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**TREE VOLUME TABLES FOR SAL (*SHOREA ROUSTA*  
Gaertn. f.) IN THE PLANTATIONS OF BANGLADESH**

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# TREE VOLUME TABLES FOR SAL (*SHOREA ROUSTA* Gaertn. f.) IN THE PLANTATIONS OF BANGLADESH

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## INTRODUCTION

Sal (*Shorea robusta* Gaertn. f.) is a medium size tree growing naturally from Tarai in the north to the Maynamoti hills in the south. The species has been planted in the forests of Tangail, Mymensingh, Dinajpur and Sylhet of Bangladesh for its extensive uses. It was also experimentally planted in the forests of Chittagong and Cox's Bazar. The bole of the tree is tall and straight. It attains generally a height of 18 m to 30 m and a diameter of 50 cm to 70 cm (Troup, 1986). The wood is durable and of good quality and hence used extensively for building and construction purposes, railway sleepers, wagons, etc. The older sal plantations are now suitable for felling and to estimate the volume, volume tables are necessary for the species. Therefore, the present volume tables have been prepared for sal growing in the plantations of Bangladesh.

## COLLECTION OF DATA

Data were collected from the standing trees of the plantations of 56 - 26 years old for Sylhet and 51 - 11 years old for Tangail and Mymensingh. The plantations were initially raised with a stocking of 2988

seedlings per hectare but at the time of data collection, there were approximately 500 - 1400 trees per hectare. Measurements on diameters at breast height (dbh), total height and diameters at 3.0 meters intervals from the ground level to the top end diameter of 10.0 cm overbark were taken. The bark thickness at each point of diameter measurements was also taken in two perpendicular directions to estimate the diameter under bark. A total of 499 trees were measured for the preparation of volume tables (Table 1). In addition to these, data were collected from a total of 85 trees for validating the selected regression equations.

## COMPIILATION OF DATA

The volumes of all the sections except the top and bottom portion were computed by using the mean cross-sectional area of the two ends of each section (smallian formula). The bottom section was assumed cylindrical. The top most section was assumed a cone and volume was computed as one third of the cylindrical volume of the portion. The top end diameter measurement for each tree was considered as the base

diameter of the cone. The volumes of the cone was ignored for estimation of under bark tree volumes. The individual tree volume was then estimated by summing up the volumes of each section of a tree. These individual tree volumes ( $V$ ) were related to dbh ( $D$ ) and total height ( $H$ ) by regression analyses using various functions and transformations as required in the regression models.

## COMPUTATION OF VOLUME FUNCTIONS

Multiple regression analyses were done to select the best suited equations. The following 10 equations were tried to select the best fitted one :

1.  $V = b_0 + b_1 D$
2.  $V = b_0 + b_1 D + b_2 D^2$
3.  $V = b_0 + b_1 D^2$
4.  $V = b_0 + b_1 D^2 H$
5.  $V = b_0 + b_1 D^2 + b_2 H + b_3 D^2 H$
6.  $V = b_0 + b_1 D^2 + b_2 DH + b_3 D^2 H$
7.  $\log_e(V) = b_0 + b_1 \log_e(D)$
8.  $\log_e(V) = b_0 + b_1 \log_e(D) + b_2 \log_e(H)$
9.  $V/D^2 = b_0 + b_1 HD^2 + b_2 /H + b_3/D^2$
10.  $V/D^2 = b_0 + b_1 /D^2 + b_2/H + b_3/D$

where,  $V$ ,  $D$  and  $H$  are described as above,  $b_0$  is the regression constant and  $b_i$ 's are regression coefficients. The logarithmic functions are to the base e.

The regression model of best fit were chosen based on small furnival index, high multiple coefficient of determination, low

mean sum of error squares and high F-Value.

Models were selected for estimation of total volume over bark and total volume under bark to a top end diameter of approximately 9.0 cm under bark. The selected equations were transformed for estimation of volume from girth at breast height ( $G$ ). The equations were also converted for imperial units.

## VALIDATION TEST PROCEDURE

The best suited regression equations were tested with a set of independent data on 85 trees collected and compiled in the same procedure. The actual volumes of these trees were collectively compared with the corresponding volumes predicted by the selected models. The independent tests for validation criteria were :

- i) The paired t - test (Dawkins, 1975) :

$$t = \frac{d}{S.E. (d)}$$

with  $(n - 1)$  df at 0.05 level

where,  $d$  = Average of the difference of the pairs of the actual and the estimated volumes.

$S.E. (d)$  = Standard error of the average difference

$n$  = Number of pairs.

The criterion of insignificant difference has been followed.

- ii) Regression analysis (Cox 1984) :

$$a) A - E = b_0 + b_1 E$$

$$b) A - E = b_0 + b_1 E + b_2 E^2$$

Where, A and E indicate the actual and the estimated volumes respectively.

The criterion of significant for F and t have been followed.

- iii) Absolute per cent deviation (% AD) :

$$\% AD = \frac{|\sum (A - E)|}{\sum A} \times 100$$

Where, A and E are the actual and the estimated total volumes respectively.

A % AD of less than 10 per cent of absolute deviation has been considered as a selection criteria.

- iv) (A - E) vs E plot :

Where, A = Actual volume

E = Estimated volume

Criterion : If the plot indicates horizontal band, the model is adequate.

- v) A vs E plot & regression

Criterion : The nearer the slope to  $45^\circ$  is the better.

## RESULTS, AND DISCUSSIONS

The equations for total volume overbark and total volume underbark to a top end diameter of 9.0 cm underbark were selected. The mean sum of squares (MSE), coefficient of determination ( $R^2$ ), F - value, and the Furnival Index (FI) of the selected equations are given in table 2.

The best selected and transformed/converted equations are given below :

## METRIC UNITS

Total volume overbark ( $V_{mo}$ ) for one way :

$$\log_e(V_{mo}) = - 9.1727759 + 2.5178944 \log_e(D)$$

$$\log_e(V_{mo}) = - 12.0554 + 2.5178944 \log_e(G)$$

Total volume underbark to a top end diameter of approximately 9.0 cm under-bark ( $V_{mu}$ ) for one way :

$$V_{mu} = - 0.1011481 + 0.0006209 D^2$$

$$V_{mu} = - 0.1011481 + 0.0000629 G^2$$

Total volume overbark for two way :

$$\log_e(V_{mo}) = - 9.615639 + 2.033071 \log_e(D) + 0.7361229 \log_e(H)$$

$$\log_e(V_{mo}) = - 11.938881 + 2.033071 \log_e(G) + 0.7361229 \log_e(H)$$

Total volume underbark to a top end diameter of approximately 9.0 cm under bark ( $V_{mu}$ ) for two way :

$$V_{mu} = 0.0032556 + 0.0000269 D^2 H$$

$$V_{mu} = 0.003255 + 0.0000027255 G^2 H$$

## IMPERIAL UNITS

Total volume overbark ( $V_{io}$ ) for one way :

$$\log_e(V_{io}) = - 3.2615386 + 2.5178944 \log_e(D)$$

$$\log_e(V_{io}) = - 6.1438476 + 2.5178944 \log_e(G)$$

Total volume underbark to a top end diameter of approximately 3.5 inches underbark ( $V_{iu}$ ) for one way :

$$V_{iu} = - 3.5720185 + 0.14146622 D^2$$

$$V_{iu} = - 3.5720185 + 0.0143335 G^2$$

Total volume overbark ( $V_{io}$ ) two way :

$$\log_e(V_{io}) = - 5.02669 + 2.033071 \log_e(D) + 0.7361229 \log_e(H)$$

$$\log_e(V_{iu}) = -7.3540131 + 2.033071 \log_e(G) + 0.7361229 \log_e(H)$$

Total volume underbark to a top end diameter of 3.5 inches underbark ( $V_{iu}$ ) for two way :

$$V_{iu} = -0.11496 + 0.001867 D^2H$$

$$V_{iu} = -0.11496 + 0.0001894 G^2H$$

where, m = metric units

i = imperial units

u = underbark

o = overbark

D = Dbh

G = Girth at breast height

H = total height

### Validation of the Selected Models

**Models** : The test statistics are presented in the table 3. The selected models satisfied all the criteria. The most vivid ones are the slopes and per cent total deviations. They are nearly 45 degree and less than 5% respectively. This nature was considered sufficient to mark the importance of little discrepancies in the horizontal bands of deviations. From the results of the validation of the models, it can be concluded that the selected models can be safely used for estimation of the volumes of the sal tree in the plantations of Bangladesh.

After the validation test, volume tables were prepared for ready use and are presented in Appendices I to VI.

### CONFIDENCE LIMIT

These volume tables should not be used to determine volume of individual tree

in a stand. These tables may be used for the mean tree of a stand which may be multiplied by the number of stem to get the volume. Estimation of volumes for trees much out side the height and dbh ranges shown in the stand table should only be done with caution.

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**Table -1.** Sal (*Shorea robusta*) in plantations of Bangladesh, diameter at breast height and height class distribution of sample trees.

DBH (cm)	Height in meters									Total
	5	8	11	14	17	20	23	26	29	
10	15	31	29	8	-	-	-	-	-	83
15	1	31	43	23	4	1	-	-	-	103
20	1	14	18	35	26	3	-	-	-	97
25	-	-	7	23	27	8	2	-	-	67
30	-	-	1	9	19	16	-	-	-	45
35	-	-	-	6	16	17	10	-	1	50
40	-	-	-	-	7	5	6	3	-	21
45	-	-	-	-	1	11	3	3	1	19
50	-	-	-	-	3	5	1	1	-	10
55	-	-	-	-	1	2	-	-	-	3
60	-	-	-	-	1	-	-	-	-	1
TOTAL	17	76	98	104	105	68	22	7	2	499

**Table 2.** Sal (*Shorea robusta*) in plantation of Bangladesh, results of regression analyses of the relating volume with height and/or dbh.

EQUATIONS	MSE	R squared	F	F.I.
1. $\log_e(V_{mo}) = b_0 + b_1 \log_e(D)$	0.03856	.9666	14383.46	0.0575
2. $\log_e(V_{mo}) = a + b \log_e(D) + c \log_e(H)$	0.01696	.9853	16669.57	0.0381
3. $V_{mu} = b_0 + b_1 D^2$	0.00776	.9551	10568.40	0.0881
4. $V_{mu} = b_0 + b_1 D^2 H$	0.00652	.9622	12666.66	0.0808

**Table 3.** Validation test statistics of the selected models for estimation of volume for sal in the plantations of Bangladesh

EQUATIONS	PAIRED t	%AD	A-E=b0+b1E		A-E=b0+b1E+b2E^2			Slope E vs A
			F	t	b1	b1	b2	
Equ. 1	1.514	3.9	51.16	0.0098	26.63	0.0617	0.0405	45.6
Equ. 2	0.037	0.1	27.45	0.0131	19.25	0.0518	0.0348	46.3
Equ. 3	1.904	4.1	28.07	0.0091	3.92	0.0489	0.0355	45.61
Equ. 4	0.204	0.5	31.23	0.0081	4.65	0.0569	0.0403	45.44

**Appendix I. Sal (*Shorea robusta*) in the plantations of Bangladesh, total volume overbark (Vmo) and total volume underbark to a top and diameter of approximately 9.0 cm (Vm<sub>u</sub>) in cubic meters for dbh and girth in centimeters.**

Dbh (cm)	Vmo	Vmu	Girth (cm)	Vmo	Vmu
6	0.009		20	0.011	
8	0.020		26	0.021	
10	0.034		32	0.036	
12	0.045		38	0.055	
14	0.080	0.021	44	0.080	0.021
16	0.112	0.058	50	0.110	0.056
18	0.150	0.100	56	0.147	0.096
20	0.196	0.147	62	0.190	0.141
22	0.249	0.199	68	0.239	0.190
24	0.310	0.257	74	0.296	0.244
26	0.379	0.319	80	0.360	0.302
28	0.457	0.386	86	0.432	0.365
30	0.544	0.458	92	0.512	0.432
32	0.640	0.535	98	0.600	0.504
34	0.746	0.617	104	0.697	0.580
36	0.861	0.704	110	0.803	0.661
38	0.987	0.795	116	0.918	0.747
40	1.123	0.892	122	1.042	0.837
42	1.269	0.994	128	1.176	0.931
44	1.427	1.101	134	1.320	1.030
46	1.596	1.213	140	1.474	1.334
48	1.777	1.329	146	1.638	1.242
50	1.969	1.451	152	1.813	1.354
52	2.173	1.578	158	1.998	1.472
54	2.390	1.709	164	2.195	1.593
56	2.619	1.846	170	2.403	1.720
58	2.861	1.988	176	2.622	1.850
60	3.116	2.134	182	2.853	1.986
62	3.384	2.286	188	3.096	2.126
64	3.666	2.442	194	3.350	2.270
66	3.961	2.604	200	3.617	2.419
68	4.270	2.770	206	3.897	2.572
70	4.594	2.941	212	4.189	2.730
72	4.932	3.118	218	4.494	2.893
74	5.284	3.299	224	4.812	3.060
76	5.651	3.485	230	5.143	3.232
78	6.033	3.676	236	5.488	3.408
80	6.430	3.873	242	5.846	3.588

**Appendix II. Sal (*Shorea robusta*) in the plantations of Bangladesh, total volume overbark (V<sub>mo</sub>) in cubic meters for dbh and gbh in centimeters and height in meters.**

Dbh (cm)	Gbh (cm)	Height in meters									
		4	7	10	13	16	19	22	25	28	31
6	19	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03
8	25	0.01	0.02	0.02	0.03	0.04	0.04	0.04	0.05	0.05	0.06
10	31	0.02	0.03	0.04	0.05	0.06	0.06	0.07	0.08	0.08	0.09
12	38	0.03	0.04	0.06	0.07	0.08	0.09	0.10	0.11	0.12	0.13
14	44	0.04	0.06	0.08	0.09	0.11	0.12	0.14	0.15	0.17	0.18
16	50	0.05	0.08	0.10	0.12	0.14	0.16	0.18	0.20	0.22	0.23
18	57	0.07	0.10	0.13	0.16	0.18	0.21	0.23	0.25	0.28	0.30
20	63	0.08	0.12	0.16	0.19	0.23	0.26	0.29	0.31	0.34	0.37
22	69	0.10	0.15	0.19	0.24	0.28	0.31	0.35	0.38	0.42	0.45
24	75	0.12	0.18	0.23	0.28	0.33	0.37	0.42	0.46	0.50	0.53
26	82	0.14	0.21	0.27	0.33	0.39	0.44	0.49	0.54	0.58	0.63
28	88	0.16	0.24	0.32	0.39	0.45	0.51	0.57	0.62	0.68	0.73
30	94	0.19	0.28	0.37	0.44	0.52	0.59	0.65	0.72	0.78	0.84
32	101	0.21	0.32	0.42	0.51	0.59	0.67	0.75	0.82	0.89	0.96
34	107	0.24	0.36	0.47	0.57	0.67	0.76	0.84	0.93	1.01	1.08
36	113	0.27	0.41	0.53	0.64	0.75	0.85	0.95	1.04	1.13	1.22
38	119	0.30	0.45	0.59	0.72	0.84	0.95	1.06	1.16	1.26	1.36
40	126	0.33	0.50	0.66	0.80	0.93	1.05	1.17	1.29	1.40	1.51
42	132	0.37	0.56	0.72	0.88	1.02	1.16	1.30	1.42	1.55	1.67
44	138	0.41	0.61	0.80	0.97	1.13	1.28	1.42	1.56	1.70	1.83
46	145	0.44	0.67	0.87	1.06	1.23	1.40	1.56	1.71	1.86	2.01
48	151	0.48	0.73	0.95	1.15	1.34	1.53	1.70	1.87	2.03	2.19
50	157	0.53	0.79	1.03	1.25	1.46	1.66	1.85	2.03	2.20	2.38
52	163	0.57	0.86	1.12	1.36	1.58	1.79	2.00	2.20	2.39	2.57
54	170	0.62	0.93	1.21	1.47	1.71	1.94	2.16	2.37	2.58	2.78
56	176	0.66	1.00	1.30	1.58	1.84	2.09	2.32	2.55	2.78	2.99
58	182	0.71	1.07	1.40	1.69	1.97	2.24	2.50	2.74	2.98	3.21
60	188	0.76	1.15	1.50	1.82	2.12	2.40	2.67	2.94	3.19	3.44
62	195	0.82	1.23	1.60	1.94	2.26	2.57	2.86	3.14	3.41	3.68
64	201	0.87	1.31	1.71	2.07	2.41	2.74	3.05	3.35	3.64	3.93
66	207	0.93	1.40	1.82	2.20	2.57	2.91	3.25	3.57	3.88	4.18
68	214	0.98	1.48	1.93	2.34	2.73	3.10	3.45	3.79	4.12	4.44
70	220	1.04	1.58	2.05	2.48	2.89	3.28	3.66	4.02	4.37	4.71
72	226	1.10	1.67	2.17	2.63	3.07	3.48	3.87	4.26	4.63	4.99
74	232	1.17	1.76	2.29	2.78	3.24	3.68	4.10	4.50	4.89	5.27
76	239	1.23	1.86	2.42	2.94	3.42	3.88	4.33	4.75	5.17	5.57
78	245	1.30	1.96	2.55	3.10	3.61	4.09	4.56	5.01	5.45	5.87
80	251	1.37	2.07	2.69	3.26	3.80	4.31	4.80	5.27	5.73	6.18

**Appendix III. Sal (*Shorea robusta*) in the plantations of Bangladesh, total volume underbark (Vm<sub>u</sub>) in cubic meters for dbh and gbh in centimeters and height in meters.**

Dbh (cm)	Ghb (cm)	Height in meters									
		4	7	10	13	16	19	22	25	28	31
6	19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
10	31	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
12	38	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
14	44	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2
16	50	0.0	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2
18	57	0.0	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.3
20	63	0.0	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3
22	69	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.4	0.4
24	75	0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.5
26	82	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.5	0.5	0.6
28	88	0.1	0.2	0.2	0.3	0.3	0.4	0.5	0.5	0.6	0.7
30	94	0.1	0.2	0.2	0.3	0.4	0.5	0.5	0.6	0.7	0.8
32	101	0.1	0.2	0.3	0.4	0.4	0.5	0.6	0.7	0.8	0.9
34	107	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
36	113	0.1	0.2	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1
38	119	0.2	0.3	0.4	0.5	0.6	0.7	1.9	1.0	1.1	1.2
40	126	0.2	0.3	0.4	0.6	0.7	0.8	1.0	1.1	1.2	1.3
42	132	0.2	0.3	0.5	0.6	0.8	0.9	1.0	1.2	1.3	1.5
44	138	0.2	0.4	0.5	0.7	1.8	1.0	1.1	1.3	1.5	1.6
46	145	0.2	0.4	0.6	0.7	0.9	1.1	1.3	1.4	1.6	1.8
48	151	0.3	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.7	1.9
50	157	0.3	0.5	0.7	0.9	1.1	1.3	1.5	1.7	1.9	2.1
52	163	0.3	0.5	0.7	1.9	1.2	1.4	1.6	1.8	2.0	2.3
54	170	0.3	0.6	0.8	1.0	1.3	1.5	1.7	2.0	2.2	2.4
56	176	0.3	0.6	0.8	1.1	1.4	1.6	1.9	2.1	2.4	2.6
58	182	0.4	0.6	0.9	1.2	1.5	1.7	2.0	2.3	2.5	2.8
60	188	0.4	0.7	1.0	1.3	1.6	1.8	2.1	2.4	2.7	3.0
62	195	0.4	0.7	1.0	1.3	1.7	2.0	2.3	2.6	2.9	3.2
64	201	0.4	0.8	1.1	1.4	1.8	2.1	2.4	2.8	3.1	3.4
66	207	0.5	0.8	1.2	1.5	1.9	2.2	2.6	2.9	3.3	3.6
68	214	0.5	0.9	1.2	1.6	2.0	2.4	2.7	3.1	3.5	3.9
70	220	0.5	0.9	1.3	1.7	2.1	2.5	2.9	3.3	3.7	4.1
72	226	0.6	1.0	1.4	1.8	2.2	2.7	3.1	3.5	3.9	4.3
74	232	0.6	1.0	1.5	1.9	2.4	2.8	3.2	3.7	4.1	4.6
76	239	0.6	1.1	1.6	2.0	2.5	3.0	3.4	3.9	4.4	4.8
78	245	0.7	1.1	1.6	2.1	2.6	3.1	3.6	4.1	4.6	5.1
80	251	0.7	1.2	1.7	2.2	2.8	3.3	3.8	4.3	4.8	5.3

**Appendix iv. Sal (*Shorea robusta*) in the plantations of Bangladesh, total volume overbark (Vmo) and total volume underbark to a top end diameter of approximately 3.5 inches underbark (Viu) in cubic feet for dbh and girth in inches.**

Dbh (cm)	Vio (cu. ft)	viu (cu. ft.)	Girth (Inch)	Vio (cu. ft)	Viu (cu. ft)
4	1.26		13	1.37	
5	2.21		16	2.31	
6	3.49	1.52	19	3.56	1.60
7	6.15	3.36	22	5.15	3.37
8	7.20	5.48	25	7.11	5.39
9	0.69	7.89	28	9.45	7.67
10	12.63	10.57	31	12.21	10.20
11	16.06	13.55	34	15.41	13.00
12	19.99	16.80	37	19.07	16.05
13	24.45	20.34	40	23.20	19.36
14	29.47	24.16	43	27.84	22.93
15	35.06	28.26	46	32.99	26.76
16	41.25	32.64	49	38.68	30.84
17	48.05	37.31	52	44.92	35.19
18	55.48	42.26	55	51.74	39.79
19	63.58	47.50	58	59.14	44.65
20	72.34	53.01	61	67.15	49.76
21	81.80	58.81	64	75.78	55.14
22	91.96	64.90	67	85.04	60.77
23	102.85	71.26	70	94.96	66.66
24	114.49	77.91	73	105.54	72.81
25	126.88	84.84	76	116.80	79.22
26	140.05	92.06	79	128.76	85.88
27	154.01	99.56	82	141.43	92.81
28	168.78	107.34	85	154.82	99.99
29	184.37	115.40	88	168.95	107.43
30	200.80	123.75	91	183.83	115.12
31	218.08	132.38	94	199.47	123.08
32	236.23	141.29	97	215.89	131.29
33	255.26	150.48	100	233.10	139.76
34	275.19	159.96	103	251.11	148.49
35	296.03	169.72	106	269.94	157.48
36	317.79	179.77	109	289.59	166.72
37	340.49	190.10	112	310.08	176.23
38	364.13	200.71	115	331.42	185.99
39	388.74	211.60	118	353.62	196.01
40	414.33	222.77	121	376.70	206.29

**Appendix v. Sal (*Shorea robusta*) in the plantations of Bangladesh, total volume underbark (V<sub>io</sub>) in cubic feet for dbh and gbh in inches and height in feet.**

Dbh (in)	Gbh (in)	Height in feet									
		15	25	35	45	55	65	75	85	95	105
3	9	0.4	0.7	0.8	1.0	1.2	1.3	1.5	1.6	1.7	1.9
4	13	0.8	1.2	1.5	1.8	2.1	2.4	2.6	2.9	3.1	3.4
5	16	1.3	1.8	2.4	2.9	3.3	3.7	4.2	4.6	4.9	5.3
6	19	1.8	2.7	3.4	4.1	4.8	5.4	6.0	6.6	7.2	7.7
7	22	2.5	3.7	4.7	5.6	6.5	7.4	8.2	9.0	9.8	10.5
8	25	3.3	4.8	6.2	7.4	8.6	9.7	10.8	11.8	12.8	13.8
9	28	4.2	6.1	7.8	9.4	10.9	12.3	13.7	15.0	16.3	17.6
10	31	5.2	7.6	9.7	11.7	13.5	15.3	17.0	18.6	20.2	21.8
11	35	6.3	9.2	11.8	14.2	16.4	18.6	20.6	22.6	24.5	26.4
12	38	7.5	11.0	14.0	16.9	19.6	22.2	24.6	27.0	29.3	31.5
13	41	8.9	12.9	16.5	19.9	23.1	26.1	29.0	31.8	34.5	37.1
14	44	10.3	15.0	19.2	23.1	26.8	30.3	33.7	36.9	40.1	43.1
15	47	11.9	17.3	22.1	26.6	30.8	34.9	38.8	42.5	46.1	49.6
16	50	13.5	19.7	25.2	30.3	35.2	39.8	44.2	48.4	52.6	56.6
17	53	15.3	22.3	28.5	34.3	39.8	45.0	50.0	54.0	59.5	64.0
18	57	17.2	25.0	32.0	38.5	44.7	50.5	56.1	61.6	66.8	71.9
19	60	19.2	27.9	35.8	43.0	49.9	56.4	62.7	68.7	74.6	80.3
20	63	21.3	31.0	39.7	47.8	55.4	62.6	69.5	76.3	82.8	89.1
21	66	23.5	34.2	43.8	52.7	61.1	69.1	76.8	84.2	91.4	98.4
22	69	25.8	37.6	48.2	58.0	67.2	76.0	84.4	92.6	100.5	108.1
23	72	28.3	41.2	52.7	63.4	73.5	83.2	92.4	101.3	110.0	118.4
24	75	30.8	44.9	57.5	69.2	80.2	90.7	100.8	110.5	119.9	129.1
25	79	33.5	48.8	62.5	75.2	87.1	98.5	109.5	120.0	130.3	140.2
26	82	36.3	52.8	67.7	81.4	94.4	106.7	118.6	130.0	141.1	151.9
27	85	39.2	57.0	73.1	87.9	101.9	115.2	128.0	140.4	152.4	164.0
28	88	42.2	61.4	78.7	94.6	109.7	124.1	137.8	151.1	164.0	176.6
29	91	45.3	65.9	84.5	101.6	117.8	133.2	148.0	162.3	176.2	189.6
30	94	48.3	70.6	90.5	108.9	126.2	142.7	158.6	173.9	188.7	203.2
31	97	51.8	75.5	96.7	116.4	134.9	152.6	169.5	185.9	201.8	217.2
32	101	55.3	80.6	103.2	124.2	143.9	162.8	180.8	198.3	215.2	231.7

**Appendix vi. Sal (*Shorea robusta*) in the plantations of Bangladesh, total volume underbark (Viu) in cubic feet for dbh and gbh in inches and height in feet.**

Dbh (in)	Ghb (in)	Height in meters									
		15	25	35	45	55	65	75	85	95	105
3	9	0.1	0.3	0.5	0.6	0.8	1.0	1.1	1.3	1.5	1.6
4	13	0.3	0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7	3.0
5	16	0.6	1.1	1.5	2.0	2.5	2.9	3.4	3.9	4.3	4.8
6	19	0.9	1.6	2.2	2.9	3.6	4.3	4.9	5.6	6.3	6.9
7	22	1.3	2.2	3.1	4.0	4.9	5.8	6.7	7.7	8.6	9.5
8	25	1.7	2.9	4.1	5.3	6.5	7.7	8.8	10.0	11.2	12.4
9	28	2.2	3.7	5.2	6.7	8.2	9.7	11.2	12.7	14.3	15.8
10	31	2.7	4.6	6.4	8.3	10.2	12.0	13.9	15.8	17.6	19.5
11	35	3.3	5.5	7.8	10.1	12.3	14.6	16.8	19.1	21.3	23.6
12	38	3.9	6.6	9.3	12.0	14.7	17.4	20.0	22.7	25.4	28.1
13	41	4.6	7.8	10.9	14.1	17.2	20.4	23.5	26.7	29.9	33.0
14	44	5.4	9.0	12.1	16.4	20.0	23.7	27.3	31.0	34.6	38.3
15	47	6.2	10.4	14.6	18.8	23.0	27.2	31.4	35.6	39.8	44.0
16	50	7.1	11.8	16.6	21.4	26.2	31.0	35.7	40.5	45.3	50.1
17	53	8.0	13.4	18.8	24.2	29.6	35.0	40.4	45.7	51.1	56.5
18	57	9.0	15.0	21.1	27.1	33.2	39.2	45.3	51.3	57.4	63.4
19	60	10.0	16.7	23.5	30.2	37.0	43.7	50.4	57.2	63.9	70.7
20	63	11.1	18.6	26.0	33.5	41.0	48.4	55.9	63.4	70.8	78.3
21	66	12.2	20.5	28.7	36.9	45.2	53.4	61.6	69.9	78.1	86.3
22	69	13.4	22.5	31.5	40.5	49.6	58.6	67.7	76.7	85.7	94.8
23	72	14.7	24.6	34.5	44.3	54.2	64.1	74.0	83.8	93.7	103.6
24	75	16.0	26.8	37.5	48.3	59.0	69.8	80.5	91.3	102.0	112.8
25	79	17.4	29.1	40.7	52.4	64.1	75.7	87.4	99.1	110.7	122.4
26	82	18.8	31.4	44.1	56.7	69.3	81.9	94.5	107.2	119.8	132.4
27	85	20.3	33.9	47.5	61.1	74.7	88.4	102.0	115.6	129.2	142.8
28	88	21.8	36.5	51.1	65.8	80.4	95.0	109.7	124.3	138.9	153.6
29	91	23.4	39.1	54.8	70.5	86.2	101.9	117.6	133.3	149.0	164.8
30	94	25.1	41.9	58.7	75.5	92.3	109.1	125.9	142.7	159.5	176.3
31	97	26.8	44.7	62.7	80.6	98.6	116.5	134.4	152.4	170.3	188.3
32	101	28.6	47.7	66.8	85.9	105.0	124.2	143.3	162.4	181.5	200.6