Volume Tables of

Shorea robusta, Terminalia alata and *Anogeissus latifolius*

for Western Terai of Nepal

Government of Nepal
Ministry of Forests and Soil Conservation
Department of Forest Research and Survey,
Babarmahal, Kathmandu,Nepal

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Foreword

The concept of volume table was evolved in early 19th century in Europe, though the first volume table was prepared in many years later. Globally, volume table keep a significant role for volume calculation of standing trees and stands as well. With the starting of first national level forest inventory, Nepal also started to prepare volume table for some Nepalese tree species, which was republished in updated form in next national level inventories. That was most widely used mainly in academic purpose and national level inventories. However, with the increasing value of forest resources, only these general volume tables cannot fulfill the practical requirement to estimate volume of standing trees. To solve the problem, the MFSC feel the authentic local volume table for particular area. The DFRS started to prepare local volume table based on direct field data. Hence, this is the first step of materialize to solve the problem.

This report presents the volume of three most important tree species of western Terai i.e, *Shoreae robusta*, *Terminalia alata* and *Anogecious latifolia* in equation and tabular form DBH as only independent variable. This report reveals the total volume of trees, volume up to 10 cm top and 20 cm top diameter within and without bark. This comprehensive report not only provides the volume in MKS system, but also provides the timber volume in cubic feet by girth in inch for the simplicity in field. We believe that it is going to be valuable tool in the field of scientific forest management and timber governance for forestry technicians, planners, managers and community forestry groups of the area. We heartily welcome the constructive comments and suggestion to improve the model in future.

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Deepak Kumar Kharal Ph.D.
Director General

Acronyms and Abbreviations

bp	bark proportion
cm	centimeter
DBH	diameter at breast height
DFRS	Department of Forest Research and Survey
eg	for example
FAO	Food and Agricultural Organization
ln	natural logarithm
m	meter
max	maximum
med	median
min	minimum
Q	quartile
SE	Standard error of estimate
Sp.	Species
v	volume

Table of contents

Contents

1. Introduction

Nepal is one of the agrarian countries. Most of the population live in rural areas and heavily dependent on natural resources as forests for timber, non-timber products, construction materials, medicinal plants and diverse environmental services such as water, recreation, ecotourism etc for their livelihood. Due to exponential population growth, and to satisfy peoples need, the demand of forest product is increasing day by day, so heavy pressure has been exerted to the forest resources. The situation is more alarming in Terai region. Ultimately, the value of timber and other forest products is increasing. This creates the situation to measure and estimate the forest products, especially the timber, more accurately and efficiently. So, quantification of fuelwood and timber needs to be improved in recent years.Volume and biomass have been the traditional measure of wood quantity and continues to be the most important measure of forest stock or productivity till now. The volume of logs or felled trees can be easily measured. However, the forest stands volume or standing trees volume can only be estimate through the volume table.

Heinrich Cotta was the first forester to introduce the concept of a volume table around 1804. However, in real world the practice of preparing volume table was started from Europe in many years later. This early study was mainly of Norway spruce. Now, several volume and biomass models have been developed for major tree species throughout the world. Even though the volume tables have been studied for many years, they continue to attract forest research till now. The volume models is derived from the measurement of diameter, height, taper of a tree etc and can be presented in different forms e.g equation, tables or diagrams. Volume table is a table showing for a given species the average contents of trees, logs or sawn timber for one or more given dimension (Chaturbedi and Khanna, 1982). The assumption of volume table is the trees of same dimensions of same species have same volume. Volume tables are prepared based on measurements of different variables   from sufficiently large number of trees. Depending on scope of uses, one or many variables of the trees or crops are measured for volume table. Level of accuracy, available resources and uses determine the number of input variables for different types of volume tables. Commonly General Volume table is developed and used for measuring the volume of a tree using two variables i.e. diameter and height. But diameter-height relationship varies considerably between site to site and is not practical to estimate the volume of site specific trees using general volume table. Local volume table is most suitable for direct field application in small geographical area of less site variation. Local volume table is developed using single independent variable. DBH is often used as a single variable because it is highly correlated to the volume of a tree. Moreover, it is easiest measurable variable with higher precision of standing trees. On the other hand, it takes low cost in comparison to the other variables of a tree. The local volume table is specially used for yield regulation (Chaturbedi and Khanna, 1982).

The Department of Forest Research and Survey (DFRS), a government research department has been mandated to provide information and knowledge products for scientific forest management of the country. In addition to other scientific information, it provides the information about trees volume and biomass through models. The DFRS has been started to prepare volume table since the inventory started in 1960s. The general volume table of 21 tree species and 2 species groups had been reconstructed in 1990 by the data collected in 1960s (Sharma and Pukkala, 1990). Some studied for Sal had been made in 1990s for general volume and growth models especially in central Bhavar of Nepal (Laamanen *et al* 1995). In addition to this, DFRS has developed biomass and volume models of some tree and bamboo species and some forest types. However, it previously focused on the preparation of general volume tables rather the site specific local volume tables (DFRS & DFOs: Parbat, Baglung and Myagdi, 2006). On the other hand, some local volume models developed was focused on smaller size diameter (Acharya and Acharya, 2004; Achrya *et al.*, 2003; Tamrakar P.R., 2000; Pukkala *et al, nd.*). Several volume and biomass models have been developed for major tree species in Europe, America, Asia and even in India. However, only a few studies have examined the Nepalese species.

Shorea robusta Gaertn (Sal), only one species found in Nepal of tropical family Dipterocarpaceae, is the multipurpose tree species and *Terminalia alata* Heynex ex Roth (Asna) is main associated of *S. robusta* with rarely pure stand. *Anogeissus latifolia* (Roxb.ex DC) Bedd. is also common constituent of *S. robusta* for dry areas where it appears dominant in more drier areas (Jackson,1994). Sal is the most valuable and important timber for construction, preferred species as fuel wood whereas Asna is the second choice, Sal seed used as industrial raw material, leaf used as plate making and fodder for livestock. Sal is still most predominant species in Terai with Asna as main associate (DFRS, 2014). Sal is found up to 1500 m but common up to 1000 m but Asna occurs at rather low altitude. *A. latifolia* found Terai to Siwaliks up to around 1700 m particularly in western Nepal (Jackson,1994). Sal occurs mostly in Terai, Siwalik and low land of Hilly areas. In most areas, pure Sal forest can be found or in many places in association with *T. alata* or in some places mixed with other broadleaved species. *S. robusta* tends to dominate except on low badly drained soils where *T. alata* tolerate better. The Terai Sal forest is mostly large and differs than hill Sal forest. In area of higher rainfall and moist, it is replaced by mixed forest. Dobremez (1976) listed nine types of Sal forest, but Champion and Seth lists more than that, most of them are expected to found in Nepal (Jackson, 1994). The forest of western is supposed different than the other part of the country. Hence, preparation of local volume tables for the western Terai is necessary.

In Nepal, sustainable forest management practices have started recently from Kapilvastu and Rupandehi districts of western Terai. Accurate estimation of tree volume and biomass is essential for efficient forest management because it facilitates the estimation of forest stand productivity, carbon stocks and the flows of energy and nutrients as well as the assessment of the forest's structure and condition. However, the preparation of local volume tables of common tree species based on direct field measurement of sample trees in localized areas are not common practices in Nepal. Similarly, the local volume tables of Kapilvastu and Rupandehi districts are not available yet now. Hence their availability would be of great value for the scientific forest management which is just started. The development of volume tables is good initiation not only to support the forest management in the study area but also to guide the future development of local volume table for other areas.

In forest management, different volume models are necessary for the same tree to get different information. As stem provides the timber of different sizes in the same tree, many models provide the volume of stems up to the desired length or diameter. To calculate total growth material of a tree stems, needs volume table for whole tree which is beneficial to know the total biomass or carbon stocks of tree. In timber management, volume of stem from ground level to different top diameter is necessary for different purpose. According to forest law timber is taken up to 20cm over bark diameter whereas the timber portion between 20 cm to 10 cm top over bark diameter is taken small timber. Thus, to manage forest properly the estimation of small wood also necessary. Furthermore, in practice the trading of timber log is done without bark. So the amount of timber without bark is also necessary. Hence, the volume table prepared by this study tries to address these issues for the western Terai. The tables prepared provide the volume of all three species in six different form: i) the total over bark volume of stem up to the tip, ii) the total under bark volume of stem up to the tip iii) the over bark volume of stem up to 10 cm over bark diameter iv) the under-bark volume up to 10 cm over bark diameter of stem v) the over bark volume of stem up to 20 cm diameter and vi) under bark volume up to 20 cm over bark diameter.

2. Materials and Methods

Study Area and Species Selection

With consultation of Department of Forests (DoF), the western Terai of Nawalparasi, Rupandehi and Kapilvastu districts were selected for the study. Later sample collection in Nawalparasi was not done due to lack of felling permission. The sample for this study was taken from the plain area of nine different forest stands of community and collaborative forest in Kapilvastu and Rupandehi districts. The study area is flat and fertile with deep loamy soil. The climate is topical to sub-tropical and sub-humid with regular monsoon between June and August (Jackson, 1994). Mean total annual precipitation is around 2452 mm of which more than 80% falls from June to September. Monthly mean minimum and maximum temperature are 17.8°C and 31.4°C respectively with an absolute minimum of 4.3°C (Jackson 1994).

The species selection for the study was done by preliminary field visit and consultation with Department of Forests and District Forests Offices staffs of Kapilvastu and Rupandehi. The most important tree species Sal (*S. robusta*), Asna (*T. tomentosa*), and Banjhi (*A. latifolias*) were selected.

Data collection

At first, all trees above 5 cm DBH were divided into different groups based on the DBH range. Groups were made of 10 cm diameter classes from 10cm DBH up to the available largest size of trees in the study area. Representative sample from each group were selected randomly among the available felling permission for each species. Most of the sample trees were selected from Sal forest and Terai mixed hardwood (TMH) forest. In sampling, consideration was made to have trees of different quality classes and crown classes. Data were collected mainly from different blocks of Lumbini collaborative forest which represent good site quality and some data were collected from Tilaurakot collaborative forest Kapilvastu which represent the poor site quality compared to Rupandehi. Lower diameter sizes trees were measured from different stands of Kapilvastu and Rupandehi Districts.

After the tree selection, basic characteristics of the site and trees were recorded for each of the sampled trees before felling. After felling, complete length of trees were measured, then 14 subsequent places of trees i.e. 1%, 2.5%, 5%, 7.5%, 10%, 15%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% of total length were marked and over bark diameter was measured at these marked positions. Under bark diameter was measured exactly at the same positions of over bark measurement after debarking (Eerikainen, 2011). In addition to those sections, over bark diameter at 15 cm above ground level was also measured as the volume table gives volume above this section (Applegate, DFRS 2/28). Over bark diameter at 10 cm and 20 cm towards the tip of trees were marked and measured both at over bark and under bark diameter. Some predetermined place of measurement could not be measured either due to damage longitudinally or cross-sectional at the time of felling or exceptional swelling or forking at predetermined point then measurement was done at the nearest normal point. The diameter was measured at 0.1 cm accuracy and tree height was measured at 0.1 m accuracy.

Data processing

Measured data were entered into excel spread sheet and rechecked the height diameter ratio, bark thickness ratio, diameter decreasing ratio etc of tree to verify data quality. In some cases,the position of exactly 10 cm or 20 cm thick diameter was not found along the tree stem, and then interpolation of upper and lower position of measurement was used. Same process was adopted if predetermined place of measurement was debarked or damaged during the felling or missing either under bark or over bark measurement. In most cases, measurement at 1% and/or 2.5% was missing due to damage during felling. In such cases, the length of log was taken from 15 cm to nearest place of measurement. But when three or more subsequent measurements were missing whole data set of that tree was discarded (FAO, 1999). In this way, the distributions of trees selected and used in model development are presented in table 1.

Table 1: Summary diameter and height of Samples trees used in analysis

spp	no of trees	DBH cm						Total height m					
		Min.	1stQu.	Median	Mean	3rdQu.	Max.	Min.	1stQu.	Median	Mean	3rdQu.	Max.
Sal	50	8.20	26.02	45.90	47.25	68.73	88.10	8.00	19.08	27.00	24.98	31.22	34.70
Asna	48	7.10	35.75	49.05	55.07	74.32	108.20	6.00	22.00	24.75	26.16	32.22	39.60
Banjhi	32	7.30	31.20	39.05	40.38	52.20	72.40	8.40	20.20	24.20	23.94	27.75	34.70

Data analysis

Volume of each stem section was calculated using Smalian's formula (FAO, 1999) and summed up the volume for trees up to the desired diameter and tip of the tree with and without bark. The resulting datasets were used to develop models of above mention six forms for each of the three species.

Since there was no volume for greater than 10 or 20 cm top diameter in small sizes trees these were taken as zero and the degree of freedom reduces for the analysis. Following candidate models were tested for total over bark volume using R software (R Core Team, 2017).

$V = a + bD$ 1

$V = a + bD^2$ 2

$V = a + b D + cD^2$ 3

$\ln V = a + b \ln D$ 4

$\ln V = a + b \ln D + \ln D^2$ 5

$\ln V = a + b \ln D^2$ 6

$\ln V = a + b D$ 7

$\ln V = a + b D + c D^2$ 8

$V = a + b \ln D$ 9

$V = a + b \ln D + c \ln D^2$ 10

In all above equations, V is volume, D is tree diameter measured at breast-height (DBH), a, b and c are regression coefficients and ln indicates natural logarithm.

Candidate models were tested using t-test and F-test to examine whether the model and its coefficients were significant or not. If the models were significant, they were evaluated by testing homogeneity and normality of residuals using graphical analysis of residuals. Then, the best fit models were selected based on standard error, Coefficient of Determination (R^2), and residual analysis (FAO, 1999; Eerikainen, 2001; Nicolas and Martin 2012; Mwakalukwa *et al* 2014).

All above models were tested and best fit models were selected for every species to the total over bark and under bark volumes. Then following two models were used to find over bark volume up to top 10 cm and 20 cm diameter (Sharma and Pukkala, 1990).

$\ln(V/v_1) = a + b \ln(DBH)$ 11

$\ln(v_2/V_t) = a + b \ln(DBH)$ 12

Here, V is total tree volume, v_1 is volume of tree beyond 10 cm diameter, v_2 is volume of stem from 10 cm to 20 cm diameter and V_t is volume up to 10 cm diameter.

To find the best fit under-bark volume up to top 10 and 20 cm diameter, following bark proportion equations were used.

$\ln(bp) = a + b \ln(DBH)$ 13

$\ln(bark) = a + b \ln(DBH)$ 14

Where bp is the bark proportion up to 10 cm calculated by over bark volume divided by under bark volume and bark is the bark volume up to 20 cm diameter calculated by subtracting under bark volume from over bark volume.

After selecting the best fit model, correction factor was applied to the equation for back transfer of natural log to get the value of depending variable (Sharma and Pukkala, 1990).

3. Findings

For the total volume, all the parameters of all candidate models were calculated and their parameter (t-test) and whole equation (f-test) were tested and analyzed the residuals graphically. Most of the models were significant except equation 2 and 3. The equation 1, 7, 9 and 10 did not show constant variance of residuals while for some equations there was no normality of residuals and for Banjhi equation 8 was heteroscedastic. The equations 4, 5 and 6 were more similar and all were significant but in equation 5 value of parameter "c" was not obtained due to singularities errors. The R^2 and standard error of all three equations were similar but because of the simplicity the equation 4 was recommended for all three species. In Sal (*S. robusta*), two sample trees decreased the model quality but they were not removed from the data sets because they represent poor site condition of Sal. The detail of parameter and its significance are given in Annex 1 and its residuals analysis in Annex 2. Similar models were used successfully by Hawkins 1987 and Achryaet al 2003. The parameter of suggested models and its statistics is given in Table 2.

Table 2: Parameter, R^2 and standard error of the model suggested

Spp.	Model	Uses of Model	a	b	R^2	SE
Sal	$\ln(V) = a + b \ln(d)$	Total volume over bark	-8.76575	2.45236	0.98690	0.18730
	$\ln(V) = a + b \ln(d)$	Total volume under bark	-9.70690	2.63662	0.98510	0.21440
	$\ln(v_1/V) = a + b \ln(d)$	Tree top volume proportion	6.08418	-2.81770	0.84500	0.79710
	$\ln(bp) = a + b \ln(d)$	Bark porportion up to 10 cm	0.93432	-0.18149	0.86710	0.04694
	$\ln(v_2/v_t) = a + b \ln(d)$	Small timber volume proportion	10.60768	-3.55340	0.88150	0.54310
	$\ln(bark) = a + b \ln(d)$	Bark volume up to 20 cm	-10.29170	2.38330	0.92520	0.28320

Asna	$\ln(V) = a + b \ln(d)$	Total volume over bark	-8.95204	2.45702	0.97800	0.22070
	$\ln(V) = a + b \ln(d)$	Total volume under bark	-9.80812	2.61605	0.97790	0.23730
	$\ln(v_1/V) = a + b \ln(d)$	Tree top volume proportion	6.01197	-2.73790	0.87290	0.55510
	$\ln(bp) = a + b \ln(d)$	Bark porportion up to 10 cm	0.83120	-0.15145	0.80370	0.04005
	$\ln(v_2/v_t) = a + b \ln(d)$	Small timber volume proportion	9.59181	-3.20470	0.92620	0.40770
	$\ln(bark) = a + b \ln(d)$	Bark volume up to 20 cm	-10.08628	2.29250	0.91750	0.31310
Banjhi	$\ln(V) = a + b \ln(d)$	Total volume over bark	-8.72226	2.42680	0.97290	0.19270
	$\ln(V) = a + b \ln(d)$	Total volume under bark	-9.14753	2.51526	0.97020	0.21270
	$\ln(v_1/V) = a + b \ln(d)$	Tree top volume proportion	6.10949	-2.82890	0.78070	0.56620
	$\ln(bp) = a + b \ln(d)$	Bark porportion up to 10 cm	0.43662	-0.09306	0.30430	0.05189
	$\ln(v_2/v_t) = a + b \ln(d)$	Small timber volume proportion	10.05114	-3.33510	0.81660	0.44280
	$\ln(bark) = a + b \ln(d)$	Bark volume up to 20 cm	-0.54351	0.17230	0.69830	0.03184

For under bark volume prediction,same equation was also chosen as over bark volume prediction. Direct under bark volume equation gave the high degree of determination and low standard error than indirect method (*i.e.* by predicting bark proportion modeled at first and subtracting bark proportion from over bark volume and then developed under bark volume). Hence the model giving direct under bark volume was chosen however, the directly measured under bark volume model was not prepared yet.

The model for volume beyond 10 cm top and 10 to 20 cm top stem was predicted by equation 11 and 12. The coefficients of determination of these equations were better than Sharma and Pukkala 1990. The under-bark volume up to different diameter limit is not additive as in different component of biomass (Hawkins, 1987). The best goodness of fit equation for top 10 to 20 cm overbark diameter was direct under bark volume modeled as in under bark volume of large timber (equation 14), however, to synchronize the under-bark volume up to 10 cm diameter, bark proportion model was used, since it had also seen satisfactory and similar model was used by Sharma and Pukkala 1990 and Laamanen 1995. The overall goodness of fit (R^2) value was higher than the model suggested by Sharma and Pukkala1990 but the standard error is slightly greater (Table 2). Data showed poorer site's respondent variable had lower values. The model could be improved better by removing extreme values in the data as outlier but it was not done because the model could represent poorer site condition.

The volume of given diameters' tree was derived from the suggested equations and presented in tabular form. The detailed volume table of Sal, Asna and Banjhi are given in Annexes 3, 4 and 5 respectively. In this table, volume was presented in MKS system in all above 6 forms. Moreover, under bark timber volume of all three species was converted to FPS system from above mentioned metric system and given in the following table 3 to 5; where, the gross volume of timber was also converted to quarter girth volume according to quality of trees based on forest regulation 2051.

Table 3: Under bark timber volume of Sal up to top 20 cm over bark diameter

Girth (")	Gross volume (CFT)	Quarter girth volume for quality I(CFT)	Quarter girth volume for quality II(CFT)	Girth (")	Gross volume (CFT)	Quarter girth volume for quality I(CFT)	Quarter girth volume for quality II(CFT)	Girth (")	Gross volume (CFT)	Quarter girth volume for quality I(CFT)	Quarter girth volume for quality II(CFT)
27	1.02	0.80	0.62	46	27.75	21.77	16.67	65	72.82	57.13	43.75
28	2.07	1.63	1.25	47	29.62	23.24	17.80	66	75.80	59.46	45.54
29	3.16	2.48	1.90	48	31.54	24.74	18.95	67	78.83	61.84	47.36
30	4.28	3.35	2.57	49	33.51	26.29	20.13	68	81.94	64.28	49.23
31	5.43	4.26	3.26	50	35.54	27.88	21.35	69	85.10	66.76	51.13
32	6.62	5.20	3.98	51	37.62	29.51	22.60	70	88.34	69.30	53.07
33	7.85	6.16	4.72	52	39.75	31.19	23.88	71	91.64	71.89	55.06
34	9.12	7.15	5.48	53	41.94	32.90	25.20	72	95.00	74.53	57.08
35	10.43	8.18	6.26	54	44.19	34.67	26.55	73	98.44	77.22	59.14
36	11.78	9.24	7.08	55	46.49	36.48	27.93	74	101.94	79.97	61.24
37	13.17	10.33	7.91	56	48.86	38.33	29.35	75	105.51	82.77	63.39
38	14.60	11.46	8.77	57	51.28	40.23	30.81	76	109.15	85.62	65.57
39	16.08	12.62	9.66	58	53.76	42.17	32.30	77	112.85	88.53	67.80
40	17.61	13.81	10.58	59	56.30	44.17	33.82	78	116.63	91.50	70.07
41	19.18	15.04	11.52	60	58.90	46.21	35.39	79	120.48	94.51	72.38
42	20.79	16.31	12.49	61	61.56	48.29	36.98	80	124.39	97.59	74.74
43	22.46	17.62	13.49	62	64.28	50.43	38.62	81	128.38	100.72	77.13
44	24.17	18.97	14.52	63	67.06	52.61	40.29	82	132.44	103.90	79.57
45	25.94	20.35	15.58	64	69.91	54.85	42.00	83	136.58	107.14	82.05

84	140.78	110.44	84.58	94	186.89	146.61	112.28	104	240.68	188.82	144.60
85	145.06	113.80	87.15	95	191.92	150.56	115.30	105	246.50	193.38	148.10
86	149.41	117.21	89.76	96	197.02	154.56	118.37	106	252.40	198.01	151.64
87	153.83	120.68	92.42	97	202.20	158.63	121.48	107	258.38	202.70	155.23
88	158.33	124.21	95.12	98	207.46	162.75	124.64	108	264.44	207.45	158.88
89	162.90	127.79	97.87	99	212.80	166.94	127.85	109	270.59	212.27	162.57
90	167.55	131.44	100.66	100	218.22	171.19	131.11	110	276.81	217.16	166.31
91	172.27	135.14	103.50	101	223.72	175.50	134.41	111	283.12	222.11	170.10
92	177.07	138.91	106.38	102	229.29	179.88	137.76	112	289.51	227.12	173.94
93	181.94	142.73	109.31	103	234.95	184.32	141.16				

Table 4: Under bark timber volume of Asna up to top 20 cm over bark diameter

Girth (")	Gross volume (CFT)	Quarter girth volume for quality I	Quarter girth volume for quality II		Girth (")	Gross volume (CFT)	Quarter girth volume for quality I	Quarter girth volume for quality II
27	0.32	0.247366	0.189442		46	22.09	17.32979	13.27182
28	1.12	0.875216	0.670274		47	23.65	18.55704	14.21169
29	1.95	1.531773	1.17309		48	25.27	19.82041	15.17922
30	2.83	2.216921	1.697803		49	26.92	21.12034	16.17476
31	3.74	2.930727	2.244462		50	28.63	22.4573	17.19866
32	4.68	3.673385	2.813218		51	30.38	23.83172	18.25124
33	5.67	4.445186	3.404293		52	32.18	25.24403	19.33284
34	6.69	5.246489	4.017961		53	34.03	26.69467	20.4438
35	7.75	6.077699	4.654533		54	35.93	28.18407	21.58443
36	8.85	6.939256	5.314347		55	37.87	29.71262	22.75506
37	9.98	7.831625	5.997757		56	39.87	31.28076	23.956
38	11.16	8.755284	6.70513		57	41.92	32.88888	25.18756
39	12.38	9.71072	7.436839		58	44.02	34.53738	26.45004
40	13.64	10.69843	8.193262		59	46.18	36.22666	27.74375
41	14.94	11.71889	8.974775		60	48.38	37.9571	29.06899
42	16.28	12.77262	9.781757		61	50.64	39.72909	30.42605
43	17.67	13.86009	10.61458		62	52.95	41.54301	31.81522
44	19.10	14.98179	11.47362		63	55.32	43.39923	33.23679
45	20.57	16.1382	12.35925		64	57.74	45.29813	34.69103

65	60.22	47.24006	36.17824		99	180.05	141.2508	108.1752
66	62.75	49.22539	37.69868		100	184.71	144.9033	110.9725
67	65.33	51.25448	39.25264		101	189.43	148.61	113.8112
68	67.98	53.32768	40.84037		102	194.23	152.3712	116.6917
69	70.68	55.44533	42.46215		103	199.09	156.187	119.6139
70	73.43	57.60779	44.11824		104	204.03	160.0577	122.5783
71	76.25	59.8154	45.80891		105	209.03	163.9837	125.585
72	79.12	62.06848	47.53441		106	214.10	167.9651	128.6341
73	82.05	64.36739	49.295		107	219.25	172.0023	131.7259
74	85.04	66.71245	51.09093		108	224.47	176.0955	134.8606
75	88.09	69.10398	52.92246		109	229.76	180.2449	138.0384
76	91.19	71.54232	54.78984		110	235.12	184.4508	141.2594
77	94.36	74.02779	56.6933		111	240.55	188.7135	144.524
78	97.59	76.5607	58.6331		112	246.06	193.0331	147.8321
79	100.88	79.14137	60.60948		113	251.64	197.4101	151.1842
80	104.23	81.77012	62.62268		114	257.29	201.8446	154.5803
81	107.64	84.44726	64.67293		115	263.02	206.3368	158.0206
82	111.12	87.1731	66.76048		116	268.82	210.887	161.5053
83	114.66	89.94794	68.88556		117	274.69	215.4955	165.0347
84	118.26	92.77209	71.0484		118	280.64	220.1625	168.6088
85	121.92	95.64584	73.24923		119	286.66	224.8883	172.228
86	125.65	98.5695	75.48828		120	292.76	229.673	175.8924
87	129.44	101.5434	77.76578		121	298.94	234.517	179.6021
88	133.29	104.5677	80.08195		122	305.19	239.4205	183.3573
89	137.21	107.6429	82.43702		123	311.52	244.3836	187.1583
90	141.20	110.7691	84.83121		124	317.92	249.4068	191.0052
91	145.25	113.9467	87.26474		125	324.40	254.4901	194.8982
92	149.36	117.176	89.73783		126	330.95	259.6338	198.8375
93	153.55	120.4572	92.2507		127	337.59	264.8383	202.8232
94	157.80	123.7906	94.80356		128	344.30	270.1036	206.8556
95	162.11	127.1765	97.39663		129	351.09	275.43	210.9348
96	166.49	130.6152	100.0301		130	357.96	280.8178	215.061
97	170.95	134.107	102.7042		131	364.90	286.2672	219.2344
98	175.46	137.6521	105.4192		132	371.93	291.7785	223.4551

133	379.03	297.3517	227.7233		135	393.48	308.6854	236.403
134	386.22	302.9873	232.0392		136	400.82	314.4462	240.8149

Table 5: Under bark timber volume of Banji up to top 20 cm over bark diameter

Girth (")	Gross volume (CFT)	Quarter girth volume for quality I	Quarter girth volume for quality II		Girth (")	Gross volume (CFT)	Quarter girth volume for quality I	Quarter girth volume for quality II
27	1.10	0.86	0.66		49	35.39	27.76	21.26
28	2.18	1.71	1.31		50	37.55	29.45	22.56
29	3.30	2.59	1.98		51	39.76	31.19	23.89
30	4.46	3.50	2.68		52	42.03	32.97	25.25
31	5.66	4.44	3.40		53	44.36	34.80	26.65
32	6.90	5.42	4.15		54	46.75	36.68	28.09
33	8.19	6.43	4.92		55	49.20	38.60	29.56
34	9.52	7.47	5.72		56	51.71	40.57	31.07
35	10.90	8.55	6.55		57	54.29	42.59	32.62
36	12.32	9.67	7.40		58	56.93	44.66	34.20
37	13.79	10.82	8.29		59	59.63	46.78	35.82
38	15.31	12.01	9.20		60	62.39	48.94	37.48
39	16.88	13.24	10.14		61	65.22	51.16	39.18
40	18.49	14.51	11.11		62	68.11	53.43	40.92
41	20.16	15.81	12.11		63	71.07	55.75	42.70
42	21.87	17.16	13.14		64	74.09	58.12	44.51
43	23.64	18.55	14.20		65	77.18	60.55	46.37
44	25.46	19.98	15.30		66	80.34	63.03	48.27
45	27.34	21.45	16.43		67	83.56	65.56	50.21
46	29.27	22.96	17.58		68	86.86	68.14	52.18
47	31.25	24.52	18.78		69	90.22	70.78	54.20
48	33.29	26.12	20.00					

The validation of the equations wasbased on statistical tests and comparison of equations; the independent data sets were not used. Different models as explained above were tested and used to get high R^2

value and low error. The significance of parameter and residual analysis of all suggested models are presented in Annexes 1 and 2.

4. Limitation and Applicability

The models appear robust and applicable to Western Terai Sal forests and Terai Mixed Hardwood forests for the effective application in the forest management. Those can be applied in other site also by testing the results, to the sites, species and trees that are beyond the sample diameter range.

The plan of data collection was to choose the sample trees from different sites representing every site quality and variation of the area but due to lack of felling permission, especially the larger sized trees were collected from limited stands. Especially the samples of *S. robusta* were collected mainly from Lumbani Colaborative Forest, Rupandehi which is considered good site quality than felling site of Kapilvastu.

In Nepal there are many species and varying site conditions but the number of models available is limited. Hence to compare and improve the models, study should be done using samples from different species and site conditions. It is also suggested that local volume model should be prepared for the particular compartment or stand or site quality rather than different site quality in a particular location.

Volume given by this model is total volume accumulated in the stem from 15 cm above the ground level to the desired top length without deducting of any defect knot etc. All the limitation imbedded in the modeling was definitely existed in this study.

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Annex 1: Parameter (before correction), residuals and its significance of the suggested model

```
lm(formula = ln(V)  =  a + b ln(d)  for total overbark volume of Shorea
robusta)

Residuals:
   Min       1Q       Median      3Q      Max
-0.50700  -0.08124    0.00264   0.11150  0.31422

Coefficients:
         Estimate   Std. Error   t value    Pr (>|t|)
a        -8.78329     0.15115     -58.11    <2e-16 ***
b         2.45236     0.04043      60.65    <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.1873 on 48 degrees of freedom
Multiple R-squared:  0.9871, Adjusted R-squared:  0.9869
F-statistic:  3679 on 1 and 48 DF,  p-value: < 2.2e-16

lm(formula = ln(V)  =  a + b ln(d)  for total under bark of Shorea
robusta)

Residuals:
     Min     1Q       Median      3Q      Max
-0.51135  -0.12922   -0.00008   0.16280  0.35833

Coefficients:
         Estimate    Std.Error   t value     Pr(>|t|)
a        -9.72988     0.17300     -56.24    <2e-16 ***
b         2.63662     0.04628      56.98    <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.2144 on 48 degrees of freedom
Multiple R-squared:  0.9854, Adjusted R-squared:  0.9851
F-statistic:  3246 on 1 and 48 DF,  p-value: < 2.2e-16

lm(formula = ln(v1/V)  =  a + b ln(d)  for Shorea robusta)

Residuals:
    Min      1Q       Median      3Q      Max
-1.8612    -0.3238    -0.0263    0.2442   4.2315

Coefficients:
         Estimate   Std. Error   t value     Pr(>|t|)
a          5.7665      0.6432     8.965 7   99e-12 ***
b         -2.8177      0.1721     -16.376   < 2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 0.7971 on 48 degrees of freedom
Multiple R-squared:  0.8482, Adjusted R-squared:  0.845
F-statistic: 268.2 on 1 and 48 DF,  p-value: < 2.2e-16
```

```
lm(formula = ln(v2/Vt)  =  a + b ln(d)  for   Shorea robusta)

Residuals:
     Min     1Q        Median       3Q         Max
-1.21920 -0.21011    0.02055    0.32422    1.16979

Coefficients:
         Estimate   Std. Error   t value    Pr(>|t|)
    a     10.4602      0.8061      12.98   9.87e-16 ***
    b     -3.5534      0.2057     -17.28   < 2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.5431 on 39 degrees of freedom
  (9 observations deleted due to missingness)
Multiple R-squared:  0.8845, Adjusted R-squared:  0.8815
F-statistic: 298.5 on 1 and 39 DF,  p-value: < 2.2e-16

lm(formula = ln(bp10)  =  a + b ln(d) for bark proportion of Shorea
robusta)

Residuals:
    Min      1Q       Median       3Q         Max
-0.10362  -0.03076   0.00006   0.03552    0.09176


Coefficients:
          Estimate  Std. Error  t value    Pr(>|t|)
     a     0.93322    0.03788     24.64    <2e-16 ***
     b    -0.18149    0.01013    -17.91    <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.04694 on 48 degrees of freedom
Multiple R-squared:  0.8699, Adjusted R-squared:  0.8671
F-statistic: 320.8 on 1 and 48 DF,  p-value: < 2.2e-16

lm(formula = ln(bark)  =  a + b ln(d)  for bark volume of Shorea
robusta)

Residuals:
    Min       1Q       Median       3Q        Max
  -0.78397  -0.15399   -0.00809   0.20860    0.56436

Coefficients:
           Estimate  Std. Error  t value   Pr(>|t|)
     a     -10.3318    0.4155     -24.87   <2e-16 ***
     b       2.3833    0.1057      22.55   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 0.2832 on 40 degrees of freedom
  (8 observations deleted due to missingness)
Multiple R-squared:  0.927,  Adjusted R-squared:  0.9252
F-statistic: 508.3 on 1 and 40 DF,  p-value: < 2.2e-16
```

```
lm(formula = ln(V)  =  a + b ln(d), for total over bark volume of
Terminalia tomentosa)

Residuals:
    Min        1Q      Median       3Q         Max
-0.70594   -0.12851   0.02452    0.14435    0.38637


Coefficients:
         Estimate   Std. Error   t value    Pr(>|t|)
    a     -8.97639     0.21449     -41.85   <2e-16 ***
    b      2.45702     0.05493      44.73   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.2207 on 44 degrees of freedom
Multiple R-squared:  0.9785, Adjusted R-squared:  0.978
F-statistic:  2001 on 1 and 44 DF,  p-value: < 2.2e-16

lm(formula = ln(V)  =  a + b ln(d), for total under bark volume of
Terminalia tomentosa)

Residuals:
   Min        1Q      Median       3Q         Max
-0.79009   -0.12313   0.03646    0.15137    0.41852

Coefficients:
         Estimate   Std. Error   t value    Pr(>|t|)
    a     -9.83628     0.23096     -42.59   <2e-16 ***
    b      2.61605     0.05924      44.16   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.2373 on 43 degrees of freedom
  (1 observation deleted due to missingness)
Multiple R-squared:  0.9784, Adjusted R-squared:  0.9779
F-statistic:  1950 on 1 and 43 DF,  p-value: < 2.2e-16

lm(formula = ln(v1/V)  =  a + b ln(d), for   Terminalia tomentosa)

Residuals:
   Min        1Q      Median       3Q         Max
-1.30670   -0.26062   -0.00967   0.18656    2.54122

Coefficients:
           Estimate  Std. Error   t value    Pr(>|t|)
     a       5.8579     0.6191      9.462   4.5e-12 ***
     b      -2.7379     0.1572    -17.413   < 2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 0.5551 on 43 degrees of freedom
  (1 observation deleted due to missingness)
Multiple R-squared:  0.8758, Adjusted R-squared:  0.8729
F-statistic: 303.2 on 1 and 43 DF,  p-value: < 2.2e-16
```

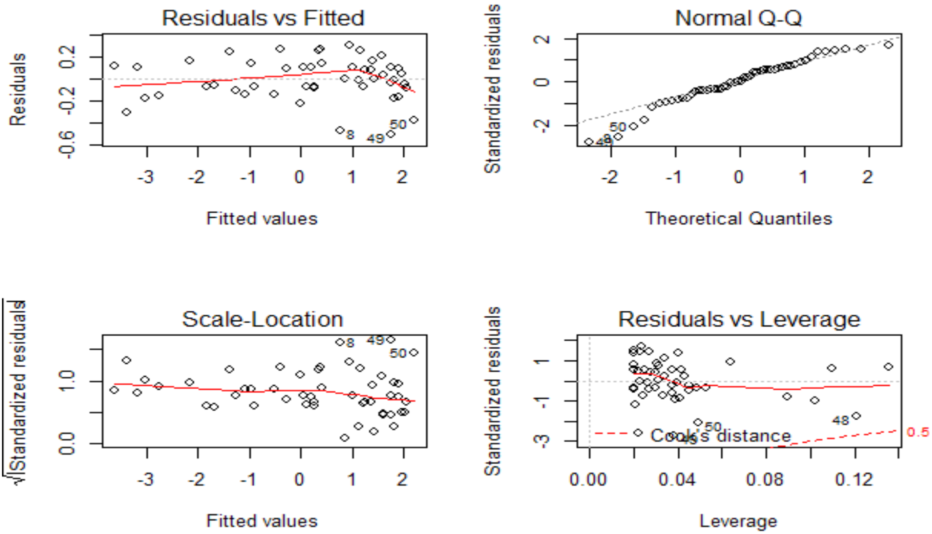
```
lm(formula = ln(bp) = a + b ln(d), for bark proportion up to 10 cm
diameter Terminalia tomentosa)

Residuals:
      Min        1Q    Median        3Q       Max
-0.062662 -0.024645 -0.005897  0.016479  0.142966

Coefficients:
            Estimate  Std. Error  t value   Pr(>|t|)
     a      0.83043    0.04475     18.56   <2e-16 ***
     b     -0.15145    0.01138    -13.31   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.04005 on 42 degrees of freedom
  (2 observations deleted due to missingness)
Multiple R-squared:  0.8083, Adjusted R-squared:  0.8037
F-statistic:   177 on 1 and 42 DF,  p-value: < 2.2e-16

lm(formula = ln(av2/aob10)  =  a + b ln(d), for   Terminalia tomentosa)

Residuals:
    Min       1Q       Median       3Q        Max
  -0.98669  -0.29546   0.03722   0.23033   1.05464

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
     a       9.5087     0.5729     16.60   <2e-16 ***
     b      -3.2043     0.1428    -22.43   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.4077 on 39 degrees of freedom
  (5 observations deleted due to missingness)
Multiple R-squared:  0.9281, Adjusted R-squared:  0.9262
F-statistic: 503.2 on 1 and 39 DF,  p-value: < 2.2e-16

lm(formula = ln(bark) = a + b ln(d), for bark volume up to 20 cm
diameter of Terminalia tomentosa)

Residuals:
     Min       1Q       Median       3Q        Max
-0.80043   -0.13208   -0.01228   0.25465   0.59470

Coefficients:
            Estimate  Std. Error  t value   Pr(>|t|)
     a     -10.1353    0.4406     -23.00   <2e-16 ***
     b      2.2925     0.1100      20.85   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 0.3131 on 38 degrees of freedom
  (6 observations deleted due to missingness)
Multiple R-squared:  0.9196, Adjusted R-squared:  0.9175
F-statistic: 434.6 on 1 and 38 DF,  p-value: < 2.2e-16
```

```
lm(formula = ln(V)  =  a + b ln(d), for total over bark volume of
Anogeissus latifolia)

Residuals:
     Min       1Q       Median      3Q        Max
-0.39580   -0.13879   -0.00197   0.17634    0.29291

Coefficients:
           Estimate  Std. Error  t value   Pr(>|t|)
     a      -8.74083   0.26453    -33.04   <2e-16 ***
     b       2.42680   0.07268     33.39   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.1927 on 30 degrees of freedom
Multiple R-squared:  0.9738, Adjusted R-squared:  0.9729
F-statistic:  1115 on 1 and 30 DF,  p-value: < 2.2e-16

lm(formula = ln(V)  =  a + b ln(d), for total under bark volume of
Anogeissus latifolia)

Residuals:
    Min       1Q       Median      3Q        Max
  -0.40792  -0.14427   -0.00943   0.20793    0.30796

Coefficients:
           Estimate  Std. Error  t value   Pr(>|t|)
     a      -9.17015   0.29591    -30.99   <2e-16 ***
     b       2.51526     0.08182   30.74   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.2127 on 28 degrees of freedom
  (2 observations deleted due to missingness)
Multiple R-squared:  0.9712, Adjusted R-squared:  0.9702
F-statistic: 945.1 on 1 and 28 DF,  p-value: < 2.2e-16

lm(formula = ln(v1/V)  =  a + b ln(d), for   Anogeissus latifolia)

Residuals:
     Min       1Q       Median      3Q        Max
-0.91204   -0.31662   -0.00398   0.22107    1.86567

Coefficients:
          Estimate    Std. Error    t value     Pr(>|t|)
      a    5.9492       1.0027       5.933    1.91e-06 ***
      b   -2.8289       0.2725      -10.383   2.79e-11 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 0.5662 on 29 degrees of freedom
  (1 observation deleted due to missingness)
Multiple R-squared:  0.788,  Adjusted R-squared:  0.7807
F-statistic: 107.8 on 1 and 29 DF,  p-value: 2.794e-11
```

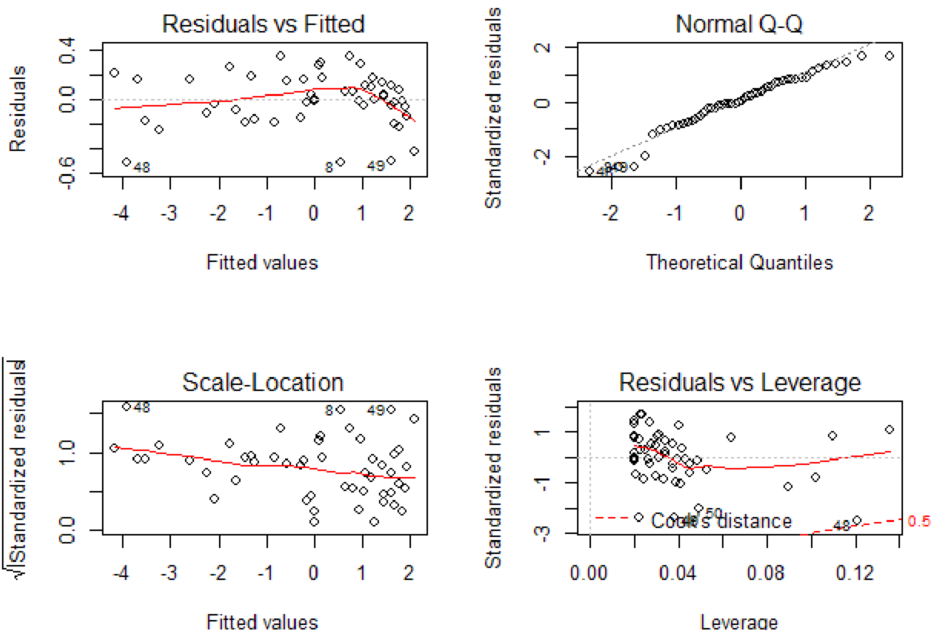
```
lm(formula =ln(bp) = a + bln(d),for bark proportion up to 10 cm diameter
of Anogeissus latifolia)

Residuals:
     Min       1Q       Median       3Q        Max
-0.04248   -0.02366   -0.01904   0.01653   0.24163

Coefficients:
           Estimate  Std. Error  t value   Pr(>|t|)
     a      0.43527   0.09358    4.652   7.77e-05 ***
     b     -0.09306   0.02557   -3.640   0.00114 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.05189 on 27 degrees of freedom
  (3 observations deleted due to missingness)
Multiple R-squared:  0.3292, Adjusted R-squared:  0.3043
F-statistic: 13.25 on 1 and 27 DF,  p-value: 0.001139

lm(formula = ln(v2/Vt)  =  a + b ln(d), for   Anogeissus latifolia)

Residuals:
     Min       1Q       Median       3Q        Max
-1.07807   -0.15070   0.04514   0.27068   0.68850

Coefficients:
           Estimate  Std. Error  t value   Pr(>|t|)
     a      9.9531    1.1359     8.762   3.08e-09 ***
     b     -3.3351    0.3029   -11.010  2.76e-11 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.4428 on 26 degrees of freedom
  (4 observations deleted due to missingness)
Multiple R-squared:  0.8234, Adjusted R-squared:  0.8166
F-statistic: 121.2 on 1 and 26 DF,  p-value: 2.756e-11

lm(formula =ln(bark) = a + b ln(d), for bark volume up to 20 cm diameter
of Anogeissus latifolia)

Residuals:
     Min       1Q       Median       3Q        Max
-0.99399   -0.16834   -0.02959   0.15713   1.07589

Coefficients:
           Estimate  Std. Error  t value   Pr(>|t|)
     a     -9.8693    1.0299    -9.583   7.52e-10 ***
     b      1.9699    0.2766     7.121   1.83e-07 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.4004 on 25 degrees of freedom
  (5 observations deleted due to missingness)
Multiple R-squared:  0.6698, Adjusted R-squared:  0.6566
F-statistic: 50.71 on 1 and 25 DF,  p-value: 1.831e-07
```

Annex 2: Residual analysis of suggested models

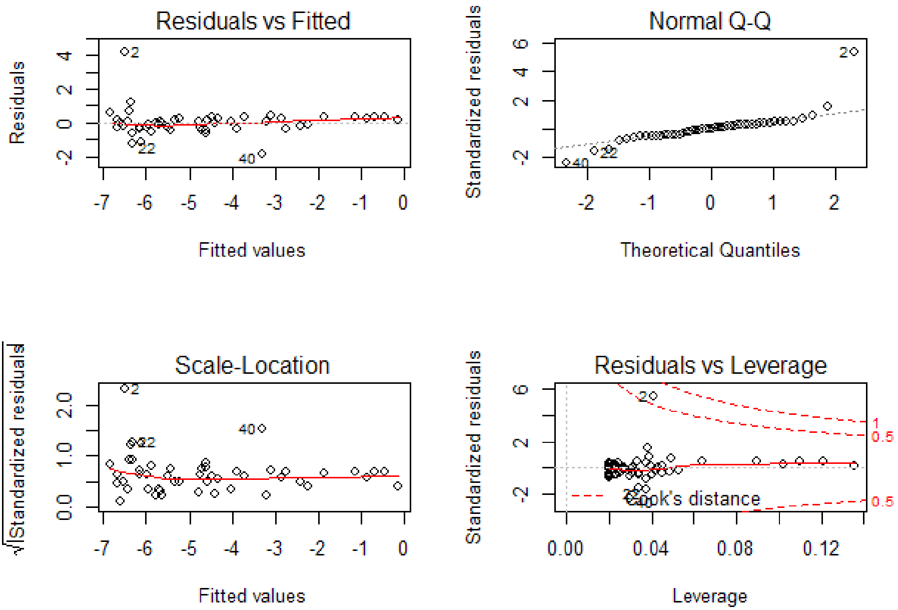
ln(V) = a + b ln(d) for total over bark l volume of *Shorea robusta*



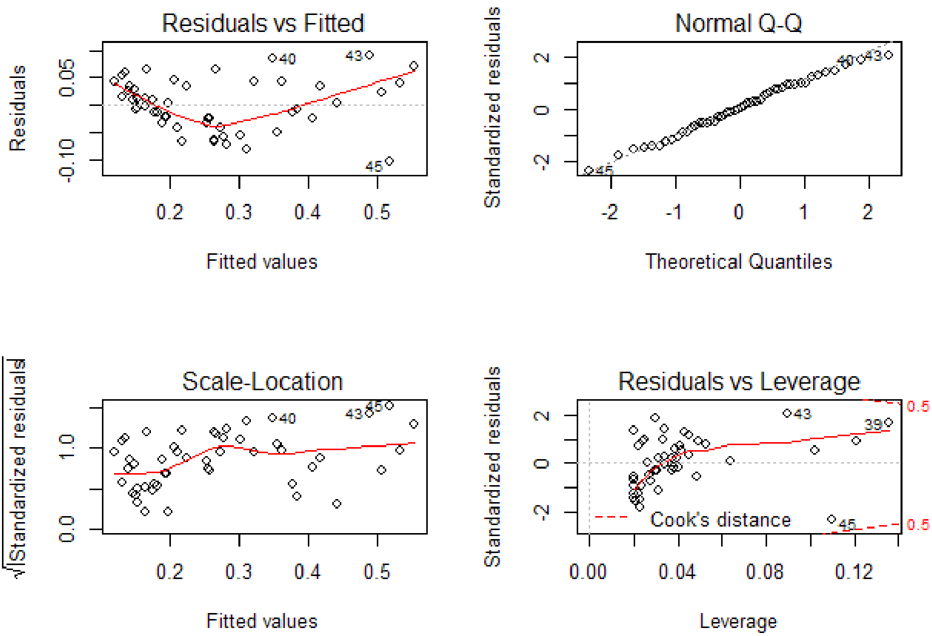
ln(V) = a + b ln(d) for total under bark l volume of *Shorea robusta*



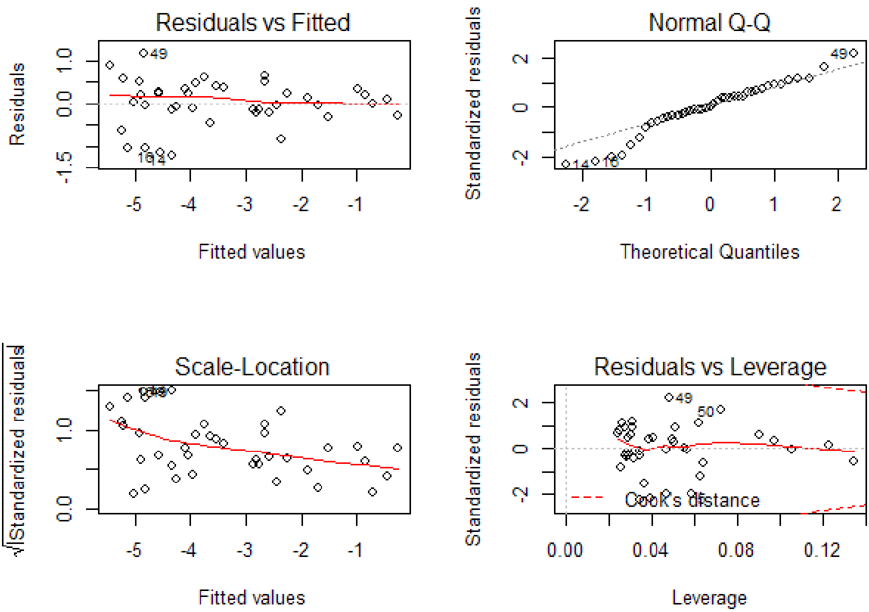
$\ln(v_1/V) = a + b \ln(d)$ for over bark stem volume of *Shorea robusta*



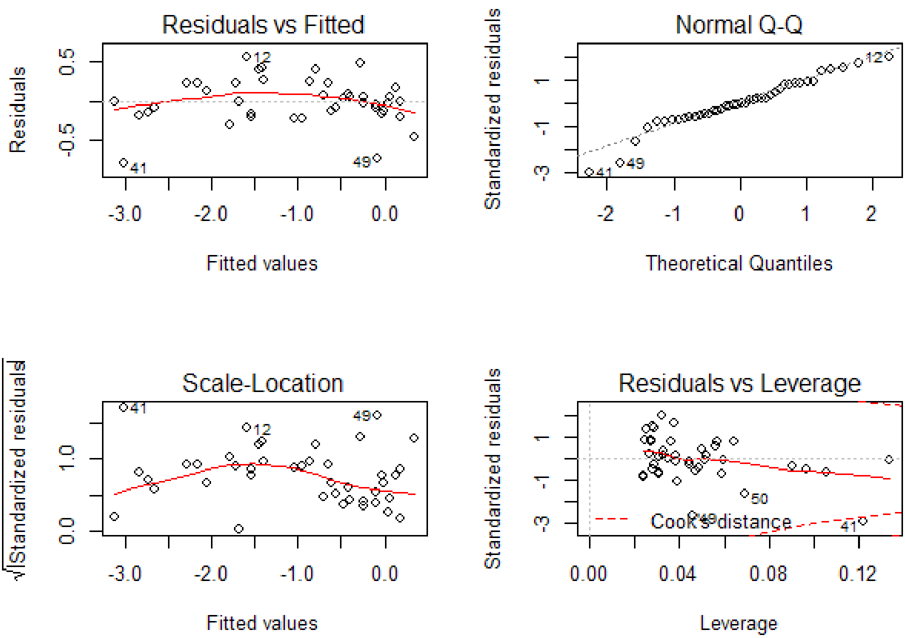
$\ln(bp) = a + b \ln(d)$ for bark proportion up to 10 cm DBH of *Shorea robusta*



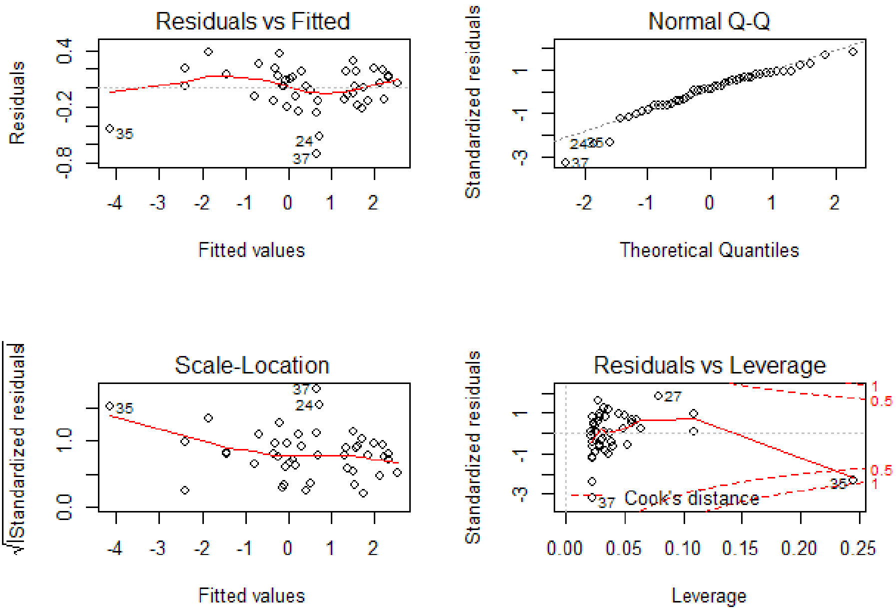
$\ln(v_2/v_t) = a + b \ln(d)$ for over bark stem volume of *Shorea robusta*



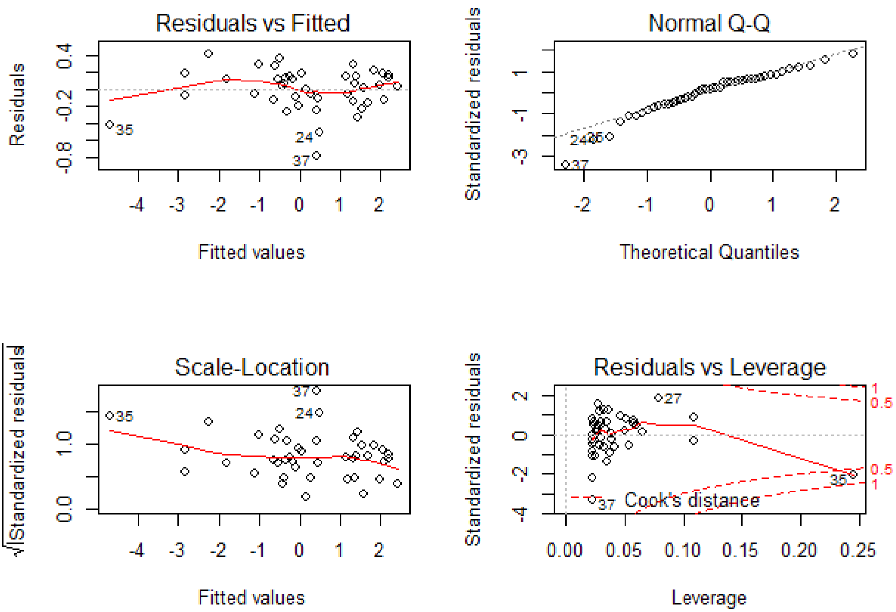
ln(bark) = a + b ln(d) for bark volume up to 20 cm DBH banjhi of *Shorea robusta*



ln(V) = a + b ln(d) for total over bark l volume of *Terminalia tomentosa*

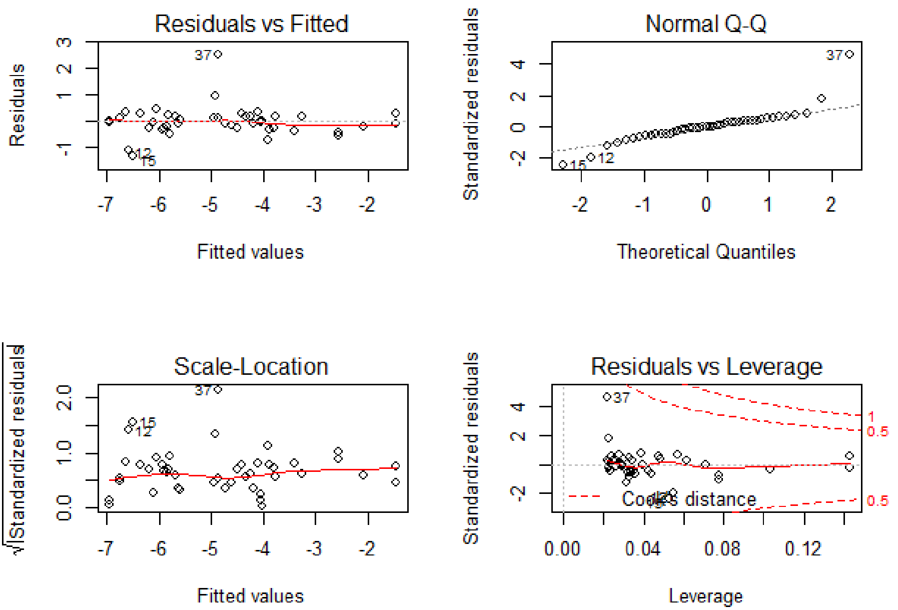


ln(V) = a + b ln(d) for total under bark l volume of *Terminalia tomentosa*

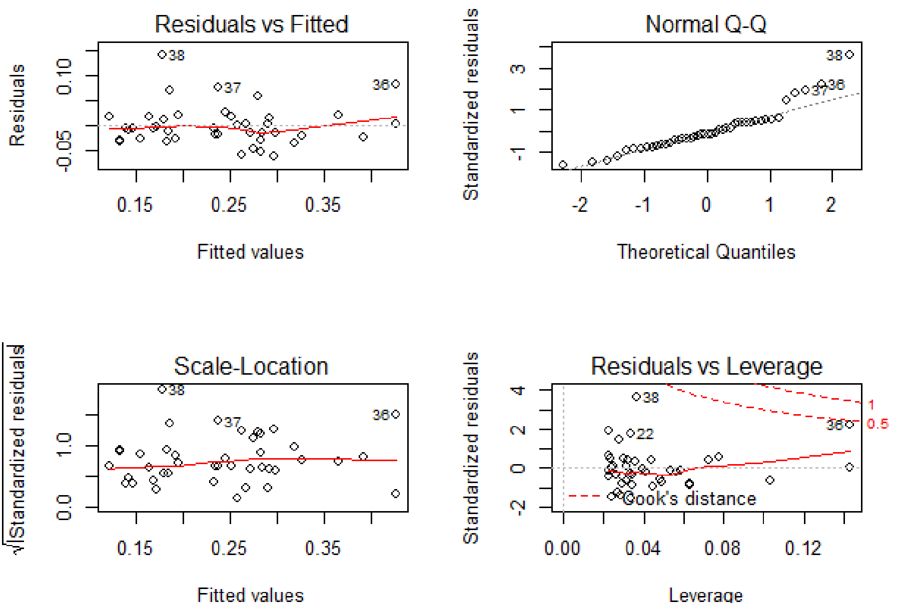


a

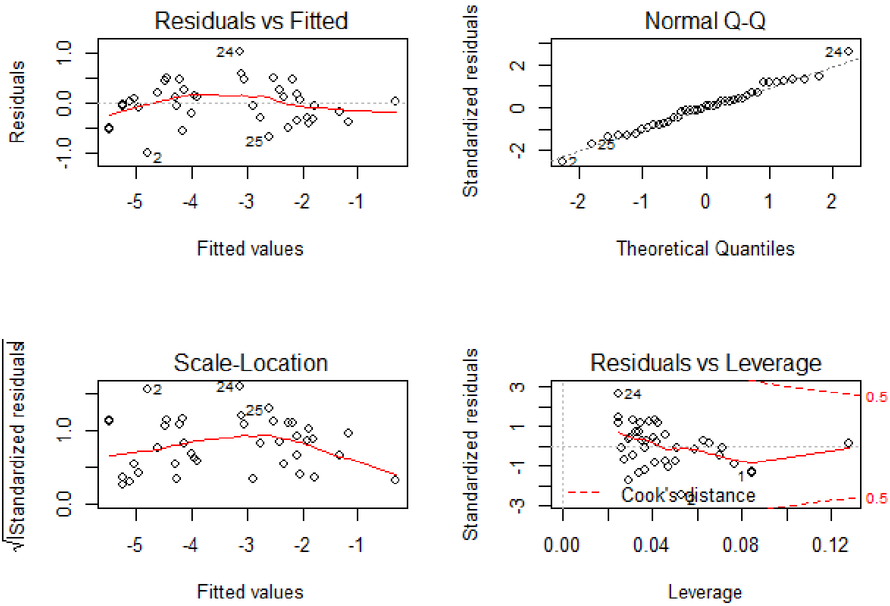
$\ln(v_1/V) = a + b \ln(d)$ for over bark stem volume of *Terminalia tomentosa*



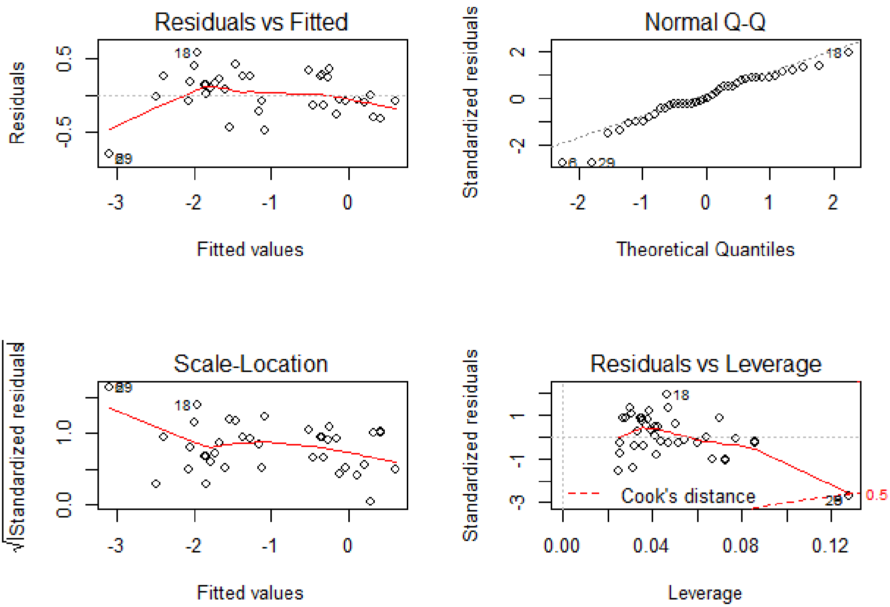
$\ln(bp) = a + b \ln(d)$ for bark proportion up to 10 cm DBH of *Terminalia tomentosa*



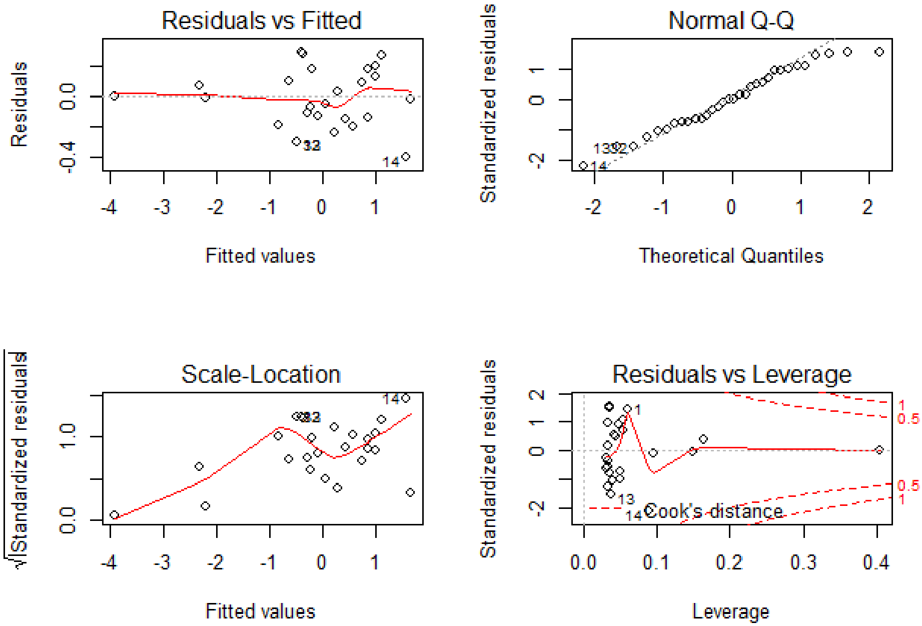
$\ln(v_2/v_t) = a + b \ln(d)$ for over bark stem volume of *Terminalia tomentosa*



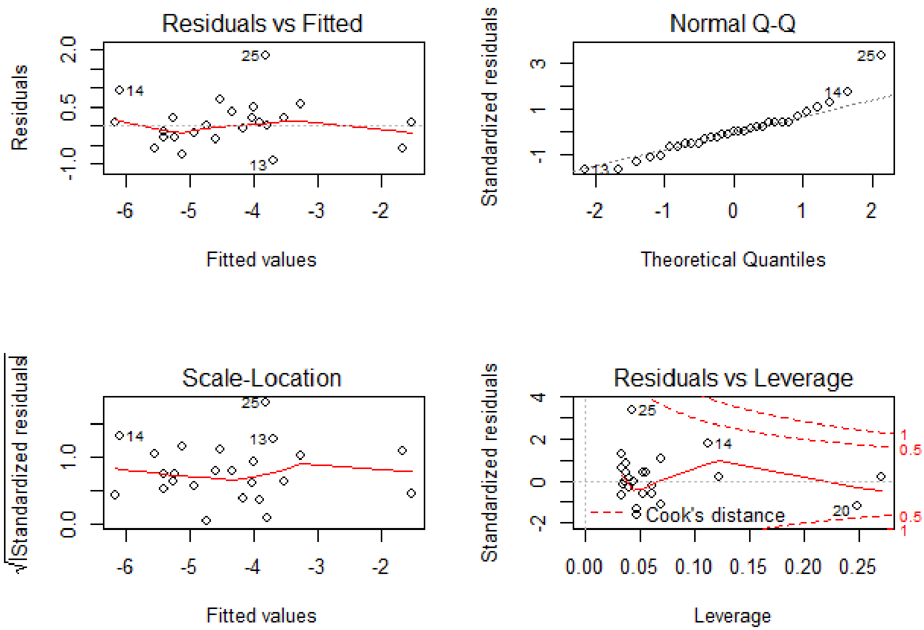
$\ln(bark) = a + b \ln(d)$ for bark volume up to 20 cm DBH banjhi of *Terminalia tomentosa*



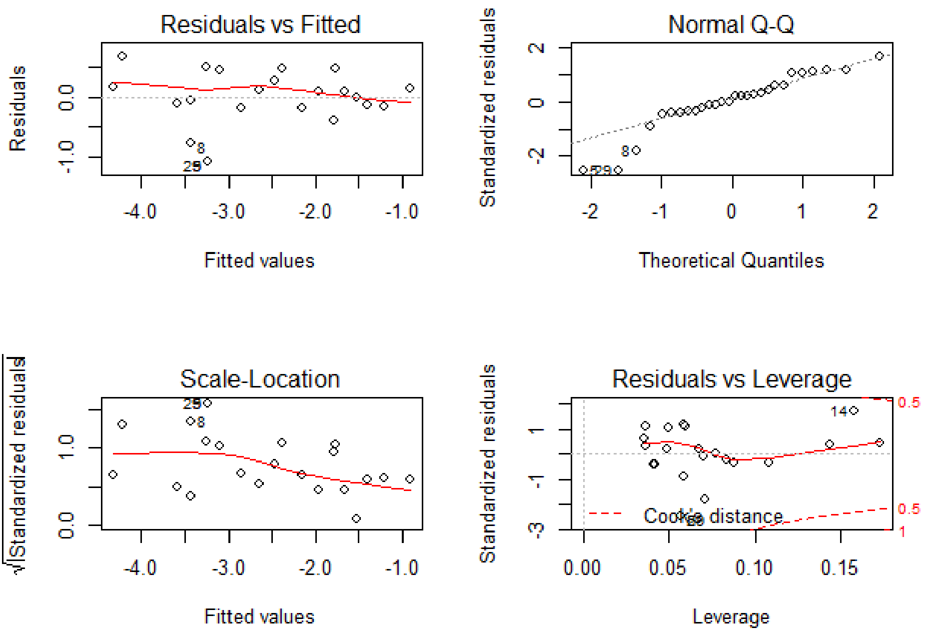
$\ln(V) = a + b \ln(d)$ for total over bark stem volume of *Anogeissus latifolia*



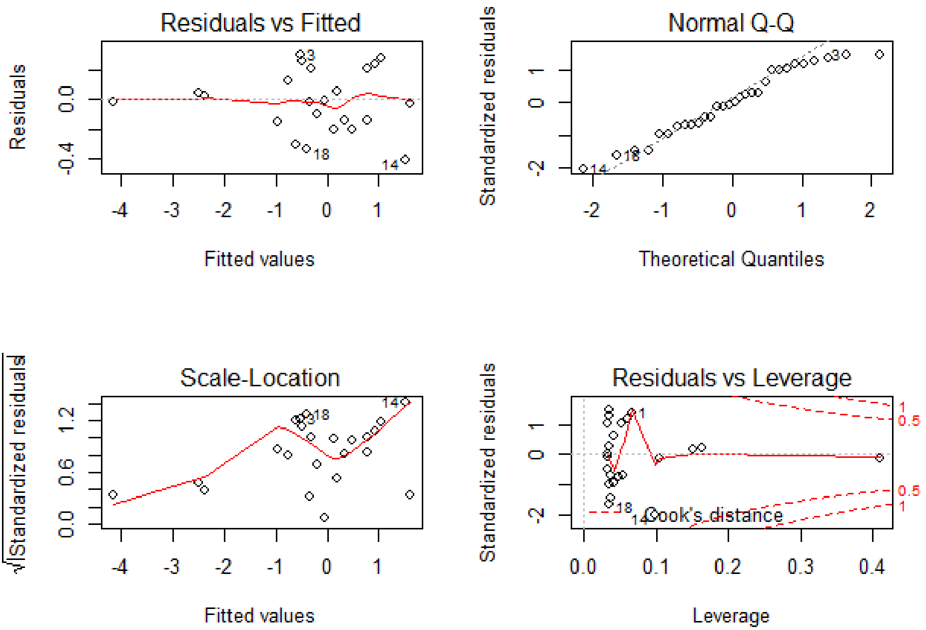
$\ln(v_1/V) = a + b \ln(d)$ for over bark stem volume of *Anogeissus latifolia*



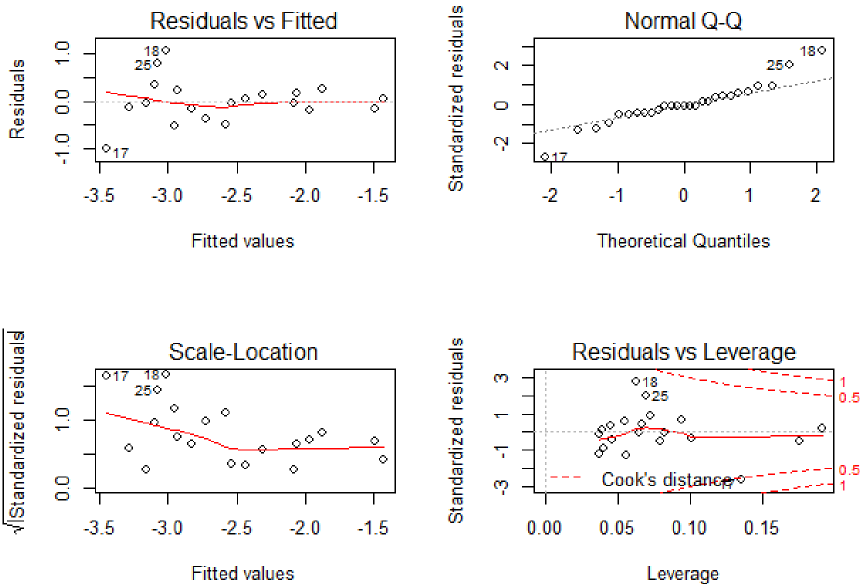
$\ln(v_2/v_t) = a + b \ln(d)$ for over bark stem volume of *Anogeissus latifolia*



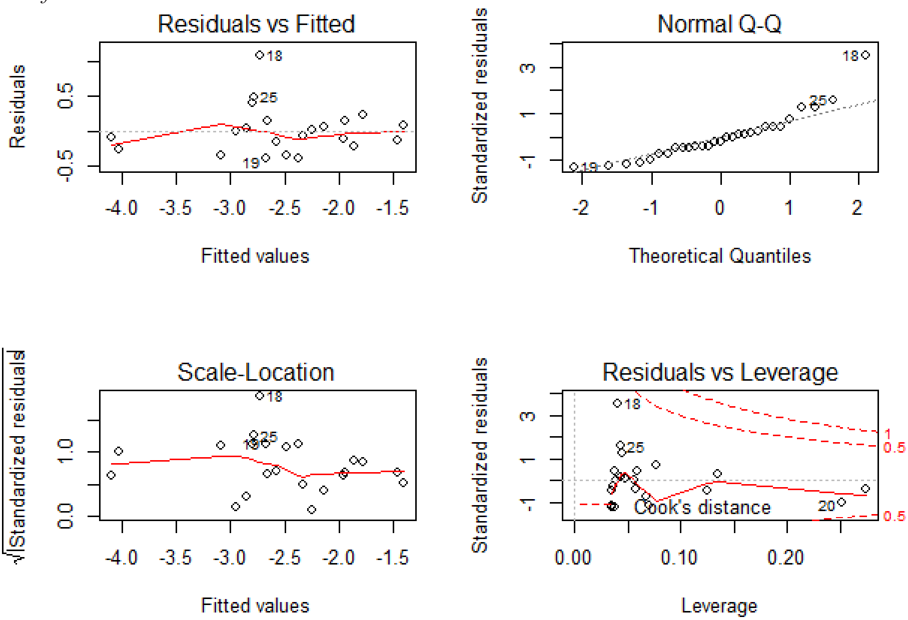
$\ln(V) = a + b \ln(d)$ for total under bark l volume of *Anogeissus latifolia*



ln(bark) = a + b ln(d) for bark volume up to 20 cm DBH banjhi of *Anogeissus latifolia*



ln(bp) = a + b ln(d) for bark proportion up to 10 cm DBH of *Anogeissus latifolia*



Annex 3: Annex 5: Volume table of Sal *(Shorea robusta)*

	Total Volume (M³)		Volume up to top 10cm (M³)		Volume up to top 20cm (M³)	
DBH	Over bark	Underbark	Over bark	Underbark	Over bark	Underbark
5	0.0081	0.0042				
6	0.0126	0.0069				
7	0.0184	0.0103				
8	0.0256	0.0146				
9	0.0341	0.0200				
10	0.0442	0.0264				
11	0.0558	0.0339	0.0351	0.0213		
12	0.0691	0.0426	0.0490	0.0302		
13	0.0841	0.0526	0.0646	0.0404		
14	0.1009	0.0640	0.0819	0.0519		
15	0.1195	0.0768	0.1010	0.0648		
16	0.1400	0.0910	0.1219	0.0792		
17	0.1624	0.1068	0.1447	0.0951		
18	0.1868	0.1242	0.1695	0.1125		
19	0.2133	0.1432	0.1963	0.1316		
20	0.2419	0.1639	0.2252	0.1524		
21	0.2727	0.1864	0.2563	0.1750		
22	0.3056	0.2108	0.2895	0.1993	0.0907	0.0371
23	0.3408	0.2370	0.3250	0.2255	0.1345	0.0748
24	0.3783	0.2651	0.3627	0.2537	0.1799	0.1139
25	0.4182	0.2952	0.4028	0.2838	0.2272	0.1544
26	0.4604	0.3274	0.4452	0.3159	0.2764	0.1965
27	0.5050	0.3617	0.4901	0.3502	0.3275	0.2401
28	0.5521	0.3981	0.5374	0.3865	0.3808	0.2854
29	0.6017	0.4367	0.5872	0.4250	0.4361	0.3324
30	0.6539	0.4775	0.6395	0.4658	0.4937	0.3813
30.5	0.6810	0.4988	0.6667	0.4870	0.5233	0.4064
31	0.7087	0.5206	0.6945	0.5088	0.5535	0.4319
31.5	0.7370	0.5430	0.7229	0.5312	0.5843	0.4580

	Total Volume (M^3)		Volume up to top 10cm (M^3)		Volume up to top 20cm (M^3)	
DBH	Over bark	Underbark	Over bark	Underbark	Over bark	Underbark
32	0.7660	0.5661	0.7520	0.5541	0.6156	0.4845
32.5	0.7957	0.5897	0.7818	0.5777	0.6476	0.5116
33	0.8261	0.6139	0.8122	0.6018	0.6802	0.5391
33.5	0.8571	0.6387	0.8433	0.6266	0.7134	0.5671
34	0.8888	0.6642	0.8751	0.6520	0.7472	0.5957
34.5	0.9212	0.6902	0.9076	0.6780	0.7816	0.6248
35	0.9543	0.7169	0.9407	0.7046	0.8167	0.6544
35.5	0.9881	0.7442	0.9746	0.7318	0.8524	0.6845
36	1.0226	0.7722	1.0091	0.7597	0.8887	0.7151
36.5	1.0578	0.8008	1.0444	0.7882	0.9257	0.7463
37	1.0936	0.8300	1.0803	0.8173	0.9634	0.7781
37.5	1.1302	0.8599	1.1170	0.8471	1.0017	0.8104
38	1.1676	0.8905	1.1544	0.8776	1.0407	0.8433
38.5	1.2056	0.9217	1.1925	0.9087	1.0804	0.8767
39	1.2444	0.9536	1.2313	0.9405	1.1208	0.9107
39.5	1.2838	0.9862	1.2708	0.9729	1.1618	0.9453
40	1.3241	1.0195	1.3111	1.0061	1.2035	0.9804
40.5	1.3650	1.0534	1.3521	1.0399	1.2460	1.0161
41	1.4067	1.0880	1.3939	1.0744	1.2891	1.0525
41.5	1.4492	1.1234	1.4364	1.1096	1.3330	1.0894
42	1.4924	1.1594	1.4796	1.1455	1.3776	1.1269
42.5	1.5363	1.1962	1.5236	1.1821	1.4229	1.1650
43	1.5810	1.2336	1.5684	1.2194	1.4689	1.2038
43.5	1.6265	1.2718	1.6139	1.2574	1.5156	1.2431
44	1.6727	1.3107	1.6602	1.2962	1.5631	1.2831
44.5	1.7197	1.3504	1.7073	1.3356	1.6113	1.3237
45	1.7675	1.3907	1.7551	1.3758	1.6603	1.3649
45.5	1.8160	1.4318	1.8037	1.4168	1.7100	1.4067
46	1.8654	1.4737	1.8531	1.4585	1.7605	1.4492
46.5	1.9155	1.5163	1.9032	1.5009	1.8118	1.4923
47	1.9664	1.5597	1.9542	1.5441	1.8638	1.5361

	Total Volume (M^3)		Volume up to top 10cm (M^3)		Volume up to top 20cm (M^3)	
DBH	Over bark	Underbark	Over bark	Underbark	Over bark	Underbark
47.5	2.0181	1.6038	2.0059	1.5880	1.9166	1.5805
48	2.0706	1.6487	2.0585	1.6327	1.9701	1.6255
48.5	2.1239	1.6944	2.1118	1.6781	2.0244	1.6712
49	2.1780	1.7408	2.1660	1.7244	2.0795	1.7176
49.5	2.2329	1.7880	2.2209	1.7714	2.1354	1.7647
50	2.2886	1.8361	2.2767	1.8192	2.1921	1.8124
50.5	2.3451	1.8849	2.3332	1.8678	2.2496	1.8607
51	2.4025	1.9345	2.3906	1.9171	2.3079	1.9098
51.5	2.4607	1.9849	2.4489	1.9673	2.3670	1.9595
52	2.5197	2.0361	2.5079	2.0183	2.4269	2.0099
52.5	2.5795	2.0881	2.5678	2.0700	2.4876	2.0610
53	2.6401	2.1410	2.6285	2.1226	2.5491	2.1128
53.5	2.7016	2.1946	2.6900	2.1760	2.6115	2.1652
54	2.7640	2.2491	2.7524	2.2302	2.6746	2.2184
54.5	2.8272	2.3044	2.8156	2.2853	2.7386	2.2723
55	2.8912	2.3606	2.8797	2.3412	2.8035	2.3268
55.5	2.9561	2.4176	2.9446	2.3979	2.8691	2.3821
56	3.0218	2.4755	3.0104	2.4554	2.9357	2.4381
56.5	3.0884	2.5342	3.0770	2.5138	3.0030	2.4948
57	3.1559	2.5937	3.1445	2.5731	3.0712	2.5522
57.5	3.2242	2.6541	3.2129	2.6332	3.1403	2.6104
58	3.2934	2.7154	3.2821	2.6942	3.2102	2.6692
58.5	3.3635	2.7776	3.3522	2.7560	3.2809	2.7288
59	3.4344	2.8406	3.4232	2.8187	3.3526	2.7891
59.5	3.5062	2.9045	3.4950	2.8823	3.4251	2.8502
60	3.5789	2.9693	3.5677	2.9467	3.4984	2.9120
60.5	3.6525	3.0350	3.6414	3.0121	3.5727	2.9745
61	3.7270	3.1016	3.7159	3.0783	3.6478	3.0378
61.5	3.8023	3.1691	3.7913	3.1454	3.7238	3.1018
62	3.8786	3.2375	3.8675	3.2134	3.8007	3.1666
62.5	3.9557	3.3068	3.9447	3.2823	3.8785	3.2321

	Total Volume (M³)		Volume up to top 10cm (M³)		Volume up to top 20cm (M³)	
DBH	Over bark	Underbark	Over bark	Underbark	Over bark	Underbark
63	4.0338	3.3770	4.0228	3.3521	3.9571	3.2983
63.5	4.1128	3.4481	4.1018	3.4229	4.0367	3.3654
64	4.1926	3.5201	4.1817	3.4945	4.1171	3.4332
64.5	4.2734	3.5931	4.2625	3.5671	4.1985	3.5017
65	4.3551	3.6670	4.3443	3.6406	4.2808	3.5710
65.5	4.4377	3.7419	4.4269	3.7150	4.3639	3.6411
66	4.5213	3.8176	4.5105	3.7904	4.4480	3.7120
66.5	4.6057	3.8944	4.5950	3.8667	4.5330	3.7837
67	4.6911	3.9720	4.6804	3.9439	4.6190	3.8561
67.5	4.7774	4.0507	4.7667	4.0221	4.7058	3.9293
68	4.8647	4.1303	4.8540	4.1012	4.7936	4.0033
68.5	4.9529	4.2108	4.9422	4.1813	4.8823	4.0781
69	5.0420	4.2923	5.0314	4.2624	4.9719	4.1536
69.5	5.1321	4.3748	5.1215	4.3444	5.0625	4.2300
70	5.2231	4.4583	5.2125	4.4274	5.1540	4.3072
70.5	5.3151	4.5428	5.3045	4.5113	5.2464	4.3851
71	5.4080	4.6282	5.3975	4.5963	5.3398	4.4639
71.5	5.5019	4.7146	5.4914	4.6822	5.4342	4.5435
72	5.5967	4.8021	5.5862	4.7691	5.5295	4.6238
72.5	5.6925	4.8905	5.6821	4.8570	5.6257	4.7050
73	5.7892	4.9799	5.7788	4.9459	5.7229	4.7870
73.5	5.8870	5.0704	5.8766	5.0358	5.8211	4.8698
74	5.9857	5.1618	5.9753	5.1267	5.9202	4.9535
74.5	6.0853	5.2543	6.0750	5.2186	6.0203	5.0379
75	6.1860	5.3478	6.1757	5.3115	6.1214	5.1232
75.5	6.2876	5.4423	6.2773	5.4055	6.2234	5.2093
76	6.3902	5.5378	6.3800	5.5004	6.3265	5.2963
76.5	6.4938	5.6344	6.4836	5.5964	6.4305	5.3841
77	6.5984	5.7320	6.5882	5.6934	6.5354	5.4727
77.5	6.7040	5.8307	6.6938	5.7915	6.6414	5.5621
78	6.8105	5.9304	6.8004	5.8906	6.7484	5.6524

	Total Volume (M^3)		Volume up to top 10cm (M^3)		Volume up to top 20cm (M^3)	
DBH	Over bark	Underbark	Over bark	Underbark	Over bark	Underbark
78.5	6.9181	6.0311	6.9080	5.9907	6.8563	5.7435
79	7.0266	6.1330	7.0165	6.0919	6.9653	5.8355
79.5	7.1362	6.2358	7.1261	6.1941	7.0752	5.9283
80	7.2468	6.3398	7.2367	6.2974	7.1861	6.0220
80.5	7.3584	6.4448	7.3483	6.4018	7.2981	6.1165
81	7.4709	6.5509	7.4609	6.5072	7.4110	6.2119
81.5	7.5845	6.6580	7.5746	6.6137	7.5250	6.3082
82	7.6992	6.7663	7.6892	6.7212	7.6400	6.4053
82.5	7.8148	6.8756	7.8049	6.8299	7.7560	6.5032
83	7.9315	6.9860	7.9216	6.9396	7.8730	6.6021
83.5	8.0492	7.0975	8.0393	7.0504	7.9910	6.7018
84	8.1679	7.2101	8.1580	7.1623	8.1101	6.8024
84.5	8.2876	7.3238	8.2778	7.2752	8.2301	6.9038
85	8.4084	7.4386	8.3986	7.3893	8.3512	7.0061
85.5	8.5302	7.5546	8.5204	7.5045	8.4734	7.1093
86	8.6531	7.6716	8.6433	7.6208	8.5966	7.2134
86.5	8.7770	7.7898	8.7672	7.7382	8.7208	7.3184
87	8.9019	7.9090	8.8922	7.8567	8.8460	7.4243
87.5	9.0279	8.0295	9.0182	7.9763	8.9723	7.5310
88	9.1549	8.1510	9.1452	8.0971	9.0997	7.6386
88.5	9.2830	8.2737	9.2733	8.2189	9.2281	7.7472
89	9.4122	8.3975	9.4025	8.3419	9.3575	7.8566
89.5	9.5424	8.5224	9.5327	8.4661	9.4880	7.9669
90	9.6736	8.6486	9.6640	8.5914	9.6196	8.0781

Annex 4: Volume table of Asna/Saj *(Terminalia alata)*

DBH	Total Volume (M3)		Volume up to top 10 cm (M3)		Volume up to top 20 cm (M3)	
	Overbark	**Underbark**	**Overbark**	**Underbark**	**Overbark**	**Underbark**
5	0.0068	0.0037				
6	0.0106	0.0060				
7	0.0154	0.0089				
8	0.0214	0.0127				
9	0.0286	0.0172				
10	0.0371	0.0227				
11	0.0469	0.0292				
12	0.0580	0.0366				
13	0.0707	0.0451				
14	0.0848	0.0548				
15	0.1004	0.0656	0.0757	0.0497		
16	0.1177	0.0777	0.0934	0.0619		
17	0.1366	0.0911	0.1127	0.0754		
18	0.1572	0.1057	0.1337	0.0902		
19	0.1795	0.1218	0.1564	0.1064		
20	0.2036	0.1393	0.1808	0.1240		
21	0.2296	0.1583	0.2071	0.1430		
22	0.2574	0.1787	0.2352	0.1636	0.0634	0.0136
23	0.2871	0.2008	0.2651	0.1857	0.0972	0.0421
24	0.3187	0.2244	0.2971	0.2093	0.1329	0.0721
25	0.3523	0.2497	0.3309	0.2347	0.1704	0.1037
26	0.3880	0.2767	0.3668	0.2617	0.2099	0.1369
27	0.4257	0.3054	0.4047	0.2904	0.2514	0.1717
28	0.4655	0.3359	0.4447	0.3208	0.2947	0.2082
29	0.5074	0.3682	0.4868	0.3531	0.3401	0.2463
30	0.5514	0.4024	0.5311	0.3872	0.3875	0.2862
30.5	0.5743	0.4201	0.5541	0.4049	0.4120	0.3067
31	0.5977	0.4384	0.5776	0.4231	0.4370	0.3277
31.5	0.6217	0.4571	0.6016	0.4418	0.4625	0.3491
32	0.6462	0.4764	0.6262	0.4610	0.4886	0.3710

DBH	Total Volume (M3)		Volume up to top 10 cm (M3)		Volume up to top 20 cm (M3)	
	Overbark	**Underbark**	**Overbark**	**Underbark**	**Overbark**	**Underbark**
32.5	0.6713	0.4961	0.6514	0.4806	0.5151	0.3934
33	0.6969	0.5163	0.6771	0.5008	0.5423	0.4161
33.5	0.7232	0.5370	0.7035	0.5214	0.5699	0.4394
34	0.7500	0.5582	0.7304	0.5426	0.5981	0.4631
34.5	0.7774	0.5800	0.7578	0.5643	0.6269	0.4873
35	0.8054	0.6022	0.7859	0.5864	0.6562	0.5119
35.5	0.8339	0.6250	0.8145	0.6091	0.6861	0.5370
36	0.8631	0.6483	0.8438	0.6323	0.7166	0.5626
36.5	0.8928	0.6721	0.8736	0.6560	0.7476	0.5887
37	0.9232	0.6964	0.9040	0.6803	0.7792	0.6153
37.5	0.9541	0.7213	0.9350	0.7050	0.8114	0.6423
38	0.9857	0.7468	0.9667	0.7304	0.8441	0.6699
38.5	1.0179	0.7727	0.9989	0.7562	0.8775	0.6979
39	1.0506	0.7993	1.0318	0.7826	0.9114	0.7265
39.5	1.0841	0.8263	1.0652	0.8096	0.9460	0.7555
40	1.1181	0.8540	1.0993	0.8371	0.9811	0.7851
40.5	1.1527	0.8822	1.1340	0.8651	1.0169	0.8152
41	1.1880	0.9110	1.1694	0.8937	1.0532	0.8458
41.5	1.2239	0.9403	1.2054	0.9229	1.0902	0.8769
42	1.2605	0.9703	1.2420	0.9527	1.1278	0.9085
42.5	1.2977	1.0008	1.2792	0.9830	1.1660	0.9407
43	1.3355	1.0319	1.3171	1.0139	1.2048	0.9734
43.5	1.3740	1.0635	1.3557	1.0454	1.2442	1.0067
44	1.4131	1.0958	1.3948	1.0775	1.2843	1.0404
44.5	1.4529	1.1287	1.4347	1.1102	1.3251	1.0748
45	1.4933	1.1622	1.4752	1.1435	1.3664	1.1096
45.5	1.5344	1.1963	1.5163	1.1773	1.4084	1.1451
46	1.5762	1.2310	1.5582	1.2118	1.4511	1.1810
46.5	1.6186	1.2663	1.6006	1.2469	1.4944	1.2176
47	1.6617	1.3022	1.6438	1.2826	1.5384	1.2547
47.5	1.7055	1.3388	1.6876	1.3189	1.5830	1.2923
48	1.7499	1.3759	1.7321	1.3558	1.6283	1.3305

DBH	Total Volume (M3)		Volume up to top 10 cm (M3)		Volume up to top 20 cm (M3)	
	Overbark	**Underbark**	**Overbark**	**Underbark**	**Overbark**	**Underbark**
48.5	1.7951	1.4137	1.7773	1.3934	1.6742	1.3693
49	1.8409	1.4522	1.8232	1.4315	1.7209	1.4087
49.5	1.8874	1.4913	1.8697	1.4704	1.7681	1.4487
50	1.9346	1.5310	1.9169	1.5098	1.8161	1.4892
50.5	1.9824	1.5714	1.9649	1.5499	1.8648	1.5303
51	2.0310	1.6124	2.0135	1.5906	1.9141	1.5720
51.5	2.0803	1.6541	2.0628	1.6320	1.9641	1.6143
52	2.1303	1.6964	2.1128	1.6740	2.0148	1.6571
52.5	2.1810	1.7394	2.1636	1.7167	2.0662	1.7006
53	2.2323	1.7831	2.2150	1.7600	2.1183	1.7447
53.5	2.2844	1.8275	2.2672	1.8040	2.1712	1.7894
54	2.3373	1.8725	2.3200	1.8487	2.2247	1.8346
54.5	2.3908	1.9182	2.3736	1.8940	2.2789	1.8805
55	2.4450	1.9645	2.4279	1.9400	2.3338	1.9270
55.5	2.5000	2.0116	2.4829	1.9867	2.3894	1.9741
56	2.5557	2.0594	2.5387	2.0341	2.4458	2.0218
56.5	2.6122	2.1078	2.5951	2.0821	2.5029	2.0702
57	2.6693	2.1570	2.6523	2.1309	2.5607	2.1192
57.5	2.7272	2.2068	2.7103	2.1803	2.6192	2.1688
58	2.7859	2.2574	2.7690	2.2304	2.6784	2.2190
58.5	2.8452	2.3086	2.8284	2.2813	2.7384	2.2698
59	2.9054	2.3606	2.8885	2.3328	2.7991	2.3213
59.5	2.9662	2.4133	2.9494	2.3850	2.8606	2.3735
60	3.0278	2.4667	3.0111	2.4380	2.9228	2.4262
60.5	3.0902	2.5209	3.0735	2.4916	2.9858	2.4796
61	3.1533	2.5757	3.1367	2.5460	3.0494	2.5337
61.5	3.2172	2.6313	3.2006	2.6011	3.1139	2.5884
62	3.2819	2.6876	3.2653	2.6569	3.1791	2.6437
62.5	3.3473	2.7447	3.3307	2.7135	3.2450	2.6997
63	3.4135	2.8025	3.3970	2.7708	3.3118	2.7564
63.5	3.4804	2.8611	3.4639	2.8288	3.3792	2.8137
64	3.5481	2.9204	3.5317	2.8876	3.4475	2.8717

DBH	Total Volume (M3)		Volume up to top 10 cm (M3)		Volume up to top 20 cm (M3)	
	Overbark	**Underbark**	**Overbark**	**Underbark**	**Overbark**	**Underbark**
64.5	3.6166	2.9805	3.6002	2.9471	3.5165	2.9304
65	3.6859	3.0413	3.6695	3.0073	3.5863	2.9897
65.5	3.7560	3.1029	3.7396	3.0683	3.6568	3.0497
66	3.8268	3.1652	3.8105	3.1301	3.7282	3.1103
66.5	3.8984	3.2283	3.8822	3.1926	3.8003	3.1717
67	3.9708	3.2922	3.9546	3.2558	3.8732	3.2337
67.5	4.0440	3.3569	4.0279	3.3199	3.9469	3.2964
68	4.1180	3.4223	4.1019	3.3847	4.0213	3.3597
68.5	4.1928	3.4885	4.1767	3.4503	4.0966	3.4238
69	4.2684	3.5556	4.2523	3.5166	4.1727	3.4885
69.5	4.3448	3.6233	4.3288	3.5837	4.2495	3.5540
70	4.4220	3.6919	4.4060	3.6516	4.3272	3.6201
70.5	4.5001	3.7613	4.4841	3.7203	4.4056	3.6869
71	4.5789	3.8315	4.5629	3.7898	4.4849	3.7544
71.5	4.6585	3.9025	4.6426	3.8601	4.5650	3.8227
72	4.7390	3.9743	4.7231	3.9311	4.6458	3.8916
72.5	4.8202	4.0469	4.8044	4.0030	4.7275	3.9612
73	4.9023	4.1203	4.8865	4.0756	4.8100	4.0316
73.5	4.9852	4.1946	4.9694	4.1491	4.8934	4.1026
74	5.0690	4.2696	5.0532	4.2234	4.9775	4.1744
74.5	5.1535	4.3455	5.1378	4.2985	5.0625	4.2469
75	5.2389	4.4222	5.2232	4.3744	5.1483	4.3200
75.5	5.3252	4.4998	5.3095	4.4511	5.2349	4.3940
76	5.4122	4.5781	5.3966	4.5286	5.3224	4.4686
76.5	5.5001	4.6573	5.4845	4.6070	5.4107	4.5440
77	5.5889	4.7374	5.5733	4.6862	5.4998	4.6201
77.5	5.6785	4.8183	5.6629	4.7662	5.5898	4.6969
78	5.7689	4.9000	5.7534	4.8471	5.6806	4.7744
78.5	5.8602	4.9826	5.8447	4.9288	5.7723	4.8527
79	5.9523	5.0661	5.9368	5.0113	5.8648	4.9317
79.5	6.0453	5.1504	6.0299	5.0947	5.9581	5.0115
80	6.1392	5.2356	6.1237	5.1789	6.0523	5.0920

DBH	Total Volume (M3)		Volume up to top 10 cm (M3)		Volume up to top 20 cm (M3)	
	Overbark	**Underbark**	**Overbark**	**Underbark**	**Overbark**	**Underbark**
80.5	6.2339	5.3216	6.2185	5.2640	6.1474	5.1732
81	6.3295	5.4085	6.3141	5.3499	6.2433	5.2552
81.5	6.4259	5.4963	6.4105	5.4367	6.3401	5.3380
82	6.5232	5.5849	6.5078	5.5244	6.4377	5.4215
82.5	6.6213	5.6745	6.6060	5.6129	6.5362	5.5057
83	6.7204	5.7649	6.7051	5.7023	6.6356	5.5907
83.5	6.8203	5.8562	6.8050	5.7926	6.7358	5.6765
84	6.9211	5.9484	6.9058	5.8837	6.8369	5.7630
84.5	7.0227	6.0414	7.0075	5.9757	6.9389	5.8503
85	7.1253	6.1354	7.1101	6.0686	7.0418	5.9383
85.5	7.2287	6.2303	7.2135	6.1623	7.1455	6.0271
86	7.3330	6.3260	7.3179	6.2570	7.2502	6.1167
86.5	7.4382	6.4227	7.4231	6.3525	7.3557	6.2070
87	7.5443	6.5203	7.5292	6.4490	7.4621	6.2981
87.5	7.6513	6.6188	7.6362	6.5463	7.5694	6.3900
88	7.7591	6.7182	7.7441	6.6445	7.6775	6.4827
88.5	7.8679	6.8185	7.8529	6.7436	7.7866	6.5762
89	7.9776	6.9197	7.9626	6.8437	7.8966	6.6704
89.5	8.0881	7.0219	8.0732	6.9446	8.0075	6.7654
90	8.1996	7.1250	8.1847	7.0465	8.1192	6.8612
90.5	8.3120	7.2290	8.2971	7.1492	8.2319	6.9578
91	8.4253	7.3339	8.4104	7.2529	8.3455	7.0552
91.5	8.5395	7.4398	8.5246	7.3575	8.4600	7.1534
92	8.6546	7.5466	8.6397	7.4631	8.5753	7.2523
92.5	8.7706	7.6544	8.7558	7.5695	8.6917	7.3521
93	8.8876	7.7631	8.8728	7.6769	8.8089	7.4527
93.5	9.0054	7.8728	8.9906	7.7852	8.9270	7.5540
94	9.1242	7.9834	9.1094	7.8945	9.0461	7.6562
94.5	9.2439	8.0950	9.2292	8.0047	9.1661	7.7592
95	9.3645	8.2075	9.3498	8.1158	9.2870	7.8629
95.5	9.4861	8.3210	9.4714	8.2279	9.4088	7.9675
96	9.6086	8.4354	9.5939	8.3409	9.5315	8.0729

DBH	Total Volume (M3)		Volume up to top 10 cm (M3)		Volume up to top 20 cm (M3)	
	Overbark	**Underbark**	**Overbark**	**Underbark**	**Overbark**	**Underbark**
96.5	9.7320	8.5508	9.7174	8.4549	9.6552	8.1792
97	9.8564	8.6672	9.8418	8.5698	9.7799	8.2862
97.5	9.9817	8.7846	9.9671	8.6857	9.9054	8.3940
98	10.1079	8.9029	10.0934	8.8025	10.0319	8.5027
98.5	10.2351	9.0222	10.2206	8.9203	10.1594	8.6122
99	10.3632	9.1425	10.3487	9.0391	10.2877	8.7225
99.5	10.4923	9.2638	10.4778	9.1588	10.4171	8.8336
100	10.6223	9.3861	10.6078	9.2796	10.5473	8.9456
100.5	10.7533	9.5094	10.7388	9.4012	10.6785	9.0584
101	10.8852	9.6336	10.8708	9.5239	10.8107	9.1720
101.5	11.0181	9.7589	11.0037	9.6476	10.9438	9.2865
102	11.1520	9.8852	11.1375	9.7722	11.0779	9.4018
102.5	11.2868	10.0124	11.2723	9.8978	11.2129	9.5179
103	11.4225	10.1407	11.4081	10.0244	11.3489	9.6349
103.5	11.5592	10.2700	11.5449	10.1520	11.4859	9.7527
104	11.6969	10.4003	11.6826	10.2806	11.6238	9.8714
104.5	11.8356	10.5316	11.8213	10.4102	11.7627	9.9909
105	11.9752	10.6640	11.9609	10.5408	11.9025	10.1113
105.5	12.1158	10.7973	12.1015	10.6724	12.0434	10.2325
106	12.2574	10.9317	12.2431	10.8050	12.1852	10.3545
106.5	12.3999	11.0671	12.3857	10.9386	12.3279	10.4775
107	12.5434	11.2035	12.5292	11.0732	12.4717	10.6012
107.5	12.6879	11.3410	12.6737	11.2089	12.6164	10.7258
108	12.8334	11.4795	12.8192	11.3455	12.7621	10.8513
108.5	12.9799	11.6191	12.9657	11.4832	12.9088	10.9777
109	13.1274	11.7597	13.1132	11.6219	13.0565	11.1049
109.5	13.2758	11.9013	13.2617	11.7617	13.2051	11.2330
110	13.4253	12.0440	13.4111	11.9024	13.3548	11.3619

Annex 5: Volume table of (*Anogeissus latifolius*)

DBH	Total Volume (M3)		Volume up to top 10 cm (M3)		Volume up to top 20 cm (M3)
	Overbark	Underbark	Overbark	Underbark	Overbark
5	0.0081	0.0061			
6	0.0126	0.0097			
7	0.0183	0.0142			
8	0.0253	0.0199			
9	0.0337	0.0268			
10	0.0435	0.0349			
11	0.0549	0.0443			
12	0.0678	0.0552			
13	0.0823	0.0675			
14	0.0985	0.0813			
15	0.1164	0.0967			
16	0.1362	0.1138	0.1121	0.0938	
17	0.1578	0.1325	0.1343	0.1130	
18	0.1812	0.1530	0.1583	0.1339	
19	0.2067	0.1753	0.1842	0.1566	
20	0.2341	0.1994	0.2121	0.1811	
21	0.2635	0.2254	0.2419	0.2075	
22	0.2950	0.2534	0.2738	0.2359	0.0820
23	0.3286	0.2834	0.3078	0.2663	0.1219
24	0.3643	0.3154	0.3439	0.2987	0.1636
25	0.4022	0.3495	0.3821	0.3332	0.2073
26	0.4424	0.3857	0.4226	0.3698	0.2530
27	0.4848	0.4242	0.4654	0.4087	0.3007
28	0.5296	0.4648	0.5104	0.4497	0.3504
29	0.5767	0.5077	0.5577	0.4930	0.4022
30	0.6261	0.5529	0.6074	0.5387	0.4562
30.5	0.6517	0.5763	0.6332	0.5624	0.4840
31	0.6780	0.6004	0.6595	0.5867	0.5123
31.5	0.7048	0.6251	0.6865	0.6116	0.5412
32	0.7323	0.6503	0.7141	0.6371	0.5707

DBH	Total Volume (M3)		Volume up to top 10 cm (M3)		Volume up to top 20 cm (M3)
	Overbark	Underbark	Overbark	Underbark	Overbark
32.5	0.7603	0.6762	0.7423	0.6632	0.6007
33	0.7890	0.7026	0.7711	0.6899	0.6313
33.5	0.8184	0.7297	0.8005	0.7172	0.6625
34	0.8483	0.7574	0.8306	0.7452	0.6943
34.5	0.8789	0.7858	0.8613	0.7738	0.7267
35	0.9102	0.8147	0.8926	0.8030	0.7597
35.5	0.9420	0.8443	0.9246	0.8329	0.7932
36	0.9746	0.8745	0.9572	0.8634	0.8274
36.5	1.0077	0.9054	0.9905	0.8946	0.8622
37	1.0416	0.9369	1.0244	0.9264	0.8976
37.5	1.0760	0.9691	1.0590	0.9588	0.9337
38	1.1112	1.0019	1.0942	0.9920	0.9703
38.5	1.1470	1.0354	1.1301	1.0258	1.0076
39	1.1835	1.0696	1.1667	1.0602	1.0456
39.5	1.2206	1.1044	1.2039	1.0954	1.0842
40	1.2585	1.1399	1.2418	1.1312	1.1234
40.5	1.2970	1.1761	1.2804	1.1677	1.1633
41	1.3362	1.2130	1.3197	1.2049	1.2038
41.5	1.3761	1.2505	1.3597	1.2428	1.2450
42	1.4167	1.2888	1.4004	1.2814	1.2868
42.5	1.4580	1.3277	1.4417	1.3207	1.3294
43	1.4999	1.3673	1.4838	1.3607	1.3726
43.5	1.5426	1.4077	1.5265	1.4014	1.4164
44	1.5860	1.4487	1.5700	1.4428	1.4610
44.5	1.6301	1.4905	1.6141	1.4850	1.5062
45	1.6749	1.5330	1.6590	1.5278	1.5522
45.5	1.7204	1.5762	1.7046	1.5714	1.5988
46	1.7666	1.6201	1.7509	1.6158	1.6461
46.5	1.8136	1.6648	1.7980	1.6609	1.6941
47	1.8613	1.7102	1.8457	1.7067	1.7429
47.5	1.9097	1.7563	1.8942	1.7532	1.7923
48	1.9589	1.8032	1.9434	1.8005	1.8425

DBH	Total Volume (M3)		Volume up to top 10 cm (M3)		Volume up to top 20 cm (M3)
	Overbark	Underbark	Overbark	Underbark	Overbark
48.5	2.0088	1.8508	1.9934	1.8486	1.8933
49	2.0594	1.8992	2.0440	1.8974	1.9449
49.5	2.1108	1.9483	2.0955	1.9470	1.9973
50	2.1629	1.9982	2.1477	1.9973	2.0503
50.5	2.2157	2.0488	2.2006	2.0485	2.1041
51	2.2693	2.1002	2.2543	2.1003	2.1586
51.5	2.3237	2.1524	2.3087	2.1530	2.2139
52	2.3788	2.2053	2.3639	2.2065	2.2699
52.5	2.4347	2.2591	2.4198	2.2607	2.3266
53	2.4914	2.3136	2.4765	2.3157	2.3841
53.5	2.5488	2.3689	2.5340	2.3715	2.4424
54	2.6070	2.4249	2.5923	2.4282	2.5014
54.5	2.6660	2.4818	2.6513	2.4856	2.5611
55	2.7257	2.5395	2.7111	2.5438	2.6217
55.5	2.7862	2.5979	2.7717	2.6028	2.6830
56	2.8476	2.6572	2.8330	2.6627	2.7450
56.5	2.9096	2.7173	2.8952	2.7233	2.8079
57	2.9725	2.7782	2.9581	2.7848	2.8715
57.5	3.0362	2.8399	3.0218	2.8471	2.9359
58	3.1007	2.9024	3.0863	2.9102	3.0011
58.5	3.1659	2.9658	3.1517	2.9742	3.0670
59	3.2320	3.0299	3.2178	3.0390	3.1338
59.5	3.2989	3.0949	3.2847	3.1046	3.2014
60	3.3666	3.1608	3.3524	3.1711	3.2697
60.5	3.4351	3.2274	3.4210	3.2385	3.3389
61	3.5044	3.2949	3.4903	3.3066	3.4088
61.5	3.5745	3.3633	3.5605	3.3757	3.4796
62	3.6454	3.4325	3.6315	3.4456	3.5511
62.5	3.7172	3.5025	3.7033	3.5163	3.6235
63	3.7897	3.5735	3.7759	3.5879	3.6967
63.5	3.8631	3.6452	3.8493	3.6604	3.7707
64	3.9374	3.7178	3.9236	3.7338	3.8455

DBH	Total Volume (M3)		Volume up to top 10 cm (M3)		Volume up to top 20 cm (M3)
	Overbark	Underbark	Overbark	Underbark	Overbark
64.5	4.0124	3.7913	3.9987	3.8080	3.9212
65	4.0883	3.8657	4.0747	3.8831	3.9977
65.5	4.1651	3.9409	4.1514	3.9591	4.0750
66	4.2427	4.0170	4.2291	4.0360	4.1531
66.5	4.3211	4.0940	4.3075	4.1138	4.2321
67	4.4004	4.1719	4.3868	4.1924	4.3119
67.5	4.4805	4.2506	4.4670	4.2720	4.3926
68	4.5614	4.3303	4.5480	4.3524	4.4741
68.5	4.6433	4.4108	4.6299	4.4338	4.5564
69	4.7259	4.4922	4.7126	4.5161	4.6396
69.5	4.8095	4.5746	4.7962	4.5993	4.7237
70	4.8939	4.6578	4.8806	4.6834	4.8086
70.5	4.9791	4.7419	4.9659	4.7684	4.8943
71	5.0653	4.8270	5.0521	4.8543	4.9810
71.5	5.1523	4.9129	5.1391	4.9412	5.0684
72	5.2402	4.9998	5.2270	5.0289	5.1568
72.5	5.3289	5.0876	5.3158	5.1177	5.2460
73	5.4185	5.1763	5.4055	5.2073	5.3361