A STUDY ON VOLUME ESTIMATION FOR INDIAN TEAK

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Introduction

Teak (*Tectona grandis*) is one of the most important species of the world. It is grown practically in all the tropical countries. Natural distribution of this species is in South and South-East Asian countries. It has been raised by plantation in vast areas in these countries and other tropical or sub-tropical countries like East and West African countries, Caribbean and South and Central American countries.

In India, which is one of the major teak producing countries, its natural zone of distribution is discontinuous and is mostly confined to the peninsular region below 24 degree latitude. The localities where most important teak forests are found are Madhya Pradesh, Maharashtra, Tamil Nadu, Karnataka and Kerala besides Uttar Pradesh, Gujarat, Orissa and Rajasthan (Troup, 1921). It has also been raised, mainly by plantation, in Assam, Dadra and Nagar Haveli, Meghalaya, West Bengal, Uttar Pradesh and Haryana.

Study Coverage

The source of data are the forest inventory surveys carried out by Forest Survey of India at various points of time covering the areas of Andhra Pradesh, Assam, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Meghalaya, Rajasthan, Uttar Pradesh, West Bengal and Dadra and Nagar Haveli.

Scope of Study

Keeping in view the utility and commercial importance of the species, scattered information on volume equations in different Forest Inventory Reports of the Forest Survey of India (FSI) and its predecessor Organisation, Pre-Investment Survey of Forest Resources (PISFR) have been collected and compiled. For estimation of growing stock, General and Local Volume Equation for each major pre-dominant and rest of species for each inventory surveys are derived. For Teak, the types of Multiple Regression Equations which have been found best fit for deriving the Local Volume Equations from the General Volume Equations along with survey areas are as follows :

(1) $V = a + bD^2$ (Andhra Pradesh, Karnataka, Madhya Pradesh and Meghalaya)

(2) $V = a + bD + cD^2$ (Andhra Pradesh, Madhya Pradesh, Maharashtra, Rajasthan and West Bengal)

(3) $V = a + bD + cD^2 + dD^3$ (Assam, Madhya Pradesh and Uttar Pradesh)

(4) $V = a + b\sqrt{D + cD^2}$ (Madhya Pradesh and Uttar Pradesh)

(5) $\sqrt{V} = a + bD + c\sqrt{D}$ (Dadra and Nagar Haveli, Gujarat, Madhya Pradesh and Maharashtra)

(6) $\sqrt{V} = a \quad bD$ (Maharashtra)

Where D = Diameter (over bark) in metre
V = Volume (under bark) in m^3
a, b, c, d are statistical constants

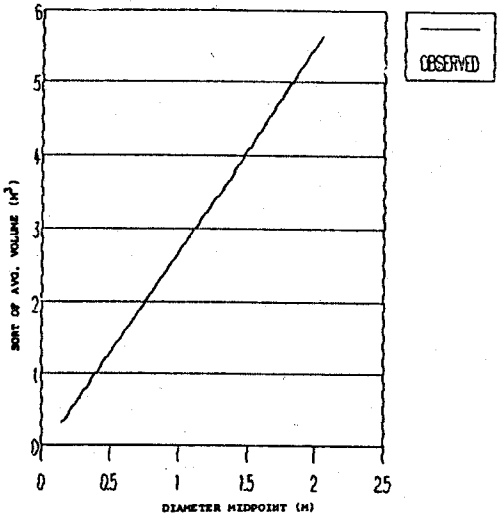
The local volume equations compiled for Teak from various Forest Inventory Surveys vary from area to area. An attempt has been made in this study as a test case to combine these local volume equations into one single volume equation.

In the present study local volume equations, which have been derived from large number of observations (varying from 30 to 2000), have been used to calculate volume factors for different diameter classes by substituting the values of D (diameter mid point) in each of the local volume equations. Average volume corresponding to each diameter mid point has been estimated from the volume table. A statistical relationship of these average volumes (dependent variable) corresponding to the mid point of each diameter class (independent variable) has been established.

Presentation and Analysis of Data

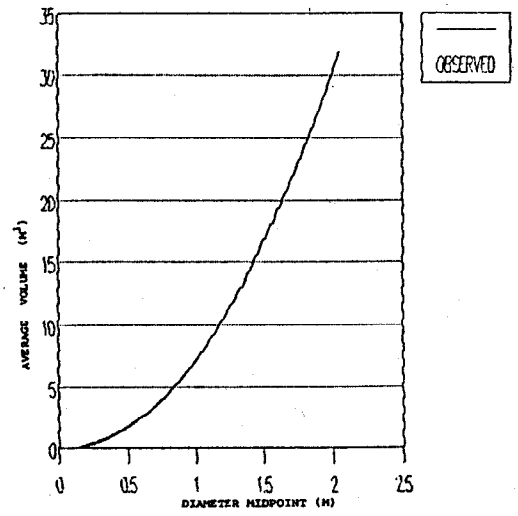
For the present study, 20 local volume equations on Teak from different inventory reports have been collected and compiled. Volume factors for diameter classes (in cm) 10-20, 20-30, 30-40, 40-50, 50-60, 60-70, 70-80, 80-90, 90-100, 100-110, 110-120, 120-130 have been calculated for each of the local volume equations by taking the mid point of the diameter class i.e. 15, 25, 35, 45, 55, 65, 75, 85, 95, 105, 115, 125 (in cm). These volume factors are presented in Table 1. Average volume corresponding to the same diameter mid point has also been estimated and is presented in the last row

Fig. 1



Scatter diagram between Square-root of Average Volume and Diameter Mid-point.

Fig. 2



Scatter diagram between Average Volume and Diameter Mid-point.

Table 1

Volume table for Indian Teak based on the local volume equations derived from FSI Inventory Reports

Name of State UT/ District Forest Division/ Forest Circle	Diameter Class (cm) 10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	100-110	110-120	120-130
	Diameter Mid-Point (m) 0.15	0.25	0.35	0.45	0.55	0.65	0.75	0.85	0.95	1.05	1.15	1.25
1	2	3	4	5	6	7	8	9	10	11	12	13
Andhra Pradesh												
1. Mehboobnagar Forest Division	0.041	0.267	0.605	1.056	1.62	2.297	3.087	3.99	5.005	6.133	7.374	8.728
2. Adilabad District	0.095	0.312	0.662	1.148	1.768	2.522	3.412	4.435	5.594	6.887	8.315	9.877
Assam												
3. Assam Survey (15 Districts) Dadra and Nagar Haveli; Gujarat; Madhya Pradesh and Maharashtra	0.101	0.472	1.176	2.204	3.546	5.191	7.13	9.352	11.848	14.608	17.621	20.879
4. Dadra and Nagar Haveli Survey; Surat circle of Gujarat; Khargone, Khandwa, Dewas, Jhabua, Indore and Dhar Districts of Madhya Pradesh and Mewasi Forest Divn., Dhulia, Nasik, Thane and Raigad Districts of Maharashtra	0.075	0.34	0.76	1.318	2.006	2.816	3.746	4.791	5.959	7.217	8.595	10.081
Karnataka												
5. Chickmgalur, Hassan and Shimoga Districts	0.213	0.439	0.777	1.228	1.792	2.469	3.259	4.162	5.177	6.305	7.546	8.9
Madhya Pradesh												
6. Balaghat, Seoni and Mandla Distts.	0.139	0.461	0.965	1.647	2.508	3.546	4.761	6.154	7.723	9.468	11.39	13.488

(Contd...)

1	2	3	4	5	6	7	8	9	10	11	12	13
7. Rajnandgaon and Durg Distt.	0.098	0.358	0.81	1.467	2.341	3.443	4.784	6.378	8.235	10.367	12.786	15.504
8. Bilaspur District	0.105	0.32	0.644	1.076	1.615	2.262	3.017	3.881	4.851	5.93	7.117	8.412
9. Indore Catchment Mandsour, Ratlam, Ujjain, Shahjapur and Raigarh Distt.	0.72	0.243	0.547	0.984	1.552	2.253	3.086	4.051	5.149	6.379	7.741	9.235
10. Raipur District	0.104	0.427	0.967	1.678	2.516	3.434	4.387	5.33	6.217	7.003	7.643	8.091
Maharastra												
11. Ballarshah Catchment-Chanda Priority-I	0.092	0.356	0.822	1.49	2.361	3.435	4.71	6.188	7.869	9.751	11.836	14.123
12. Sondad Catchment Bhandara Distt.	0.083	0.3	0.644	1.115	1.714	2.44	3.294	4.275	5.383	6.619	7.982	9.473
13. Wadsa Catchment-Chanda Priority - II	0.077	0.285	0.624	1.095	1.697	2.43	3.295	4.29	5.418	6.676	8.066	9.587
14. Melghat Forest Divn.	0.106	0.403	0.898	1.591	2.483	3.573	4.861	6.347	8.031	9.914	11.995	14.274
Meghalaya												
15. Whole Meghalaya Survey	0.131	0.524	1.114	1.89	2.883	4.062	5.438	7.011	8.78	10.745	12.907	15.266
Rajasthan												
16. Udaipur Forest Division	0.072	0.243	0.547	0.984	1.552	2.253	3.086	4.051	5.149	6.379	7.741	9.235
17. Southern and Eastern parts	0.061	0.158	0.294	0.469	0.683	0.936	1.228	1.56	1.93	2.34	2.789	3.276
Uttar Pradesh												
18. Hill and Tarai Region	0.144	0.501	1.127	2.035	3.235	4.74	6.562	8.712	11.203	14.046	17.252	20.835
19. Southern Region	0.115	0.322	0.59	0.923	1.324	1.795	2.335	2.946	3.628	4.38	5.204	6.1
West Bengal												
20. Darjeeling and Kalimpong Division	0.062	0.277	0.631	1.126	1.76	2.535	3.449	4.504	5.698	7.033	8.508	10.122
Average Volume	0.993	0.3504	0.7602	1.3267	2.0478	2.9216	3.9464	5.1204	6.4424	7.909	9.5204	11.274

Table 2

Comparison of Observed and Expected Values

Diameter Class (cm)	Mid Dia Class (m)	Calculated Average (m^3)	Expected Volume (Equation 1) (m^3)	Expected Volume (Equation 2) (m^3)	Percentage Differences from calculated values	
					Equation 1	Equation 2
10-20	0.15	0.0993	0.0924	0.1791	7	-80
20-30	0.25	0.3504	0.3411	0.3902	3	-11
30-40	0.35	0.7602	0.7468	0.7629	2	0
40-50	0.45	1.3267	1.3094	1.2974	1	2
50-60	0.55	2.0478	2.029	1.9936	1	3
60-70	0.65	2.9216	2.9055	2.8515	1	2
70-80	0.75	3.9464	3.9389	3.8712	0	2
80-90	0.85	5.1204	5.1293	5.0525	0	1
90-100	0.95	6.4424	6.4767	6.3955	-1	1
100-110	1.05	7.909	7.981	7.9003	-1	0
110-120	1.15	9.5204	9.6422	9.5667	-1	0
120-130	1.25	11.2743	11.4604	11.3949	-2	-1
130-140	1.35	13.169	13.4356	13.3848	-2	-2
140-150	1.45	15.5696	15.5676	15.5364	0	0
150-160	1.55	17.8765	17.8567	17.8497	0	0
160-170	1.65	20.3459	20.3026	20.3247	0	0
170-180	1.75	22.9786	22.9056	22.9614	0	0
180-190	1.85	25.7753	25.6654	25.7598	0	0
190-200	1.95	28.737	28.5822	28.72	1	0
200-210	2.05	31.8639	31.656	31.8418	1	0

of this table. The scattered diagrams between Square root of the Average volume and corresponding diameter mid point has been presented in Fig. 1 and between diameter mid point and average volume is presented in Fig. 2. For this purpose observations upto diameter class 200-210 (in cm) have been considered. It may be seen from Fig. 1 that there exists a linear relationship between square root of average volume and diameter mid point. Fig 2 shows that a parabolic relationship exists between average volume and diameter mid point.

In view of the above facts an attempt has been made in this study to fit the following two regression equations :

(1) $\sqrt{V} = a + bD$

(2) $V = a + bD + cD^2$

Where a, b and c are constants

V = Volume in m^3 (under bark)

D = mid point of diameter class in m

Using the method of Least Squares the regression equations have been derived and the two equations come out to be

(1) $\sqrt{V} = -0.1163 + 2.8013D$

(2) $V = 0.1657 - 1.1235\ D + 8.0855\ D^2$

A comparison of the calculated average volume and the expected average volume obtained from both the equations is presented in Table 2. It is seen from this Table that the difference between the calculated and expected values is below 1% for most of the entries in case of equation (1) and may be considered as negligible. In case of equation (2) the percentage difference is more in lower diameter classes (i.e. 10-20 and 20-30 cm) and as diameter increases the difference becomes 0.

The determination coefficient (R^2) of regression equation (1) comes out to be 0.99993 which justifies the linearity of the relationship. Also the standard error of the estimate works out to be 0.0056.

There may be cases that fit can be bad with a high value of R and it can also happen that the fit is good and R is low. Numerous measures other than R can be considered (Anon., 1980). The most used are the residual standard deviation, residual coefficient of variation, aggregate deviation and average deviation.

For both the fitted equations the above measures were calculated and are presented below :

	Equation 1	Equation 2
(1) Residual Standard Deviation	1.0932	0.7305
(2) Residual Coefficient of Variation	0.0959	0.0641
(3) Aggregate Deviation	0.000045	0.000001
(4) Average Deviation	0.006085	0.00443

The above analysis reveals that equation (2) is the best fit.

Conclusion

It has been found that different types of local volume equations for teak exist for different forest areas but as per the findings of the present study for the country as a whole, the volume of teak may be estimated by using equation (2). However, for lower diameter classes (up to 30 cm) equation (1) can also be used.

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SUMMARY

The Forest Survey of India has been carrying out inventory surveys for estimating the growing stock of various species and has developed a number of local volume equations based on ground inventory. An effort has been made to establish statistical relationship between average volume and diameter mid-point for country as a whole. Two relationships have been established by using Method of Least Squares. One is linear and the other is parabolic relationship. Volume of teak can be estimated by using parabolic relationship. However, for lower diameter classes (upto 30 cm) linear relationship can also be used to calculate the volume.

भारतीय सागौन के आयतन का अनुमान करने विषयक अध्ययन

एस० के० चक्रवर्ती व के० एस० गहरवार

सारांश

भारत का वन सर्वेक्षण विभाग विभिन्न जातियों के वनसछ वनों का अनुमान लगाने के वानिकी सर्वेक्षण कार्यों में लगा हुआ है और भूमि की वृक्ष तालिकाओं के आधार पर उसने अनेक स्थानीय आयतन समीकरण विकसित किए हैं । पूरे देश के लिए भी औसत आयतन और मध्य बिन्दु व्यास के दरम्यान सांख्यकीय सम्बन्ध स्थापित करने का प्रयास किया गया है । अल्पतम वर्ग विधि अपनाकर दो सम्बन्ध स्थापित किए गए हैं । एक रेखीय सम्बन्ध और दूसरा परावलयी सम्बन्ध । परावलयी सम्बन्ध उपयोग में लाकर सागौन के आयतन का अनुमान लगाया जा सकता है । तथापि, छोटे व्यास (30 से० मी० तक के) श्रेणियों के लिए आयतन की गणना करने के लिए रेखीय सम्बन्ध भी उपयोग में लाया जा सकता है।

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