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Timber, Small Timber and Fuelwood Calculations for Certain Species of Trees Found Outside Forests in the State of Gujarat

Dr. S. Tyagi[1*], Rinkuben A. Patel[2], Dr. K. P. Gadekar[3]

[1]IFS, Director GFRF & APCCF, Research & Training, Gujarat Forestry Research Foundation, TRO Bhavan, Gandhinagar, Gujarat, India

[2]Senior Research Fellow, Gujarat Forestry Research Foundation, TRO Bhavan, Gandhinagar, Gujarat, India

[3]Co-PI, Gujarat Forestry Research Foundation, TRO Bhavan, Gandhinagar, Gujarat, India

[*]Corresponding author's E-mail: *patelrinkuben2020[at]gmail.com*

Abstract: ***Measurement of trees and consequently calculation of timber has posed challenges to foresters in Indian forests. The determination of timber yield, small timber yield and fuelwood production from an individual tree outside forest area has been equally challenging. This paper attempts at making mathematical calculation of the three values based on size and shape of the tree. The proportionate yield of timber, small timber and fuelwood has been estimated and realistic figures have been arrived at.***

Keywords: Timber, Small timber, Fuelwood, Girth, Volume, TOF

One liner: The shape and size parameters such as girth; clean bole height and total height of a tree determine the proportionate value of yield of timber, small timber and fuelwood from it.

1. Introduction

The measurement of trees, especially the ones to determine the timber yield, was started in India in the middle of the 19 century. The Britishers wanted to start the Scientific Management of forests after the transfer of East India company to British Crown in 1858. Accordingly, Dietrich Brandis was first appointed as forest officer for Burma (now known as Myanmar) and subsequently as Inspector General of Forest for India in 1864, when the Indian Forest Department was created.

It was Dietrich Brandis, who started the practice of calculation of sustainable yield from the forests leading to the development of concept of Working Plan. The measurement of tree was started in a systematic manner for calculation of timber yield from forests. The British required timber from Indian forest for British Navy and for sleepers of Indian Railway, which was started at 1853. An accurate calculation of timber yield from forest was required to be done and the detailed exercise of tree measurement and forest mensuration was started.

2. Objective of the study

1) Importance of timber and wood calculation: -
The timber calculation needs to be done for the following reasons: -

a) To determine yield from trees
b) To know growth pattern of trees species wise
c) Calculation of Timber, Small timber and Fuelwood separately and accurately from the desired species.

In the present exercise, certain selected species of Gujarat outside forest have been taken up.

The list of timber yielding species in Gujarat is given in Annexure 1. Out of this, only 7 species have been taken up for this study.

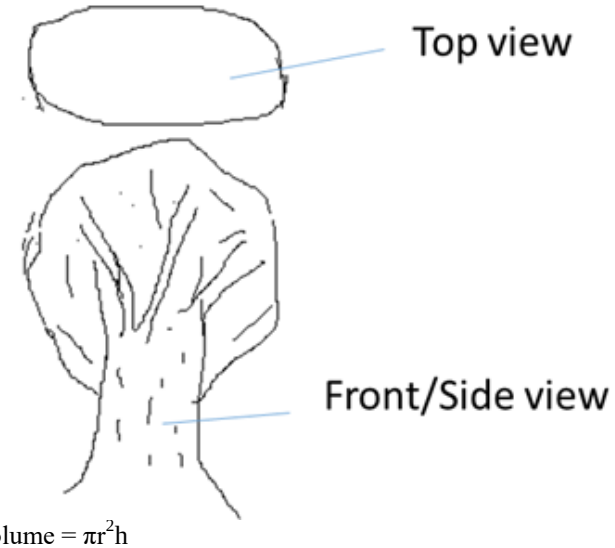
2) The main timber yielding species of Gujarat found outside forests: -
The list of main timber yielding species found in study area is given in Annexure 1. For this study, 7 species which were found in the area of 50 acres' area of TRO at Akshardham, Gandhinagar have been selected.

3. Methodology

Wood Calculation: -
The wood calculation has been done based on the first principle i.e. assuming a clean bole trunk that gets forked at the crown level and crown assumes the shape almost semi-circular at the top.
The discussion pertaining to wood calculation and subsequently the derivation of formulas follows in the subsequent paragraphs.

3.1 Total wood Calculation

A typical front/side view of a tree is given below along with the top view of the tree, which shows the crown portions. The crown portion above the clean bole area of a tree almost assumes a semi-circular shape, when viewed from the side. The volume of timber of a tree is calculated assuming the clean bole portion to have a cylindrical shape and is given by the following formula.



Volume = $\pi r^2 h$

But, Girth (G) = $2\pi r$

$$\therefore \quad r = \frac{G}{2\pi}$$

Where, r is the radius of the cylinder shaped tree and h is height of clean bole.

Substituting in the formula of volume

Volume $= \pi * \frac{G^2}{4\pi^2} * h$

$= \frac{G^2}{4\pi} * h$

The quarter girth formula based on above is given by volume = $\left(\frac{G}{4}\right)^2 h$

3.2 Small timber and fuelwood Calculations.

The following hypothesis is proposed for small timber and fuelwood calculations: -

A tree normally gets forked into two to three portions each having a branch of even girth.

Thus girth of the forked portion is G/2 and G/3 for trees that gets forked into two and three portions respectively.

Where, G is girth of the main trunk of the tree. In a tree, the number of total branches would be number of main branches plus number of small branches. The number of small branches would be very many in number but would aggregate to equivalent to yet another two branches in case of tree that fork into two.
Thus,

Number of branches= No. of main branches + No. of small branches
= 2 + Aggregating to equivalent three branch
= 4

But we have already stated that girth of one branch.
G' = Girth of tree /2
G' = G/2

Therefore, the volume of the total number of branches that is main and small branches would be given by following formula.
Volume = Branches * Volume of each branch

$= 4 * \frac{\pi}{4}\left(\frac{G}{2\pi}\right)^2 * Avarage\ length\ of\ branch$

$= 4 * \frac{\pi G^2}{4*4\pi^2} * Avarage\ length\ of\ branch$

$= 4 * \frac{\pi G^2}{16\pi^2} * Avarage\ length\ of\ each\ branch\ (L_b)$

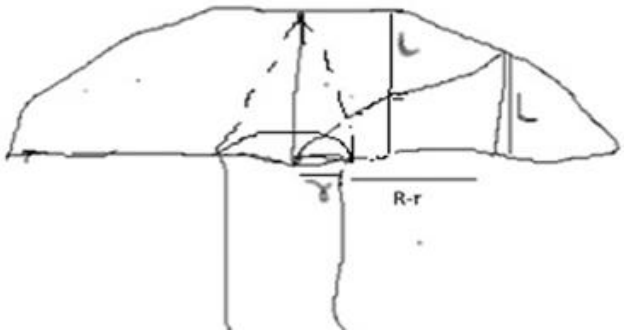
$= \frac{G^2}{4\pi} * L_b$

The total volume of fuelwood would, therefore, become: -

$$\mathbf{V_{FW} = \frac{g^2}{4\pi} * L_b}$$

Where, V_{FW} implies volume of fuelwood of average length of branch

The fuelwood is mostly found in crown portions. Where the length of such fuelwood portion varies.



The length of branch would vary form (R-r) at extreme of crown spread to L at the top of the crown. The average length of branch - L_B in our case can be taken as

$$L_B = \frac{(R-r)+L}{2}$$

∴ The average volume of fuelwood would be given by

$$\textbf{Volume of Fuelwood} = \frac{G^2}{4\pi}\left(\sqrt{(R-r)^2 + L^2}\right)$$

3.3 Small Timber

The Small Timber calculation assumes that the area above clean bole portions of the tree tapers up to the top of the crown. Thus, the volume of small timber

$ST = \frac{1}{2} * \pi r^2 * Length\ of\ the\ crown$

Which can be seen from the shape of the tree above bole.

Thus,

Volume of Small timber $= \frac{1}{2} * \frac{G^2}{4\pi} * Length$

$= \frac{G^2}{8\pi} L$

4. Measurements and Calculations

The measurements were carried out for 7 species and 35 trees which have been tabulated in Annexure 2, Based on the above discussion, the following formulae have used for the calculations.

S. No.	Formulas
1	Crown length = L ($h_t - h_c$)
2	Average radius of tree r (in m) = $\frac{G}{2\pi}$
3	Timber volume (A) = $\frac{G^2}{4\pi} * h_c$
4	Small timber volume (B) = $\frac{G^2}{8\pi} * L$
5	Fuelwood (C) = $\frac{G^2}{4\pi}\left[\frac{(R-r)+L}{2}\right]$
6	Total wood = A + B + C
7	Timber (%) = $\frac{Timber\ volume}{Total\ wood} * 100$
8	Small timber (%) = $\frac{Small\ timber\ volume}{Total\ wood} * 100$
9	Fuelwood (%) = $\frac{Fuelwood}{Total\ wood} * 100$

Tabulation of Results

The tabulation of results based on above formulas has been done in Annexure 1.

Inferences: -

The timber, small timber and fuelwood calculation which is tabulated in the previous paragraph can be summed up as follows.

Sr. No.	Species	Timber (%)	Average Timber (%)	Small timber (%)	Average Small timber (%)	Fuelwood (%)	Average Fuelwood (%)
1	Arjun	55-64	59.5	12-16	14.0	23-27	25.0
2	Baheda	48-77	62.5	8-20	14.0	14-31	22.5
3	Baval	34-52	43.0	16-26	21.0	28-41	34.5
4	Boswelia	52-56	54.0	17-21	19.0	25-28	26.5
5	Kadam	55-73	64.0	7-14	10.5	18-32	25.0
6	Khijadi	55-75	65.0	6-13	9.5	18-30	24.0
7	Neem	36-60	43.0	13-22	17.5	24-41	32.5

From the above it is clear that of the total wood, the timber percent varies from 34% in case of Baval to 77% in case of Baheda. However, the average timber percent varies from 43 to 65 %. Similarly, small timber percent varies from 6 to 26 % whereas average timber percent varies from 9.5 to 21 %. The fuelwood percent varies from 14 to 41 % while average fuelwood percent varies from 22.5 to 34.5%.

From the above its can be concluded that the average timber yield of a tree varies from 43 to 65 %; small timber from 9.5 to 21 %; and fuelwood from 22.5 to 34.5%.

Thus, it can be said that a tree is likely to yield a minimum of 50% timber with most likely value of 60%. The small timber percent is likely to be around 10 % with most likely value been 15%. Lastly the fuelwood percent at the minimum would be 20 % with mostly likely value would be 25 %.

5. Conclusion

A fully grown tree is likely to yield 50-60% of its wood in the form of timber and another 10 to 15% in small timber form. The fuelwood yield is likely to vary from 20 to 30%. In a clean boled tree with less forking, the timber yield would go up to 65% and small timber up to 15%.

References

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Annexure 1

List of timber yielding species

Sr. No.	Common Name	Botanical Name	Number of Forking Observed at bole height
1	Amla	Emblicaofficinalis	–
2	Arduso	Ailanthus excelsa	–
3	Arjun	Terminalia arjuna	2
4	Baheda	Terminalia bellirica	Almost single
5	Baval	Acacia nilotica	2
6	Boswelia	Boswelliaserrata	Almost single
7	Kadam	Anthocephaluscadamba	Almost single
8	Khijadi	Prosopis cineraria	2
9	Neem	Azadirachtaindica	2
10	Saptaparni	Alstoniascholaris	–
11	Gandobaval	Prosopisjuliflora	–
12	Subaval	Leucaenaleucocephala	–
13	Gorasambli	Pithecellobiumduice	–
14	Bordi	Zizyphusmauritiana	–
15	Sharu	Casuarina equisetifolia	–
16	Jambu	Syzygiumcumini	–
17	Gunda	Cordiadichotoma	–
18	Simalo	Bombexceiba	–
19	Gulmahor	Delonixregia	–
20	Sevan	Gmelinaarborea	–
21	Sisoo	Dalbergiasisoo	–
22	Kilai	Albiziaprocera	–

Annexure 2

Species wise volume calculation:

S. No.	Species	Girth of tree G (in m)	Total Height of tree h_T (in m)	Clean boled height of tree h_C (in m)	Crown length t (L)=ht-hc	Average Radius of tree r (in m)	Crown spread R (in m)	Timber Volume (A)	Small Timber Volume (B)	Fuel wood (C)	Total Wood =A+B+C	Timber (%)	Small Timber (%)	Fuel wood (%)
1	Arjun	0.28	6	4	2	0.045	1.8	0.025	0.006	0.012	0.043	58.159	14.540	27.301
		0.65	8	5	3	0.104	2	0.168	0.050	0.082	0.301	55.877	16.763	27.360
		0.82	10	7	3	0.131	2.5	0.375	0.080	0.144	0.599	62.585	13.411	24.003
		0.98	12	8	4	0.156	2.5	0.612	0.153	0.243	1.007	60.735	15.184	24.081
		1	11	8	3	0.159	3	0.637	0.119	0.233	0.989	64.410	12.077	23.513
2	Baheda	0.62	11	7	4	0.099	2.3	0.214	0.061	0.095	0.370	57.848	16.528	25.624
		0.85	12	8	4	0.135	2	0.460	0.115	0.169	0.744	61.861	15.465	22.674
		0.9	11	9	2	0.143	1.5	0.580	0.064	0.108	0.753	77.066	8.563	14.371
		1	11	6	5	0.159	3	0.478	0.199	0.312	0.989	48.308	20.128	31.564
		1.2	14	9	5	0.191	3	1.032	0.287	0.448	1.766	58.425	16.229	25.346
3	Baval	0.43	7	4	3	0.069	1.5	0.059	0.022	0.033	0.114	51.842	19.441	28.717
		0.55	8	4	4	0.088	2.5	0.096	0.048	0.077	0.222	43.449	21.724	34.827
		0.65	10	4	6	0.104	3	0.135	0.101	0.150	0.385	34.940	26.205	38.855
		0.65	12	7	5	0.104	3	0.235	0.084	0.133	0.452	52.051	18.590	29.359
		1.35	9	5	4	0.215	6	0.726	0.290	0.710	1.726	42.043	16.817	41.139
4	Boswelia	0.6	9	5	4	0.096	1	0.143	0.057	0.070	0.271	52.897	21.159	25.944
		0.65	9	5	4	0.104	1	0.168	0.067	0.082	0.318	52.920	21.168	25.912
		0.72	12	7	5	0.115	2	0.289	0.103	0.142	0.534	54.085	19.316	26.600
		0.82	10	6	4	0.131	1.5	0.321	0.107	0.144	0.572	56.155	18.718	25.127
		0.85	10	6	4	0.135	2.5	0.345	0.115	0.183	0.643	53.656	17.885	28.458
5	Kadam	1.05	14	10	4	0.167	4	0.878	0.176	0.344	1.397	62.828	12.566	24.606
		1.15	12	10	2	0.183	3.3	1.053	0.105	0.269	1.428	73.755	7.375	18.870
		1.2	10	7	3	0.191	5.2	0.803	0.172	0.459	1.434	55.980	11.996	32.024
		1.3	12	9	3	0.207	5.4	1.211	0.202	0.551	1.964	61.659	10.276	28.065
		1.4	15	10	5	0.223	5.3	1.561	0.390	0.786	2.737	57.017	14.254	28.728
6	Khijadi	0.52	6	4	2	0.083	2.5	0.086	0.022	0.048	0.155	55.489	13.872	30.638
		0.62	7	5	2	0.099	2.1	0.153	0.031	0.061	0.245	62.495	12.499	25.006
		0.75	7	5.5	1.5	0.119	2.2	0.246	0.034	0.080	0.360	68.405	9.328	22.267
		0.8	7	6	1	0.127	2	0.306	0.025	0.073	0.404	75.602	6.300	18.098
		0.83	8	6.5	1.5	0.132	2.5	0.357	0.041	0.106	0.504	70.776	8.166	21.058
7	Neem	1.05	12	8	4	0.167	2.5	0.702	0.176	0.278	1.156	60.761	15.190	24.049
		1.07	10	6	4	0.170	2.9	0.547	0.182	0.307	1.036	52.795	17.598	29.607
		1.1	9	5	4	0.175	2.6	0.482	0.193	0.309	0.984	48.960	19.584	31.456
		1.1	12	8	4	0.175	5	0.771	0.193	0.425	1.388	55.508	13.877	30.615
		1.8	11	5	6	0.287	5.5	1.290	0.774	1.446	3.510	36.747	22.048	41.205

Declaration

"I declare that the manuscript has not been published in any journal/ book or proceedings or in any other publication, or offered for publication elsewhere in substantially the same or abbreviated form, either in print or electronically.