326) in Chittagong and minimum (1533) in Rajshahi. The variation of planted seedlings may be due to unequal number of rows. In Chittagong coastal embankment, the number of rows in both the sides was found 10. The elimination rates varied from 10% to 72% depending on plantation year and location. The elimination rate was found 10% in the area of Jessore (1993-94's plantation). More than 50% elimination rates were found in Rajshahi (1982-83's and 1983-84's plantation) and Jessore (1992-93, 1994-95 plantation).

Table 3: Mean annual increments

Location	Age	GBH(cm)			Height (M)			Volume (M3/Tree)	Tree (Nos/ha)	Yield M3/ha)	MAI M3/ha)
		Maxi	Mini	Mean	Maxi	Mini	Mean				
	18	205.74	132.08	112.65	24.00	19.00	19.23	1.224	988	1209	68
	17	124.46	72.39	112.42	20.00	13.50	19.22	0.655	1024	670	39
Rajshahi	16	157.48	71.76	112.42	22.25	16.50	19.22	1.024	2087	2137	64
	15	146.05	57.15	94.25	22.75	12.50	18.60	0.793	2404	1907	53
	14	140.12	62.65	93.94	21.33	11.50	16.28	0.544	2477	1348	39
	13	129.96	59.69	93.18	21.00	9.50	16.08	1.00	3730	3746	77
Dinajpur, Jessore, Rajshahi	12	135.04	61.17	93.56	21.17	10.50	16.18	0.77	3104	2547	68
	11	132.50	60.43	93.37	21.08	10.00	16.13	0.89	3417	3147	84
	10	76.20	46.99	61.19	17.00	8.00	14.18	0.213	5567	1188	21
Rajshahi	9	60.96	33.02	41.17	12.5	90.00	10.96	0.069	5567	384	8
	8	68.58	40.005	51.18	14.75	8.50	12.57	0.14122	5567	786	18
Mymensingh, Jessore, Rajshahi	7	71.87	35.56	53.00	17.00	8.09	11.51	0.121	2615	317	17
Dinajpur, Mymensingh, Jessore,	6	73.24	36.62	54.13	13.17	6.50	10.07	0.120	2973	358	20
Dinajpur, Mymensingh, Jessore, Chittagong	5	60.89	31.28	43.62	11.72	5.95	8.78	0.075	2061	154	15

Table 3 showed the height and girth at breast height (maximum and minimum), mean height and girth, volume yield and mean annual increment (MAI). To find out the MAI, the number of trees per hectare was assumed 1000. The mean height and girth were found to be 19.22m and 112.42 cm in the 16th year plantation. The number of existing trees per hectare was recorded highest (5567) of 8th, 9th and 10th year plantation and lowest (988) of 18th year plantation in the area of Rajshahi. This may

be due to unauthorized felling, the spacing and conversion of kilometer into hectare. It was found that the highest MAI (84m3/ha) was found at age 11 year and second highest (77m3/ha) at age 13 year plantation in Dinajpur, Jessore and Rajshahi As fuel wood up to 9 year, the highest MAI was found 20m3/ha at age 6. If the MAI is considered as rotation criterion, rotation age as 6 year for fuel wood and 11 to 13 year for timber may be suggested.

Table 4: Location wise economics of sissoo plantation

Locations	Plan.age	NPV	IRR	B/C	EI	Le	EAELe	EAEnpv
Rajshahi	18	2049992	49%	6.40	5.40	449568	54816	249956
	17	1685020	53%	6.40	5.40	415596	51810	210062
	16	3942540	65%	6.54	5.54	1096681	104174	503922
	15	3608265	63%	6.41	5.41	1135657	149309	474392
	14	10141503	78%	6.57	5.57	3625204	492108	1376671
	10	953424	57%	2.34	1.34	598230	97359	155165
	9	1697	10%	1.03	0.03	1249	217	295
	8	63033	25%	1.90	0.90	55119	10332	11815
Chittagong	7	-45601	1%	0.76	-0.24	-74693	-19704	-12029
	6	-54618	9%	0.57	-0.43	-89462	-23600	-14408
	5	-18183	1%	0.76	-0.24	29784	-7857	-4797
Mymensingh	7	14170	21%	1.49	0.49	14936	3068	2911
	6	47716	39%	2.16	1.16	61844	14200	10956
	5	-1806	8%	0.95	-0.05	-2959	-781	-477
Dinajpur	14	334191	51%	5.97	4.97	119461	16216	45365
	7	-32662	12%	0.37	-0.63	-34427	-7072	-6709
	6	-11449	3	0.80	-0.20	-14838	-3407	-2629
	5	8417	17	1.19	0.19	13786	3637	2220
Jessore	14	3036607	68	6.41	5.41	1085472	147349	412208
	13	6395599	85	6.57	5.57	2608031	367155	900363
	7	399	10	1.01	0.01	421	86	82
	6	1226	11	1.03	0.03	1589	365	281
	5	-23803	10	0.30	-0.07	-38989	-10285	-6279

The table 4 showed the plantation age and location wise Net Present Value (NPV), Benefit-Cost ratio (B/C), Internal Rate of Return (IRR), Efficiency Index (EI) Land Expectation Value (Le) and Equal Annual Equivalents (EAEs) of different plantations. Almost in all areas, the NPVs were found negative for the 5th, 6th and 7 year plantations. For 6 year plantation of Mymensingh, the IRR was found highest (39%). In the 14th year plantation of Rajshahi

NPV, IRR, B/C ratio, Le, El and EAEnpv were found Tk. 10141503, 78%, 6.57, Tk. 3625204, Tk. 5.57 and Tk. 1376671 respectively and the second highest NPV, IRR, B/C ratio, Le, EL and EAEnpv were found in the 16th year plantation. In the 13th year plantation of Jessore, NPV, IRR, B/C ratio, Le, EL and EAEnpv were found to be Tk. 6395599, 85% 6.57, Tk. 2068031, Tk. 5.57 and Tk. 900363 respectively and the second highest NPV, IRR, B/C ratio, Le, El

and EAEnpv were found in the 14th year plantation. From these, it can be inferred that

economic rotation may be fixed at 13 or 14 year for timber and 6 year for fuel wood.

Table 5: Economics of sissoo plantation in Bangladesh

Plantation age (year)	NPV	IRR	B/C	EI	Le	EAELe	EAEnpv
18	2049992	49%	6.40	5.40	449568	54816	249956
17	1685020	53%	6.40	5.40	415596	51810	210062
16	3942540	65%	6.54	5.54	1096681	140174	503922
15	3608265	63%	6.41	5.41	1135657	149309	474392
14	4504100	66%	6.32	5.32	1610046	218558	611415
13	6395599	85%	6.57	5.57	2608031	367155	900363
12	3674512	71%	4.45	3.45	1603130	232257	527764
11	1838104	41%	2.74	1.74	802190	116237	264029
10	953424	57%	2.34	1.34	598230	97359	155165
9	1697	10%	1.03	0.03	1249	217	295
8	63033	25%	1.90	0.90	55119	10332	11815
7	-6031	6%	0.96	-0.04	-6357	-1306	-1239
6	12498	18%	1.33	0.33	16198	3719	2870
5	-22599	1%	0.76	-0.24	-37017	-9765	-5962

The economic criterea and rotation age for Bangladesh as a whole were shown in table 5. From the table, it is revealed that the highest NPV (Tk. 6395599), IRR (85%), B/C ratio (6.57), EI (Tk. 5.57) and Le (Tk. 2068031) come from the plantation age 13th year. The second highest NPV (Tk. 3674512), IRR (71%), B/C ratio (4.45), EI (3.45), EI (3.45) and Le (Tk. 1603130) were found at age 12th year. At 8th year plantation the highest NPV, IRR, B/C ration, EI and Le as fuel wood were found to be Tk. 63033, 25%, 1.90, Tk. 0.90 and Tk. 55119 respectively. Among the economic criteria NPV, IRR and Le are the important criteria for assessing the economic rotation. In this context, the economic rotations may be suggested at 13 or 12 year for timber and 8 year for fuel wood.

Conclusion

The elimination rates varied from 10% to 72% depending on plantation years and locations. It was found 19% in the areas of Jessore. More than 50% elimination rates were found in Rajshahi, Jessore and Dinajpur. Under the socio-economic condition, intensive research study may initiate to explore the real disguised

dominating causes of elimination. The average number of seedlings planted per hectare was recorded highest 12260 and lowest 3078. The variation in number of seedlings may be due to the spacing and conversion of kilometer into hectare. If we consider the MAI as rotation criterion, rotation ages 6 year for fuel wood and 11 to 13 years for timber may be suggested. Considering the economic criterea for Bangladesh as a whole, 12 or 13 year for timber and 8 year for fuel wood may be suggested as roation ages. It was cleared that no single method can be considered to meet the objectives. Moreover, which criterion should be applied for fixation of rotation depends on the objectives? From these it was also revealed that under the present socio-economic forestry management system, rotations might be based on economic and end-use criterea.

Reference

Gittinger, J. P. (1974). *Economic analysis of agricultural projects.* The Jhons Hoskins University press Baltimore and London. P. 98.

Goswami, K. V. (1976). Cost benefits analysis of afforestation in deep

ravines of Gujrat. *Indian Agriculture Economic,* 31(1), 48-55.

Gunter, J. E. (1984). *Essentials of forestry investment analysis*. Library of Congress Catalog 83-063342. P. 68-80.

Gupta, G. B. L. (1973). An economic evaluation in soil conservation measures in Vranasi District, (U. P). *Indian Agricultural Economic,* 28(4), 205-211.

Gupta, A. C., & Karnik, M. G. (1983). *Dalbergia Sisso: An annotated bibliography*. Winrock International -F/FRED: Bangkok, Thailand.

Latif, M. A. (1995). Volume tables for Acacia auriculiformis, Cassia siamia and Pinus caribaea in Bangladesh. *Bangladesh Journal of Forest Science*, 24(2), 22-30.

Tewari, D. N. (1994). *A monograph on dalbergia sissoo roxb.* International Book Distributors, Dehra Dun-248001. India: pp. 192-201.

Trivedi, S. N. (1986). Financial appraisal for some afforestation species in Bihar (India) under the risk of illicit felling. *Forest Ecology and Management*, 17, 261-277.