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Estimating Tree Biomass of Sub-Saharan African Forests: a Review of Available Allometric Equations

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In response to the growing interest in estimating carbon stocks in forests, available allometric equations have been compiled for sub-Saharan Africa. Tree, sprout and stand volume and biomass equations were reviewed. The 850 equations and 125 related references were incorporated into an open-access database on the Carboafrica website (http://www.carboafrica.net). The collected information provides a basic tool for the estimation of biomass and carbon stocks and other purposes, such as bioenergy and fodder supply assessment. A Tier-method approach was developed to illustrate the possible use of the equations. Current available biomass expansion factors that are used to convert a volume to the total aboveground biomass appear to be limited; incomplete species-specific allometric equations are preferred to generalised equations. The analysis of the database highlighted important gaps in available tools to assess forest carbon stocks and changes in these stocks. A quality control assessment revealed that 22% of the equations were misreported and recommendations were proposed to guide further research. Further statistical analyses, such as the Bayesian approach, would help to produce more accurate biomass estimates.

Keywords aboveground biomass, databases, inventories, models, Tier method,
wood specific gravity
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1 Introduction

After a gap in scientific research of approximately 30 years, interest in forest biomass is again growing (Zianis et al. 2004). Traditionally, the determination of aboveground tree biomass has been conducted to ensure sustainable management of forest resources. Fuel wood management has motivated the calculation of biomass equations, whereas timber management has mainly driven volume equations. Today, the accurate estimation of forest biomass is crucial for many applications, from the commercial use of wood (Morgan and Moss 1985) to the global carbon (C) cycle (Bombelli et al. 2009). Because of interest in the global C cycle, estimating aboveground biomass with sufficient accuracy to establish the increments or decrements of C stored in forests is increasingly important. Forests form a major component of the C reserves in the world's ecosystems (Houghton 2007) and greatly influence both the lives of other organisms and human societies (Whittaker and Likens 1975). Trees also play a key role in the global C cycle. Managing forests through agroforestry, forestry and plantation systems is seen as an important opportunity for climate change mitigation and adaptation (IPCC 2007, Canadell and Raupach 2008).

Afforestation and reforestation (A/R) project activities are eligible under the Clean Development Mechanism (CDM) of the Kyoto Protocol (UN 1998) of the United Nations Framework Convention on Climate Change (UNFCCC). Consequently, allometric equations are needed to estimate the changes in C stocks that result from afforestation activities with the aim to implement A/R CDM projects worldwide (including Africa). Furthermore, the current (2010) negotiations on Reducing Emissions from Deforestation and forest Degradation and the role of conservation, sustainable forest management and enhancement of forest C stocks in developing countries (REDD+) under the next commitment periods of the Kyoto protocol have focused even more attention on methods for estimating biomass and C stocks (UNFCCC 2009). Under the UNFCCC, countries have to regularly report the state of their forest resources. Under emerging mechanisms such as REDD+, they are likely to require high-resolution temporal and spatial assessments of C stocks. Except in the very rare cases where a whole tree population can be harvested to determine its biomass (Augusto et al. 2009), the tree biomass is generally determined based on forest inventory data and allometric equations. The allometric method uses allometric equations to estimate the whole or partial (by compartments) mass of a tree from measurable tree dimensions, including trunk diameter and height (Kangas and Maltamo 2006). Thus, the dendrometric parameters of all of the trees are measured and the allometric equation is then used to estimate the stand biomass by summing the biomass of individual trees. When building allometric equations for an individual tree, sprout or stand, different methods (destructive or not) may be considered. Destructive methods directly measure the biomass by harvesting the tree and measuring the actual mass of each of its compartments, (e.g., roots, stem, branches and foliage) (Kangas and Maltamo 2006). Indirect methods are attempts to estimate tree biomass by measuring variables that are more accessible and less time-consuming to assess (e.g., wood volume and gravity) (Peltier et al. 2007). Weighing trees in the field is undoubtedly the most accurate method of estimating aboveground tree biomass, but it is time-consuming and is generally based on small sample sizes.

Species-specific allometric equations are preferred because tree species may differ greatly in tree architecture and wood gravity (Ketterings et al. 2001). However, in a tropical forest stand, more than 300 tree species may be found (Gibbs et al. 2007) and allometric equations should represent the variability of biomass for those species. As highlighted by McWilliam et al. (1993), destructive harvesting to build allometric models is seldom conducted in the tropics and sample plot sizes have been small compared to the scale of species diversity patterns; therefore, results may not be representative. Grouping all species together and using generalised allometric relationships that are stratified by broad forest types or ecological zones has been highly effective in the tropics (Brown 2002). However, there are very few allometric equations for sub-Saharan Africa. None of the trees used by Chave et al. (2005) to develop generalized allometric equations was from African forests. Zianis and Mencuccini (2004) reported 279 allometric equations from all of the continents except for Africa. While some authors have inventoried allometric functions for trees of South America (Návar 2009) and Europe (Zianis et al. 2005), we are not aware of any inventory of allometric equations for the trees of sub-Saharan Africa (SSA). Similarly, we know of no attempt to estimate tree biomass for SSA using already existing and incomplete allometric equations. This problem is not only relevant for scientific purposes. Indeed, obtaining financial rewards for sequestered C, or for emission reductions from management of terrestrial biomass (currently of great interest to many), will require the ability to control for the uncertainties and biases involved in using inaccurate biomass equations.

The aims of this work are (1) to make a survey of the allometric equations that could be used for biomass and C stock estimation in SSA, (2) to organize them in a way that could make them useful in the framework of the Clean Development Mechanism of the Kyoto protocol or the nascent REDD+ mechanism, including the identification of gaps for some forest ecosystems and (3) to analyse the potential of using already existing allometric equations to estimate tree biomass and C stocks in comparison to generalized allometric equations.

2 Material and Methods

2.1 Data Compilation and Classification

Data collection focused on wood gravity, volume and biomass equations for assessments of individual trees, sprouts and stands. Biomass is defined as the oven-dry weight of organic matter (kg/tree or tons/ha depending on the studied subject). Wood gravity is defined as the oven-dry weight (in mega grams) divided by the green volume (in m^3) of the sample. To compile the available information, a literature survey was conducted in libraries worldwide (e.g., The World Agroforestry Centre ICRAF, the C*entre de Coopération Internationale en Recherche Agronomique pour le Développement* CIRAD, the Institut de Recherche pour le Développement IRD, the Institut National de Recherche Agronomique INRA, the Paris Institute of Technology for Life, Food and Environmental Sciences AgroParisTech-ENGREF, The Forest Research Institute of Ghana FORIG and The Food and Agriculture Organization of the United Nations FAO). A search was also conducted of articles in 31 forest-related journals (Appendix A). The data compilation included theses, reports, conference proceedings and publications. No selection criteria (such as R^2-values, species, ages, sizes, site conditions, or sampling methods) were applied *a priori*.

The equations reported different tree compartments, including the stem wood and bark, stump, thin and gross branches, leaves and roots (Fig. 1). Because it is difficult to measure the volume of the leaves or thin branches, the volume equations did not consider all of the tree compartments but focused on the bole and the merchantable compartments. Merchantable volume excluded non-merchantable aboveground compartments such as tree tops, branches, twigs, foliage, stumps (sometimes excluded) and roots. On the other hand, biomass equations often considered more compartments that have fodder (leaves) or firewood (twigs) purposes.

The data were georeferenced using the geographical location (longitude, latitude, name of the location). When only the name of the location was available, the geographic coordinates were obtained using administrative maps and Google Earth. Among the 850 equations that were collected, 495 were georeferenced (Fig. 2) and these corresponded to 89 sites in SSA. The sites were spatially represented using ArcGIS 9.3 (ESRI 2008) and each site was categorised according to the ecological classification from the FAO Forestry Resource Assessment (FAO 2001). Twenty-four generalised equations (Brown 1997, Ponce-Hernandez 2004, Chave et al. 2005) were selected because they were the equations most commonly used to estimate biomass and C in SSA. Climatic parameters, such as precipitation, were obtained using the Local Climate Estimator FAO software (FAO 2005).

Additional classifications were achieved according to the ecosystem type (plantation or natural vegetation) and the level of population (individual tree, sprouts and stand) considered. Many combinations of factors are used to predict biomass.

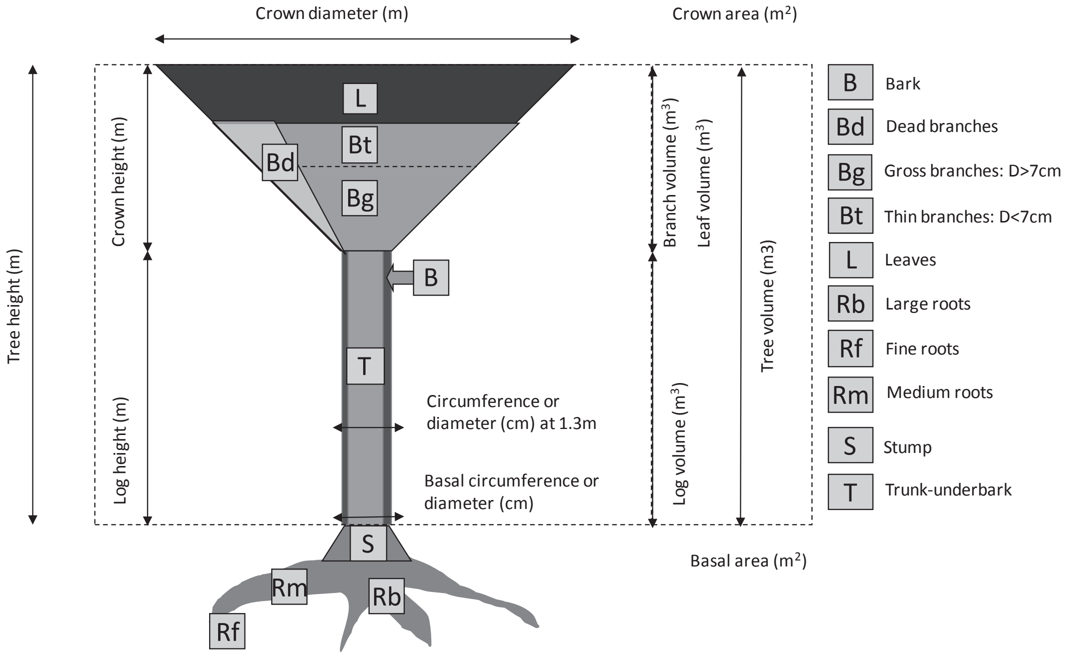

Fig. 1. Representation of the different tree components referred to in this study. The different dendrometric parameters are represented on the diagram. The diameter at breast height (D1.3) is measured at a height of 1.3 m, whereas B0 is measured at base of the tree or at collar height. The different tree components are represented by letters. The volume under bark corresponds to the volume of the trunk component T, whereas the volume over bark corresponds to the components T and B. The log height and volume correspond to the height of component T. The rooting system is divided into Rb, Rm and Rf according to the size of the roots (Rb: diameter > 10mm, Rf: diameter < 5 mm, and 5 mm < Rm diameter < 10 mm).

While some equations predicted the volume or the biomass of a stand according to age or precipitation, others predicted the biomass of a sprout by the stem length, whereas still others predicted the biomass and the volumes of individual trees based on their diameters.

For individual trees, the variables considered were the diameter and the circumference at the base of the tree (D_0, C_0) and at 1.30 m height ($D_{1.3}$, $C_{1.3}$), the stem cross-sectional area at 1.30 m, the total tree height, trunk height and merchantable height, the crown diameter and vertically-projected area, the crown height and the wood gravity.

For stands biomass assessments, the variables considered were the mean annual rainfall, the stand dominant height, the stand basal area or the sum of the stem cross-sectional areas at the base of the trees, the stand age, and the wood gravity.

Because a given equation can be cited in various documents, informations were filtered to avoid redundancy. In the final data set, one equation represents only one tree species or one group of tree species in one location. On the other hand, the same equation can be used in two or more places and for one given location, different equations can be found for the same species.

2.2 Quality Control Assessment

This control simply consists in flagging each equation in order to facilitate their use in the database. Equations were examined in the following three steps: 1) standardization of the output variable, 2) identification of the interval of consistency and 3) assigning an indicative flag on the quality of the equations. As recommended

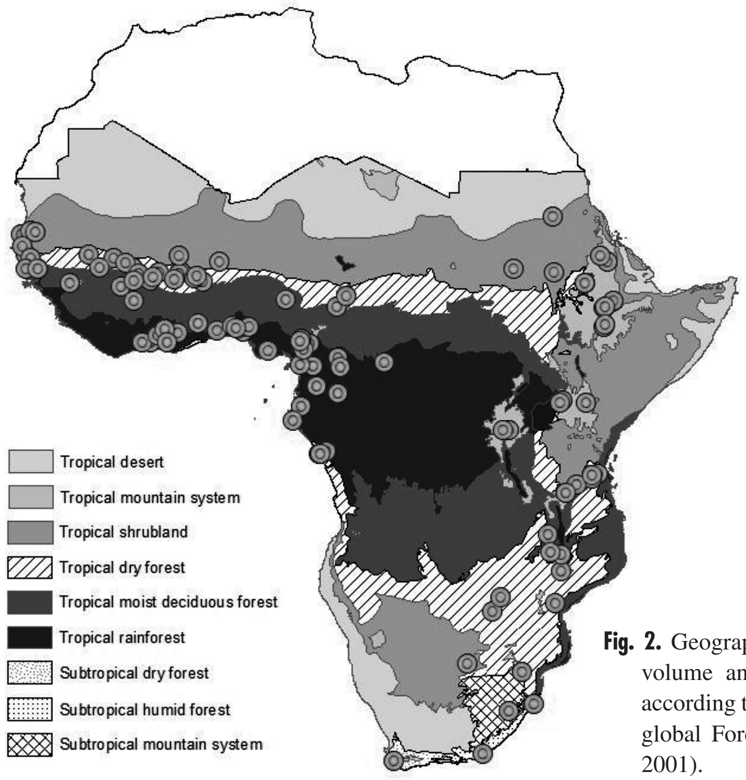

Fig. 2. Geographic distribution of the available volume and biomass allometric equations according to the global ecological zoning for global Forest Resources Assessment (FAO 2001).

by the UNFCCC, any user of the database should perform its own quantitative and statistical evaluation before using any of the reported equations. As equations do not necessarily predict the same quantity, comparing equations first requires standardizing the output variable to a common quantity. The standardization consisted in converting the output of the equation into total aboveground biomass. The conversion was achieved using the available conversion coefficients and biomass proportions. The volume was converted using the mean species-specific average wood gravity. The species-specific wood gravities for Africa were collected from various databases (including Chudnoff 1984; Lemmens et al. 1995, Faridah Hanum 1997, CIRAD 2009, Hong et al. 2009, ICRAF 2009, Oxford Forestry Institute 2009). Specific wood gravity was collected from 3812 tree and 1256 plant species growing in Africa. When the authors did not report the total biomass the missing biomass was estimated biomass proportions respective to the missing components. When only merchatable volume was available, total biomass was estimated from this volume, the mean wood gravity and biomass proportions. This assumes the identical distribution of the wood gravity within and between tree of the sames species (as done for example in Chave et al. 2005). The biomass proportions were obtained from the only published average biomass proportions for a species growing in sub-Saharan Africa. This study concerned *Eucalyptus* (E.) plantations in Congo: 45, 6.5, 4, 11, 5.5, 8, 1.8, 8, 2, and 8.2% for the trunk (T), gross branches (Bg), thin branches (Bt), leaves (L), bark (B), stump(S), dead branches (Bd) and large (Rg), medium (Rm) and fine roots (Rf), respectively (Saint-André et al. 2005). We acknowledge that this conversion is certainly too straightforward, however, in the absence of more detailed data for sub-saharan Africa and considering the framework of this part (consistency assessment), we kept these values as proxys for biomass expansion factors.

The second step consisted of controlling the interval of calibration (Fig. 3). The interval of calibration was not always mentioned and it was

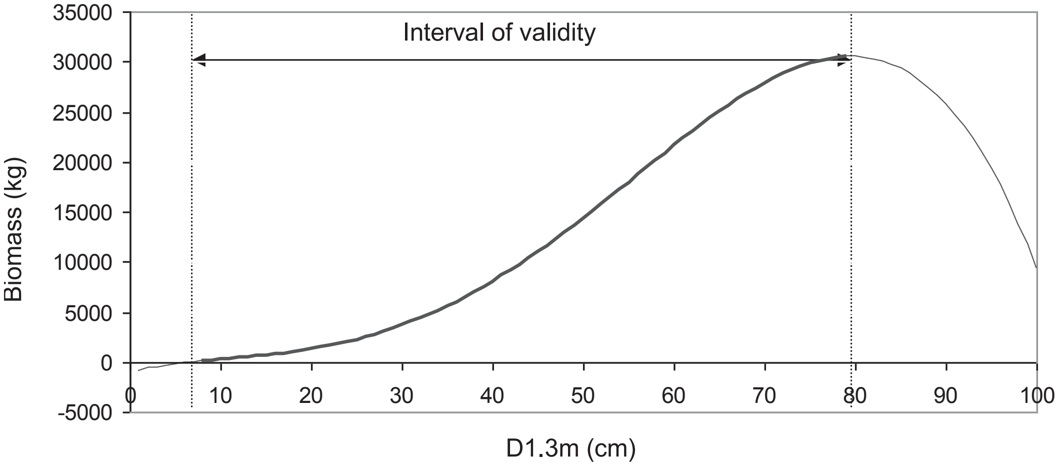

Fig. 3. Control of the interval of calibration. The figure represents the method used to identify the minimum and the maximum tree diameter at 1.3m height when the range of calibration was not specified by the author of a study. The black line represents the selected portion of the function. The grey dotted line represents the portion that was considered to be erroneous (negative and decreasing biomass). The figure uses equation 382 as an example.

impossible to access all of the data used to build the 850 models. Moreover, the quality control assessment resulted in the calculation of a new interval of calibration and, when possible, made comparisons with the published information (Fig. 3). The interval of calibration was calculated considering that volume and biomass should be positive and should increase with $D_{1.3}$.

The third step consisted of identifying the consitency of the equations. Because some of the equations were erroneously reported in the literature, we developed an indicative criterion based on the percentage of estimated biomass within a realistic interval. This interval was named interval of possibility and was defined as the interval from 0 to twice the average biomass, where:

$$Volume_{average} = \pi \times (DBH / 200)^2 \times H \times 0.5 \quad (1)$$

Where DBH is in cm and H is in m.

$$H = \exp(1.0710 + 0.5677 \times \log(DBH)) \quad (2)$$

Tree height equation was obtained form Brown et al. (1989).

$$Biomass_{average} = Volume_{average} \times 0.62 \times 10^3 \quad (3)$$

where 0.62×10^3 is the average wood gravity (Mg m^{-3}) given by the Intergovernmental Panel on Climate Change (IPCC 2006) and 0.5 is the average coefficient form for conic trees (CIRAD and MAE 2004).

Three flags were then built to help the user in using the database: quality 1 is the lowest one (less than 90% of the estimated values of volume or biomass fall within the interval of possibility), quality 2 (more than 90% of the estimated values fall within the interval of possibility but the number of samples and r^2 values of the equations were not specified) and quality 3 is the best one (n, r^2 and the range of calibration were specified and more than 90% of the estimated values fall within the interval of possibility).

2.3 Comparison of Tier Methods

The Tier method proposed in this article refers to the Tier approach proposed by the IPCC in which catalogues of equations as done here for sub-saharan Africa may be very usefull. A tier represents a level of methodological complexity. Three tiers were provided in this study. Tier-1 was the basic method (based on generalized equation), Tier-2 an intermediate one (based on volume equation and wood gravity) and finally Tier-3, the most demanding in terms of complexity and data requirements (based on biomass equation). The precision for a given species generally increases with the number of the tier method.

The Tier-1 was proposed when no species-specific equations existed and a generalised equation for the ecological zone was used.

The Tier-2 was proposed when species-specific volume equations exist. The volume was then converted to biomass using a wood gravity and a default biomass expansion factor (IPCC 2003) or a default biomass conversion and expansion factor (IPCC 2006).

Aboveground biomass was computed from merchantable biomass using:

$$Biomass_{partial} = V \times WD \text{ and}$$
$$Biomass = Biomass_{partial} \times BEF \qquad (4)$$

Or directly by

$$Biomass = V \times BCEF \qquad (5)$$

Where $biomass_{partial}$ is the biomass of the merchantable volume (kg), V is the merchantable volume (m^3), WD is the wood gravity ($kg\ m^{-3}$), BEF is the biomass expansion factor and $BCEF$ is the biomass conversion and expansion factor.

The Tier-3 consisted of using a species-specific biomass equation to calculate either the total or the partial biomass. Partial biomass was obtained by summing the biomass estimates obtained from the species-specific equations for the different compartments or by using a BEF when the equation was giving a merchantable biomass.

In the following text, the various tiers are denoted Tier-1, Tier-2, Tier-3-partial and Tier-3-total. When different equations were available for the same tier method, the equation with the best quality-flag was selected. In the absence of true datasets to test the equations, we assumed Tier-3-total biomass as the reference value. However, in practice, this should be done by the user of the database before applying the equations to his case studies.

The proposed approach to assess total aboveground biomass from volume or partial biomass assumes the additivity among the components of tree biomass. Parresol (2001) indicated that the use of nonlinear joint-generalized regression is a superior procedure than using a simple combination approach. However, this was rarely done before 2000 (i.e. most of the reported equations were fitted compartment by compartment from linear regression procedures) and our study was limited by the fact that few allometric equations were available for all tree components at a given location (the only study reporting the biomass proportion of the different tree components was the one by Saint-André et al. 2005). We chose *Acacia senegal* to provide a comparison using different tier levels. A comprehensive set of species-specific equations was reported for *Acacia senegal*, including equations for trunk, gross branches, thin branches, aboveground, belowground and total dry biomasses, aboveground fresh biomass, and trunk volume. The tier method was then applied for other tree species and for multi-species equations for different ecological zones.

2.4 Data Analyses and Access

The equations and the wood gravity data were compiled and made available on the website of the Carboafrica project (www.carboafrica.net). The volume and biomass equations and the information used in this article are presented in Appendix B and Appendix C, respectively. Computation of the interval of possibility and quality control assessments were achieved using MATLAB (The MathWorks 2005). This allowed for the identification of the range of calibration. Fisher least significant difference tests were used to compare wood density values using XLSTAT (AddinSoft 2003).

2.5 Correcting the Bias of a Model Fitted on Log-Transformed Data

Many of the biomas and volume equations presented in Appendix B and C were fitted in the logarithmic scale. When the logarithmic transformation is used, it is usually desirable to express estimated values of Y in arithmetic. However, the conversion of the unbiased logarithmic estimates of the mean and variance to arithmetic is not direct. If exponential functions are applied to the unbiased predictor in the logarithmic scale, the obtained predictor is biased in the arithmetic scale. If ln(Y) has a normal distribution with mean β ln(X) and standard deviation σ, the expectation of the log-normal distribution with parameter β ln(X) and σ is:

$$E(Y) = \exp\left(\beta \ln(X) + \frac{\sigma^2}{2}\right)$$

Hence, when deriving the equations in arithmic scale, predictions have to be multiplied by $\exp(\sigma^2/2)$ (Parresol 1999). When the base 10 logarithm is used instead of the natural logarithm, the correction factor is $\exp[(\sigma \ln(10)^2/2]$. While some authors (e.g. Chave et al. 2005) included the correction factors in the equations, most of the other authors did not. In this study, we took as reference the equations reported by the authors without considering the correction factor.

3 Results

3.1 Description of the Database

3.1.1 Information Sources

Data collection was based on 125 references, most of which were reports (n= 52) or articles (n = 51). In addition, nine sources were MSc or PhD theses, six were books or book sections and seven were conference proceedings. Data from various sources is preferable for meta-analyses (Scargle 2000). If this analysis had focused only on scientific journals, 72% of the information would not have been included. The resulting study would have been biased and would have not reflected verified and reliable data (27% of the equations published in the scientific journals were considered to be quality 1 equations, but this percentage was 22% for the entire dataset (Table 1, Appendix A and Appendix B).

3.1.2 Geographic Distribution of the Equations

Volume and biomass equations were unevenly distributed among countries (Fig. 2). Most of the volume equations (44%) were developed in Nigeria (n = 88), Gabon (n = 84), Ivory Coast (n = 73) and Mali (n = 42) (Table 1). Most of the biomass equations (70%) were developed in Ethiopia (n = 63), Senegal (n = 56), South Africa (n = 38), Mali (n = 38), Botswana (n = 24) and Congo (n = 22). Twenty-nine of the 52 SSA countries, representing 73% of the total area of SSA, had one or more volume or biomass equations. From the 850 equations that were found for SSA, most (52%) were for Western Africa. The countries with the greatest number of equations were Nigeria (13%), Mali (9%), Ivory Coast (9%) and Senegal (9%).

Most of the equations found were for tropical rainforests (43%), tropical dry forests (16%), tropical moist forests (11%), shrublands (13%) and tropical mountain forests (13%). Tropical deserts, subtropical humid and dry forests and subtropical mountain forests represented less than 1% (Fig. 4). Most of the volume equations were developed for tropical rainforests (63%). On the other hand, most of the biomass equations were developed for tropical shrublands (23%), tropical dry forests (23%) and tropical mountain forests (21%), whereas equations for tropical rainforests and the tropical moist deciduous zones represented only 13 and 12%. Only six biomass equations were found for the sub-tropical zones. In total, 17 countries had biomass equations that predicted the total aboveground biomass for at least one ecological zone. Considering that at least one equation would be needed to estimate the biomass of each ecological zone within each country, we estimated that fewer than 18% of the equations needed were available when the study was conducted. This estimate was very conservative; when considering the 18 vegetation classes that are generally considered in national forest inventories (FAO 2004), only 1% of the needed equations were available.

The equations'outputs differed between ecological zones. For tropical shrublands, most equations were to calculate biomass (79%), whereas for tropical rainforests, most were for volume

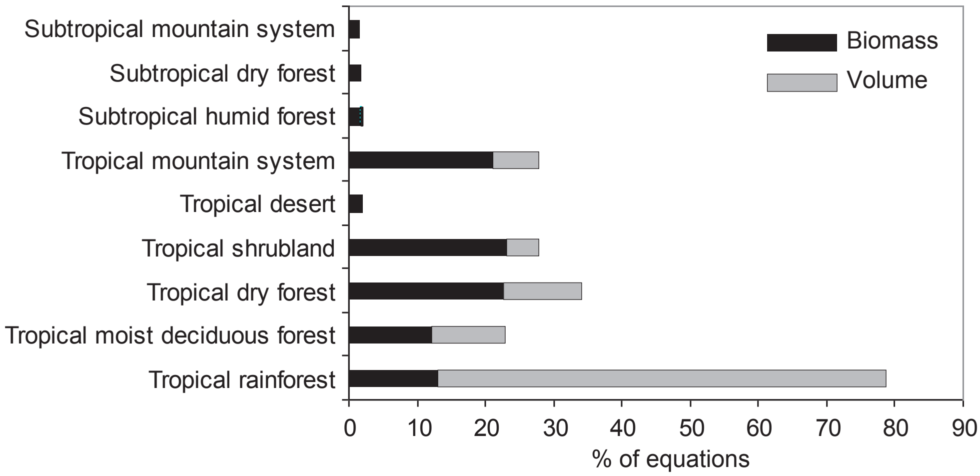

Fig. 4. Distribution of volume and biomass equations in the FAO ecological zones.

(88%). In the tropical dry zone, biomass estimates were crucial for estimating the availability of bioenergy, whereas in the humid tropics, estimation of merchantable timber volume was used to assess the profitability of forestry operations. At the time of this study, only two biomass equations were found for estimation of total tree biomass in tropical rainforests. The first was developed to estimate forest regeneration in Cameroon (Deans et al. 1996), whereas the second was developed to estimate the biomass of a tropical rainforest in Ghana (Henry et al. 2010). The other total aboveground biomass equations were developed for tree plantations.

3.1.3 Predictors of Tree Volume and Biomass

The $D_{1.3}$ was the most frequent predictor of tree biomass (63%), although 12% of the equations used the tree circumference (Appendix A and Appendix B). When considering the volume equations, $D_{1.3}$ was also the most common predictor (65%) whereas circumference and height were used in 12 and 9% of the equations, respectively. More combinations of the predictors were used for biomass equations than for volume. Indeed, $D_{1.3}$ was used in 49% of the biomass equations, whereas height, circumference, basis circumference and basal area were used in 15, 8.6 and 6% of the equations, respectively. Additionally, the diameter and circumference at the base of the tree were used only in equations for tropical shrublands and tropical dry forests. Most of the equations used only one predictor (74%) whereas 24 and 2% of the equations used two and more than two predictors, respectively. In the later case, risks of multicolinearity exist but most of these equations use three different variables instead of using a single variable raised to different powers.

3.1.4 Tree Species

While 80% of the equations focused on natural ecosystems, 20% dealt with plantations (Table 1). Only 12 and 32% of the volume and biomass equations focused on plantations, respectively. In total, 263 tree species were considered. In 14.8% of the equations, the tree species was not specified. The exact number of tree species in sub-Saharan Africa is unknown (Newton and Oldfield 2008), but assuming a total of 227 studied natural tree species and 11,342 existing tree species in SSA (FAO 2006), it appears that only 2% of the tree species in SSA were analysed in this study (Table 1). Tropical rainforests and dry forests accounted for 42 and 16%, respectively, of the total tree species (Appendix A and Appendix B). Most of the generalised volume equations were developed for tropical dry forests (n=28) and tropical rainforests (n=17), particularly in Burkina Faso, Tanzania, Ghana and Ivory Coast (Table 2). Generalised volume equations were not

Table 1. Statistics on registered volume- and biomass equations for sub- Saharan African countries.

Region and country	Quality control (%)	n equations			Tree species		Estimated number of natural tree species	% of unknown tree species
		Total	Biomass	Volume	n plantation	n natural		
EASTERN AFRICA								
Burundi	–	–	–	–	–	–	–	–
Comoros	–	–	–	–	–	–	62	–
Djibouti	–	–	–	–	–	–	–	–
Eritrea	–	–	–	–	–	–	–	–
Ethiopia	1 (36), 2 (50), 3 (15)	64	63	1	4	18	1027	98
Kenya	1 (5), 2 (71), 3 (24)	15	11	4	8	14	–	–
Madagascar	–	–	–	–	–	–	5000	–
Malawi	1 (0), 2 (91), 3 (9)	21	0	21	7	21	–	–
Mauritius	–	–	–	–	–	–	194	–
Mozambique	1 (0), 2 (71), 3 (29)	5	4	–	–	5	–	–
Rwanda	1 (18), 2 (67), 3 (15)	22	0	22	1	16	300	95
Seychelles	–	–	–	–	–	–	93	–
Somalia	1 (0), 2 (100), 3 (0)	2	2	0	2	2	–	–
Uganda	1 (30), 2 (70), 3 (0)	7	4	3	–	4	–	–
Tanzania	1 (4), 2 (60), 3 (36)	27	7	20	4	25	–	–
Zambia	1 (0), 2 (100), 3 (0)	7	4	3	3	7	665	99
Zimbabwe	1 (0), 2 (100), 3 (0)	4	2	2	1	4	1747	100
Total	1 (9), 2 (78), 3 (13)	174	97	76	9	28	–	–
MIDDLE AFRICA								
Angola	–	–	–	–	–	–	–	–
Cameroon	1 ( ), 2 ( ), 3 ( )	24	13	11	7	20	600	97
CAR	1 (0), 2 (79), 3 (21)	11	0	11	9	11	–	–
Chad	1 (0), 2 (100), 3 (0)	1	1	0	1	1	109	99
Congo	1 (47), 2 (51), 3 (2)	29	22	7	2	2	334	99
DRC	–	–	–	–			870	–
Equatorial Guinea	1 (0), 2 (100), 3 (0)	2	0	2	–	–	–	–
Gabon	1 (2), 2 (68), 3 (31)	84	0	84	77	82	–	–
Sao Tome and Principe	–	–	–	–			–	–
Total	1 (10), 2 (79), 3 (11)	151	36	115	5	85	–	–
NORTHERN AFRICA								
Sudan	1 (0), 2 (75), 3 (25)	6	1	5	4	6	533	–
Total	1 (0), 2 (75), 3 (25)	6	1	5	4	0	–	–
SOUTHERN AFRICA								
Botswana	1 (2), 2 (83), 3 (14)	36	31	5	4	6	–	–
Lesotho	–	–	–	–	–	–	60	–
Namibia	1 (0), 2 (100), 3 (0)	7	7	–	17	35	200	83
South Africa	1 (34), 2 (51), 3 (16)	38	37	1	–	–	649	–
Swaziland	–	–	–	–	7	7	–	–
Total	1 (12), 2 (78), 3 (10)	81	75	6	8	27	–	–
WESTERN AFRICA								
Benin	–	2	0	2	–	–	–	–
Burkina Faso	1 (0), 2 (83), 3 (17)	19	10	9	–	–	90	–
Cape Verde	–	–	–	–	1	2	240	99
Gambia	–	–	–	–	–	–	140	–
Ghana	1 (22), 2 (71), 3 (7)	39	2	37	29	64	680	91
Guinea	–	–	–	–	–	–	–	–
Guinea-Bissau	1 (0), 2 (89), 3 (11)	16	0	16	–	27	2243	99
Ivory Coast	1 (10), 2 (77), 3 (13)	74	2	72	6	19	–	–

Liberia	–	–	–	–	–	–	–	–
Mali	1 (0), 2 (85), 3 (15)	79	37	42	15	16	1739	99
Mauritania	–	–	–	–	–	–	52	–
Niger	1 (33), 2 (67), 3 (0)	2	2	0	27	79	227	65
Nigeria	1 (19), 2 (71), 3 (10)	108	20	88	–	–	560	–
Saint Helena	–	–	–	–	1	1	–	–
Senegal	1 (0), 2 (78), 3 (22)	76	68	–	77	79	315	75
Sierra Leone	–	–	–	–	–	–	213	–
Togo	–	–	–	–	13	76	1451	95
Total	1 (11), 2 (77), 3 (12)	415	141	266	9	124	–	–
GENERALIZED		23	23	–	–	–	–	–
TOTAL	1 (22), 2 (61), 3 (17)	850	373	468	26	227	11342	98

The number of natural tree species was obtained from FAO (2006).
CAR : Central African Republic, DRC : Democratic Republic of Congo
The percentages of values found in three quality levels are shown in brackets. The three quality levels were identified as quality 1 (the interval of possibility is lower than 90%), quality 2 (the equation is within the interval of possibility but with no records of sampling methods or correlation) and quality 3 (n, r^2 and the calibration ranges were specified and the interval of possibility was higher than 90%). The % of unknown tree species represents the percentage of tree species without any allometric equation.

found for subtropical zones or tropical deserts. Most of the generalised biomass equations were developed for tropical dry forests (n=25), particularly in Cameroon, Mali, Senegal and Tanzania (Table 2). Generalised biomass equations were not found for subtropical dry forests, subtropical mountain forests, tropical deserts, or tropical mountain forests.

Volume equations were found for 191 tree species (Table 3). The tree species most frequently studied for volume were *Terminalia superba* (n = 28), *Grevillia robusta* (n = 16), *Triplochiton scleroxylon* (n = 10) and *Vitellaria paradoxa* (n = 10). Those tree species represented 14% of the total number of volume equations. Biomass equations were found for 77 tree species (Table 4). The most commonly studied tree species for biomass, representing 23% of the total number of biomass equations, were *Eucalyptus globulus* (n = 33), *Eucalyptus* sp (n = 18), *E. camadulensis* (n = 16) and *Nauclea diderichii* (n = 12). Volume equations were found for more tree species than biomass equations. The analysis reflected a disproportionate interest in certain tree species (Table 1, 2 and 3). The country with the highest proportion of studied species was Senegal (equations were found for 24% of the Senegal's tree species), whereas the average for SSA was about 2%. Most researchers focused on common forestry and agroforestry tree species, leaving most of the existing species unstudied.

3.1.5 Tree Compartments

Allometric research focuses on different tree compartments depending on the goals of the research (e.g., studies for bioenergy, commercial timber and fodder). Most of the volume equations focused on the stump plus the trunk and the branches (44%), whereas some focused only on the trunk (38%) or on the trunk plus the bark and the stump (15%) (Table 5). In total, 18 countries had equations to estimate the volume of the stump plus the trunk and the branches, whereas eight countries had equations that allow for a full estimation of the volume. Twenty-four countries did not have any volume equations. From the 373 biomass equations found for SSA (Table 6), 38% considered all aboveground compartments, 19% considered the leaves and 11% considered the trunk plus the stump and the branches. For the tropical rainforest zone, 10 equations predicted the total tree biomass. Out of those 10 equations, 8 considered small trees in forest regeneration and plantations, whereas one considered tree biomass in an agroforestry system in western Kenya (Henry et al. 2009). Only one considered the tree biomass of a mature tropical rainforest in Ghana (Henry et al. 2010).

Table 2. Distribution of registered equations on countries and types.

Ecological zones and countries	Volume			Biomass			Total		
	Generalized	Species-specific	Total	Generalized	Species-specific	Total	Generalized	Species-specific	Total
TROPICAL RAINFOREST									
Benin		2	2						2
Cameroon	1	10	11	6	5	11	7	15	22
Congo		7	7					7	7
Gabon	1	83	84				1	83	84
Ghana	7	29	36	1	1	2	8	30	38
Guinea-Bissau	1	15	16				1	15	16
Ivory Coast	4	43	47				4	43	47
Kenya				1		1	1		1
Niger				8	1	9		1	1
Nigeria	2	84	86		20	20	2	104	106
RCA	1	10	11				1	10	11
Uganda	17	3	20					3	3
General							8		8
Total		286	286	16	27	43	33	313	346
TROPICAL MOIST DECIDUOUS FOREST									
Ghana		1	1					1	1
Ivory Coast		24	24		2	2		26	26
Malawi	4	11	15				4	11	15
Mali	2	8	10				2	8	10
Senegal	6		6	3	31	34	3	31	34
Uganda				4		4	4		4
Zambia		3	3	4		4	4	3	7
General				6		6	6		6
Total		47	47	17	33	50	23	80	103
TROPICAL DRY FOREST									
Botswana		4	4		2	2		6	6
Burkina Faso	8		8	3	4	7	11	4	15
Cameroon					2	2		2	2
Congo					22	22		22	22
Malawi	2	2	4				2	2	4
Mali	10	21	31	1	4	5	11	25	36
Mozambique	1		1	4		4	5		5
Senegal				3		3	3		3
South Africa					20	20		20	20
Tanzania	7	9	16	7		7	14	9	23
Zimbabwe	28	2	30	2		2	2	2	4
General				5		5	5		5
Total		38	38	25	54	79	53	92	145
TROPICAL SHRUBLAND									
Botswana	1		1	2	27	29	3	27	30
Burkina Faso	1		1		3	3	1	3	4
Chad					1	1		1	1
Equatorial Guinea	1	1	2				1	1	2
Ivory Coast		1	1					1	1
Malawi	2		2				2		2
Mali	1		1	4	28	32	5	28	33
Niger					1	1		1	1
Senegal		8	8		31	31		39	39
Somalia					2	2		2	2

Sudan	1	4	5	1		1	2	4	6
Tanzania	1	1	2				1	1	2
General	8		8	4		4	4		4
Total				11	93	104	19	108	127
TROPICAL DESERT									
Namibia		15	15		7	7		7	7
TROPICAL MOUNTAIN SYSTEM									
Ethiopia		1	1		63	63		64	64
Kenya		4	4		10	10		14	14
Nigeria		2	2					2	2
Rwanda		22	22					22	22
Tanzania	1	1	2				1	1	2
Total		30	30		73	73	1	103	104
SUBTROPICAL HUMID FOREST									
South Africa		1	1	1	5	6	1	6	7
SUBTROPICAL DRY FOREST									
South Africa		1	1		6	6		6	6
SUBTROPICAL MOUNTAIN SYSTEM									
South Africa					5	5		5	5
TOTAL	60	417	477	70	303	373	130	720	850

3.1.6 Data Quality Control

The data quality control revealed that 22, 61 and 17% of equations were classified as quality 1, 2 and 3, respectively (Table 1). Most of the equations were quality 2 for both biomass and volume (81 and 69% of the biomass and volume estimates, respectively, for trees of 2 to 200 cm in diameter were found within the interval of possibility, respectively). When considering only publications in peer-reviewed journals, 17% of the equations were considered to be quality 1. The sample size, correlation coefficient and range of calibration were given for only 60, 49 and 38% of the equations, respectively. The data quality control identified important variability in the quality of data reporting. In total, 456 equations reported the coefficient of determination (ranging from 0.22–0.99) and 550 equations reported the sample size (ranging from 4–6511). Although 318 equations gave the range of calibration ($D_{1.3}$ ranging from 1.8–180 cm), when applying the whole range of calibration to the equations, 45 equations resulted in negative biomass or volume predictions; for these equations the range of calibration was corrected (Appendix A and Appendix B). For 14.8% of the equations, the list of species names was not complete or was absent.

Tables 1, 2, 3 and 4 show available equations for each country. For instance, Gabon had 84 volume equations for the trunk, but none for the other tree compartments or for biomass. These tables facilitate identification of data gaps.

3.2 Chronology of Forest Biomass Research in Tropical Sub-Saharan Africa

The equations were all developed during the period of 1961–2010; this clearly illustrates evolution in the interests of those who study trees in SSA. The concern for equations has been continuously increasing, with only 4 articles published during the 1960s (all of which were devoted to volume prediction only) but 50 articles published during the period from 2000–2010 (Fig. 5). From 2000–2010, 54% of the articles and 53% of the equations were developed for biomass purposes, whereas in the ‘80s, biomass articles and equations accounted for 41 and 43%, respectively.

Table 3. Distribution of registered volume equations on countries and species.

Country	Tree species (number of allometric equations)	Equations	Species
Benin	*Acacia auriculiformis* (2)	2	1
Botswana	*Baikiaea plurijuga* (1) *Burkea africana* (1) *Colophospermum mopane* (1) *Pycnanthus angolensis* (1) , Generalized (1)	5	4
Burkina Faso	Generalized (9)	9	0
Cameroon	*Baillonella toxisperma* (2) *Entandrophragma cylindricum* (2) *Lophira alata* (1) *Terminalia ivorensis* (3), Generalized (1)	11	5
Congo	*Entandrophragma cylindricum* (1) *Terminalia superba* (6)	7	2
Equatorial Guinea	*Aucoumea klaineana* (1) , Generalized (1)	2	1
Ethiopia	*Eucalyptus globulus* (1)	1	1
Gabon	*Afzelia bipindensis* (1) *Afzelia pachyloba* (1) *Antiaris africana* (1) *Antrocaryon klaineanum* (1) *Aucoumea klaineana* (3) *Autranella congolensis* (1) *Baillonella toxisperma* (1) *Berlinia bracteosa* (1) *Berlinia confusa* (1) *Canarium schweinfurthii* (1) *Ceiba pentandra* (1) *Celtis brieyi* (1) *Coelocaryon klaineana* (1) *Copaifera mildbraedii* (1) *Dacryodes buettneri* (1) *Dacryodes igaganga* (1) *Dacryodes normandii* (2) *Daniellia klainei* (1) *Daniellia soyauxii* (1) *Desbordesia glaucescens* (1) *Detarium macrocarpum* (1) *Didelotia africana* (1) *Diospyros sanza-minika* (1) *Entandrophragma angolensis* (1) *Entandrophragma candollei* (1) *Entandrophragma congeonse* (1) *Entandrophragma cylindricum* (1) *Entandrophragma utile* (1) *Eribroma oblongum* (1) *Erythrophleum ivorensis* (1) *Fagara heitzii* (1) *Gambeya africana* (1) *Gambeya lacourtiana* (1) *Gambeya perpulchra* (1) *Gilbertiodendron dewevrei* (1) *Gossweilerodendron balsamiferum* (1) *Guarea cedrata* (1) *Guarea thompsonii* (1) *Guibourtia demeusei* (1) *Guibourtia ehie* (1) *Guibourtia tessmannii* (1) *Hallea ciliata* (1) *Khaya ivorensis* (1) *Lophira alata* (1) *Lovoa trichilioides* (1) *Mammea africana* (1) *Milicia excelsa* (1) *Milletia stuhlmannii* (1) *Mitragyna ciliata* (1) *Monopetalanthus coriaceus* (1) *Monopetalanthus durandii* (1) *Monopetalanthus heitzii* (1) *Monopetalanthus letestui* (1) *Monopetalanthus microphyllus* (1) *Monopetalanthus pellegrini* (1) *Monopetalanthus* sp (1) *Nauclea diderichii* (1) *Nesogordonia papaverifera* (1) *Nesogordonia* sp (1) *Ongokea gore* (1) *Oxystigma oxyphyllum* (1) *Paraberlinia bifoliolata* (1) *Petersianthus macrocarpus* (1) *Piptadeniastrum africanum* (1) *Pterocarpus soyauxii* (1) *Pycnanthus angolensis* (1) *Rhodognaphalon brevicuspe* (1) *Sindoropsis letestui* (1) *Staudtia stipitata* (2) *Sterculia Oblongata* (1) *Swartzia fistuloides* (1) *Tarrietia densiflora* (1) *Terminalia superba* (3) *Testulea gabonensis* (1) *Tetraberlinia bifoliolata* (1) *Tetraberlinia polyphylla* (1) *Tieghemella africana* (1) Generalized (1)	84	77
Ghana	*Terminalia superba* (11), *Group* (19), Generalized (7)	37	1
Guinea-Bisseau	*Chlorophora excelsa* (1) *Chrysophyllum* sp (1) *Daniellia ogea* (1) *Distemonanthus benthamianus* (1) *Entandrophragma angolensis* (1) *Entandrophragma utile* (1) *Hallea ciliata* (1) *Mammea africana* (1) *Mansoniaaltissima* (1) *Nauclea diderichii* (1) *Pycanathus gymnorrhiza* (1) *Terminalia ivorensis* (1) *Terminalia superba* (1), Generalized (1)	16	15
Ivory Coast	*Acacia mangium* (1) *Afzelia africana* (3) *Antiaris africana* (2) *Ceiba pentandra* (1) *Chlorophora excelsa* (2) *Diospyros mespiliformis* (7) *Distemonanthus benthamianus* (1) *Entandrophragma angolensis* (1) *Entandrophragma candollei* (1) *Entandrophragma cylindricum* (2) *Entandrophragma utile* (1) *Guarea cedrata* (1) *Heritiera utilis* (2) *Isoberlinia doka* (7) *Khaya ivorensis* (2) *Khaya senegalensis* (6) *Lophira alata* (2) *Lovoa trichilioides* (1) *Mansonia altissima* (2) *Nauclea diderichii* (1) *Nesogordonia papaverifera* (2) *Pterygota macrocarpa* (1) *Pycanathus gymnorrhiza* (2) *Rhodognaphalon brevicuspe* (1) *Scottellia* sp (1) *Tarrietia utilis* (2) *Tectona grandis* (3) *Terminalia ivorensis* (1) *Terminalia superba* (3) *Tieghemella heckelii* (1) Generalized (4)	72	32
Kenya	*Cupressus lusitanica* (2) *Eucalyptus saligna* (1) *Pinus patula* (1)	4	3

Malawi	Generalized (8) *Brachystegia boehmii* (1) *Brachystegia floribunda* (1) *Brachystegia spiciformis* (2) *Brachystegia utilis* (1) *Group* (4) *Julbernardia paniculata* (2) *Pterocarpus angolensis* (1)	21	7
Mali	*Afzelia africana* (4) Generalized (13) *Bombax buonopozense* (1) *Combretum fragrans* (1) *Combretum ghazalense* (2) *Combretum glutinosum* (1) *Cordyla pinnata* (1) *Daniellia oliveri* (2) *Isoberlinia doka* (2) *Khaya senegalensis* (1) *Lannea* sp (1) *Pterocarpus erinaceus* (1) *Terminalia* sp (2)	42	13
Mozambique	Generalized (1)	1	0
Nigeria	*Afzelia africana* (1) *Albizzia ferruginea* (1) *Albizzia zygia* (1) Generalized (2) *Alstonia boonei* (1) *Amphimas pterocarpoides* (1) *Antiaris toxicaria* (1) *Antrocaryon klaineanum* (1) *Blighia sapida* (1) *Bombax buonopozense* (1) *Brachystegia eurycoma* (1) *Brachystegia kennedyi* (1) *Brachystegia nigerica* (1) *Canarium schweinfurthii* (1) *Carapa procera* (1) *Ceiba pentandra* (1) *Celtis zenkeri* (1) *Chrysobalanus icaco* (1) *Coelocaryon preussii* (1) *Copaifera mildbraedii* (1) *Cordia millenii* (1) *Cylicodiscus gabonensis* (1) *Daniellia ogea* (1) *Detarium senegalensis* (1) *Dialium guineense* (1) *Diospyros mespiliformis* (1) *Distemonanthus benthamianus* (1) *Entandrophragma cylindricum* (1) *Eribroma oblongum* (1) *Erythrophleum suaveolens* (1) *Funtumia africana* (1) *Funtumia elastica* (1) *Gmelina arborea* (4) *Gossweilerodendron balsamiferum* (1) *Guarea cedrata* (1) *Guarea thompsonii* (1) *Hannoa klaineana* (1) *Holoptelea grandis* (1) *Hylodendron gabunense* (1) *Irvingia gabonensis* (1) *Khaya grandifoliola* (1) *Khaya ivorensis* (1) *Lannea welwitschii* (1) *Lophira alata* (1) *Lovoa trichilioides* (1) *Manilkara obovata* (1) *Mansonia altissima* (1) *Milicia excelsa* (1) *Mitragyna ledermannii* (1) *Mitragyna stipulosa* (1) *Nauclea diderichii* (4) *Nesogordonia papaverifera* (1) *Pentaclethra macrophylla* (1) *Pentadesma butyracea* (1) *Petersianthus macrocarpus* (1) *Piptadeniastrum africanum* (1) *Poga oleosa* (1) *Pterocarpus osun* (1) *Pterocarpus santalinoides* (1) *Pterygota macrocarpa* (1) *Pycnanthus angolensis* (1) *Ricinodendron heudelotii* (1) *Scottellia coriacea* (1) *Staudtia stipitata* (1) *Stemonocoleus micranthus* (1) *Sterculia rhinopetala* (1) *Sterculia tragacantha* (1) *Strombosia pustulata* (1) *Symphonia globulifera* (1) *Terminalia ivorensis* (1) *Terminalia superba* (3) *Tetrapleura tetraptera* (1) *Trichilia gilgiana* (1) *Trichilia monadelpha* (1) *Trichilia prieureana* (1) *Trichilia retusa* (1) *Trilepisium madagascariense* (1)	88	78
RCA	Generalized (1) *Autranella congolensis* (1) *Cedrelopsis grevei* (1) *Chlorophora excelsa* (1) *Entandrophragma angolensis* (1) *Entandrophragma cylindricum* (2) *Entandrophragma utile* (1) *Lovoa trichilioides* (1) *Terminalia superba* (1)	11	9
Rwanda	*Cederella serrata* (2) *Cupressus lucastica* (2) *Cupressus lusitanica* (1) *Grevillia robusta* (16) *Pinus patula* (1)	22	5
Senegal	*Acacia senegal* (1) *Afzelia africana* (1) *Balanites aegyptiaca* (1) *Boscia senegalensis* (1) *Commiphora africana* (1) *Grewia bicolor* (1) *Rhizophora racemosa* (2)	8	7
South Africa	*Eucalyptus Camadulensis* (1)	1	1
Sudan	*Acacia mellifera* (1) *Acacia nilotica* (1) *Acacia senegal* (1) *Dalbergia melanoxylon* (1) Generalized (1)	5	4
Tanzania	*Brachystegia spiciformis* (2) *Cupressus lusitanica* (1) *Dalbergia melanoxylon* (2) *Julbernardia globiflora* (3) *Pinus patula* (1) *Pycnanthus angolensis* (2) Generalized (9)	20	6
Uganda	*Eucalyptus grandis* (1) *Pinus caribaea* (2)	3	2
Zambia	*Baikiaea plurijuga* (1) *Guibourtia coleosperma* (1) *Pterocarpus angolensis* (1)	3	3
Zimbabwe	*Acacia karoo* (2)	2	1
Total	–	477	191

( ): number of allometric equations per species.

Table 4. Distribution of registered biomass equations on countries and species.

Country	Tree species (number of allometric equations)	Equations	Species
Botswana	*Acacia erioloba* (1) *Acacia erubescens* (2) *Acacia karoo* (3) *Acacia luederitzii* (1) *Acacia mellifera* (3) *Acacia tortillis* (5) Generalized (2) *Beilschmiedia diversiflora* (1) *Boscia albitrunca* (1) *Colophospermum mopane* (1) *Combretum apiculatum* (1) *Combretum molle* (2)*Croton gratissimus* (1) *Dichrostachys cinerea* (3)	30	15
Burkina Faso	*Acacia laeta* (1) *Acacia senegal* (1) *Acacia tortillis* (1) *Combretum aculeatum* (1) *Guiera senegalensis* (2) Pterocarpus lucens (1) Generalized (3)	10	7
Cameroon	*Acacia senegal* (1) *Terminalia ivorensis* (1) *Terminalia* sp (4) *Vitellaria paradoxa* (1) Generalized (6)	13	5
Chad	*Acacia tortillis* (1)	1	1
Congo	*Acacia auriculiformis* (2)*Acacia mangium* (2)*Eucalyptus* sp (18)	22	3
Ethiopia	*Dichrostachys cinerea* (5) *Eucalyptus Camadulensis* (16) *Eucalyptus globulus* (29) *Euclea shimperi* (5) *Grewia bicolor* (4)*Otostegia integrifolia* (4)	63	6
Ghana	Generalized (1) *Terminalia superba* (1)	2	2
Ivory Coast	*Khaya senegalensis* (2)	2	1
Kenya	*Acacia drepanolobium* (3) *Croton macrostachyus* (1) *Eucalyptus saligna* (1) *Markhamia lutea* (1)*Psidium guajava* (1)*Sesbania sesban* (1) *Group* (2) Generalized (1)	11	8
Mali	*Acacia albida* (3) *Acacia seyal* (3)*Acacia senegal* (1) *Balanites aegptiaca* (2)*Boscia senegalensis* (1) *Combretum aculeatum* (1) *Combretum glutinosum* (2) *Combretum nigricans* (2) *Commiphora africana* (2)*Detarium microcarpum* (2) *Faidherbia albida* (3) *Gardenia ternifolia* (1) *Guiera senegalensis* (1)*Pterocarpus lucens* (3) *Pterocarpus lucens* (1) *Ziziphus mauritiana* (3) Generalized (5)	37	18
Mozambique	Generalized (4)	4	1
Namibia	*Acacia erubescens* (1) *Acacia fleckii* (1) *Acacia mellifera* (1) *Acacia reficiens* (1) *Colophospermum mopane* (1)*Dichrostachys cinerea* (1) *Terminalia sericea* (1)	7	7
Niger	*Guiera senegalensis* (1)*Terminalia superba* (1)	2	2
Nigeria	*Gmelina arborea* (8) *Nauclea diderichii* (12)	20	2
Senegal	*Acacia senegal* (11) *Balanites aegyptiaca* (3) *Boscia senegalensis* (3) *Combretum geitonophyllum* (7) *Combretum glutinosum* (7)*Commiphora africana* (4) *Grewia bicolor* (5) *Guiera senegalensis* (3) *Piliostigma thonningii* (6) *Pterocarpus lucens* (2)*Terminalia macroptera* (6) *Group* (5) Generalized (6)	68	13
Somalia	*Acacia senegal* (1) *Excoecaria bussei* (1)	2	2
South Africa	*Acacia karoo* (1) *Acacia tortillis* (1) *Coddia rudis* (1) *Diospyros dichrophylla* (1) *Eucalyptus donai* (4) *Eucalyptus emithii* (4) *Eucalyptus globulus* (4) *Eucalyptus nitens* (4) *Eucalyptus viminalis* (4) *Olea europaea* (1) *Pinus patula* (5) *Protea neriifolia* (2) *Protea repens* (2) *Ptaeroxylon obliquum* (1) *Widdringtonia nodiflora* (2) Generalized (1)	38	16
Sudan	Generalized (1)	1	1
Tanzania	Generalized (7)	7	1
Uganda	Generalized (4)	4	1
Zambia	Generalized (4)	4	1
Zimbabwe	Generalized (2)	2	1
(blank)	Generalized (23)	23	1
Grand Total		373	77

( ): number of allometric equation per species.

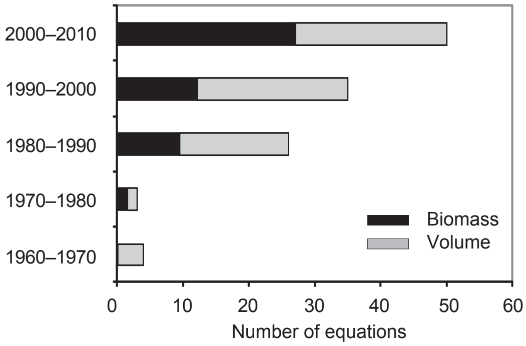

Fig. 5. Change over time in the number of literature references used in this study during the period 1950–2009.

3.3 Wood Gravity

In total, 3846 wood gravity values from 54 references were identified for SSA. Most data were found in reports (69%), whereas books accounted for 11% of the information. Data collected were published between 1951 and 2010 (mostly in the 1950s). According to the sources, most of the wood gravity data were obtained from logging companies in the tropical rainforest zone and from scientific research in the tropical dry zone. The data concerned 1066 tree species. Wood gravity ranged from 0.15–1.2 g cm^{-3} with a minimum for *Schinziophyton rautanenii* (ranging from 0.15–0.19 g cm^{-3}) and a maximum for *Dalbergia melanoxylon* (ranging from 0.8–1.2 g cm^{-3} for this species). As little or no information was given regarding the geographic locations where the samples were collected, it is difficult to give a picture of the spatial variability of wood gravity. With respect to the plant functional types identified by Hawthorne (1995), it was possible to classify 1,340 wood samples (Fig. 6). The highest wood gravities were found in savannah/non-forest (WD = 0.65 ± SE 0.03 g cm^{-3}), whereas the lowest wood gravities were found for pioneer trees (WD = 0.51 ± SE0.01 g cm^{-3}. Using a Fisher LSD statistical test, the following classification of plant functional types was obtained with respect to wood gravity: savannah, shade-bearer > non-pioneer, light-demander, swamp > pioneer ($\alpha < 0.0001$, F=35.89, n=1340).

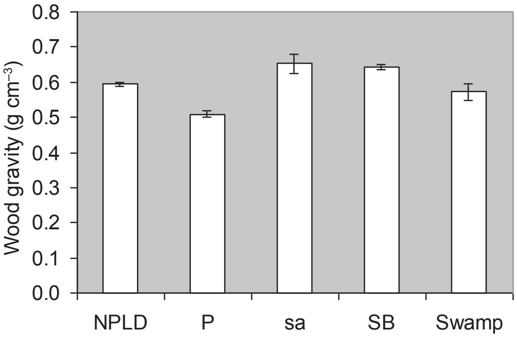

Fig. 6. Variations in wood gravity (g cm^{-3}) in tropical sub-Saharan Africa by plant functional types using classifications created for Ghana by Hawthorne (1995). P: pioneer, NPLD: Non-Pioneer Light Demander, SB: Shade Bearer, Swamp, sa: Savannah tree species have many common characteristics, which makes it convenient to consider them separately from the other tree species. The other three guilds refer to the characteristics of each species with respect to canopy gaps, disturbance and light. The error bars represent the 95% confidence interval.

3.4 Sources of Variability in Volume and Biomass

3.4.1 Variation of Tree Biomass across Different Ecological Zones

Differences in simulated biomass were found between and within ecological zones (Fig. 7). For the same diameter and among all ecological zones, equation 641 predicted the highest biomass (6.3 Mg; $D_{1.3}$=30 cm) and equation 813 predicted the lowest biomass (12 kg; $D_{1.3}$=30 cm) (Appendix C). Tree biomass differed largely within ecological zones. Considering Fig. 7a, the difference in woody biomass between species could be as high as 2.83 Mg in the tropical rainforest zone (at $D_{1.3}$=50 cm). For the tropical desert zone, equation 668 predicted 99 times higher biomass than did equation 683. The lowest variability in tree biomass was observed for subtropical dry forests, where the difference between equations could reach up to 50% of biomass estimate, but was limited by the number of equations (n=3). For tropical rainforests, the maximum difference between equations reached 66% of tree biomass.

Table 5. Number of volume allometric equations per tree compartment and country in sub-Saharan Africa.

Pool Countries	Trunk	Trunk + bark + stump	Gross branches	Trunk +stump + branches	All the branches	Total
Benin				2		2
Botswana				5		5
Burkina Faso	2		2	5		9
Cameroon	8			3		11
Congo	5			2		7
Equatorial Guinea	2					2
Ethiopia		1				1
Gabon	84					84
Ghana	24	5		8		37
Guinea-Bissau	16					16
Ivory CoastIvory Coast	54	1		15	2	72
Kenya				4		4
Malawi		1		20		21
Mali		2		35	5	42
Mozambique				1		1
Nigeria	79	7		2		88
CAR	10	1				11
Rwanda		14			8	22
Senegal		5		3		8
South Africa		1				1
Sudan		4		1		5
Tanzania		2		16	2	20
Uganda				3		3
Zambia				3		3
Zimbabwe				2		2
Total	284	44	2	128	17	477

General allometric equations are annotated as “general” in the tree component column and indicate only biomass.

3.4.2 Variability of Biomass and Volume Prediction within Forest Types

Important differences in volume between tree species were predicted within and between forest types (Fig. 8). Nine equations for different species were selected to illustrate the variation of volume in tropical rainforests, tropical plantations, tropical dry forests and mangroves. For tropical rainforests (Fig. 8a), only two of the nine selected equations were given a range of calibration. For a $D_{1.3}$ of 40 cm, volumes ranged from 1.02–3.47 m^3, with a minimum for *Turraeanthus africanus* (eq. 261) and a maximum for *Entandrophragma cylindricum* (eq. 76). For $D_{1.3}$=100 cm, volumes ranged from 6.74–14.85 m^3, with a minimum for *T. africanus* and a maximum for *Lophira alata*. It is difficult to compare volume estimation from allometric equations because measured yields are often difficult to find; for example, for *T. superba* in SSA, no volume tables have been published (Ugalde and Perez 2001). For tropical plantations (Fig. 8b), six of the nine equations reported the range of calibration. At 50 cm of $D_{1.3}$, the minimum volume was 1.16 m^3 (*Cupressus lusitanica*), the maximum was 4 m^3 (*Triplochiton scleroxylon*) and the average volume was 2.8 m^3. Similar results were reported for *C. lusitanica* in Teshome (2005), with a volume of approximately 1 m^3 at 40 cm of $D_{1.3}$. Differences in rainfall between the two sites were not important enough to explain the differences in volume between the two species.

For tropical dry forests and mangrove ecosystems (Fig. 8c), six of the nine selected equations had an interval of calibration. At $D_{1.3}$=25 cm, the minimum volume was 0.11 m^3 (for *Rhizophora racemosa* in a mangrove ecosystem), whereas the maximum was 0.41 m^3 (for *A. africana*). At $D_{1.3}$=50 cm, the average individual aboveground volume in tropical dry forests was 1.74 m^3,

Table 6. Number of biomass allometric equations per tree compartment and country in sub-Saharan Africa.

Volume allometric equations Biomass allometric equations	Trunk	Trunk+ bark+ stump	Bark	Gross branches	Thin branches	Dead branches	Leaves	Stump	Roots	Trunk+ stump- branches	All the branches	Trunk+ stump+ branches+ leaves	Above and below ground	Total
Botswana										2		28		30
Burkina Faso							6			2		2		10
Cameroon										1	2	2	8	13
Chad							1							1
Congo	2		2			1	4	1	6	2	2	1	1	22
Ethiopia	3	2	9	3	9		13			14		10		63
Ghana												2		2
Ivory Coast										2				2
Kenya					1					1		9		11
Mali		1					25			1		10		37
Mozambique										2		2		4
Namibia												7		7
Niger										1		1		2
Nigeria		5					4				5	6		20
Senegal		12		2	1		11	9	7	3	5	11	7	68
Somalia										2				2
South Africa		6	6		1		6		1	6	8	4		38
Sudan														1
Tanzania		2								1	2	2		7
Uganda												4		4
Zambia												4		4
Zimbabwe										2				2
General												23		23
Total	5	28	17	5	12	1	70	10	14	42	24	128	16	373

Trunk (T), Trunk+bark+stump (T+B+S , T+B), Bark (B), Gross Branches (Bg), Thin Branche (Bt, Bt<6 , Bt+L), Dead branches (Bd), Leaves (L), Stump (S), Roots (Rb, Rb+Rm+Rf , Rm and S+Rb), Trunk +stump+branches (T+ Bg+ Bt3.2+B+S, Total , T+S+Bg, T+Bg+Bt6+B+S, T+Bg+Bt5+S, T+Bg+TB5+B+S , T+Bg+Bt3+B+S, T+ Bg+Bt3.2+B+S+Bd, T+Bg+Bt+L+B+S, T+Bg+Bt+Bd+B+S, T+ Bg+Bt+B+S, T+Bg+Bt , T+Bg+B+S+Bd, T+Bg, T+Bg+B+S), All the branches (Bg+TB, Bg+Bt+Bd, Bg+Bt+L+Bd), Trunk+stump+branches+leaves (T+Bg+Bt+L+B+S+Rb+Bd+Rm+Rf , T+Bg+ Bt+L+S+Bd , T+ Bg+ Bt2+B+S, T+Bg+Bt+L+B+S+Bd)

General allometric equations are annotated as “general” in the tree component column and indicate only biomass.

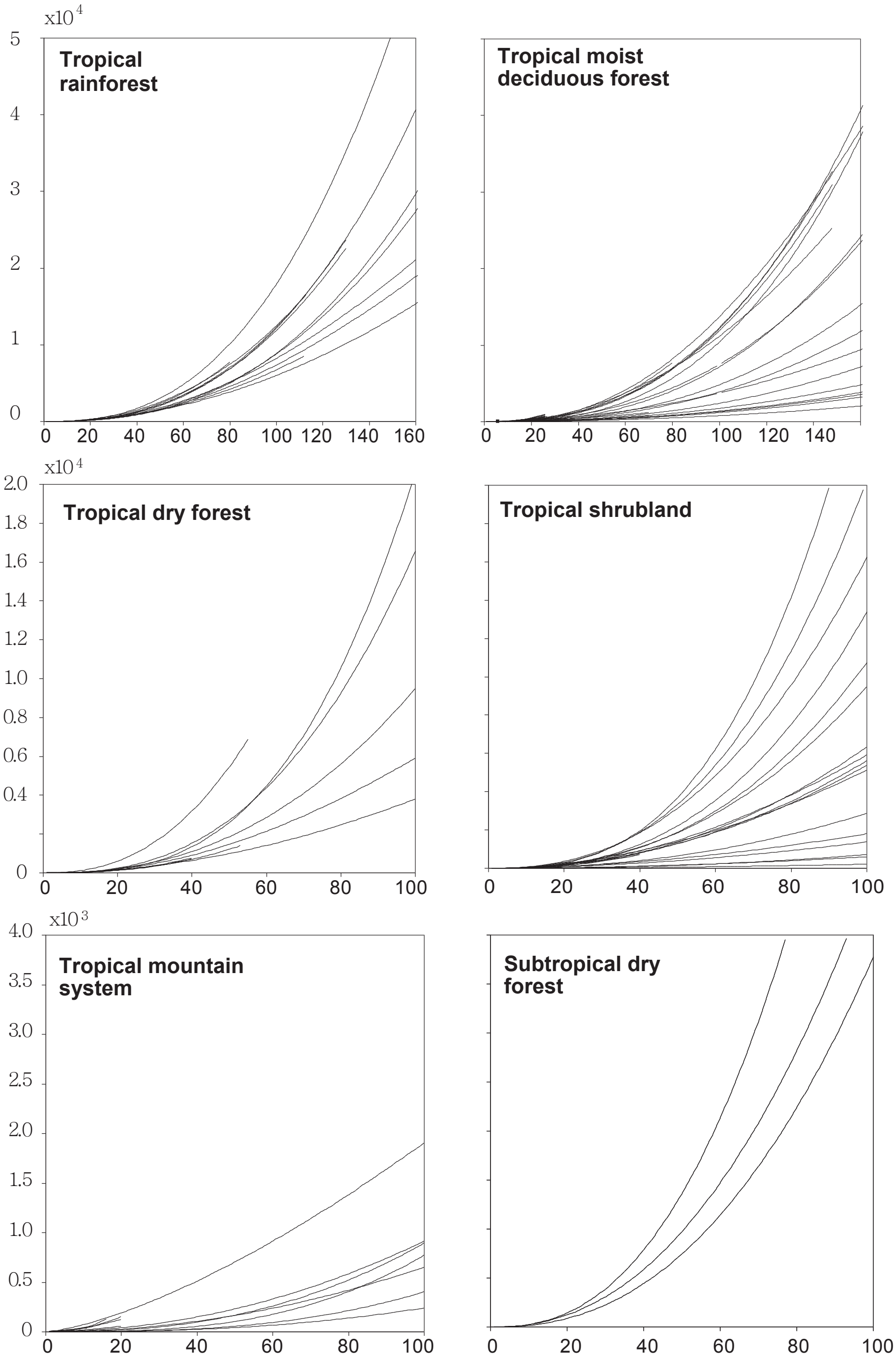

Fig. 7. Tree biomass (kg by tree) equations in different ecological zones of sub-Saharan Africa. The equations that were considered to be erroneous were not included in the figure (e.g., de Klerk 2002; Chamshama et al. 2004; Onyekwelu 2007).

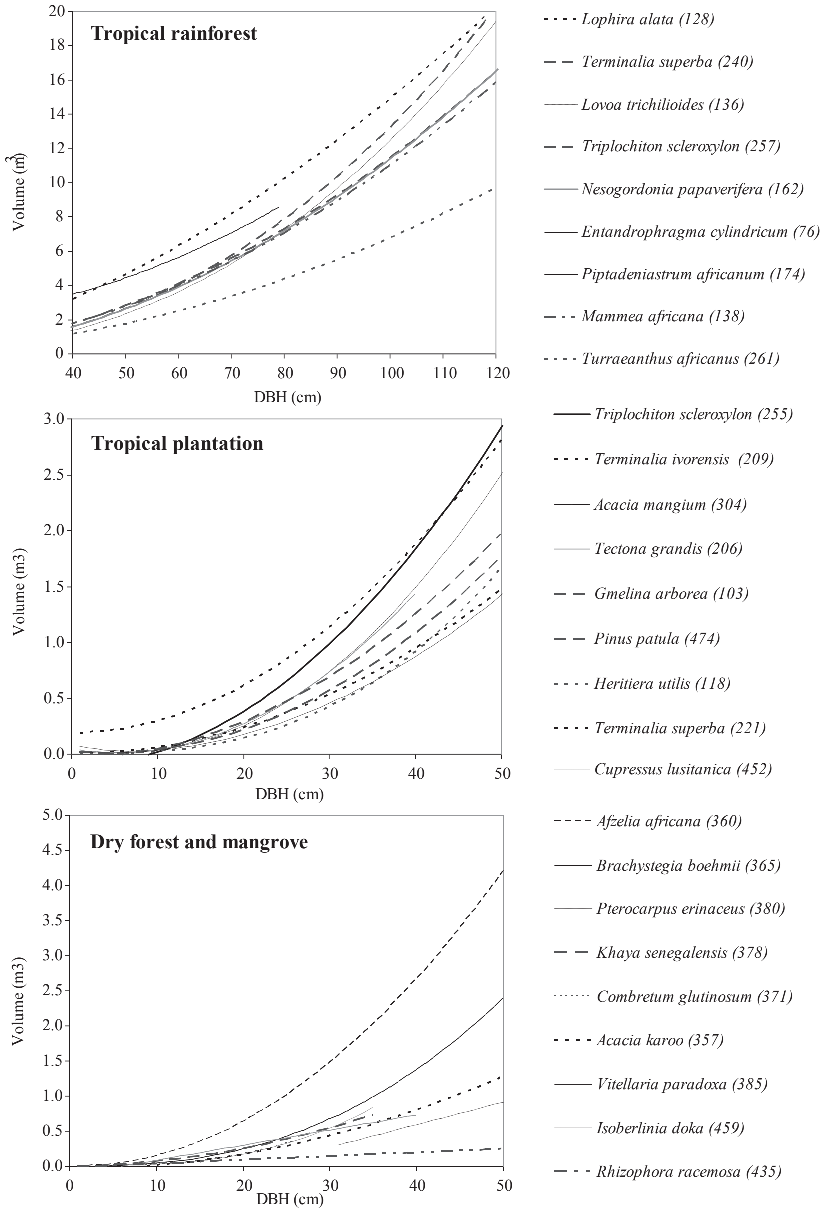

Fig. 8. Volume of tree species in various forest types. Volume equations were selected for three different forest types: tropical forests, plantations and mangroves. Distinction was made between the equations found for the tropical rainforest and equations for dry forest zones. (A) Tree species volume in tropical rainforests. The volume is for the trunk component. Calibration ranges are presented for equations 76, 174 and 257 but not for the equations 128, 136, 138, 162, 240 and 261 (Appendix A). (B) Tree species volume in tropical plantations. The volume is for the trunk component. Calibration ranges are presented for equations 255, 474, 452 and 234 but not for equations 209, 103, 221 and 118 (Appendix A). (C) Tree species volume in dry forests and in mangroves. The volume is for the trunk, bark, stump and large branches. Calibration ranges are presented for equations 364, 371, 378, 380 and 459 but not for equations 357, 360, 365 and 435 (Appendix A). []: equation number.

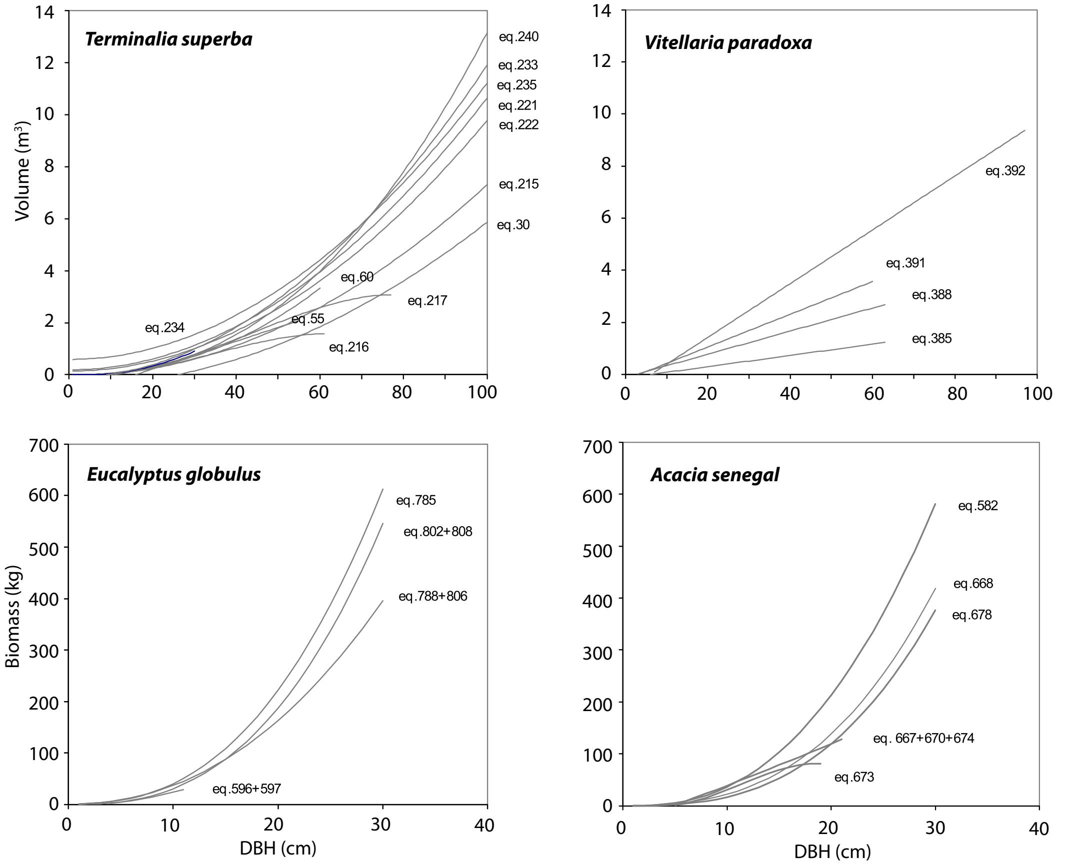

Fig. 9. Tree volume and aboveground biomass of four tree species in various geographic locations. *Terminalia superba*, *Vitellaria paradoxa*, *Eucalyptus globulus* and *Acacia senegal* were selected to represent the variability among tree species within tropical rainforests, moist deciduous forests, and tropical dry forests and tropical shrublands. These species were considered to best represent the variability among tree species (based on the available data) because they were measured in the greatest number of locations

Terminalia superba is a common tree species found in plantations. The calibration ranges are presented for equations 220 and 232 but not for equations 215, 221, 222, 232, 233 and 235.
Vitellaria paradoxa is commonly found in Sahelian transition zones. The calibration ranges are presented for all of the equations (385, 388, 391 and 392).
Eucalyptus globulus is commonly used in African plantations (Pohjonen and Pukkala 1990) and is productive in tropical plantations. The calibration ranges are presented for equations 596, 598 and 788 but not for equations 802, 806, 808, and 827.
Acacia senegal is a typical tree species of the Sahel found in agroforestry and natural ecosystems. The calibration ranges are presented for equations 673 and 667 but not for equations 583 and 668. The notation 670+674+667 indicates that biomass values from different equations (for T+B+S, Bg and Bt) were added to estimate total aboveground biomass.

whereas it was 1.97 m^3 and 2.86 m^3 in tropical plantations and rainforests, respectively. When considering the average wood gravity for tropical rainforest species, *T. africanus* had lower wood gravity (0.65 ± 0.01 kg m^{-3}, n=7) than *L. alata* (0.86 ± 0.05 kg m^{-3}, n=33).

3.4.3 Between-Source Variation of Volume and Biomass within Four Selected Species

The four most-studied tree species were selected to illustrate the within-species variation of volume and biomass (Fig. 9). *T. superba* is a common tree found in plantations, in tropical rainforests and in the moist deciduous zone (Groulez and Wood 1984). The highest volume for *T. superba* was found in RCA (eq. 240), whereas the lowest was found in Gabon (eq. 30). *V. paradoxa* is commonly found in Sahelian transitional ecosystems (Peltier et al. 2007). The highest volume for *V. paradoxa* was obtained in Ténéfi (eq. 392), whereas the lowest was found in Badougou (eq. 385) (both locations are in Mali). The volume for *V. paradoxa* was modelled as linear functions with contrasted slopes. The volume of a tree of 40 cm of $D_{1.3}$ was 3.7 times higher in Ténéfi than in Badougou. *E. globulus* is one of the most common tree species in plantations in SSA (Komakech et al. 2009, Zewdie et al. 2009). The lowest biomass was found in Ager (eq. 807 and 802) and the highest in the Heritage Forest Park (eq. 785) (both locations are in Ethiopia). *A. senegal* is an emblematic tree species of the tropical shrubland zone. Available equations predict similar values, with the lowest values in Fété Olé, Senegal (eq. 678) and the highest in Boboyo, Cameroon (eq. 582). Based on the volume equations, the lowest variation in volume was found for *A. senegal*, whereas the highest was found for *V. paradoxa*.

3.4.4 Illustrating the Tiers Method to Estimate Tree Species Biomass

Diverse models were found for *A. senegal*, which was selected to illustrate the Tier approach. To choose the appropriate Tier for *A. senegal*, this section explains the different steps and compares different models. Several equations predicted the aboveground biomass of *A. senegal* (eq. 582, 668, 673 and 678), as well as its trunk biomass (eq. 667, 676 and 677), thin and gross branches biomass (eq. 670 and 674), trunk volume (eq. 425) and leaf biomass (eq. 665, 666, 676, 679, 680 and 681). Moreover four equations were available for Tier-3-total, three equations were available for Tier-3-partial and one equation was available for Tier-2.

When considering the selection of the equations for the Tier-3-total method, it appeared that equation 673 predicted biomass based on the number of tree rings, equation 668 was a refinement of equation 673 and used a more appropriate mathematical model, equation 582 predicted fresh biomass and equation 678 predicted total aboveground dry biomass. Equation 678 revealed higher estimates of total aboveground biomass than did equations 582, 668 and 673 (with estimates of 96, 21 and 30% at $D_{1.3}$=15 cm, respectively). Converting tree rings into diameter was an additional step that added possible error to the estimation of equation 673. In equation 582, converting fresh biomass into dry biomass added uncertainty regarding the estimate of the moisture content (Nygård et al. 2004). Thus, Bird and Shepherd's model (1989) (eq. 678) was selected to predict aboveground dry biomass for equations assessed using the Tier-3-total method (Tier-3-total in Fig. 10).

The same procedure was followed to select the equations for Tier-3-partial, Tier-2 and Tier-1. Equations were selected according to the quality rank and the number of samples used for the calibration. The following equations were selected to make comparison between Tier-1, -2, -3-partial and 3-total approaches for *A. senegal*. Equations 425 and 677 came from Poupon (1979) and equation 678 came from Bird and Shepherd (1989); these equations were specific to *A. senegal*. Equation 651 came from Chave et al. (2005) and was a pan-tropical equation for tropical dry forests.

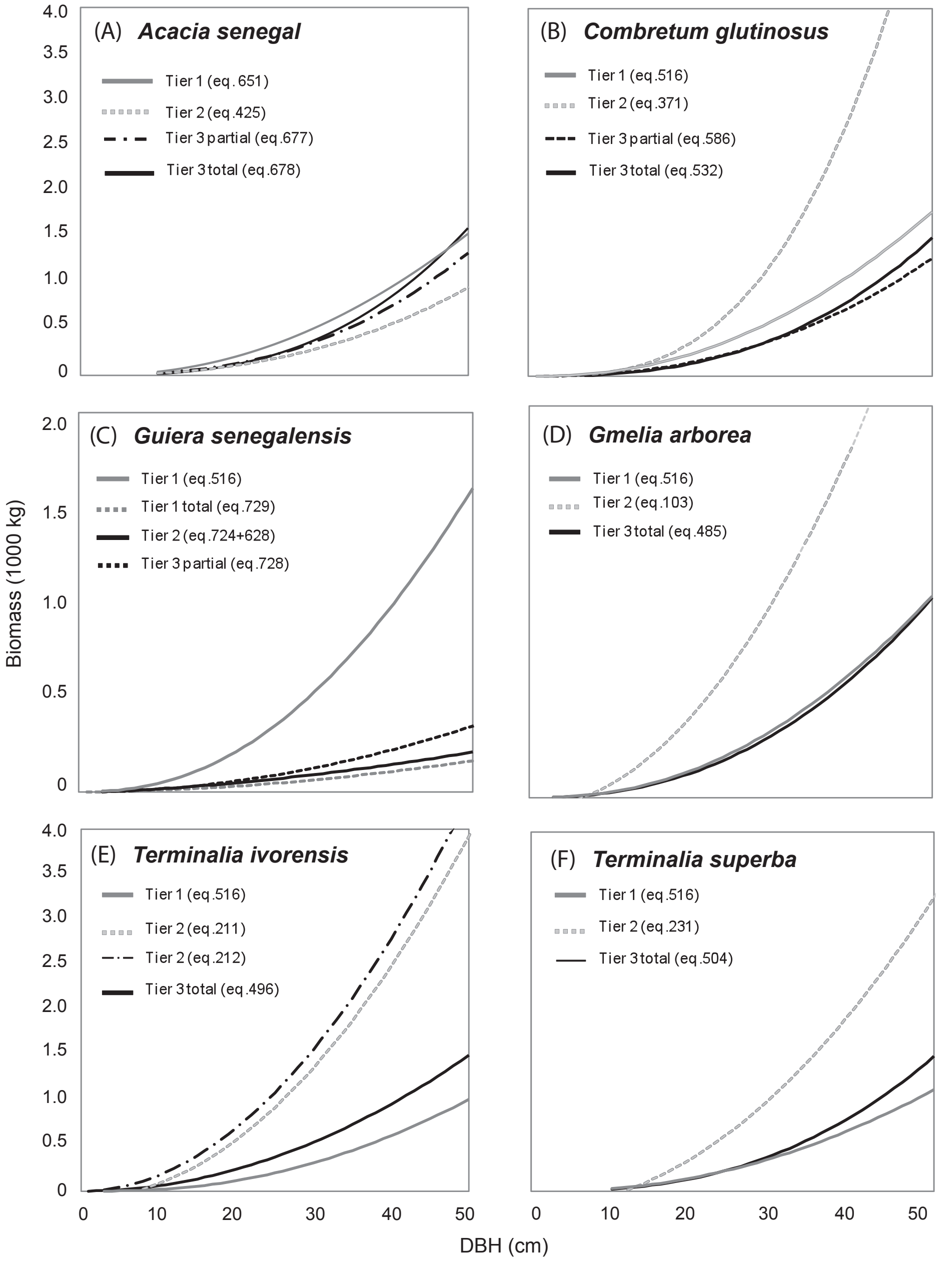

Fig. 10. Aboveground biomass estimation for individual trees using the tier method for tree species.

(A) *Acacia senegal:* the confidence intervals were absent. The average wood gravity was 0.63 g cm^{-3}. (B) *Combretum glutinosum*: the calibration ranges are presented for equations 516, 532 and 371 but not for the equation 586. The average wood gravity was 0.73 g cm^{-3}. (C) *Gmelina arborea*: the ranges of validity were absent. The average wood gravity was 0.42 g cm^{-3}. (D) *Guiera senegalensis*: the ranges of validity were absent. The average wood gravity was 0.66 g cm^{-3}. (E) *Terminalia ivorensis*: the ranges of validity were absent. The average wood gravity was 0.45 g cm^{-3}. (F) *Terminalia superba*: the ranges of validity were absent. The average wood gravity was 0.46 g cm^{-3}.

Tier-3-total: eq. 678
$BAG(kg) =$
$\mathrm{Exp}((2.83568 \times \log(D_{1.3}) - 3.75637) + 0.043274)$
$(n = 44, r^2 = 0.99)$

Tier-3-partial: eq. 677
$\mathrm{Log10}(B_1) = -3.45 + 2.73\ \mathrm{Log10}C_b$
$(n = 21, r^2 = 0.98)$

Tier-2: eq. 425
$\mathrm{Log10}(V_t) = 0.07 + 2.55\ \mathrm{Log10}C$
$(n = 56, r^2 = 0.9)$

Tier-1: eq. 651
$B_t = \rho\exp[-0.667 + 1.784\ \ln(D_{1.3}) +$
$0.207(\ln D_{1.3})^2 - 0.0281(\ln D_{1.3})^3]$
$(n = 316, r^2 = 0.99)$

where: BAG was the aboveground dry biomass in kg (without leaves), B_t was the trunk dry biomass in kg, V_t was the trunk volume in m^3, C_b was the girth at the base of the tree in cm, $D_{1.3}$ was the diameter at breast height in cm, ρ was the wood gravity (0.643 Mg m^{-3}), Log_{10} was the base ten logarithm and ln was the natural (or neperian) logarithm.

Assessing the Use of the Tiers Method for Equations for Other Species

The procedure described for *A. senegal* was applied to five other tree species. Fig. 10 compares the estimates of the aboveground dry biomass for the different tree species. Tier-3 relied either on a specific aboveground dry biomass (Tier-3-total) or on a trunk dry biomass equation (Tier-3-partial). Tier-2 relied on the trunk volume equation. Tier-1 relied on a pan-tropical aboveground dry biomass equation. Assuming Tier-3-total biomass is the reference value, then the best proxies ranked as follows: Tier-3-partial biomass > Tier-1 > Tier-2 for *C. glutinosum*, *G. senegalensis*, *G. arborea*, *T. ivorensis* and *T. superba*. Tier-3-total and Tier-3-partial predicted similar values. Tier-2 used average wood gravity but this alone did not explain the overestimation in biomass values. Tier-1 and Tier-3-total predicted similar values for the whole range of diameters (Fig. 10d and 10f). When considering *A. senegal*, Tier-3-partial biomass and Tier-2 were very close to Tier-3-total biomass for small trees. Tier-1 was inaccurate for small trees, for which deviation reaches 51% for $D_{1.3} = 10$ cm. However for $D_{1.3} >$ 30 cm, the deviation between Tier-3-total biomass and Tier-1 decreased as diameter increased.

Assessing the Tiers Method for Estimating Biomass of Ecological Zones

Fig. 11 represents the variation of aboveground biomass in three ecological zones of SSA as predicted by different Tiers. In dry regions, the difference between the two Tier-1 equations was about 30% at 50 cm of $D_{1.3}$. Tier-2 overestimated the biomass by about 188% at 50 cm of $D_{1.3}$ and used an average wood gravity of 0.6 g cm^{-3}. Using equation 635 as the reference, the best estimation was obtained with Tier-1-equation 653. When considering tropical moist forests, Tier-3-total and Tier-3-partial assessments resulted in a difference in about 20% at 50 cm of $D_{1.3}$. Tier-2 (eq. 356) overestimated biomass up to four times. Using a Tier-2 model (eq. 445) provided better biomass estimates but values were still overestimated. Tier-1 biomass estimates (eq. 571, 568) were similar to the Tier-2 estimates (eq. 445). In the absence of a Tier 3-total model, the Tier-3-partial model was the least biased. Using Tier-1 and Tier-2 approaches largely overestimated the biomass. For tropical rainforests, Tier-2 estimates were much higher than Tier-3-total estimates. The Tier-2 method consistently overestimated by about 100%. However, the Tier-1 method underestimated by about 40 and 30% for equations 514 and 517, respectively.

4 Discussion

4.1 Current Knowledge of Tree Biomass Allometric Equations in Sub-Saharan Africa

This database is an attempt to inventory, as comprehensively as possibly, volume and biomass equations for SSA. This study suggests that less than 1% of the tree species in this region

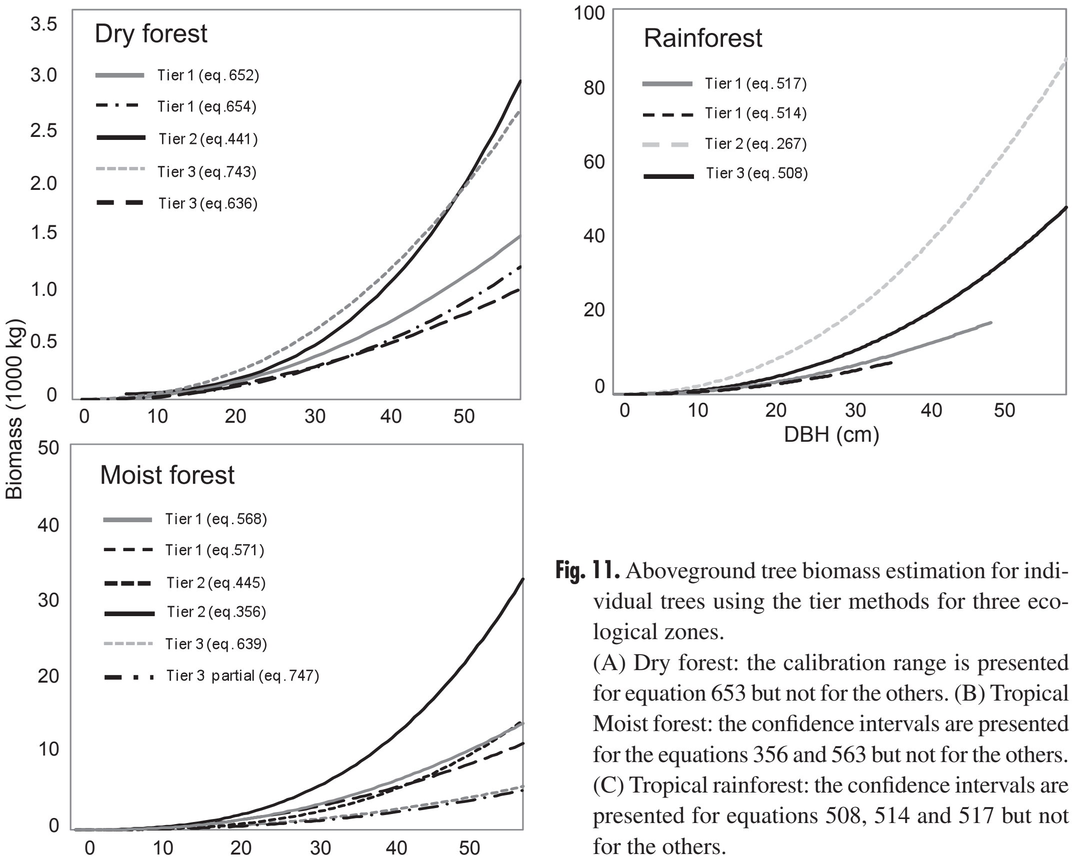

Fig. 11. Aboveground tree biomass estimation for individual trees using the tier methods for three ecological zones.
(A) Dry forest: the calibration range is presented for equation 653 but not for the others. (B) Tropical Moist forest: the confidence intervals are presented for the equations 356 and 563 but not for the others. (C) Tropical rainforest: the confidence intervals are presented for equations 508, 514 and 517 but not for the others.

have country-specific models. This lack clearly limits the development of forestry inventories of commercial volume, biomass and carbon in SSA. The IPCC states that under Tier-2 or Tier-3 approaches, national greenhouse gas inventories must report estimates based on country-specific data; this study highlights important gaps for this region (Tables 1, 2, 3 and 4). Seven tree species account for about 20% of all the equations available. West Africa is the region where most of the studies were carried out; however, 8 West African countries had no equations available. The data analyses reflect the disparity of efforts to create forest biomass assessment tools between countries, regions (Table 1) and ecological zones (Fig. 2 and 5). Currently, none of the SSA's countries have enough national models to report forest C stocks and their variation under the Tier-2 and Tier-3 approaches of the IPCC. Applying the current rate of scientific data production of about 67 equations per year, it would take more than a century to cover the 11,342 species reported in the Forest Resources Assessment of the FAO (2006). The analysis of the compiled equations resulted in the surprising finding that only 22% of the equations had less than 90% of the estimated values of volume or biomass within expected intervals. The quality analysis is biased by the fact that we used average equations to estimate the percentage of results within the interval of possibility. However, gaining access to the original raw data used to build the models is highly improbable, making estimation of model accuracy and precision difficult. Further research should develop meta-databases for tree biomass to allow foresters to assess the validity of volume and biomass estimates from models or field measurements and to develop models that are more appropriate. Hofstad's (2005) review of models for trees and shrubs of southeast Africa was limited to visual observation of the biomass found in 34 models. Sylla and Picard (2005) did an exhaustive inventory of available equations but restricted the analysis to the Sahel. The present study goes much farther, as it reviews the current knowledge for the entire SSA region, explores tree volume and biomass variability and provides a tool for C stock estimation. Because additional results on biomass and volume equations in SSA are continuously published, some of the recent work may be missing (Ibrahima et al. 2002, Djomo et al. 2010).

4.2 Variability of Tree Volume and Biomass

The important differences in volume and biomass found in Fig. 7, 8 and 9 result from a combination of various ecological, environmental and human factors that determine the biomass of a tree. Reduced water stress in tropical rainforests would allow for high growth and biomass (Fig. 7). However, on average, tree biomass is lower in wet climatic zones than in moist ones (Brown 1997). This may be because soils are more acid and less deep in wet than in moist ecological zones. Moreover, soil properties also affect tree biomass and could be integrated in future national or continental allometric models.

Within climatic zones, floristic composition, tree species and growth strategies also influence biomass (Fig. 8 and 10). Important differences in tree biomass were found in Boi Tano Forest reserve in Ghana by Henry et al. (2010), where the differences in tree biomass estimates reached 25% between plant functional types. Tree height and wood gravity also differ between tree functional types (Fig. 6). The development of allometric models by plant functional types integrates part of the variability related to the tree architecture and growth and for forests with high diversity, this is probably an adequate method to improve biomass model per forest ecological types.

Important differences in volume and biomass estimates were found between equations for the same species (Fig. 10). A comparison was made between equations that considered the same tree compartments and ecological zones (using comparable methods to reduce the uncertainty). For example, in Fig. 10, the equations for *V. paradoxa* were developed by Nouvellet et al. (2006). The equations were all developed using the same methodology but still showed great differences in their results. The different mathematical forms alone do not justify the differences in volume between sites and authors. Most of the differences would be explained by the different environmental conditions and anthropogenic factors at the different sites. Environmental factors are not limited to climate factors; for example, Fig. 9 shows no link between rainfall and tree volume (e.g., *Vitellaria paradoxa* eq. 391, 392, 388 and 385). Differences between equations remain unexplained, but various hypothetical factors (e.g., soil, climate and sampling methodology), as well as the modelling process, may account for them.

4.3 Using the Tier Approach Provides Consistent Biomass Estimations

Some authors report that using generalised equations built either by grouping all species together, or by stratifying equations by broad forest types or ecological zones, is highly effective for the tropics. This is because $D_{1.3}$ alone explains more than 95% of the variation in aboveground tropical forest C stocks, even in highly diverse regions (Brown 2002, Gibbs et al. 2007), However, the analyses of the present database reveal important variation in wood gravity, volume and biomass between and within ecological zones and tree species (Fig. 6, 7, 8 and 9).

To develop biomass estimates using the current set of functions, the tier approach proposed in this study provides a decision tree that guides the users in using the most consistent biomass estimations. The tier approach references the IPCC tier method. This study reported differences between the accuracy levels of the equations. It is difficult to quantify the accuracy and the precision of the estimates, as very few destructive measurements exist for SSA and very few authors did comparisons between models. Moreover, when several equations are available, it is preferable to use the same guidelines to maintain consistent methodologies.

The tier approach allows for choosing the best models taking into consideration available datasets for SSA, as illustrated by the case of *A. senegal*. Although no similar efforts exist for other tree species, it was possible to make this type of analysis for other five tree species (Fig. 10) and for three ecological zones (Fig. 11). When considering the tree species, the results show the difficulty of choosing the most suitable equation. Compared to Tier-3-total biomass, Tier-3-partial approach yielded better estimates than did the Tier-2 or Tier-1 approach; the latter largely overestimated or underestimated biomass.

The BEF from the IPCC (2003) in the Tier-2 approach does not consider the tree size and tree species and its use would induce an overestimation of the biomass. Allocation of biomass between the tree compartments varies during a tree's life (Boar et al. 1999) and the BEF should vary with tree dimensions and age. Furthermore, the BEF can still be improved by constructing BEF that considers tree species or functional types and tree dimensions. Lack of accuracy of the BEF clearly limits the use of the Tier-2 approach.

An additional limit for the Tier-2 approach is the selection of a BEF adapted for the tree compartments that are considered in the volume equations. The BEFs in the IPCC (2003) were developed by Brown (1997) for tropical rainforests; they convert industrial volume into biomass. In tropical dry forests however, the merchantable volume is not limited to the trunk but could also include the stump and branches up to 3 cm (eq. 411 and Table 5). An additional limit of the Tier-2 method is the availability of wood gravity values (Fig. 10c). When it is not possible to find a species-specific wood gravity, it is preferable to use an average wood gravity for the family or the functional group rather than the average presented in the IPCC (2006).

The *A. senegal* example leaves some unresolved questions. For instance, is it better to use Tier-3 or Tier-2 approach when the biomass equation (Tier-3) relies on 8 trees and the volume equation (Tier-2) relies on 800 trees? The latter has presumably better precision and lower accuracy, whereas the former has presumably lower precision and better accuracy. Hence, even if Tier-3 is better than Tier-2 in terms of accuracy, it may be advantageous in use Tier-2 (because of quadratic error) when the volume equation relies on much more data than does the biomass equation. In other words, the selection of one specific tier shown in Fig. 11 should also depend on the number of observations used for calibrating each model.

Furthermore, when no BEF parameters are specifically developed for the tree species (including the different ranges of tree volume, tree dimensions and tree compartments), the use of Tier-3-partial is preferable to Tier-1, which is in turn preferable to Tier-2. Other authors have also raised questions about the selection of tree models. For instance, Ares and Fownes (2000) concluded that similar biomass estimates were found using species-specific and generalised equations. However, we suggest the development of species-specific models and BEFs to achieve more accurate biomass estimates.

This review shows that there are several equations available for estimating biomass or volume for any given species particularly in cases for which both species-specific and generalised pluri-specific equations are available. Rather than choosing an equation that is presumably the most appropriate (with the risk of choosing the wrong one), one option is to combine these equations into a single model. Combining several models (e.g., through Bayesian techniques) would improve the reliability of the estimate. Bayesian model averaging (BMA), e.g., defines the multimodel prediction as a weighted mean of each model's prediction. Weights are inferred using a training data set. The weight assigned to each model can be interpreted as its posterior probability of being the best available one, and the BMA predictive variance can be decomposed into two components, one corresponding to the between-model variability, and the second to the within-model variability. These techniques have been fruitfully applied to climatic forecast models (Furrer et al. 2007, Berliner and Kim 2008) and recently to biomass models (Li et al. 2008, Picard et al. 2010). Further research should mobilise correct statistical methods to produce more generalised equations that are adapted to the various forms of vegetation, tree species and ecological zones.

4.4 Improving Methods and Data Reporting for Volume and Biomass Estimates

The current increasing attention to the global C cycle encourages the development of biomass models. However, much progress is still needed to reach an accurate, transparent, consistent and robust greenhouse gas (GHG) balance assessment of forest C stocks and their variations. This study reveals that very few equations have been developed for SSA and many of the countries do not have the information needed to allow for accurate reporting of GHG balance. This highlights the problems experienced when developing equations and the need for standardised methods. Moreover, the following recommendations can be generated by taking into account examples of previous experience and errors.

4.4.1 The Interval of Calibration

The use of the current available equations is limited by the interval of calibration. While the use of generalised equations from Brown (1997), Chave et al. (2005) and Henry et al. (2010) for tropical rainforests are limited to trees with $D_{1.3}$<148, 156 and 180 cm, respectively, the estimation for trees with larger $D_{1.3}$ is limited. The presence of trees with larger $D_{1.3}$ is rare but does occur. For instance, Chave et al. (2003) reported that trees with $D_{1.3}$ > 150 cm represent 9.75% of total biomass in a Brazilian tropical rainforest. Thus, they may account for a significant proportion of the forest biomass. Current available equations cannot predict the biomass of these very big trees. In this case for carbon accounting purposes, it is recommended to calculate conservative estimate of the biomass using the maximum diameter of the interval of calibration instead of the measured tree diameter.

4.4.2 Identification of the Predictors

Various authors have reported that increasing the number of predictors (and particularly incorporating the crown diameter and tree height) improves precision of the models. Chave et al. (2005) reported that for tropical forests, the most important predictors of tree biomass were, in decreasing order of importance, trunk diameter at 1.3 m, wood specific gravity, total height and forest type. Gibbs et al. (2007) reported that $D_{1.3}$ alone explains more than 95% of the variation in aboveground tropical forest carbon stocks. The present results (e.g., those shown in Fig. 10) are a good representation of the biomass variability that results when using only the $D_{1.3}$ as input. While the model developed by Brown (2002) explains 95% of the variability found in less than 150 tree samples, our results (Fig. 7, 8, 9 and 10) clearly illustrate that one generalised model based only on $D_{1.3}$ cannot explain the important variability found in a single ecological zone.

Only 24% of the equations reviewed here use more than one predictor, (diameter and circumferences being the most common). Models could be developed that include the crown diameter or crown area in open forests and these could be integrated with high resolution remote sensing analyses to estimate biomass over large spatial scales (Goetz et al. 2009). Analyses of the database also showed that diameter at the base of the tree is mainly used in tropical dry forests, whereas $D_{1.3}$ is used in 91% of the equations for tropical rainforests.

4.4.3 Selection of Method and Data Reporting

Destructive measurements are limited by technical, financial and in some cases, legal considerations (Attua and Laing 2005, Peltier et al. 2007, Henry et al. 2010). Destructive sampling is, however, the most accurate method. The development of destructive measurements should be supported to limit the use of conversion coefficients that decrease the accuracy of the estimates. Statistical analyses should take into account various possible models and researchers should select the most precise and least biased ones. Resulting graphics and data reporting should also present units of measurement in homogeneous and consistent ways. The following information should be explicitly reported: the interval of calibration, the residual standard deviation, the coefficient of correlation, the number of samples and the address where the primary data used to create the regression is stored (to facilitate data checking and meta-analysis of tree biomass). Units in the figures and in the body of the text should be coherent to facilitate the use of the equations by other researchers, projects and national institutions, who may use them to inventory timber volume, biomass and carbon stocks. Editors should ensure that equations have been reported correctly (as noted earlier, 27% of the publications reported the wrong equations, hindering the present work). Tree taxonomy should be provided in a scientific, authoritative and well-identified system.

4.4.4 Belowground Biomass

While this study focused on the aboveground compartments, the belowground compartment is equally important for assessing forest C stock change and is one of the five C pools considered by the IPCC (2006). Belowground biomass can represent an important portion of the total biomass, especially in dry areas (House and Hall 2001). While the tree height of *Balanites aegyptiaca* reaches 8 m, the rooting system often reaches 20 meters depth (Fournier 1993, Mokany et al. 2006). Several savannah tree species develop important rooting systems (particularly in the context of arid climates). However, only 1.3% of the equations consider the rooting system. It is clear that more root biomass studies are needed (Snowdon et al. 2000). However, measuring the biomass of rooting systems is very costly and time consuming. In most cases, C inventories use root-to-shoot ratios. The IPCC (2006) has created an inventory of available root-to-shoot ratios varying from 0.09–0.68 for the entire tropical domain. When considering the difficulty of root biomass measurements and the current state of knowledge, fractal geometry could be a promising tool to overcome the practical problems arising from the destructive sampling of belowground tree biomass (Hairiah et al. 2001).

5 Conclusions

This study contains a comprehensive database of allometric equations for SSA. The various equations found in the database reflect the variability in volume and biomass of different ecological zones, tree species, ages, management types and sites found in SSA. This work highlights important gaps in researchers' ability to use equations for estimating biomass and C stocks in the various ecological zones and countries found in SSA. Currently, estimating biomass based on available equations is difficult. The study proposes the use of a Tier approach and specifies rules to facilitate consistent and comparable estimations. The use of species-specific biomass equations, rather than volume and generalised equations, are encouraged. Recommendations made in this study should facilitate standardization and improved use of the equations in the context of global observation systems. Future research should develop Bayesian statistical approaches to better utilise the richness of this database and should propose alternative equations that are better adapted to specific ecological, climate and anthropogenic contexts.

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Total of 78 references

Appendix A: List of the consulted scientific journals during the literature survey

Agriculture, Ecosystems and Environment,
Agroforestry Systems,
Ambio,
Annuals of Forest Science,
Applied Soil Ecology,
Aquatic Botany,
Biodiversity and Conservation,
Biomass and Bioenergy,
Bois et forêt des tropiques,
CAB International,
Canadian Journal of Forest Research,
Climate Research,
Climatic Change,
Danish Journal of Geography,
Ecology,
Forest Ecology and Management,
Geoderma,
Global Change Biology,
Intercencia,
ITC journal,
Journal of Applied Ecology,
Journal of Arid Environments,
Journal of the Tanzania Association of Foresters,
Journal of Tropical Forest Science,
New Phytologist,
Oecologia, Plant Soil,
Remote Sensing,
Silvae genetica,
The Journal of Ecology,
Tropical Ecology,
Tropical Woods.

Appendix B. Allometric equations predicting individual tree and stand volumes in sub-Saharan Africa.

The calibration ranges of the variable X are presented in brackets. When no calibration range was mentioned in the article, it was calculated (see 2.2). The symbols * and ** indicate that one and two thresholds, respectively, were calculated from this study. The maximum $D_{1.3}$ was considered to be 200 cm. The calibration ranges of the variables W, Z, U and V are not mentioned in this table. The value of the column "Interval of possibility" corresponds to the percentage of values falling within the interval of possibility. Acronyms used: As: stem cross-sectional area at $D_{1.3}$, BA: basal area, D_0: basal diameter, C: circumference, C (10,180): circumference at 10 cm and 180 cm, CA: crown area, Cb: basal circumference, CD: crown diameter, CH: crown height, CV: canopy volume, D20 – 30: diameter at 20 and 30 cm height, $D_{1.3}$: diameter at breast height, H: height, Log: natural logarithm, Log10: logarithm in basis 10, SQRT: square root, wd: wood gravity and yr: age. Adj means adjusted squared correlation coefficient.

Tree compartments are represented by the following abbreviations.

T: Trunk-underbark, B: Bark, Bg: Gross branches (D>7 cm), Bt: Thin branches (D<7 cm), Bd: dead branches, L: Leaves, S: Stump, Rb: Large root, Rm: Medium root and Rf: Fine root. The number that follows the acronym Bt indicates the minimum branch diameter.

Group 1: *Bombax brevicuspe*, *Celtis mildbraedii*, group 2: *Afzelia africana*, *Pericopsis elata*, group 3: *Aningeria robusta*, *Mansonia altissima*, *Nauclea diderichii*, *Nesogordonia papaverifera*, *Parkia bicolor*, *Petersianthus macrocarpus*, *Pterygota macrocarpa*, *Pycnanthus angolensis*, *Tieghemella heckelii*, *Terminalia superba*, *Triplochiton scleroxylon*, group 4: *Antiaris toxicaria*, *Entandrophragma utile*, *Milicia excelsa*, *Nesogordonia papaverifera*, group 5*:Mansonia altissima*, *Triplochiton scleroxylon*, group 6: *Aningeria altissima*, *Lophira alata*, *Milicia excelsa*, *Piptadeniastrum africanum*, group 7: *Guibourtia ehie*, *Khaya anthotheca*, *Strombosia glaucescens*, group 8: *Distemonanthus benthamianus*, *Entandrophragma cylindricum*, *Entandrophragma utile*, *Entandrophragma angolensis*, *Ehretia acuminata*, *Khaya ivorensis*, *Sterculia oblonga*, *Terminalia ivorensis*, group 9: *Combretum glutinosum*, *Cenchrus biflorus*, group 10: *Combretum glutinosum*, *Guiera senegalensis*, group 11: *Daniellia oliveri*, *Pterocarpus erinaceus*, *Bombax costatum*, group 12: *Daniellia oliveri*, *Cordyla pinnata*, *Pericopsis laxiflora* , group 13: *Guiera senegalensis*, *Pterocarpus lucens*, group 14: *Guiera senegalensis*, *Grewia bicolour*, group 15: *Pterocarpus lucens*, *Grewia bicolor*, *Guiera senegalensis*, *Combretum micranthum* , group 16: *Afzelia africana*, *Daniellia oliveri*, *Pterocarpus erinaceus*, group 17: *Acacia seyal*, *Balanites aegyptiaca*, *Acacia nilotica*, *Anogeissus leiocarpus*, group 18: *Pterocarpus lucens*, *Combretum micranthum*, group 19: *Acacia seyal*, *Anogeissus leiocarpus*, group 20: *Brachystegia boehmii*, *Brachystegia longifolia*, group 21: *Brachystegia floribunda*, *Brachystegia manga*, group 22: *Faurea saligna*, *Faurea speciosa*, group 23: *Pterocarpus angolensis*, *Pterocarpus rotundifolius*, group 24: *Combretum geitonophyllum*, *Combretum glutinosum*, *Piliostigma thonningii*, *Terminalia macroptera*

Appendix B

ID	Tree species and location (annual rainfall)	Model Equations (m^3)	Variables X (min, max), W, Z, U and V
INDIVIDUAL TREE IN TROPICAL RAINFOREST (CLASSIFICATION PER TREE SPECIES)			
1	*Acacia auriculiformis* in Lama in Benin (1065)	log10Y= 1.37+(2.65×log10(X))	D1.3 in m (0.01, 1.69)**
2	*Afzelia africana* in Nigeria	Y= 0.0075+0.000049×(X^(2.091))×(W^(0.8871))	D1.3 in cm, Hme in m (1, 200)**
3	*Afzelia bipindensis* in Gabon	Y= 0.6+10.8×(X^2)	D1.3 in m (0.01, 0.4)*
4	*Afzelia pachyloba* in Gabon	Y= 9.72×(X^2.46)	D1.3 in m (0.01, 0.4)*
5	*Albizzia ferruginea* in Nigeria	Y= 0.0983+0.000002×(X^(2.4307))×(W^(1.5607))	D1.3 in cm, Hme in m (1, 200)**
6	*Albizzia zygia* in Nigeria	Y= 0.001+0.000073×(X^(1.9472))×(W^(0.9638))	D1.3 in cm, Hme in m (1, 200)**
7	*Alstonia boonei* in Nigeria	Y= –0.1488+0.000683×(X^(1.636))×(W^(0.5998))	D1.3 in cm, Hme in m (13, 200)**
8	*Amphimas pterocarpoides* in Nigeria	Y= –0.1372+0.000501×(X^(1.5873))×(W^(0.7744))	D1.3 in cm, Hme in m (13, 200)**
9	*Antiaris africana* in Gabon	Y= 9.72×(X^2.46)	D1.3 in m (0.01, 0.4)*
10	- in Ivory Coast	Y= –0.580+10.378×(X^2)	D1.3 in m (0.24, 1.69)**
11	- in Bossématié in Ivory Coast(1325)	Y= 12.81×(X^2)–3.31×X+0.35	D1.3 in m (0.13, 1.69)**
12	*Antiaris toxicaria* in Nigeria	Y= 0.0434+0.000031×(X^(1.9463))×(W^(1.2133))	D1.3 in cm, Hme in m (1, 200)**
13	*Antrocaryon klaineanum* in Gabon	Y= 9.28×(X^2.07)	D1.3 in m (0.01, 0.4)*
14	- in Nigeria	Y= –0.072+0.000337×(X^(1.4886))×(W^(0.9625))	D1.3 in cm, Hme in m (11, 200)**
15	*Aucoumea klaineana* in Gabon	Y= 10×(X^2)	D1.3 in m (0.01, 1.69)**
16	- in Fernan-Vaz in Gabon (1953)	Y= –0.146424+9.16325×(X^2)	D1.3 in m (0.13, 1.69)**
17	- in Mvoum in Gabon (2157)	Y= –0.1+11×(X^2)	D1.3 in m (0.1, 1.69)**
18	*Autranella congolensis* in Gabon	Y= 9.72×(X^2.46)	D1.3 in m (0.01, 0.4)*
19	- in RCA	Y= 12.16×(X^(1.91))	D1.3 in m (0.01, 1.69)**
20	*Baillonella toxisperma* in Mbalmayo in Cameroon (1628)	Y= 0.000139×(X^2.362)	D1.3 in cm (1, 80)*
21	- idem	Y= 1.062+7.689×(X^2)	D1.3 in m (0.5, 1.2)
22	- in Gabon	Y= 11.59×(X^1.94)	D1.3 in m (0.01, 0.7)*
23	*Berlinia bracteosa* in Gabon	Y= 9.72×(X^2.46)	D1.3 in m (0.01, 0.4)*
24	*Berlinia confusa* in Gabon	Y= 9.28×(X^2.07)	D1.3 in m (0.01, 0.7)*
25	*Blighia sapida* in Nigeria	Y= 0.0967+0.000016×(X^(2.2774))×(W^(1.0182))	D1.3 in cm, Hme in m (1, 200)**
26	*Bombax buonopozense* in Nigeria	Y= –0.0339+0.000107×(X^(2.1219))×(W^(0.5608))	D1.3 in cm, Hme in m (10, 200)**
27	*Brachystegia eurycoma* in Nigeria	Y= –0.0666+0.000208×(X^(1.7482))×(W^(0.8732))	D1.3 in cm, Hme in m (11, 200)**
28	*Brachystegia kennedyi* in Nigeria	Y= –0.2308+0.001043×(X^(1.5817))×(W^(0.5632))	D1.3 in cm, Hme in m (15, 200)**
29	*Brachystegia nigerica* in Nigeria	Y= –0.0785+0.000154×(X^(1.7479))×(W^(1.019))	D1.3 in cm, Hme in m (11, 200)**
30	*Canarium schweinfurthii* in Gabon	Y= 9.72×(X^2.46)	D1.3 in m (0.01, 0.6)*
31	- in Nigeria	Y= –0.1538+0.000487×(X^(1.5191))×(W^(0.8941))	D1.3 in cm, Hme in m (13, 200)**
32	*Carapa procera* in Nigeria	Y= –0.0729+0.000189×(X^(1.9179))×(W^(0.6436))	D1.3 in cm, Hme in m (12, 200)**
33	*Cedrelopsis grevei* in RCA	Y= 11.48×(X^(1.95))	D1.3 in m (0.01, 1.69)**
34	*Ceiba pentandra* in Gabon	Y= 9.72×(X^2.46)	D1.3 in m (0.01, 0.4)*
35	- in Bossématié in Ivory Coast (1325)	Y= 12.5×(X^2)–2.9×X+0.28	D1.3 in m (0.12, 1.69)**
36	- in Nigeria	Y= 0.0286+0.000047×(X^(1.9788))×(W^(1.0475))	D1.3 in cm, Hme in m (1, 200)**
37	*Celtis brieyi* in Gabon	Y= 9.72×(X^2.46)	D1.3 in m (0.01, 0.4)*
38	*Celtis zenkeri* in Nigeria	Y= 0.0224+0.000078×(X^(1.695))×(W^(1.2034))	D1.3 in cm, Hme in m (1, 200)**
39	*Chlorophora excelsa* in Guinea-Bisseau	Y= 9.7×(X^2)–X+0.11	D1.3 in m (0.05, 1.69)**
40	- in Ivory Coast	Y= –1.05+10.078×(X^2)	D1.3 in m (0.33, 1.69)**

Tree components	n, r^2	Interval of possibility (%)	Quality	References
T+Bg+Bt3+B+S	190, 0.96	100	2	Fonton, N. H., Kakai, R. G., et al. (2002)
T	80,–	98	2	Akindele, S.O. (2005)
T	–	0	1	Bilé Allogho, J. (1999)
T	–	100	2	Bilé Allogho, J. (1999)
T	25,–	95	2	Akindele, S.O. (2005)
T	35,–	99	2	Akindele, S.O. (2005)
T	39,–	100	2	Akindele, S.O. (2005)
T	23,–	100	2	Akindele, S.O. (2005)
T	–	100	2	Bilé Allogho, J. (1999)
T	–	100	2	CTFT (1967)
T	–	100	2	Pieper, Y., and Laumans, P. (1992)
T	49,–	96	2	Akindele, S.O. (2005)
T	–	80	1	Bilé Allogho, J. (1999)
T	7,–	100	2	Akindele, S.O. (2005)
T	–	95	2	Mapaga, D., Ingueza, D., et al. (2002)
T	–	100	2	CTFT (1979)
T	–	100	2	Mapaga, D., Ingueza, D., et al. (2002)
T	–	100	2	Bilé Allogho, J. (1999)
T	–	74	1	CTFT (1964)
T	–	100	2	Mapaga, D., Ingueza, D., et al. (2002)
T	–	100	2	Mapaga, D., Ingueza, D., et al. (2002)
T	–	51	1	Bilé Allogho, J. (1999)
T	–	100	2	Bilé Allogho, J. (1999)
T	–	84	1	Bilé Allogho, J. (1999)
T	20,–	93	2	Akindele, S.O. (2005)
T	18,–	100	2	Akindele, S.O. (2005)
T	27,–	100	2	Akindele, S.O. (2005)
T	11,–	100	2	Akindele, S.O. (2005)
T	21,–	100	2	Akindele, S.O. (2005)
T	–	100	2	Bilé Allogho, J. (1999)
T	12,–	100	2	Akindele, S.O. (2005)
T	30,–	100	2	Akindele, S.O. (2005)
T	–	77	1	CTFT (1964)
T	–	100	2	Bilé Allogho, J. (1999)
T	–	100	2	Pieper, Y., and Laumans, P. (1992)
T	31,–	98	2	Akindele, S.O. (2005)
T	–	100	2	Bilé Allogho, J. (1999)
T	75,–	96	2	Akindele, S.O. (2005)
T	–	95	2	CTFT (1986)
T	–	100	2	CTFT (1967)

ID	Tree species and location (annual rainfall)	Model Equations (m^3)	Variables X (min, max), W, Z, U and V
41	- idem	Y= 0.037+9.07×(X^2)	D1.3 in m (0.01, 1.69)**
42	- in RCA	Y= 11.95×(X^(2.22))	D1.3 in m (0.01, 1.69)**
43	*Chrysobalanus icaco* in Nigeria	Y= –0.002+0.001032×(X^(1.064))×(W^(1.1164))	D1.3 in cm, Hme in m (1, 200)**
44	*Chrysophyllum sp* in Guinea-Bisseau	Y= 13.3×(X^2)–3.2×X+0.27	D1.3 in m (0.12, 1.69)**
45	*Coelocaryon klaineana* in Gabon	Y= 11.24×(X^1.96)	D1.3 in m (0.01, 0.4)*
46	*Coelocaryon preussii* in Nigeria	Y= –0.038+0.000264×(X^(1.3081))×(W^(1.2792))	D1.3 in cm, Hme in m (8, 200)**
47	*Copaifera mildbraedii* in Gabon	Y= 9.28×(X^2.07)	D1.3 in m (0.01, 0.4)*
48	- in Nigeria	Y= 0.1092+0.000092×(X^(1.3779))×(W^(1.4803))	D1.3 in cm, Hme in m (1, 200)**
49	*Cordia millenii* in Nigeria	Y= 0.0189+0.000041×(X^(2.0049))×(W^(1.0888))	D1.3 in cm, Hme in m (1, 200)**
50	*Cylicodiscus gabonensis* in Nigeria	Y= 0.0102+0.000166×(X^(1.79))×(W^(0.822))	D1.3 in cm, Hme in m (1, 200)**
51	*Dacryodes buettneri* in Gabon	Y= 9.2×(X^1.9)	D1.3 in m (0.01, 0.7)*
52	*Dacryodes igaganga* in Gabon	Y= 11.24×X^1.96	D1.3 in m (0.01, 0.4)*
53	*Dacryodes normandii* in Gabon	Y= 9.72×(X^2.46)	D1.3 in m (0.01, 0.4)*
54	- in Fernan-Vaz in Gabon (1953)	Y= 0.43094+8.2619×(X^2)	D1.3 in m (0.01, 1.69)**
55	*Daniellia klainei* in Gabon	Y= 9.72×(X^2.46)	D1.3 in m (0.01, 0.6)*
56	*Daniellia ogea* in Guinea-Bisseau	Y= 9.3×(X^2)+5.3×X–0.6	D1.3 in m (0.1, 1.69)**
57	- in Nigeria	Y= –0.0501+0.000389×(X^(1.3084))×(W^(1.184))	D1.3 in cm, Hme in m (8, 200)**
58	*Daniellia soyauxii* in Gabon	Y= 9.72×(X^2.46)	D1.3 in m (0.01, 0.4)*
59	*Desbordesia glaucescens* in Gabon	Y= 9.72×(X^2.46)	D1.3 in m (0.01, 0.4)*
60	*Detarium macrocarpum* in Gabon	Y= 9.72×(X^2.46)	D1.3 in m (0.01, 0.4)*
61	*Detarium senegalensis* in Nigeria	Y= 0.0214+0.000054×(X^(1.9785))×(W^(1.1273))	D1.3 in cm, Hme in m (1, 200)**
62	*Dialium guineense* in Nigeria	Y= –0.0553+0.00056×(X^(1.3336))×(W^(0.9561))	D1.3 in cm, Hme in m (9, 200)**
63	*Didelotia africana* in Gabon	Y= 9.28×(X^2.07)	D1.3 in m (0.01, 0.4)*
64	*Diospyros mespiliformis* in Nigeria	Y= –0.0779+0.000329×(X^(1.5498))×(W^(0.9614))	D1.3 in cm, Hme in m (11, 200)**
65	*Diospyros sanza-minika* in Gabon	Y= 9.28×(X^2.07)	D1.3 in m (0.01, 0.4)*
66	*Distemonanthus benthamianus* in Guinea-Bisseau	Y= 9.06×(X^2)–0.02	D1.3 in m (0.05, 1.69)**
67	- in Bossématié in Ivory Coast(1325)	Y= 9.06×(X^2)–0.02	D1.3 in m (0.05, 1.69)**
68	- in Nigeria	Y= –0.0221+0.000107×(X^(1.9082))×(W^(0.8747))	D1.3 in cm, Hme in m (8, 200)**
69	*Entandrophragma angolensis* in Gabon	Y= 10.82×(X^1.89)	D1.3 in m (0.01, 0.8)*
70	- in Guinea-Bisseau	Y= 10.25×(X^2)	D1.3 in m (0.01, 1.69)**
71	- in Ivory Coast	Y= –1.022+12.041×(X^2)	D1.3 in m (0.3, 1.69)**
72	- in RCA	Y= 11.82×(X^(2.13))	D1.3 in m (0.01, 1.69)**
73	*Entandrophragma candollei* in Gabon	Y= 10.82×(X^1.89)	D1.3 in m (0.01, 0.8)*
74	- in Ivory Coast	Y= 1.966+9.542×(X^2)	D1.3 in m (0.01, 1.69)**
75	*Entandrophragma congeonse* in Gabon	Y= 10.82×(X^1.89)	D1.3 in m (0.01, 0.8)*
76	*Entandrophragma cylindricum* in Api in Cameroon (1485)	Y= 2.003–1.094×X+11.89×(X^2)	D1.3 in m (0.8, 1.69)*
77	- in Mbalamayo in Cameroon (1628)	Y= 0.000459×(X^2.14853)	D1.3 in cm (1, 80)*
78	-in Mayombe in Congo (1424)	Y= –0.631+13.173×(X^2)	D1.3 in m (0.22, 1.69)**
79	-in Gabon	Y= 10.82×(X^1.89)	D1.3 in m (0.01, 0.8)*
80	-in Ivory Coast	Y= 0.590+12.180×(X^2)	D1.3 in m (0.01, 1.69)**
81	-in Mopri in Ivory Coast (1272)	Y= 12.3×(X^2)+0.04	D1.3 in m (0.01, 1.69)**
82	-in Nigeria	Y= 0.0176+0.000008×(X^(2.2857))×(W^(1.2502))	D1.3 in cm, Hme in m (1, 200)**

Tree components	n, r^2	Interval of possibility (%)	Quality	References
T	–	91	2	CTFT (1967)
T	–	95	2	CTFT (1964)
T	20,–	95	2	Akindele, S.O. (2005)
T	–	100	2	CTFT (1986)
T	–	40	1	Bilé Allogho, J. (1999)
T	36,–	100	2	Akindele, S.O. (2005)
T	–	68	1	Bilé Allogho, J. (1999)
T	17,–	93	2	Akindele, S.O. (2005)
T	64,–	98	2	Akindele, S.O. (2005)
T	15,–	96	2	Akindele, S.O. (2005)
T	–	79	1	Bilé Allogho, J. (1999)
T	–	53	1	Bilé Allogho, J. (1999)
T	–	100	2	Bilé Allogho, J. (1999)
T	–	85	1	CTFT (1979)
T	–	100	2	Bilé Allogho, J. (1999)
T	–	87	1	CTFT (1986)
T	30,–	100	2	Akindele, S.O. (2005)
T	–	100	2	Bilé Allogho, J. (1999)
T	–	100	2	Bilé Allogho, J. (1999)
T	–	100	2	Bilé Allogho, J. (1999)
T	74,–	96	2	Akindele, S.O. (2005)
T	12,–	100	2	Akindele, S.O. (2005)
T	–	63	1	Bilé Allogho, J. (1999)
T	29,–	100	2	Akindele, S.O. (2005)
T	–	58	1	Bilé Allogho, J. (1999)
T	–	100	2	CTFT (1986)
T	–	100	2	Pieper, Y., and Laumans, P. (1992)
T	26,–	100	2	Akindele, S.O. (2005)
T	–	78	1	Bilé Allogho, J. (1999)
T	–	93	2	CTFT (1986)
T	–	100	2	CTFT (1967)
T	–	95	2	CTFT (1964)
T	–	70	1	Bilé Allogho, J. (1999)
T	–	72	1	CTFT (1967)
T	–	68	1	Bilé Allogho, J. (1999)
T	–	100	2	Palla, F., Louppe, D., et al. (2002)
T	–	93	2	Palla, F., Louppe, D., et al. (2002)
T	–	100	2	Palla, F., Louppe, D., et al. (2002)
T	–	70	1	Bilé Allogho, J. (1999)
T	–	78	1	CTFT (1967)
T	–	88	1	Palla, F., Louppe, D., et al. (2002)
T	8,–	97	2	Akindele, S.O. (2005)

ID	Tree species and location (annual rainfall)	Model Equations (m^3)	Variables X (min, max), W, Z, U and V
83	-in RCA	Y= 11.44×(X^(2.27))	D1.3 in m (0.01, 1.69)**
84	-in M'Baïki in RCA (1671)	Y= 9.68×(X^2)+0.2×X	D1.3 in m (0.01, 1.69)**
85	*Entandrophragma utile* in Gabon	Y= 10.82×(X^1.89)	D1.3 in m (0.01, 0.8)*
86	-in Guinea-Bisseau	Y= 10.01×(X^2)–0.06	D1.3 in m (0.08, 1.69)**
87	-in Ivory Coast	Y= 0.848+10.365×(X^2)	D1.3 in m (0.01, 1.69)**
88	-in RCA	Y= 13.06×(X^(2.05))	D1.3 in m (0.01, 1.69)**
89	*Eribroma oblongum* in Gabon	Y= 9.72×(X^2.46)	D1.3 in m (0.01, 0.4)*
90	-in Nigeria	Y= 0.0252+0.000036×(X^(1.8522))×(W^(1.2872))	D1.3 in cm, Hme in m (1, 200)**
91	*Erythrophleum ivorensis* in Gabon	Y= 9.72×(X^2.46)	D1.3 in m (0.01, 0.6)*
92	*Erythrophleum suaveolens* in Nigeria	Y= –0.0119+0.000428×(X^(1.3979))×(W^(1.0433))	D1.3 in cm, Hme in m (4, 200)**
93	*Fagara heitzii* in Gabon	Y= 9.72×(X^2.46)	D1.3 in m (0.01, 0.4)*
94	*Funtumia africana* in Nigeria	Y= 0.2594+0.000000012×(X^(2.9144))×(W^(2.5063))	D1.3 in cm, Hme in m (1, 200)**
95	*Funtumia elastica* in Nigeria	Y= 0.0076+0.000057×(X^(1.9577))×(W^(1.0165))	D1.3 in cm, Hme in m (1, 200)**
96	*Gambeya africana* in Gabon	Y= 9.72×(X^2.46)	D1.3 in m (0.01, 0.4)*
97	*Gambeya lacourtiana* in Gabon	Y= 9.2×X^1.9	D1.3 in m (0.01, 0.4)*
98	*Gambeya perpulchra* in Gabon	Y= 9.28×(X^2.07)	D1.3 in m (0.01, 0.4)*
99	*Gilbertiodendron dewevrei* in Gabon	Y= 9.72×(X^2.46)	D1.3 in m (0.01, 0.4)*
100	*Gmelina arborea* in Omo in Nigeria (2293)	Y= 0.00007141×(X^(1.8562))×(W^(0.98123))	D1.3 in cm, H in m (7, 200)*
101	-in Onigambari in Nigeria (1316)	Y= 0.0206+0.00004×(X^2)×W	D1.3 in cm, Ht in m (1, 200)**
102	-idem	Y= 0.0394+0.0005×(X^2)	BD in cm (1.33, 225.33)**
103	-idem	Y= –0.0345+0.0008×(X^2)	D1.3 in cm (7, 200)**
104	*Gossweilerodendron balsamiferum* in Gabon	Y= 11.7×(X^2.16)	D1.3 in m (0.01, 0.6)*
105	-in Nigeria	Y= 0.2512+0.00000084×(X^(2.4695))×(W^(1.7271))	D1.3 in cm, Hme in m (1, 200)**
106	*Guarea cedrata* in Gabon	Y= 9.72×(X^(2.46))	D1.3 in m (0.01, 0.4)*
107	-in Ivory Coast	Y= –0.478+12.942×(X^2)	D1.3 in m (0.2, 1.69)**
108	-in Nigeria	Y= 0.1184+0.000002×(X^(2.4381))×(W^(1.554))	D1.3 in cm, Hme in m (1, 200)**
109	*Guarea thompsonii* in Gabon	Y= 9.72×(X^2.46)	D1.3 in m (0.01, 0.4)*
110	-in Nigeria	Y= –0.6121+0.036142×(X^(0.7003))×(W^(0.4544))	D1.3 in cm, Hme in m (14, 200)**
111	*Guibourtia demeusei* in Fernan-Vaz in Gabon (1953)	Y= –0.24434+8.397×(X^2)	D1.3 in m (0.18, 1.69)**
112	*Guibourtia ehie* in Gabon	Y= 9.72×(X^2.46)	D1.3 in m (0.01, 0.4)*
113	*Guibourtia tessmannii* in Gabon	Y= 1.05+10.08×(X^2)	D1.3 in m (0.01, 0.7)*
114	*Hallea ciliata* in Fernan-Vaz in Gabon (1953)	Y= –0.38493+9.9592×(X^2)	D1.3 in m (0.2, 1.69)**
115	-in Guinea-Bisseau	Y= 14.03×(X^2)–3.6×X+0.34	D1.3 in m (0.13, 1.69)**
116	*Hannoa klaineana* in Nigeria	Y= 0.085+0.000014×(X^(1.7008))×(W^(1.7901))	D1.3 in cm, Hme in m (1, 200)**
117	*Heritiera utilis* in Yapo in Ivory Coast (1434)	Y= 1.95×X^(2.7) ×10^(–6)	C in cm (3.14, 530.93)**
118	-idem	Y(dm3)= 42.9×X^(2.7)×10^(–6)	D1.3 in dm (1, 200)**
119	*Holoptelea grandis* in Nigeria	Y= 0.2908+0.000002×(X^(1.1882))×(W^(3.0336))	D1.3 in cm, Hme in m (1, 200)**
120	*Hylodendron gabunense* in Nigeria	Y= 0.0773+0.000021×(X^(1.9464))×(W^(1.3307))	D1.3 in cm, Hme in m (1, 200)**
121	*Irvingia gabonensis* in Nigeria	Y= –0.0467+0.000123×(X^(1.8552))×(W^(0.9061))	D1.3 in cm, Hme in m (10, 200)**
122	*Khaya grandifoliola* in Nigeria	Y= –2.0966+0.372804×(X^(0.5351))×(W^(0.0824))	D1.3 in cm, Hme in m (18, 200)**
123	*Khaya ivorensis* in Gabon	Y= 10.82×(X^(1.89))	D1.3 in m (0.01, 0.8)*

Tree components	n, r^2	Interval of possibility (%)	Quality	References
T	–	98	2	CTFT (1964)
T+B	–	91	2	Palla, F., Louppe, D., et al. (2002)
T	–	73	1	Bilé Allogho, J. (1999)
T	–	100	2	CTFT (1986)
T	–	79	1	CTFT (1967)
T	–	88	1	CTFT (1964)
T	–	100	2	Bilé Allogho, J. (1999)
T	54,–	96	2	Akindele, S.O. (2005)
T	–	100	2	Bilé Allogho, J. (1999)
T	34,–	98	2	Akindele, S.O. (2005)
T	–	100	2	Bilé Allogho, J. (1999)
T	6,–	76	1	Akindele, S.O. (2005)
T	55,–	98	2	Akindele, S.O. (2005)
T	–	100	2	Bilé Allogho, J. (1999)
T	–	48	1	Bilé Allogho, J. (1999)
T	–	73	1	Bilé Allogho, J. (1999)
T	–	100	2	Bilé Allogho, J. (1999)
T+B	60,–	100	2	FORMECU (1991)
T+B	75, 0.98	97	2	Akinnifesi, F. and Akinsanmi, F. (1995)
T+B	75, 0.86	94	2	Akinnifesi, F. and Akinsanmi, F. (1995)
T+B	75, 0.94	100	2	Akinnifesi, F. and Akinsanmi, F. (1995)
T	–	88	1	Bilé Allogho, J. (1999)
T	9,–	92	2	Akindele, S.O. (2005)
T	–	100	2	Bilé Allogho, J. (1999)
T	–	100	2	CTFT (1967)
T	30,–	94	2	Akindele, S.O. (2005)
T	–	100	2	Bilé Allogho, J. (1999)
T	12,–	100	2	Akindele, S.O. (2005)
T	–	100	2	CTFT (1979)
T	–	100	2	Bilé Allogho, J. (1999)
T	–	30	1	Bilé Allogho, J. (1999)
T	–	100	2	CTFT (1979)
T	–	100	2	CTFT (1986)
T	5,–	96	2	Akindele, S.O. (2005)
T	114,–	100	2	Martinot-Lagarde, P. (1961)
T	114,–	100	2	Martinot-Lagarde, P. (1961)
T	5,–	91	2	Akindele, S.O. (2005)
T	47,–	93	2	Akindele, S.O. (2005)
T	22,–	100	2	Akindele, S.O. (2005)
T	6,–	100	2	Akindele, S.O. (2005)
T	–	79	1	Bilé Allogho, J. (1999)

ID	Tree species and location (annual rainfall)	Model Equations (m³)	Variables X (min, max), W, Z, U and V
124	-in Ivory Coast	Y= –1.531+12.047×(X^2)	D1.3 in m (0.36, 1.69)**
125	-in Bossématié in Ivory Coast (1325)	Y= 12.91×(X^2)–3.07×X+0.27	D1.3 in m (0.12, 1.69)**
126	-in Nigeria	Y= –0.0391+0.000107×(X^(1.6115))×(W^(1.2689))	D1.3 in cm, Hme in m (9, 200)**
127	*Lannea welwitschii* in Nigeria	Y= 0.0808+0.000009×(X^(2.2765))×(W^(1.2))	D1.3 in cm, Hme in m (1, 200)**
128	*Lophira alata* in Cameroon	Y= 0.00619×(X^(1.690))	D1.3 in cm (1, 200)**
129	-in Gabon	Y= 9.72×(X^(2.46))	D1.3 in m (0.01, 0.7)*
130	-in Ivory Coast	Y= 0.437+11.210×(X^2)	D1.3 in m (0.01, 1.69)**
131	-idem	Y= 13×(X^2)–0.7×X	D1.3 in m (0.06, 1.69)**
132	-in Nigeria	Y= –0.0091+0.000127×(X^(1.9816))×(W^(0.7462))	D1.3 in cm, Hme in m (5, 200)**
133	*Lovoa trichilioides* in Gabon	Y= 0.48+10.2×(X^2)	D1.3 in m (0.01, 0.7)*
134	-in Ivory Coast	Y= 0.252+12.942×(X^2)	D1.3 in m (0.01, 1.69)**
135	-in Nigeria	Y= 0.0469+0.000023×(X^(1.9187))×(W^(1.3645))	D1.3 in cm, Hme in m (1, 200)**
136	-in RCA	Y= 12.43×(X^(2.43))	D1.3 in m (0.01, 1.69)**
137	*Mammea africana* in Gabon	Y= 9.72×(X^2.46)	D1.3 in m (0.01, 0.4)*
138	-in Guinea-Bisseau	Y= 10.98×(X^2)	D1.3 in m (0.01, 1.69)**
139	*Manilkara obovata* in Nigeria	Y= –0.0688+0.000218×(X^(1.6895))×(W^(0.9203))	D1.3 in cm, Hme in m (11, 200)**
140	*Mansonia altissima* in Guinea-Bisseau	Y= 11.62×(X^2)–0.05	D1.3 in m (0.07, 1.69)**
141	-in Ivory Coast	Y= –0.524+13.127×(X^2)	D1.3 in m (0.2, 1.69)**
142	-in Bossématié in Ivory Coast (1325)	Y= 11.62×(X^2)–0.05	D1.3 in m (0.07, 1.69)**
143	-in Nigeria	Y= 0.0212+0.00005×(X^(2.0284))×(W^(0.9383))	D1.3 in cm, Hme in m (1, 200)**
144	*Milicia excelsa* in Gabon	Y= 1.05+10.08×(X^2)	D1.3 in m (0.01, 0.7)*
145	-in Nigeria	Y= 0.0733+0.000013×(X^(2.0596))×(W^(1.4004))	D1.3 in cm, Hme in m (1, 200)**
146	*Milletia stuhlmannii* in Gabon	Y= 9.72×(X^2.46)	D1.3 in m (0.01, 0.4)*
147	*Mitragyna ciliata* in Gabon	Y= 1.24+13.33×(X^2)	D1.3 in m (0.01, 0.4)*
148	*Mitragyna ledermannii* in Nigeria	Y= 0.0892+0.000015×(X^(2.1194))×(W^(1.2398))	D1.3 in cm, Hme in m (1, 200)**
149	*Mitragyna stipulosa* in Nigeria	Y= 0.1479+0.000029×(X^(1.3729))×(W^(1.9167))	D1.3 in cm, Hme in m (1, 200)**
150	*Monopetalanthus coriaceus* in Gabon	Y= 9.28×(X^2.07)	D1.3 in m (0.01, 0.7)*
151	*Monopetalanthus durandii* in Gabon	Y= 9.28×(X^2.07)	D1.3 in m (0.01, 0.7)*
152	*Monopetalanthus heitzii* in Gabon	Y= 9.72×(X^2.46)	D1.3 in m (0.01, 0.7)*
153	*Monopetalanthus letestui* in Gabon	Y= 9.28×(X^2.07)	D1.3 in m (0.01, 0.7)*
154	*Monopetalanthus microphyllus* in Gabon	Y= 9.28×(X^2.07)	D1.3 in m (0.01, 0.4)*
155	*Monopetalanthus pellegrini* in Gabon	Y= 9.28×(X^2.07)	D1.3 in m (0.01, 0.7)*
156	*Monopetalanthus sp* in Gabon	Y= 9.28×(X^2.07)	D1.3 in m (0.01, 0.4)*
157	*Nauclea diderichii* in Gabon	Y= 9.72×(X^2.46)	D1.3 in m (0.01, 0.4)*
158	- in Guinea-Bisseau	Y= 13.43×(X^2)–1.55×X+0.06	D1.3 in m (0.06, 1.69)**
159	-in Ivory Coast	Y= –1.240+13.334×(X^2)	D1.3 in m (0.31, 1.69)**
160	in Nigeria	Y= 0.1678+0.000005×(X^(1.98))×(W^(1.8463))	D1.3 in cm, Hme in m (1, 200)**
161	*Nesogordonia papaverifera* in Gabon	Y= 0.04+9.07×(X^2)	D1.3 in m (0.01, 0.4)*
162	- in Ivory Coast	Y= –0.329+11.665×(X^2)	D1.3 in m (0.17, 1.69)**
163	-in Bossématié in Ivory Coast (1325)	Y= 13.9×(X^2)–2.2×X+0.16	D1.3 in m (0.08, 1.69)**
164	-in Nigeria	Y= –0.6346+0.003726×(X^(1.3977))×(W^(0.4029))	D1.3 in cm, Hme in m (20, 200)**
165	*Nesogordonia sp* in Gabon	Y= 9.72×(X^2.46)	D1.3 in m (0.01, 0.4)*
166	*Ongokea gore* in Gabon	Y= 9.72×(X^2.46)	D1.3 in m (0.01, 0.4)*

Tree components	n, r^2	Interval of possibility (%)	Quality	References
T	–	100	2	CTFT (1967)
T	–	100	2	Pieper, Y., and Laumans, P. (1992)
T	23,–	100	2	Akindele, S.O. (2005)
T	29,–	95	2	Akindele, S.O. (2005)
T	–	53	1	Palla, F., Louppe, D., et al. (2002)
T	–	100	2	Bilé Allogho, J. (1999)
T	–	68	1	CTFT (1967)
T	–	77	1	Palla, F., Louppe, D., et al. (2002)
T	20,–	100	2	Akindele, S.O. (2005)
T	–	63	1	Bilé Allogho, J. (1999)
T	–	85	1	CTFT (1967)
T	24,–	96	2	Akindele, S.O. (2005)
T	–	100	2	CTFT (1964)
T	–	100	2	Bilé Allogho, J. (1999)
T	–	86	1	CTFT (1986)
T	62,–	100	2	Akindele, S.O. (2005)
T	–	100	2	CTFT (1986)
T	–	100	2	CTFT (1967)
T	–	100	2	Pieper, Y., and Laumans, P. (1992)
T	59,–	96	2	Akindele, S.O. (2005)
T	–	43	1	Bilé Allogho, J. (1999)
T	9,–	95	2	Akindele, S.O. (2005)
T	–	100	2	Bilé Allogho, J. (1999)
T	–	3	1	Bilé Allogho, J. (1999)
T	31,–	94	2	Akindele, S.O. (2005)
T	9,–	93	2	Akindele, S.O. (2005)
T	–	89	1	Bilé Allogho, J. (1999)
T	–	89	1	Bilé Allogho, J. (1999)
T	–	100	2	Bilé Allogho, J. (1999)
T	–	87	1	Bilé Allogho, J. (1999)
T	–	73	1	Bilé Allogho, J. (1999)
T	–	90	1	Bilé Allogho, J. (1999)
T	–	73	1	Bilé Allogho, J. (1999)
T	–	100	2	Bilé Allogho, J. (1999)
T	–	100	2	CTFT (1986)
T	–	100	2	CTFT (1967)
T	13,–	31	1	Akindele, S.O. (2005)
T	–	53	1	Bilé Allogho, J. (1999)
T	–	100	2	CTFT (1967)
T	–	98	2	Pieper, Y., and Laumans, P. (1992)
T	5,–	100	2	Akindele, S.O. (2005)
T	–	100	2	Bilé Allogho, J. (1999)
T	–	100	2	Bilé Allogho, J. (1999)

ID	Tree species and location (annual rainfall)	Model Equations (m^3)	Variables X (min, max), W, Z, U and V
167	*Oxystigma oxyphyllum* in Gabon	Y= 9.72×(X^2.46)	D1.3 in m (0.01, 0.4)*
168	*Paraberlinia bifoliolata* in Gabon	Y= 9.28×(X^2.07)	D1.3 in m (0.01, 0.6)*
169	*Pentaclethra macrophylla* in Nigeria	Y= –0.1424+0.001426×(X^(1.2539))×(W^(0.823))	D1.3 in cm, Hme in m (11, 200)**
170	*Pentadesma butyracea* in Nigeria	Y= 0.0944+0.000013×(X^(2.0961))×(W^(1.3257))	D1.3 in cm, Hme in m (1, 200)**
171	*Petersianthus macrocarpus* in Gabon	Y= 0.33+11.66×(X^2)	D1.3 in m (0.01, 0.4)*
172	-in Nigeria	Y= –0.116+0.000276×(X^(1.7476))×(W^(0.7508))	D1.3 in cm, Hme in m (13, 200)**
173	*Pinus caribaea* in Uganda	Y= 0.00001638×(X^(1.9497))×(W^(1.2006))	D1.3 in cm, Hd in m (1, 200)**
174	*Piptadeniastrum africanum* in Gabon	Y= 9.72×(X^2.46)	D1.3 in m (0.01, 0.4)*
175	-in Nigeria	Y= –0.1873+0.000908×(X^(1.5394))×(W^(0.6294))	D1.3 in cm, Hme in m (14, 200)**
176	*Poga oleosa* in Nigeria	Y= –0.0577+0.000147×(X^(1.7572))×(W^(0.994))	D1.3 in cm, Hme in m (10, 200)**
177	*Pterocarpus osun* in Nigeria	Y= 0.0326+0.000061×(X^(1.9204))×(W^(1.0331))	D1.3 in cm, Hme in m (1, 200)**
178	*Pterocarpus santalinoides* in Nigeria	Y= 0.1281+0.0000000047×(X^(1.978))×(W^(4.7225))	D1.3 in cm, Hme in m (1, 200)**
179	*Pterocarpus soyauxii* in Gabon	Y= 9.72×(X^2.46)	D1.3 in m (0.01, 0.7)*
180	*Pterygota macrocarpa* in Bossématié in Ivory Coast (1325)	Y= 17×(X^2)–3.4×X+0.3	D1.3 in m (0.1, 1.69)**
181	-in Nigeria	Y= 0.0238+0.000041×(X^(2.0923))×(W^(0.9443))	D1.3 in cm, Hme in m (1, 200)**
182	*Pycanathus gymnorrhiza* in Guinea-Bisseau	Y= 10×(X^2)–0.25×X–0.05	D1.3 in m (0.09, 1.69)**
183	-in Ivory Coast	Y= 1.17+8.099×(X^2)	D1.3 in m (0.01, 1.69)**
184	in Bossématié in Ivory Coast (1325)	Y= 10×(X^2)–0.25×X–0.05	D1.3 in m (0.09, 1.69)**
185	*Pycnanthus angolensis* in Gabon	Y= 9.72×(X^2.46)	D1.3 in m (0.01, 0.6)*
186	-in Nigeria	Y= –0.1088+0.000185×(X^(1.8474))×(W^(0.8031))	D1.3 in cm, Hme in m (13, 200)**
187	*Rhodognaphalon brevicuspe* in Gabon	Y= 9.72×(X^(2.46))	D1.3 in m (0.01, 0.4)*
188	-in Bossématié in Ivory Coast (1325)	Y= 12×(X^2)–0.05	D1.3 in m (0.07, 1.69)**
189	*Ricinodendron heudelotii* in Nigeria	Y= 0.0064+0.000099×(X^(1.9762))×(W^(0.762))	D1.3 in cm, Hme in m (1, 200)**
190	*Scottellia coriacea* in Nigeria	Y= –0.0997+0.000354×(X^(1.66))×(W^(0.7596))	D1.3 in cm, Hme in m (12, 200)**
191	*Scottellia sp* in Bossématié in Ivory Coast (1325)	Y= 11.25×(X^2)–0.08	D1.3 in m (0.09, 1.69)**
192	*Sindoropsis letestui* in Gabon	Y= 9.28×(X^2.07)	D1.3 in m (0.01, 0.7)*
193	*Staudtia stipitata* in Gabon	Y= 9.72×(X^2.46)	D1.3 in m (0.01, 0.4)*
194	-in Fernan-Vaz in Gabon (1953)	Y= –0.353040+10.8736×(X^2)	D1.3 in m (0.19, 1.69)**
195	-in Nigeria	Y= –0.0869+0.00014×(X^(1.8223))×(W^(0.8974))	D1.3 in cm, Hme in m (13, 200)**
196	*Stemonocoleus micranthus* in Nigeria	Y= –0.0346+0.000349×(X^(1.6717))×(W^(0.7359))	D1.3 in cm, Hme in m (8, 200)**
197	*Sterculia Oblongata* in Gabon	Y= 10×(X^2)	D1.3 in m (0.01, 0.7)*
198	*Sterculia rhinopetala* in Nigeria	Y= 0.0307+0.000037×(X^(2.0726))×(W^(1.017))	D1.3 in cm, Hme in m (1, 200)**
199	*Sterculia tragacantha* in Nigeria	Y= 0.1335+0.000002×(X^(2.7221))×(W^(1.0965))	D1.3 in cm, Hme in m (1, 200)**
200	*Strombosia pustulata* in Nigeria	Y= 0.0031+0.000083×(X^(1.8401))×(W^(1.0424))	D1.3 in cm, Hme in m (1, 200)**
201	*Swartzia fistuloides* in Gabon	Y= 9.72×(X^2.46)	D1.3 in m (0.01, 0.4)*
202	*Symphonia globulifera* in Nigeria	Y= –0.009+0.000205×(X^(1.4431))×(W^(1.2301))	D1.3 in cm, Hme in m (4, 200)**
203	*Tarrietia densiflora* in Gabon	Y= 1.11+13.23×(X^2)	D1.3 in m (0.01, 0.4)*
204	*Tarrietia utilis* in Ivory Coast	Y= –1.110+13.226×(X^2)	D1.3 in m (0.29, 1.69)**
205	*Tectona grandis* in Ivory Coast	Y= 0.03077×(X^2)×W+0.01827×X×(W^0.05)–0.0186	C in m, H in m (0.25, 5.31)**
206	-idem	Y= 1.1957×(X^2)–0.3933×X+0.0456	C in m (0.16, 5.31)**
207	-idem	Y= 0.03077×(X^2)×W+0.01827×X×(W^0.05)	C in m, H in m (0.03, 5.31)**
208	*Terminalia ivorensis* in Mbalmayo in Cameroon (2445)	Y= 5.04×X	As in m^2 (0, 2.24)**

Tree components	n, r^2	Interval of possibility (%)	Quality	References
T	–	100	2	Bilé Allogho, J. (1999)
T	–	77	1	Bilé Allogho, J. (1999)
T	15,–	100	2	Akindele, S.O. (2005)
T	48,–	93	2	Akindele, S.O. (2005)
T	–	3	1	Bilé Allogho, J. (1999)
T	28,–	100	2	Akindele, S.O. (2005)
T+Bg+Bt5+S	594, 0.96	100	2	Alder, D., Drichi, P., et al. (2003)
T	–	100	2	Bilé Allogho, J. (1999)
T	34,–	100	2	Akindele, S.O. (2005)
T	17,–	100	2	Akindele, S.O. (2005)
T	33,–	95	2	Akindele, S.O. (2005)
T	13,–	18	1	Akindele, S.O. (2005)
T	–	100	2	Bilé Allogho, J. (1999)
T	–	99	2	Pieper, Y., and Laumans, P. (1992)
T	32,–	97	2	Akindele, S.O. (2005)
T	–	100	2	CTFT (1986)
T	–	77	1	CTFT (1967)
T	–	100	2	Pieper, Y., and Laumans, P. (1992)
T	–	100	2	Bilé Allogho, J. (1999)
T	31,–	100	2	Akindele, S.O. (2005)
T	–	100	2	Bilé Allogho, J. (1999)
T	–	94	2	Pieper, Y., and Laumans, P. (1992)
T	34,–	98	2	Akindele, S.O. (2005)
T	23,–	100	2	Akindele, S.O. (2005)
T	–	100	2	Pieper, Y., and Laumans, P. (1992)
T	–	83	1	Bilé Allogho, J. (1999)
T	–	100	2	Bilé Allogho, J. (1999)
T	–	100	2	CTFT (1979)
T	18,–	100	2	Akindele, S.O. (2005)
T	20,–	100	2	Akindele, S.O. (2005)
T	–	76	1	Bilé Allogho, J. (1999)
T	72,–	96	2	Akindele, S.O. (2005)
T	18,–	93	2	Akindele, S.O. (2005)
T	113,–	98	2	Akindele, S.O. (2005)
T	–	100	2	Bilé Allogho, J. (1999)
T	142,–	100	2	Akindele, S.O. (2005)
T	–	0	1	Bilé Allogho, J. (1999)
T	–	100	2	CTFT (1967)
T+Bg+B+S	–	100	2	Dereix, C., and Maitre, H.F. (1979)
T+Bg+B+S	–	100	2	Dereix, C., and Maitre, H.F. (1979)
T+Bg+B+S	–	99	2	CTFT (1990)
T+Bg+Bt+B+S	13, 0.95	100	2	Norgrove, L. and Hauser, S. (2002)

ID	Tree species and location (annual rainfall)	Model Equations (m^3)	Variables X (min, max), W, Z, U and V
209	-idem	Y= 7.49×X	As in m^2 (0, 2.24)**
210	-idem	Y= (5.46×log(X))+36.16	Ht in cm (175.1, 3221.45)**
211	-in Guinea-Bisseau	Y= 10.4×(X^2)–0.05	D1.3 in m (0.07, 1.69)**
212	-in Ivory Coast	Y= –1.230+11.334×(X^2)	D1.3 in m (0.33, 1.69)**
213	-in Nigeria	Y= –0.1616+0.000242×(X^(1.772))×(W^(0.8073))	D1.3 in cm, Hme in m (15, 200)**
214	*Terminalia superba* in Mayombe in Congo (1424)	Y= (4.196268×(X^2)×W+26954.8–0.002050×(X^4))×10^(–6)	C180 in cm, H in m (2.27, 226.89)**
215	-idem	Y= (–55.4+0.0746×(X^2))×10^(–3)	C180 in cm (29.5, 383.45)**
216	-idem	Y= ((88.86137×(X^2)–71831.8–0.00119822×(x^4))×10^(–6)	C180 in cm (29.5, 190.59)**
217	-idem	Y= (–119233+108.961×(X^2)–0.00093×(X^4))×10^(–6)	C in cm (34.56, 238.76)**
218	-idem	Y= (–208.0477×X×SQRT(W)+400663–49954.6×W+1545.5×(W^2)+5.7716×(X^2)×W –0.130701×(X^2)×(W^2)–0.00118288×(X^4))×10^(–6)	C in cm, H in m (34.56, 153.94)**
219	-idem	Y= 220.7–147.28×X+35.33×(X^2)–1.3×(X^3)	Yr in Yr
220	-in Gabon	Y= 10.34×(X^2.22)	D1.3 in m (0.01, 0.6)*
221	-in Mekambo in Gabon (1583)	Y= 0.19+10.46×(X^2)	D1.3 in m (0.01, 1.69)**
222	-in Oyem in Gabon (1784)	Y= 0.14+9.64×(X^2)	D1.3 in m (0.01, 1.69)**
223	-in Ghana	Y= (Exp(–9.022+1.904×log(X)+0.765×log(W)))×10^(–3)	D1.3 in cm, H in m (1, 200)**
224	-idem	Y= (–0.416+6.288×(X^2))×10^(–3)	D1.3 in m (7, 200)*
225	-idem	Y= (–0.149+1.0758×X+0.2016×(X^2)×W)×10^(–3)	D1.3 in m, H in m (7, 200)*
226	-idem	Y= (–8.7752+0.0273118×(X^2)×W)×10^(–3)	D1.3 in cm, H in m (7, 200)**
227	-idem	Y= (–18.6+0.03036872×(X^2)×W+0.5739685×X×SQRT(W))×10^(–3)	D1.3 in cm, H in m (7, 200)*
228	-idem	Y= (–129.11+9.2599×X+0.02659×(X^2)×W)×10^(–3)	D1.3 in cm, H in m (11, 200)**
229	-in Kabo forest reserve in Ghana (1442)	Y= (–9.304+0.0335525×(X^2)×W)×10^(–3)	D1.3 in cm, H in m (7, 200)*
230	-idem	Y= (–113.62+0.87401×(X^2))×10^(–3)	D1.3 in cm (12, 55)*
231	-idem	Y= (–10.832+2.22052×X×W)×10^(–3)	D1.3 in cm, H in m (20, 200)*
232	-idem	Y= (–840.99+53.21335×X)×10^(–3)	D1.3 in cm (16, 55)*
233	-in Guinea-Bisseau	Y= 12×(X^2)–0.09	D1.3 in m (0.09, 1.69)**
234	-in Ivory Coast	Y= 0.024–1.126×X+13.521×(X^2)	D1.3 in m (0.04, 1.69)*
235	-idem	Y= 0.590+10.629×(X^2)	D1.3 in m (0.01, 1.69)**
236	-in Bossématié in Ivory Coast (1325)	Y= 12×(X^2)–2.9×X+0.28	D1.3 in m (0.12, 1.69)**
237	-in Nigeria	Y= –0.0768+0.000156×(X^(1.7972))×(W^(0.8976))	D1.3 in cm, Hme in m (12, 200)**
238	-in Onigambari in Nigeria (1316)	Y= –0.46023+0.0661×X–0.003×(X^2)+0.0001×(X^3)	D1.3 in cm (10, 200)**
239	-idem	Y= –11.0625+2.19641×X+(1.145×log10(W))	D1.3 in cm, H in m (5, 200)**
240	-in RCA	Y= 13.16×(X^(2.34))	D1.3 in m (0.01, 1.69)**
241	*Testulea gabonensis* in Gabon	Y= 9.72×(X^2.46)	D1.3 in m (0.01, 0.7)*
242	*Tetraberlinia bifoliolata* in Gabon	Y= 9.72×(X^2.46)	D1.3 in m (0.01, 0.4)*
243	*Tetraberlinia polyphylla* in Gabon	Y= 9.28×(X^2.07)	D1.3 in m (0.01, 0.7)*
244	*Tetrapleura tetraptera* in Nigeria	Y= 0.1198+0.00001×(X^(2.1258))×(W^(1.3961))	D1.3 in cm, Hme in m (1, 200)**
245	*Tieghemella africana* in Gabon	Y= 0.72+11.32×(X^2)	D1.3 in m (0.01, 0.7)*
246	*Tieghemella heckelii* in Ivory Coast	Y= –0.723+11.317×(X^2)	D1.3 in m (0.26, 1.69)**
247	*Trichilia gilgiana* in Nigeria	Y= –0.071+0.000073×(X^(2.1097))×(W^(0.8126))	D1.3 in cm, Hme in m (12, 200)**

Tree components	n, r^2	Interval of possibility (%)	Quality	References
T+Bg+Bt+B+S	11, 0.93	99	2	Norgrove, L. and Hauser, S. (2002)
T+Bg+Bt+B+S	24, 0.9	32	1	Norgrove, L. and Hauser, S. (2002)
T	–	100	2	CTFT (1986)
T	–	100	2	CTFT (1967)
T	31,–	100	2	Akindele, S.O. (2005)
T	–	95	2	Groulez, J. and Wood, P.J. (1984)
T+Bg+B+S	–	100	2	Groulez, J. and Wood, P.J. (1984)
T	–	100	2	Groulez, J. and Wood, P.J. (1984)
T	–	100	2	Groulez, J. and Wood, P.J. (1984)
T	–	100	2	Groulez, J. and Wood, P.J. (1984)
T+Bg+B+S	21, 0.99	NA	3	Groulez, J. and Wood, P.J. (1984)
T	–	95	2	Bilé Allogho, J. (1999)
T	–	91	2	Groulez, J. and Wood, P.J. (1984)
T	–	92	2	Groulez, J. and Wood, P.J. (1984)
T+B+S	–	100	2	Forster, H. (1994)
T+Bg+B+S	–	100	2	Forster, H. (1994)
T+B+S	–	100	2	Forster, H. (1994)
T	–	100	2	Forster, H. (1994)
T+Bg+B+S	–	100	2	Forster, H. (1994)
T+B+S	–	100	2	Forster, H. (1994)
T+Bg+B+S	60,–	100	2	Forster, H. (1994)
T+BG+B+S	60, 0.89*	100	3	Forster, H. (1994)
T+B+S	60,–	98	2	Forster, H. (1994)
T+Bg+B+S	60, 0.89*	100	3	Forster, H. (1994)
T	–	100	2	CTFT (1986)
T+Bg+B+S	–	100	2	CTFT (1988a)
T	–	83	1	CTFT (1967)
T	–	100	2	Pieper, Y., and Laumans, P. (1992)
T	51,–	100	2	Akindele, S.O. (2005)
T+B	–, 0.62	18	1	Osho, J. S. A. (1991)
T+B	–, 0.87	0	1	Osho, J. S. A. (1991)
T	–	99	2	CTFT (1964)
T	–	100	2	Bilé Allogho, J. (1999)
T	–	100	2	Bilé Allogho, J. (1999)
T	–	84	1	Bilé Allogho, J. (1999)
T	14,–	93	2	Akindele, S.O. (2005)
T	–	43	1	Bilé Allogho, J. (1999)
T	–	100	2	CTFT (1967)
T	6,–	100	2	Akindele, S.O. (2005)

ID	Tree species and location (annual rainfall)	Model Equations (m^3)	Variables X (min, max), W, Z, U and V
248	*Trichilia monadelpha* in Nigeria	Y= 0.0281+0.000006×(X^(2.6881))×(W^(1.0475))	D1.3 in cm, Hme in m (1, 200)**
249	*Trichilia prieureana* in Nigeria	Y= 0.0133+0.000141×(X^(1.7424))×(W^(0.9536))	D1.3 in cm, Hme in m (1, 200)**
250	*Trichilia retusa* in Nigeria	Y= 0.1884+0.00000027×(X^(2.7502))×(W^(1.9723))	D1.3 in cm, Hme in m (1, 200)**
251	*Trilepisium madagascariense* in Nigeria	Y= –0.042+0.000499×(X^(1.4052))×(W^(0.9385))	D1.3 in cm, Hme in m (8, 200)**
252	*Triplochiton scleroxylon* in Cameroon	Y= 0.000209×(X^(2.3528))	D1.3 in cm (1, 80)*
253	-idem	Y= 1.192–0.0465×X+0.00162×(X^2)	D1.3 in cm (14, 60)*
254	-in Guinea-Bisseau	Y= 15.15×(X^2)–3.12×X+0.24	D1.3 in m (0.1, 1.69)**
255	-in Ivory Coast	Y= –0.108+12.092×(X^2)	D1.3 in m (0.1, 0.55)
256	-idem	Y= –1.357+13.951×(X^2)	D1.3 in m (0.32, 1.69)**
257	-idem	Y= –0.094+11.496×(X^2)	D1.3 in m (0.2, 0.55)
258	-in Bossématié in Ivory Coast (1325)	Y= 15.15×(X^2)–3.12×X+0.24	D1.3 in m (0.1, 1.69)**
259	-in Nigeria	Y= 0.0333+0.000092×(X^(1.8307))×(W^(1.017))	D1.3 in cm, Hme in m (1, 200)**
260	-in RCA	Y= 11.73×(x^(2.1))	D1.3 in m (0.01, 1.69)**
261	*Turraeanthus africanus* in Guinea-Bisseau	Y= 6.67×(X^2)+0.07	D1.3 in m (0.01, 1.69)**
262	-in Ivory Coast	Y= –0.131+6.811×(X^2)	D1.3 in m (0.14, 1.69)**
263	*Xylopia aethiopica* in Nigeria	Y= –0.0286+0.000239×(X^(1.6937))×(W^(0.8309))	D1.3 in cm, Hme in m (8, 200)**
264	All in Nkamouna in cameroon (1654)	Y= 0.000347×X^(2.211969)	D1.3 in cm (1, 200)**
265	-in Fernan-Vaz in Gabon (1953)	Y= –0.47207+10.1186×(X^2)	D1.3 in m (0.22, 1.69)**
266	-in Ghana	Y= 0.0004478×(X^(2.216))	D1.3 in cm (1, 200)**
267	-idem	Y= 0.0004634×(X^(2.201))	D1.3 in cm (1, 200)**
268	-idem	Y= 0.0005229×(X^(2.140))	D1.3 in cm (1, 200)**
269	-in Subiri in Ghana (1792)	Y= –0.627153+0.00095007×(X^2)	D1.3 in cm (40, 150)
270	-idem	Y= 0.000490047×(x^(2.28048))×0.7410	D1.3 in cm (40, 150)
271	-idem	Y= 0.000490047×(X^(2.28048))	D1.3 in cm (40, 150)
272	-idem	Y= –0.984221+1.00437×10^(–3)×(X^2)	D1.3 in cm (32, 200)**
273	-in Guinea-Bisseau	Y= 11.6×(X^2)–1.4×X+0.1	D1.3 in m (0.06, 1.69)**
274	-in Bossématié in Ivory Coast (1325)	Y= (–168.02+1.02092×(X^2))×10^(–3)	D1.3 in cm (13, 200)**
275	-idem	Y= (–541.8+0.039808×(X^2)×W+ 0.32088×(X^2))×10^(–3)	D1.3 in cm, Ht in m (27, 200)**
276	-idem	Y= (–169.7+0.24421×(X^2)+ 0.040606×(X^2)×W)×10^(–3)	D1.3 in cm, H in m (15, 200)**
277	-idem	Y= (–568.7+1.1375×(X^2))×10^(–3)	D1.3 in cm (23, 200)**
278	-in Nigeria	Y= 0.0011×(X^2)–0.0165×X	D1.3 in cm (15, 200)**
279	-idem	Y= 0.0009×(X^2)–0.0147×X	BD in cm (17.33, 225.33)**
280	-in RCA	Y= 10.35×(X^(2.08))	D1.3 in m (0.01, 1.69)**
INDIVIDUAL TREE IN TROPICAL RAINFOREST (GROUP OF TREE SPECIES)			
281	Group 1 in Ghana	log10Y= LOG10(0.0001346)+2.538×LOG10(X)	D1.3 in cm (1, 200)**
282	Group 2 in Ghana	log10Y= LOG10(0.0006426)+2.058×LOG10(X)	D1.3 in cm (1, 200)**
283	Group 3 in Ghana	log10Y= LOG10(0.0003494)+2.287×LOG10(X)	D1.3 in cm (1, 200)**
284	Group 4 in Ghana	log10Y= LOG10(0.0006027)+2.104×LOG10(X)	D1.3 in cm (1, 200)**
285	Group 5 in Ghana	log10Y= LOG10(0.0002678)+2.337×LOG10(X)	D1.3 in cm (1, 200)**
286	Group 6 in Ghana	log10Y= LOG10(0.0006245)+2.114×LOG10(X)	D1.3 in cm (1, 200)**

Tree components	n, r^2	Interval of possibility (%)	Quality	References
T	14,–	63	1	Akindele, S.O. (2005)
T	25,–	96	2	Akindele, S.O. (2005)
T	5,–	37	1	Akindele, S.O. (2005)
T	33,–	100	2	Akindele, S.O. (2005)
T	–	100	2	Palla, F.and Louppe, D. (2002)
T	–	83	1	Palla, F.and Louppe, D. (2002)
T	–	100	2	CTFT (1986)
T	–	100	2	CTFT (1990)
T	–	100	2	CTFT (1967)
T+B	–	100	2	Palla, F.and Louppe, D. (2002)
T	–	100	2	Pieper, Y., and Laumans, P. (1992)
T	46,–	97	2	Akindele, S.O. (2005)
T	–	97	2	CTFT (1964)
T	–	92	2	CTFT (1986)
T	–	100	2	CTFT (1967)
T	72,–	100	2	Akindele, S.O. (2005)
T	–	99	2	Azegue Temgoua, R. C. (2004)
T	–	100	2	CTFT (1979)
T	–	96	2	Wong, J.L.G. (1989)
T	–	96	2	Wong, J.L.G. (1990)
T	–	96	2	Wong, J.L.G. (1989)
T+Bg+B+S+L	101,–	100	2	Alder, D (1982)
T+Bg+B+S+L	101, 0.85*	100	3	Alder, D (1982)
T+Bg+B+S+L	101, 0.85*	100	3	Alder, D (1982)
T	–	100	2	Alder, D. (1982)
T	2878,–	97	2	CTFT (1986)
T	2878, 0.86	100	2	Pieper, Y., and Laumans, P. (1992)
T	47, 0.97	100	2	Pieper, Y., and Laumans, P. (1992)
T	2878, 0.96	100	2	Pieper, Y., and Laumans, P. (1992)
T	47, 0.87	100	2	Pieper, Y., and Laumans, P. (1992)
T	2391, 0.8	100	2	Akindele, S.O. (2005)
T	–, 0.81	100	2	Akindele, S.O. (2005)
T	–	92	2	CTFT (1964)
T	–	100	2	Wong, J.L.G. (1990)
T	–	95	2	Wong, J.L.G. (1990)
T	–	97	2	Wong, J.L.G. (1990)
T	–	95	2	Wong, J.L.G. (1990)
T	–	99	2	Wong, J.L.G. (1990)
T	–	94	2	Wong, J.L.G. (1990)

ID	Tree species and location (annual rainfall)	Model Equations (m^3)	Variables X (min, max), W, Z, U and V
287	Group 7 in Ghana	log10Y= LOG10(0.0006724)+2.117×LOG10(X)	D1.3 in cm (1, 200)**
288	Group 8 in Ghana	log10Y= LOG10(0.0004639)+2.204×LOG10(X)	D1.3 in cm (1, 200)**
289	Group 9 in Subiri in Ghana (1792)	Y= 2.20514+5.7881×10^(–4)×(X^2)	D1.3 in cm (1, 200)**
290	Group 10 in Subiri in Ghana (1792)	Y= 0.788905+4.9658×10^(–4)×(X^2)	D1.3 in cm (1, 200)**
291	Group 11 in Subiri in Ghana (1792)	Y= –1.511335+1.07504×10^(–3)×(X^2)	D1.3 in cm (38, 200)**
292	Group 12 in Subiri in Ghana (1792)	Y= –0.966844+1.0322×10^(–3)×(X^2)	D1.3 in cm (31, 200)**
293	Group 13 in Subiri in Ghana (1792)	Y= –0.891429+8.81682×10^(–4)×(X^2)	D1.3 in cm (32, 200)**
294	Group 14 in Subiri in Ghana (1792)	Y= –0.857533+9.0746×10^(–4)×(X^2)	D1.3 in cm (31, 200)**
295	Group 15 in Subiri in Ghana (1792)	Y= 0.854324+6.06056×10^(–4)×(X^2)	D1.3 in cm (1, 200)**
296	Group 16 in Subiri in Ghana (1792)	Y= –0.826005+1.0255×10^(–3)×(X^2)	D1.3 in cm (29, 200)**
297	Group 17 in Subiri in Ghana (1792)	Y= –1.75185+1.15209×10^(–3)×(X^2)	D1.3 in cm (39, 200)**
298	Group 18 in Subiri in Ghana (1792)	Y= –1.46159+1.16385×10^(–3)×(X^2)	D1.3 in cm (36, 200)**
299	Group 19 in Subiri in Ghana (1792)	Y= –1.54161+1.15891×10^(–3)×(X^2)	D1.3 in cm (37, 200)**
STAND IN TROPICAL RAINFOREST			
300	*Eucalyptus grandis* in Uganda	$Y(m^3\ ha^{-1})$ = 0.00003805–0.00009789×(X^2)+ 0.0001325×X×W+0.00002967×(X^2)×W	D1.3 in cm, H in m (–, –)
301	*Nauclea diderichii* in Omo in Nigeria (2293)	$Y(m^3\ ha^{-1})$ = 63.98+21.02×X–0.55×(X^2)+ 0.016×(X^3)	Yr in Yr
302	*Pinus caribaea* in Uganda	$Y(m^3\ ha^{-1})$ = 0.00004534×(X^(1.8875))×(W^(1.0304))	D1.3 in cm, Hd in m (–, –)
SPROUT IN TROPICAL RAINFOREST			
303	*Acacia auriculiformis* in Lama in Benin (1065)	Y= 0.00259+0.407×(X^2)×W	D1.3 in m, H in m (–, –)
INDIVIDUAL TREE IN TROPICAL MOIST DECIDUOUS FOREST (CLASSIFICATION PER TREE SPECIES)			
304	*Acacia mangium* in Ivory Coast	Y= 1.3511×(X^2)–0.5872×X+0.0861	C in m (0.22, 5.31)**
305	*Afzelia africana* in Badénou in Ivory Coast (1211)	Y= 0.1271–0.5633×X+1.0608×(X^2)	C in m (0.25, 5.31)**
306	- idem	Y= –0.9121+1.3419×X–0.1806×(X^2)	C in m (0.79, 3.68)**
307	-idem	Y= –0.0019+0.04846×(X^2)×W	C in m, H in m (0.09, 5.31)**
308	*Baikiaea plurijuga* in Zambia	Y= 0.2421143+0.0029874×(X/2)^(2)	D1.3 in cm
309	*Brachystegia floribunda* in Dedza in Malawi (896)	log10Y= –4.22+2.77×log10(X)	D1.3 in cm (1, 200)**
310	*Brachystegia spiciformis* in Chimaliro in Malawi (923)	log10Y= –3.63+2.35×log10(X)	D1.3 in cm (1, 200)**
311	-in Dedza in Malawi (896)	log10Y= –4.30+2.85×log10(X)	D1.3 in cm (1, 200)**
312	*Brachystegia utilis* in Chimaliro in Malawi (923)	log10Y= –4.03+2.72×log10(X)	D1.3 in cm (1, 200)**
313	*Combretum fragrans* in Sikasso in Mali (1067)	Y= –0.0066+0.0023×X+0.4752×(X^2)	C in m (0.15, 0.7)
314	*Combretum ghazalense* in Siani in Mali (954)	Y= (0.23/(1+(95×exp(–29×X))))×10^(–6)	D1.3 in cm (1, 200)**
315	*Daniellia oliveri* in Sikasso in Mali (1067)	Y= –0.0057–0.0386×2+0.5539×(X^2)	C in m (0.41, 0.94)*
316	-idem	Y= –0.04295+0.21910×X+0.38396×((X^3))	C in m (0.22, 1.5)
317	*Diospyros mespiliformis* in Badénou in Ivory Coast (1211)	Y= –0.0982+0.1066×X×SQRT(W)+ 0.03628×(X^2)×W	C in m, H in m (0.25, 5.31)**
318	-idem	Y= 0.2304+0.2001×(X^2)	C in m (0.03, 5.31)**
319	-idem	Y= 0.0602–0.3299×X+0.8604×(X^2)	C in m (0.19, 5.31)**
320	-idem	Y= –0.203+0.03694×X×SQRT(W)+0.03383×(X^2)×W	C in m, H in m (0.53, 5.31)**

Tree components	n, r^2	Interval of possibility (%)	Quality	References
T	–	93	2	Wong, J.L.G. (1990)
T	–	96	2	Wong, J.L.G. (1990)
T	–	74	1	Alder, D. (1982)
T	–	82	1	Alder, D. (1982)
T	–	100	2	Alder, D. (1982)
T	–	100	2	Alder, D. (1982)
	–	100	2	Alder, D. (1982)
T	–	100	2	Alder, D. (1982)
	–	81	1	Alder, D. (1982)
T+B	–	100	2	Alder, D. (1982)
T	–	100	2	Alder, D. (1982)
T	–	100	2	Alder, D. (1982)
	–	100	2	Alder, D. (1982)
T+Bg+Bt5+B+S	–	-	2	Alder, D., Drichi, P., et al. (2003)
T+B	–	-	2	Onyekwelu, J. C. (2007)
T+Bg+Bt5+B+S	594, 0.97*	-	2	Alder, D., Drichi, P., et al. (2003)
T+Bg+Bt3+B+S	190, 0.94	-	2	Fonton, N. H., Kakai, R. G., et al. (2002)
T+B	435, 0.98	100	2	Dupuy, B. and N'Guessan, K. (1989)
T+Bg+B+S	84,–	99	2	Louppe, D., M'BlaKoua, et al. (1994)
T+B+S	84,–	100	2	Louppe, D., M'BlaKoua, et al. (1994)
T+Bg+B+S	84,–	100	2	Louppe, D., M'BlaKoua, et al. (1994)
	245, 0.95	-	-	Banks, P. F. and Burrows, P. M. (1966)
T+Bg+Bt+B+S	166, 0.92	100	2	Abbot, P., Lowore, J., et al. (1997)
T+Bg+Bt+B+S	20, 0.93	100	2	Abbot, P., Lowore, J., et al. (1997)
T+Bg+Bt+B+S	47, 0.92	100	2	Abbot, P., Lowore, J., et al. (1997)
T+Bg+Bt+B+S	54, 0.94	100	2	Abbot, P., Lowore, J., et al. (1997)
T+Bg+B+S	–, 0.93	100	2	Bagnoud, N. and Kouyaté, A. M. (1996)
T+Bg+Bt+B+S+D	–	100	2	Manlay, R.J., Kairé, M., et al. (2002)
T+Bg+B+S	60, 0.95*	100	3	Bagnoud, N. and Kouyaté, A. M. (1996)
T+Bg+B+S	94,–	100	2	Nouvellet, Y. (2002)
T+B+S	82,–	100	2	Louppe, D., M'BlaKoua, et al. (1994)
T+Bg+B+S	82,–	91	2	Louppe, D., M'BlaKoua, et al. (1994)
T+Bg+B+S	82,–	99	2	Louppe, D., M'BlaKoua, et al. (1994)
T+Bg+B+S	82,–	100	2	Louppe, D., M'BlaKoua, et al. (1994)

ID	Tree species and location (annual rainfall)	Model Equations (m^3)	Variables X (min, max), W, Z, U and V
321	-idem	Y= –0.2893+0.509×(X^2)	C in m (0.75, 5.31)**
322	-idem	Y= 0.2668+0.01048×(X^2)×W	C in m, H in m (0.03, 5.31)**
323	-idem	Y= –0.0715+0.02370×(X^2)×W	C in m, H in m (0.5, 5.31)**
324	*Guibourtia coleosperma* in Zambia	Y= –0.2925408+0.0033458×(X/2)^(2)	D1.3 in cm
325	*Isoberlinia doka* in Badénou in Ivory Coast (1211)	Y= 0.0408+0.06187×(X^2)×W	C in m, Ht in m (1, 2.2)
326	-idem	Y= –0.2229+0.6627×(X^2)	C in m (1, 2.2)
327	-idem	Y= –0.3554+0.1682×X×sqrt(W)+0.003023×(X^2)×W	C in m, H in m (1, 2.2)
328	-idem	Y= –0.7131+1.0422×X–0.006513×(X^2)	C in m (1, 2.2)
329	-idem	Y= –0.2186+0.1346×X×sqrt(W)+0.03615×(X^2)×W	C in m, H in m (0.5, 2.2)
330	-idem	Y= 0.1355–0.6999×X+1.3266×(X^2)	C in m (0.5, 2.2)
331	-idem	Y= 0.0491+0.03037×(X^2)×W	C in m, H in m (1, 2.2)
332	-in Sikasso in Mali (1067)	Y= –0.05182+0.24489×X+0.56703×((X^3))	C in m (0.22, 1.5)
333	-idem	Y= 0.0444–0.3464×X+1.0141×(X^2)	C in cm (15, 100)
334	*Julbernardia paniculata* in Bunda in Malawi (837)	log10Y= –4.00+2.65×log10(X)	D1.3 in cm (1, 200)**
335	in Chimaliro in Malawi (923)	log10Y= –3.84+2.48×log10(x)	D1.3 in cm (1, 200)**
336	*Khaya senegalensis* in Badénou in Ivory Coast (1211)	Y= 0.0498+0.05757×(X^2)×W	C in m, Ht in m (0.03, 5.31)**
337	-idem	Y= –0.1743+0.02705×(X^2)×W	C in m, H in m (0.66, 5.31)**
338	-idem	Y= –0.3972+0.6291×(X^2)	C in m (0.82, 5.31)**
339	-idem	Y= 0.3207–1.1957×X+1.4870×(X^2)	C in m (0.41, 5.31)**
340	-idem	Y= –0.00537×X+0.06233×(X^2)+0.54878×((X^3))	C in m (0.2, 1.5)
341	-idem	Y= –0.00485+0.04211×(X^2)×W	C in m, H in m (0.16, 5.31)**
342	*Pterocarpus angolensis* in Chimaliro in Malawi (923)	log10Y= –3.68+2.34×log10(x)	D1.3 in cm (1, 200)**
343	-in Zambia	Y= –0.3687583+0.0041467×(X/2)^(2)	D1.3 in cm
344	*Terminalia sp* in Sikasso in Mali (1067)	Y= –0.01564+0.13174×X+0.57929×((X^3))	C in m (0.22, 1.4)
345	-idem	Y= 0.0067–0.1114×X+0.6995×(X^2)	C in cm (15, 79)
346	*Terminalia superba* in Ghana	Y= (1.915×log10(X^2))+(0.942×log10(W))–4.281	D1.3 in cm, H in m (8, 200)**
347	*Uapaca kirkiana* in Dedza in Malawi (896)	log10Y= –4.19+2.76×log10(X)	D1.3 in cm (1, 200)**
INDIVIDUAL TREE IN TROPICAL MOIST DECIDUOUS FOREST (CLASSIFICATION PER GROUP OF SPECIES)			
348	Group 20 in Chimaliro in Malawi (923)	log10Y= –3.68+2.37×log10(X)	D1.3 in cm (1, 200)**
349	Group 21 in Chimaliro in Malawi (923)	log10Y= –3.88+2.53×log10(X)	D1.3 in cm (1, 200)**
350	Group 22 in Dedza in Malawi (896)	SQRTY= –0.08+0.0268×X	D1.3 in cm (3, 200)**
GENERALIZED EQUATIONS FOR INDIVIDUAL TREE IN TROPICAL MOIST DECIDUOUS FOREST			
351	Generalized in Chimaliro in Malawi (923)	log10Y= –3.86+2.52×log10(X)	D1.3 in cm (1, 200)**

Tree components	n, r^2	Interval of possibility (%)	Quality	References
T+Bg+B+S	82,–	100	2	Louppe, D., M'BlaKoua, et al. (1994)
T+Bg+B+S	82,–	91	2	Louppe, D., M'BlaKoua, et al. (1994)
T+B+S	82,–	100	2	Louppe, D., M'BlaKoua, et al. (1994)
	75, 0.94	-	-	Banks, P. F. and Burrows, P. M. (1966)
T+B	85,–	100	2	Louppe, D., Koua, M., et al. (1994)
T+Bg+Bt+B+S+D	85,–	0	1	Louppe, D., Koua, M., et al. (1994)
T+B	85,–	100	2	Louppe, D., Koua, M., et al. (1994)
T+B	85,–	100	2	Louppe, D., Koua, M., et al. (1994)
T+Bg+B+S	85,–	100	2	Louppe, D., Koua, M., et al. (1994)
T+Bg+B+S	85,–	100	2	Louppe, D., Koua, M., et al. (1994)
T+Bg+Bt+B+S+D	85,–	0	1	Louppe, D., Koua, M., et al. (1994)
T+Bg+B+S	100	100	2	Nouvellet, Y. (2002)
T+Bg+B+S	60, 0.96*	0	1	Bagnoud, N. and Kouyaté, A. M. (1996)
T+Bg+Bt+B+S	40, 0.95	100	2	Abbot, P., Lowore, J., et al. (1997)
T+Bg+Bt+B+S	101, 0.9	100	2	Abbot, P., Lowore, J., et al. (1997)
T+B	84,–	94	2	Louppe, D., M'BlaKoua, et al. (1994)
T+B	84,–	100	2	Louppe, D., M'BlaKoua, et al. (1994)
T+B	84,–	100	2	Louppe, D., M'BlaKoua, et al. (1994)
T+Bg+B+S	84,–	100	2	Louppe, D., M'BlaKoua, et al. (1994)
	81,–	100	2	Nouvellet, Y. (2002)
T+Bg+B+S	84,–	100	2	Louppe, D., M'BlaKoua, et al. (1994)
T+Bg+Bt+B+S	25, 0.89	100	2	Abbot, P., Lowore, J., et al. (1997)
	91, 0.9	-	-	Banks, P. F. and Burrows, P. M. (1966)
	116	100	2	Nouvellet, Y. (2002)
T+Bg+B+S	60, 0.92*	0	1	Bagnoud, N. and Kouyaté, A. M. (1996)
T+B	–	82	1	JAFTA (1999)
T+Bg+Bt+B+S	75, 0.91	100	2	Abbot, P., Lowore, J., et al. (1997)
T+Bg+Bt+B+S	39, 0.89	100	2	Abbot, P., Lowore, J., et al. (1997)
T+Bg+Bt+B+S	84, 0.91	100	2	Abbot, P., Lowore, J., et al. (1997)
T+Bg+Bt+B+S	22, 0.96	100	2	Abbot, P., Lowore, J., et al. (1997)
T+Bg+Bt+D+B+S	330, 0.91	100	2	Abbot, P., Lowore, J., et al. (1997)

ID	Tree species and location (annual rainfall)	Model Equations (m^3)	Variables X (min, max), W, Z, U and V
352	-idem	log10Y= –3.87+2.4310×log10(X)	D1.3 in cm (1, 200)**
353	-in Dedza in Malawi (896)	SQRTY= –0.0722+0.0273×X	D1.3 in cm (3, 200)**
354	- idem	log10Y= –4.29+2.78×log10(X)	D1.3 in cm (1, 200)**
355	-in Sikasso in Mali (1067)	Y= 0.0148–0.1497×X+0.719×(X^2)	C in m (0.15, 1.95)
356	-idem	Y= (–0.03263×X+0.16223×(X^2)+0.49948× ((X^3)))×10^(–6)	C in cm (1.6, 1.6)**
INDIVIDUAL TREE IN TROPICAL DRY FOREST (CLASSIFICATION PER TREE SPECIES)			
357	*Acacia karoo* in Umguza in Zimbabwe (513)	Y= –0.042+0.000668×X	As in cm^2 (63.62, 22431.81)**
358	-idem	Y= –0.089+0.000634×X	BA in cm^2 (168.95, 39878.77)**
359	*Afzelia africana* in Bamako in Mali (1152)	Y= 0.0782+0.05665×(X^2)×W	C in m, Ht in m (0.03, 5.31)**
360	-idem	Y= 2.3731–3.5751×X+1.7462×(X^2)	C in m (1.04, 5.31)**
361	-idem	Y= –0.6023+0.2531×X×SQRT(W)–0.00566×(X^2)×W	C in m, H in m (0.66, 3.42)**
362	-idem	Y= 1.0481–0.3698×X×SQRT(W)+0.06082×(X^2)×W	C in m, H in m (0.72, 5.31)**
363	*Baikiaea plurijuga* in Botswana	Y= 0.0000785×X^(2.598)	D1.3 in cm
364	*Bombax buonopozense* in Bamako in Mali (1152)	Y= –0.00387×X+0.04665×(X^2)+0.58410×(X^3)	C in m (0.22, 1.5)
365	*Brachystegia boehmii* in Phuyu in Malawi (800)	log10Y= –3.85+2.49×log10(X)	D1.3 in cm (1, 200)**
366	*Brachystegia spiciformis* in Tanzania	100Y= 10^(–1.2875+2.8436×log10(X))	D1.3 in cm
367	-idem	100Y= –271+1.401×X^(2)	D1.3 in cm
368	*Burkea africana* in Botswana	Y= 0.0000214×(3.030)	D1.3 in cm
369	*Colophospermum mopane* in Botswana	Y= 0.0001065×X^(2.471)	D1.3 in cm
370	*Combretum ghazalense* in Mali	Y= 0.23/(1+95×exp(–29×X))	D1.3 in cm (1, 200)**
371	*Combretum glutinosum* in Bamako in Mali (1152)	Y= –0.00707×X+0.07584×(X^2)+0.57874×(X^3)	C in m (0.22, 1.1)
372	*Cordyla pinnata* in Bamako in Mali (1152)	Y= –0.02038×X+0.13130×(X^2)+0.51060×(X^3)	C in m (0.22, 1.5)
373	*Dalbergia melanoxylon* in Tanzania	logY= –9.887+1.824×LOG(X)+1.155×LOG(W)	D1.3 in cm, H in m
374	-idem	Y= 0.00023×X^(2.231)	D1.3 in cm
375	*Julbernardia globiflora* in Tanzania	100Y= 369–88.2315×X+6.4175×X^(2)– 0.1168×X^(3)+0.0009×X^(4)	D1.3 in cm
376	in Kitulanghalo forest reserce in Tanzania ()	Y= 0.0295×X^(3.015)	D1.3 in cm
377	-idem	Y= –35.85+0.76×X^(2)×W	D1.3 in cm
378	*Khaya senegalensis* in Badénou in Mali ()	Y= –0.00537+0.06233×X+0.54878×(X^2)	C in m (0.06, 1.5)*
379	*Lannea sp* in Bamako in Mali (1152)	Y= –0.00442×X+0.05448×(X^2)+0.56476×(X^3)	C in m (0.22, 1.3)
380	*Pterocarpus erinaceus* in Bamako in Mali (1152)	Y= –0.01161×X+0.10180×(X^2)+0.54409×(X^3)	C in m (0.22, 1.5)
381	*Pycnanthus angolensis* in Botswana	Y= 0.0000686×X^(2.678)	D1.3 in cm
382	-in Tanzania	100Y= –170+35.8721×X–2.1968×X^(2)+ 0.08011×X^(3) –0.0006×X^(4)	D1.3 in cm
383	-in Kitulanghalo forest reserce in Tanzania ()	Y= 0.092×X^(2.59)	D1.3 in cm
384	*Vitellaria paradoxa* in Mali	Y= 2.4612×X–1.5130	C in m (0.63, 3.1)*
385	-in Badougou in Mali (814)	Y= 0.6868×X–0.1314	C in m (0.22, 2)*
386	- idem	Y= 162.52×X–51.264	C in m (0.35, 3.1)*
387	-idem	Y= 328.3×x–167.34	C in m (0.53, 3.1)*
388	-in Massala in Mali (640)	Y= 0.0141×x–0.1065	C in m (2, 2)**

Tree components	n, r^2	Interval of possibility (%)	Quality	References
T+Bg+Bt+D+B+S	101, 0.91	100	2	Abbot, P., Lowore, J., et al. (1997)
T+Bg+Bt+D+B+S	110, 0.93	100	2	Abbot, P., Lowore, J., et al. (1997)
	237, 0.92	100	2	Abbot, P., Lowore, J., et al. (1997)
T+Bg+B+S+D	286, 0.91*	100	3	Bagnoud, N. and Kouyaté, A. M. (1996)
T+Bg+B+S	725, 0.95*	100	3	Nouvellet, Y. (2002)
T+Bg+Bt5+B+S	138, 0.96	100	3	Gourlay, I. D., Smith, J. P., et al. (1996)
T+Bg+Bt5+B+S	138, 0.93	100	3	Gourlay, I. D., Smith, J. P., et al. (1996)
T+B+S	84,–	93	2	Louppe, D., M'BlaKoua, et al. (1994)
T+Bg+B+S	84,–	100	2	Louppe, D., M'BlaKoua, et al. (1994)
T+B+S	84,–	100	2	Louppe, D., M'BlaKoua, et al. (1994)
T+Bg+B+S	84,–	100	2	Louppe, D., M'BlaKoua, et al. (1994)
	142, 0.98	-	-	Norwegian Forestry Society (1992)
T+Bg+B+S	103,–	100	2	Nouvellet, Y. (2002)
T+Bg+Bt+B+S	27, 0.96	100	2	Abbot, P., Lowore, J., et al. (1997)
	–	-	-	Temu, A. B. (1981)
	–	-	-	Temu, A. B. (1981)
	40, 0.93	-	-	Norwegian Forestry Society (1992)
	18, 0.89	-	-	Norwegian Forestry Society (1992)
T+Bg+B+S+D	–	92	2	Alexandre, D.-Y., and Kaïré, M. (2001)
T+Bg+Bt3.2+B+S	110,–	100	2	Nouvellet, Y. (2002)
T+Bg+B+S	663,–	100	2	Nouvellet, Y. (2002)
	24, 0.99	-	-	Malimbi, R. E., Luoga, E., et al. (2000)
	24, 0.97	-	-	Malimbi, R. E., Luoga, E., et al. (2000)
	–	-	-	Temu, A. B. (1981)
	–, 0.75	-	-	Malimbwi, R. E., Solberg, B., et al. (1994)
	–, 0.95	-	-	Malimbwi, R. E., Solberg, B., et al. (1994)
T+Bg+Bt5+B+S	–	93	2	Clément, J. (1982)
T+Bg+B+S	98,–	100	2	Nouvellet, Y. (2002)
T+Bg+B+S	104,–	100	2	Nouvellet, Y. (2002)
	50, 0.95	-	-	Norwegian Forestry Society (1992)
	–	-	-	Temu, A. B. (1981)
	–, 0.97	-	-	Malimbwi, R. E., Solberg, B., et al. (1994)
T+Bg+Bt3.2+B+S	405, 0.53	100	3	Nouvellet, Y., Kassambara, A., et al. (2006)
T+Bg+Bt3.2+B+S	63, 0.42	100	3	Nouvellet, Y., Kassambara, A., et al. (2006)
T+Bg+Bt3.2+B+S	63, 0.49	0	1	Nouvellet, Y., Kassambara, A., et al. (2006)
T+Bg+Bt3.2+B+S	405, 0.56	0	1	Nouvellet, Y., Kassambara, A., et al. (2006)
T+Bg+Bt3.2+B+S	122, 0.45	100	3	Nouvellet, Y., Kassambara, A., et al. (2006)

ID	Tree species and location (annual rainfall)	Model Equations (m^3)	Variables X (min, max), W, Z, U and V
389	-idem	Y= 280.36×x–142.44	C in m (0.53, 3.1)*
390	-in M'Péresso in Mali (883)	Y= 222.32×x–78.062	C in m (0.38, 3.1)*
391	-idem	Y= 0.0200×x–0.2007	C in m (2, 2)**
392	-in Ténéfi in Mali (986)	Y= 0.0328×x–0.6301	C in m (3.1, 3.1)**
393	-idem	Y= 368.01×x–189.97	C in m (0.53, 3.1)*
INDIVIDUAL TREE IN TROPICAL DRY FOREST (CLASSIFICATION PER GROUP OF SPECIES)			
394	Group 22 in Phuyu in Malawi (800)	log10Y= –4.20+2.69×log10(X)	D1.3 in cm (1, 200)**
GENERAL EQUATIONS FOR INDIVIDUAL TREE IN TROPICAL DRY FOREST			
395	All in Burkina Faso	Y= 0.01225+0.00599×(X^2)	CD in m (1, 29.25)**
396	-idem	Y= 0.01433–0.75661×X+7.35209×(X^2)	D1.3 in m (0.08, 1.69)**
397	-idem	Y= 0.01173+0.44527×(X^2)×W	D1.3 in m, H in m (0.01, 1.69)**
398	-idem	Y= 0.10364+0.01206×W^2×X	D1.3 in m, CD in m (0.01, 1.69)**
399	-idem	Y= –0.0309+7.8477×(X^2)+0.1754×X	D1.3 in m (0.06, 1.69)**
400	-idem	Y= 0.11068–1.7905×X+13.08245×(X^2)	D1.3 in m (0.07, 1.69)**
401	-idem	Y= 0.06576+0.72532×(X^2)×W	D1.3 in m, H in m (0.01, 1.69)**
402	-in Boucle du Mouhoun in Burkina Faso (796)	Y= –0.0018199+0.0011781×X+ 0.000021004064×((X^3))	D1.3 in cm (2, 200)**
403	-in Phuyu in Malawi (800)	SQRTY= 0.0570+(0.000918×X^2)	D1.3 in cm (1, 200)**
404	-idem	log10Y= –4.22+2.76×log10(X)	D1.3 in cm (1, 200)**
405	-in Mali	Y= (3107.5–331.1×X+13.998×(X^2))×10^(–6)	Cb in cm (12.57, 160)*
406	-idem	Y= –0.03263+0.16223×X+0.49948×(X^3)	C in m (0.19, 1.6)*
407	-idem	Y= 0.03879–0.33235×X+0.83915×(X^2)	Cb in m (0.21, 7.08)**
408	-in Bamako in Mali (1152)	Y= –0.0326×X+0.16223×(X^2)+0.49948×(X^3)	C in m (0.22, 1.3)
409	- in Cinzana in Mali (725)	Y= (10.442×(X^2)–179.68×X+1666.8)×10^(–6)	Cb in cm (10, 50)
410	-idem	Y= (5.9788×(X^2)–44.356×X+359.7)×10^(–6)	Cb in cm (10, 45)
411	-idem	Y= (6.5439×(X^2)–1.6117×x–557.09)×10^(–6)	Cb in cm (12.57, 85)*
412	-idem	Y= (13.59×(X^2)–434.7×X–978.89)×10^(–6)	Cb in cm (37.7, 60)*
413	-idem	Y=(6.188×(X^2)–55.855×X+510.21)×10^(–6)	Cb in cm (10, 35)
414	-idem	Y= (5.463×(X^2)+52.748×X–978.89)×10^(–6)	Cb in cm (12.57, 80)*
415	-in Kitulangalo forest, Morogoro in Tanzania (935)	logY= 0.0000442+(1.373×log(X))+(1.781×log(W))	D1.3 in m, H in m (0.01, 0.5)
416	-idem	logY= 0.0000312+(2.721×log(X))	BD in m (1, 2.25)
417	-idem	logY= 0.000048+(1.445×log(X))+(1.7026×log(W))	D1.3 in m, H in m (1, 1.69)
418	-idem	logY= 0.00002+(0.88×log(X))+(1.80×log(W))	BD in m, H in m (1, 2.25)
419	-idem	logY= 0.000047+2.56×log(X)	BD in m (1, 2.25)
420	-idem	logY= 0.000328+(2.163×log(X))	D1.3 in m (1, 1.69)
421	-in Kitulanghalo forest reserce in Tanzania (956)	Y= 0.0001×(X^(2.032))×(W^(0.659))	D1.3 in cm, H in m (1, 200)**
STAND IN TROPICAL DRY FOREST			
422	in Mozambique	Y= 6.18×X^0.86	BA in m^2 ha^{-1}
INDIVIDUAL TREE IN TROPICAL SHRUBLAND (CLASSIFICATION PER TREE SPECIES			
423	*Acacia mellifera* in Kazgail in Sudan (414)	Y= 0.7245×X–0.0009×W+0.020009×Z–0.15673	BD in m, CD in m, H in m (0.05, 2.25)**

Tree components	n, r^2	Interval of possibility (%)	Quality	References
T+Bg+Bt3.2+B+S	122, 0.46	0	1	Nouvellet, Y., Kassambara, A., et al. (2006)
T+Bg+Bt3.2+B+S	121, 0.55	0	1	Nouvellet, Y., Kassambara, A., et al. (2006)
T+Bg+Bt3.2+B+S	121, 0.55	100	3	Nouvellet, Y., Kassambara, A., et al. (2006)
T+Bg+Bt3.2+B+S	99, 0.62	100	3	Nouvellet, Y., Kassambara, A., et al. (2006)
T+Bg+Bt3.2+B+S	99, 0.56	0	1	Nouvellet, Y., Kassambara, A., et al. (2006)
T+Bg+Bt+B+S	30, 0.94	100	2	Abbot, P., Lowore, J., et al. (1997)
Bg	–, 0.81	78	1	Paquet, J. (1981)
T	–, 0.86	100	2	Paquet, J. (1981)
T	–, 0.88	96	2	Paquet, J. (1981)
Bg	–, 0.79	38	1	Paquet, J. (1981)
T+Bg+S+B	–, 0.68	100	2	Paquet, J. (1981)
T+Bg+S+B	–, 0.83	99	2	Paquet, J. (1981)
T+Bg+S+B	–, 0.86	92	2	Paquet, J. (1981)
T+Bg+B+S+D	118, 0.92*	100	2	Kaboré, C. (1992)
T+Bg+Bt+D+B+S	168, 0.88	34	1	Abbot, P., Lowore, J., et al. (1997)
T+Bg+Bt+D+B+S	51, 0.95	100	2	Abbot, P., Lowore, J., et al. (1997)
	1410	100	2	Nouvellet, Y. (2002)
T+Bg+Bt5+B+S	725, 0.95*	100	3	Bagnoud, N. and Kouyaté, A. M. (1996)
	725, 0.95*	100	2	PIRL (1991)
T+Bg+Bt5+B+S	–, 0.93	100	2	PIRL (1991)
T+Bg+Bt+B+S	150, 0.93*	100	3	Nouvellet, Y., Ladj Sylla, M., et al. (2000)
T+Bg+Bt+B+S	150, 0.93*	100	3	Nouvellet, Y., Ladj Sylla, M., et al. (2000)
T+Bg+Bt+B+S	150, 0.93*	100	3	Nouvellet, Y., Ladj Sylla, M., et al. (2000)
T+Bg+Bt+B+S	150, 0.93*	100	3	Nouvellet, Y., Ladj Sylla, M., et al. (2000)
T+Bg+Bt+B+S	150, 0.93*	100	3	Nouvellet, Y., Ladj Sylla, M., et al. (2000)
T+Bg+Bt+B+S	150, 0.93*	100	3	Nouvellet, Y., Ladj Sylla, M., et al. (2000)
T+B+S	30, 0.97	0	1	Chamshama, S. A. O., Mugasha, A. G., et al. (2004)
T+B+S	30, 0.97	100	3	Chamshama, S. A. O., Mugasha, A. G., et al. (2004)
T+Bg+Bt+B+S+D	30, 0.97	0	1	Chamshama, S. A. O., Mugasha, A. G., et al. (2004)
B+Bt+D	30, 0.78	0	1	Chamshama, S. A. O., Mugasha, A. G., et al. (2004)
T+Bg+Bt+B+S+D	30, 0.98	100	3	Chamshama, S. A. O., Mugasha, A. G., et al. (2004)
Bg+Bt+D	30, 0.89	100	3	Chamshama, S. A. O., Mugasha, A. G., et al. (2004)
T+Bg+Bt+D+B+S	–	100	2	Luoga, E. L., Witkowski, E. T. F., et al. (2002)
T+Bg+Bt5+B+S	–, 0.89	-	2	Williams, M., Ryan, C.M., et al. (2008)
T+B	32, 0.72	91	2	Mohie el Deen, F. A. . (1991)

ID	Tree species and location (annual rainfall)	Model Equations (m^3)	Variables X (min, max), W, Z, U and V
424	*Acacia nilotica* in Kazgail in Sudan (414)	Y= 0.2437×X–0.0215×W+0.021434×Z–0.02144	BD in m, CD in m, H in m (0.01, 2.25)**
425	*Acacia senegal* in Fété Olé in Senegal (224)	log10Y= (2.55×log10(X))+0.07	Cb in cm (4.19, 707.91)**
426	in Kazgail in Sudan (414)	Y= 0.6881×X–0.012238×W+0.002957×Z–0.07137	BD in m, CD in m, H in m (0.11, 2.25)**
427	*Afzelia africana* in Fété Olé in Senegal (224)	Y= –0.05182×X+0.24489×(X^2)+ 0.56703×(X^3))×10^(–6)	C in cm (22, 150)
428	*Aucoumea klaineana* in Equatorial Guinea	Y= 0.000106837×(X^2.0742)×W^0.665713	D1.3 in cm, H in m (1, 200)**
429	*Balanites aegyptiaca* in Fété Olé in Senegal (224)	log10Y= (2.55×log10(X))+0.07	Cb in m (0.96, 7.08)**
430	*Boscia senegalensis* in Fété Olé in Senegal (224)	log10Y= 2.26×LOG10(X)+0.38	Cb in m (0.04, 7.08)**
431	*Commiphora africana* in Fété Olé in Senegal (224)	log10Y= (2.26×log10(X))+0.38	Cb in m (0.04, 7.08)**
432	*Cupressus lusitanica* in Usambaras in Tanzania (558)	Y= 0.0355 + 0.00003X^2×W	D1.3 in cm, H in m (1, 200)**
433	*Dalbergia melanoxylon* in Kazgail in Sudan (414)	Y= 0.3425×X–0.00859×W–0.10698×W	BD in m, CD in m, H in m (–, –)*
434	*Grewia bicolor* in Fété Olé in Senegal (224)	log10Y= (2.26×log10(X))+0.38	Cb in m (0.04, 7.08)**
435	*Rhizophora racemosa* in Saint Louis in Senegal (302)	Y= (5620.3×X–23349.6)×10^(–6)	H in cm (291.83, 5369.09)**
436	- idem	Y= (1267×X–17867.4)×10^(–6)	Cb in cm (16.76, 707.91)**
437	*Tarrietia utilis* in Ivory Coast	Y= (1.95×(X^(2.7)))×10^(–6)	C in cm (3.14, 140)*
GENERAL EQUATIONS FOR INDIVIDUAL TREE IN TROPICAL SHRUBLAND			
438	All in Gaborone in Botswana (552)	Y= 0.003295+0.00001272×(X^3)	D1.3 in cm (1, 200)**
439	-in Burkina Faso	Y= 0.11068–1.7905×X+13.08245×(X^2)	D1.3 in m (0.07, 1.69)**
440	-in Equatorial Guinea	Y= 0.000059541×(X^2.061)×W^0.87907	D1.3 in cm, H in m (1, 200)**
441	-in Malawi	Y= 0.0213+0.000011×(X^3)+0.0115×W	D1.3 in cm, Ht in m (6, 35)
442	-idem	Y= 0.0168+0.000023×(X^3)	D1.3 in cm (5, 35)
443	-in Mali	Y= 1.14×X+9.986×W–9.4	D1.3 in cm, BA in m^2 (9, 200)**
444	-in Sudan	Y= 0.000406×X^(2)×W	CD in m, H in m (–, –)
445	-in Kitonga in Tanzania (621)	Y(m^3 ha^{-1})= 6.18×(X^(0.86))	BA in m^2 ha^{-1} (0, 3.99)**
INDIVIDUAL TREE IN TROPICAL MOUNTAIN (CLASSIFICATION PER TREE SPECIES)			
446	*Cederella serrata* in Nyungwe in Rwanda (1412)	Y= (182.65–5.482×X–24.9×W–0.0701×(X^2)+ 1.7777×X×W+0.004679×(X^2)×W)×10^(–3)	D1.3 in cm, H in m (7, 24)*
447	-idem	Y= (183.39+9.879×X+0.7365×(X^2))×10^(–3)	D1.3 in cm (3, 24)
448	*Cupressus lucastica* in Ruhande in Rwanda (1104)	Y= (121.6–22.845×X+1.9909×(X^2)– 0.012×(X^3))×10^(–3)	D1.3 in cm (10, 40)
449	-idem	Y= (418.96–81.524×X+3.3418×(X^2)+ 1.1237×X×W–0.02771×(X^3)– 0.000288×(X^2)×(W^2))×10^(–3)	D1.3 in cm, H in m (11, 40)*
450	*Cupressus lusitanica* in Kakamega forest in Kenya (2002)	Y= 0.007×X–0.0440	D1.3 in cm (7, 15)*
451	-idem	Y= 0.0258×X–0.3216	D1.3 in cm (15, 200)*
452	-in Nyungwe in Rwanda (1412)	Y= 6.828×10^(–4)×(X^2)–6.223× 10^(–3)×X+2.212×10^(–2)	D1.3 in cm (7, 32)
453	*Eucalyptus globulus* in Munessa Shashamane in Ethiopia (983)	Y= ((0.08283×(X^1.873))×(W^0.8242))×10^(–3)	D1.3 in cm, H in m (1, 33)
454	*Eucalyptus saligna* in Kakamega forest in Kenya (2002)	log10Y= (2.41141×log10(X))–1.90244	D1.3 in cm (16, 45)
455	*Grevillia robusta* in Ruhande in Rwanda (1104)	Y= (–11.93+3.0386×X+0.2063×(X^2))×10^(–3)	D1.3 in cm (7, 23)

Tree components	n, r^2	Interval of possibility (%)	Quality	References
T+B	31, 0.69	95	2	Mohie el Deen, F. A. . (1991)
	–, 0.99	70	1	Poupon, H. (1979)
T+B	18, 0.76	100	2	Mohie el Deen, F. A. . (1991)
T+Bg+Bt3.2+ B+S+D	100	100	2	Nouvellet, Y. (2002)
T	1206	100	2	FAO (1991)
T+B+S	–, 0.99	100	2	Poupon, H. (1979)
T+B+S	179, 0.99*	0	1	Poupon, H. (1979)
T+B+S	–, 0.99	41	1	Poupon, H. (1979)
T+Bg+S+B	–	96	2	Mugasha, A. G., Chamshama, S. A. O., et al. (1997)
T+B	10, 0.97	0	1	Mohie el Deen, F. A. . (1991)
T+B+S	–, 0.99	0	1	Poupon, H. (1979)
T+Bg+Bt+B+S	9, 0.85*	45	1	Doyen, A. (1983)
T+Bg+Bt+B+S	9, 0.85*	100	2	Doyen, A. (1983)
T	144	100	2	Martinot-Lagarde, P. (1961)
T+Bg+Bt+B+S	–, 0.91	99	2	Mabowe, R. B. (2006)
T+Bg+Bt5+B+S	470, 0.89	99	2	Clément, J. (1982)
T	1206	100	2	FAO (1991)
T+B	88, 0.97	80	1	Abbot, P., Lowore, J., et al. (1997)
T+Bg+Bt2+B+S	88, 0.92	97	3	Abbot, P., Lowore, J., et al. (1997)
T+Bg+Bt5+B+S	6511, 0.95	0	1	Clément, J. (1982)
	58, 0.95	-	-	Glen, W. M. (1996)
T+Bg+Bt+B+S	–	91	2	Isango, J. A. (2007)
T+B+S	263, 0.99	100	3	Deleporte, P. (1987)
T+B+S	263, 0.97	5	1	Deleporte, P. (1987)
T+B+S	422, 0.95*	100	3	Deleporte, P. (1987)
T+B+S	422, 0.96*	100	3	Deleporte, P. (1987)
T+Bg+Bt+B+S+D	–	100	2	Bradley, P. N. and Kuyper, J.B.H. (1988)
T+Bg+Bt+B+S+D	–	100	2	Bradley, P. N. and Kuyper, J.B.H. (1988)
T+B	170, 0.93*	100	3	Pleines, V. (1987)
T+B	–	100	2	Pukkala, T. and Pohjonen, V. (1989)
	137,–	0	1	Bradley, P.N. (1988)
T+B+S	38, 0.95	100	3	Deleporte, P. (1987)

ID	Tree species and location (annual rainfall)	Model Equations (m^3)	Variables X (min, max), W, Z, U and V
456	-idem	Y= (–3.27+0.2353×(X^2)×W)×10^(–3)	CD in m, CH in m (7, 23)
457	-idem	Y= (–0.0046+0.3855×(X^2))×10^(–3)	D1.3 in cm (7, 23)
458	-idem	Y= (9.68+0.025×(X^2)×W)×10^(–3)	D1.3 in cm, H in m (7, 23)
459	-idem	Y= (–29.41+6.02×X×3.3318×(X^2))×10^(–3)	CD in m (7, 23)
460	-idem	Y= (0.1979+0.2859×(X^2)×W)×10^(–3)	CD in m, CH in m (7, 23)
461	-idem	Y= (–4.04+0.3197×(X^2))×10^(–3)	D1.3 in cm (7, 23)
462	-idem	Y= (1.0696×X^(0.9159))×10^(–3)	Vs in dm^3 (7, 23)
463	-idem	Y= (–1.87+0.1063×(X^2)×W)×10^(–3)	CD in m, CH in m (7, 23)
464	-idem	Y= (5.12–2.46×X+0.5496×W)×10^(–3)	H in m, D1.3 in cm (7, 25)
465	-idem	Y= (–39.85+21.05×X)×10^(–3)	CD in m (7, 23)
466	-idem	Y= (15.65–7.0320×(X^2)+0.8998×(X^2)×W)×10^(–3)	CD in m, CH in m (7, 23)
467	-idem	Y= (1.45+0.009617×(X^3))×10^(–3)	D1.3 in cm (7, 23)
468	-idem	Y= (0.4376×(X^(0.8839)))×10^(–3)	Vs in dm^3 (7, 23)
469	-idem	Y= (–15.59+7.51×X)×10^(–3)	CD in m (7, 23)
470	-idem	Y= (–18.86+3.3635×(X^2))×10^(–3)	CD in m (7, 23)
471	*Nauclea diderichii* in Miango in Nigeria (1378)	Y= 0.0001416×(X^2)+0.0000314×(X^2)×W–0.0124	D1.3 in cm, H in m (6, 200)**
472	-idem	Y= 0.00002134×(X^2)+0.00003023×(X^2)×W	D1.3 in cm, H in m (1, 200)**
473	*Pinus patula* in Kakamega forest in Kenya (2002)	Y= –0.00041–0.00005711×X+0.0001352×(X×W)+0.00003313×(X×W)	D1.3 in cm, H in m (1, 200)**
474	-in Nyungwe in Rwanda (1412)	Y= 8.42×10^(–4)×(X^2)–7.354×10^(–3)×X+2.506×10^(–2)	D1.3 in cm (6, 40)
475	All in Uluguru in Tanzania (1474)	Y= (194.8803×X^(2.3982))×10^(–6)	D1.3 in cm (6, 200)*
	STAND IN TROPICAL MOUNTAIN		
476	*Pinus patula* in Sao Hill Forest in Tanzania (867)	Y(m^3 ha^{-1})= Exp(–0.0476+(1.00679×log(X))–(1.4379/W)+(0.88471×log10(Z)))	As in m^2, yr in yr, Hd in m (–, –)
	INDIVIDUAL TREE IN TROPICAL SUBTROPICAL HUMID FOREST (CLASSIFICATION PER TREE SPECIES)		
477	*Eucalyptus Camadulensis* in Teza in South Africa (1344)	log10Y= –4.584+log10(X)+log10(W)	D1.3 in cm, Ht in m (1, 20)*

Tree components	n, r^2	Interval of possibility (%)	Quality	References
	33, 0.5	100	3	Deleporte, P. (1987)
T+B+S	33, 0.89*	100	3	Deleporte, P. (1987)
	33, 0.93	100	3	Deleporte, P. (1987)
T+B+S	33, 0.47	0	1	Deleporte, P. (1987)
	33, 0.5	100	3	Deleporte, P. (1987)
	33, 0.66	6	1	Deleporte, P. (1987)
	33, 0.58	0	1	Deleporte, P. (1987)
	38, 0.73	100	3	Deleporte, P. (1987)
	38, 0.96	0	1	Deleporte, P. (1987)
	38, 0.58	100	3	Deleporte, P. (1987)
	38, 0.82	100	3	Deleporte, P. (1987)
	38, 0.89	100	3	Deleporte, P. (1987)
	38, 0.92	100	3	Deleporte, P. (1987)
	38, 0.64	100	3	Deleporte, P. (1987)
	33, 0.47	100	3	Deleporte, P. (1987)
	–, 0.89	100	2	Abayomi, J. O. (1983)
	–, 0.92	100	2	Abayomi, J. O. (1983)
	–	100	2	Bradley, P. N. and Kuyper, J.B.H. (1988)
	181, 0.93*	100	3	Pleines, V. (1987)
	30, 0.99	100	3	Brown, S. and Lugo, E. Q. (1992)
	–	0	2	Malimbwi, R. E., Mugasha, A. G., et al. (1998)
	–, 0.99	100	2	Little, K. M. (2007)

Appendix C. Allometric equations predicting individual tree and stand biomass in sub-Saharan Africa.

When no specific location is mentioned, the name of the country is used, except in the case of general allometric equations (e.g., Chave, 2005 and Brown, 1997). The calibration ranges of the variable X are presented in brackets. When no calibration range was mentioned in the article, it was calculated (see 2.2). The symbols * and ** indicate that one and two thresholds, respectively, were calculated from this study. The maximum $D_{1.3}$ was considered to be 200 cm. The calibration ranges of the variables W, Z, U and V are not mentioned in this table. The value of the column "Interval of possibility" corresponds to the percentage of values falling within the interval of possibility. Three quality levels were identified: quality 1 (the interval of possibility is lower than 90%), quality 2 (the equation is within the interval of possibility without indication of the sampling methods or correlation) and quality 3 (n, r^2 and the calibration ranges were mentioned and the interval of possibility was higher than 90%). Adj means adjusted squared correlation coefficient. Tree compartments are represented by the following abbreviations.

T: Trunk-underbark, B: Bark, Bg: Gross branches (D>7 cm), Bt: Thin branches (D<7 cm), Bd: dead branches, L: Leaves, S: Stump, Rb: Large root, Rm: Medium root and Rf: Fine root. The number that follows the acronym Bt indicates the minimum branch diameter.

Acronyms used: As: stem cross-sectional area at $D_{1.3}$, BA: basal area, D_0: basal diameter, C: circumference, C (10,180): circumference at 10 cm and 180 cm, CA: crown area, Cb: basal circumference, CD: crown diameter, CH: crown height, CV: canopy volume, D20 – 30: diameter at 20 and 30 cm height, $D_{1.3}$: diameter at breast height, H: height, Log: natural logarithm, Log10: logarithm in basis 10, SQRT: square root, wd: wood gravity and yr: age. Adj means adjusted squared correlation coefficient.

Group 24: *Combretum geitonophyllum*, *Combretum glutinosum*, *Piliostigma thonningii*, *Terminalia macroptera*, group 25: *Persea americana*, *Mangifera indica*, *Spathodea nilotica*, group 26: *Cupressus lusitanica*, *Pinus patula*

Appendix C

ID	Tree species and location (annual rainfall)	Model Equations	Variables X (min, max), W, Z, U and V
INDIVIDUAL TREE IN TROPICAL RAINFOREST (CLASSIFICATION PER TREE SPECIES)			
478	*Gmelina arborea* in Oluwa forest reserve in Nigeria (1545)	logY= –3.38+(0.92×log((X^2)×W))	D1.3 in cm, H in m (1, 200)**
479	-idem	logY= –3.45+(0.91×log((X^2)×W))	D1.3 in cm, H in m (1, 200)**
480	-idem	logY= –5.57+(0.94×log((X^2)×W))	D1.3 in cm, H in m (1, 200)**
481	-idem	logY= –6.91+(0.94×log((X^2)×W))	D1.3 in cm, H in m (1, 200)**
482	-idem	logY= –5.82+(2.41×log(X))	D1.3 in cm (1, 200)**
483	-idem	logY= –4.36+(2.39×log(X))	D1.3 in cm (1, 200)**
484	-idem	logY= –2.24+(2.3×log(X))	D1.3 in cm (1, 200)**
485	-idem	logY= –2.07+(2.3×log(X))	D1.3 in cm (1, 200)**
486	*Nauclea diderichii* in Omo in Nigeria (2293)	logY= –1.47+0.06×X+1.27×log((X^2))	D1.3 in cm (1, 200)**
487	-idem	logY= –3.65+1.46×log(X^2)+ 0.00003×(X^2)×W+0.43×log(z)	D1.3 in cm, H in m (1, 200)**
488	-idem	logY= –2.92+1.28×log(X^2)+0.06×X	D1.3 in cm (1, 200)**
489	-idem	logY= –2.26+0.56×log((X^2)×W)+0.0009×(X^2)	D1.3 in cm, H in m (1, 200)**
490	-idem	Y= 0.05+3.71×X+0.0007×(X^2)	D1.3 in cm (1, 200)**
491	-idem	logY= 3.56+0.09×X–7.85×(X^(–1))	D1.3 in cm (1, 200)**
492	-idem	logY= 0.35+(1.38×log(X^2))+0.05×X	D1.3 in cm (1, 200)**
493	-idem	logY= –0.07+(0.55×log((X^2)×W))+0.0008×(X^2)	D1.3 in cm, H in m (1, 200)**
494	-idem	logY= –0.216+(0.55×log((X^2)×W))+0.0008×(X^2)	D1.3 in cm, H in m (1, 200)**
495	-idem	logY= –1.97+0.5×log((X^2)×W)+0.0009× (X^2)+0.015×W	D1.3 in cm, H in m (1, 200)**
496	*Terminalia ivorensis* in Mbalmayo in Cameroon (2445)	Y= 0.7631×X	As in cm^2 (1, 22432)**
497	*Terminalia superba* in Kumasi in Ghana (1405)	Y= 0.066×(X^(2.565))	D1.3 in cm (1, 200)**
498	*Terminalia sp* in Mbalmayo in Cameroon (2445)	Y= 0.02489×(X^2)×W	D1.3 in cm, H in m (1, 200)**
499	-idem	Y= 0.7631×X	As in cm^2 (1, 22432)**
500	-idem	Y= 30.56+0.02435×(X^2)×W	D1.3 in cm, H in m (1, 200)**
501	-idem	Y= 26.15+0.7487×X	As in cm^2 (1, 22432)**
GENERAL EQUATIONS FOR INDIVIDUAL TREE IN TROPICAL RAINFOREST			
502	GeneralizeBd in Mbalmayo in Cameroon (2445)	Y= 0.02477×(X^2)×W	D1.3 in cm, H in m (1, 200)**
503	-idem	Y= –0.259+0.1669×X+0.0006809×(X^2)	BA in cm^2 (6, 120)*
504	-idem	Y= –0.969+0.236×X	BA in cm^2 (6, 120)*
505	-idem	Y= –3.37+0.02483×(X^2)×W	D1.3 in cm, H in m (5, 200)**
506	-idem	Y= –30.87+0.7684×X	As in cm^2 (50, 22432)**
507	-idem	Y= 0.7489×X	As in cm^2 (1, 22432)**
508	-in Boi Tano in Ghana (2155)	Y= 0.30×X^(2.31)	D1.3 in cm (2, 180)*
509	-in Maseno in Kenya (1819)	logY= (0.93×log((X^ 2)×W))–2.97	D1.3 in cm, H in m (5, 32)

Tree components	n, ,R^2	Interval of possibility (%)	Quality	References
T+Bg+Bt+L+B+S+Bd	25, 0.99	100	2	Onyekwelu, J. C. (2004)
T+B+S	25, 0.99	100	2	Onyekwelu, J. C. (2004)
Bg+Bt+Bd	25, 0.99	100	2	Onyekwelu, J. C. (2004)
L	25, 0.98	100	2	Onyekwelu, J. C. (2004)
L	25, 0.98	100	2	Onyekwelu, J. C. (2004)
Bg+Bt+Bd	25, 0.98	100	2	Onyekwelu, J. C. (2004)
T+B+S	25, 0.99	100	2	Onyekwelu, J. C. (2004)
T+Bg+Bt+L+B+S+Bd	25, 0.99	100	2	Onyekwelu, J. C. (2004)
Bg+Bt	–	0	1	Onyekwelu, J. C. (2007)
L	–	0	1	Onyekwelu, J. C. (2007)
L	–	0	1	Onyekwelu, J. C. (2007)
Bg+Bt	–	28	1	Onyekwelu, J. C. (2007)
T+Bg+Bt+L+B+S+Bd	–	96	2	Onyekwelu, J. C. (2007)
T+B	–	27	1	Onyekwelu, J. C. (2007)
T+B	–	0	1	Onyekwelu, J. C. (2007)
T+Bg+Bt+L+B+S+Bd	–	30	1	Onyekwelu, J. C. (2007)
T+B	–	26	1	Onyekwelu, J. C. (2007)
Bg+Bt	–	27	1	Onyekwelu, J. C. (2007)
T+Bg+Bt+L+B+S+Bd	6, 0.99	96	2	Norgrove, L. and Hauser, S. (2002)
T+Bg+Bt+L+B+S+Bd	–, 0.97	100	2	Asomaning, G. (2006)
T+Bg+Bt+L+B+S+BD+RB+RM+RF	6, 0.99	100	2	Deans, J. D., Moran, J., et al. (1996)
T+Bg+Bt+L+B+S+BD+RB+RM+RF	6, 0.99	98	2	Deans, J. D., Moran, J., et al. (1996)
T+Bg+Bt+L+B+S+BD+RB+RM+RF	6, 0.99	96	2	Deans, J. D., Moran, J., et al. (1996)
T+Bg+Bt+L+B+S+BD+RB+RM+RF	6, 0.99	95	2	Deans, J. D., Moran, J., et al. (1996)
T+Bg+Bt+L+B+S+BD+RB+RM+RF	14, 0.99	100	2	Deans, J. D., Moran, J., et al. (1996)
Bg+Bt+Bd	–, 0.99	0	1	Deans, J. D., Moran, J., et al. (1996)
Bg+Bt+Bd	–, 0.98	0	1	Deans, J. D., Moran, J., et al. (1996)
T+Bg+Bt+L+B+S+BD+RB+RM+RF	14, 0.99	100	2	Deans, J. D., Moran, J., et al. (1996)
T+Bg+Bt+L+B+S+BD+RB+RM+RF	14, 0.97	100	2	Deans, J. D., Moran, J., et al. (1996)
T+Bg+Bt+L+B+S+BD+RB+RM+RF	14, 0.97	98	2	Deans, J. D., Moran, J., et al. (1996)
T+Bg+Bt+L+B+S+Bd	42, 0.98adj	99	3	Henry, M., Besnard, A., et al. (2010)
T+Bg+Bt+L+B+S	26, 0.94adj		3	Henry, M. (2009)

ID	Tree species and location (annual rainfall)	Model Equations	Variables X (min, max), W, Z, U and V
510	-idem	Y= exp(–2.977+log(X×W^2×Z))	WD in g.cm^{-3}, D1.3 in cm, H in m (–, –)**
511	-idem	Y= exp(–2.134+2.530×log(X))	D1.3 in cm (1, 80)*
512	-idem	Y= EXP(–2.409+0.9522×LN((X^2)×W×Z))	D1.3 in cm, H in m, wd in g cm^{-3} (5, 130)
513	-idem	Y= exp(–3.1141+(0.9719×log((X^2)×W)))	D1.3 in cm, H in m (5, 130)
514	-idem	Y= 21.297–6.953×(X)+0.740×((X^2))	D1.3 in cm (5, 112)*
515	-idem	Y= exp(–2.557+0.940×log(X×W^2×Z))	WD in g.cm^{-3}, D1.3 in cm, H in m (–, –)**
516	-idem	Y= X×exp(–1.349+(1.980×log(W))+ (0.207×(log(W))^2)–(0.0281×(log(W))^3))	WD in g.cm^{-3}, D1.3 in cm (–, –)**
517	-idem	Y= X×exp(–1.239+(1.98×log(W))+ (0.207×(log(W))^2)–(0.0281×(log(W))^3))	WD in g.cm^{-3}, D1.3 in cm (–, –)**
STAND IN TROPICAL RAINFOREST			
518	*Nauclea diderichii* in Akure for in Nigeria (1390)	logY(kg ha–1)= 38.41–8.23×X	H in m
519	-idem	Y(kg ha–1)= 26.341–10.16×X	H in m
520	*Terminalia superba* in Gambari in Niger (1231)	Y(kg ha–1)= 1.51+10.5×X	yr in yr
INDIVIDUAL TREE IN TROPICAL MOIST DECIDUOUS FOREST (CLASSIFICATION PER TREE SPECIES)			
521	*Acacia erubescens* in Botswana	Y= 0.0137×(X+W+Z)^(3.2840)	H in m, CD in m, CD in m (3, 54)**
522	*Acacia karoo* in Botswana	Y= 0.0079×(X+W+Z)^(3.1858)	H in m, CD in m, CD in m (3, 54)**
523	*Acacia mellifera* in Botswana	Y= 0.0548×(X+W+Z)^(2.5767)	H in m, CD in m, CD in m (3, 54)**
524	*Acacia tortillis* in Botswana	Y= 0.0096×(X+W+Z)^(3.3015)	H in m, CD in m, CD in m (3, 54)**
525	*Combretum geitonophyllum* in Saré Yorobana in Senegal (1022)	Y= 0.103×(X^2.44)	D1.3 in cm (1, 200)**
526	-idem	Y= 0.2046×x^(1.63)	D1.3 in cm (1, 200)**
527	-idem	Y= 0.205×(X^1.63)	BD in cm (1, 225)**
528	-idem	Y= 0.283×(X^2.17)	D1.3 in cm (1, 20)*
529	-idem	Y= 0.0682×(X^1.74)	Bd in cm (1, 25)*
530	-idem	Y= 0.07×x^(1.74)	D1.3 in cm (1, 200)**
531	-idem	Y= 0.0947×(X^2.15)	D1.3 in cm (1, 200)**
532	*Combretum glutinosum* in Saré Yorobana in Senegal (1022)	Y= 0.0512×X^(2.63)	D1.3 in cm (1, 20)*
533	-idem	Y= 0.0676×(X^1.99)	D1.3 in cm (1, 200)**
534	-idem	Y= 0.149×(X^2.33)	Bd in cm (1, 25)*
535	-idem	Y= 0.0782×(X^2.16)	D1.3 in cm (1, 200)**
536	-idem	Y= 0.175×(X^1.78)	BD in cm (1, 225)**
537	-idem	Y= 0.0965×(X^2.43)	D1.3 in cm (1, 200)**
538	-idem	Y= 0.1753×X^(1.78)	D1.3 in cm (1, 200)**
539	*Dichrostachys cinerea* in Botswana	Y= 0.0029×(X+W+Z)^(3.7422)	H in m, CD in m, CD in m (3, 54)**
540	*Khaya senegalensis* in Badénou in Ivory Coast (1211)	Y= 2.2598–3.4804×x+1.6684×(X^2)	C in m (1, 6)**
541	-idem	Y= 0.0213+0.01953×(X^2)×W	C in m, H in m (3, 628)**

Tree components	n, ,R^2	Interval of possibility (%)	Quality	References
T+Bg+Bt+L+B+S+Bd	143, 0.97adj	100	3	Chave, J., Andalo, C., et al. (2005)
T+Bg+Bt+L+B+S+Bd	–, 0.97adj	100	2	Ponce-Hernandez, R. (2004)
T+Bg+Bt+L+B+S+Bd	94, 0.99adj	100	3	Brown, S.A.J., Gillespie, J.R., et al. (1989)
T+Bg+Bt+L+B+S+Bd	168, 0.97adj	100	3	Brown, S.A.J., Gillespie, J.R., et al. (1989)
T+Bg+Bt+L+B+S+Bd	169, 1adj	100	3	Brown, S. (1997)
T+Bg+Bt+L+B+S+Bd	143, 0.97adj	100	3	Chave, J., Andalo, C., et al. (2005)
T+Bg+Bt+L+B+S+Bd	143, 0.97adj	100	3	Chave, J., Andalo, C., et al. (2005)
T+Bg+Bt+L+B+S+Bd	143, 0.97adj	100	3	Chave, J., Andalo, C., et al. (2005)
T+Bg+Bt+L+B+S+Bd	12, 0.71	-	2	Fuwape, J. A., Onyekwelu, J. C., et al. (2001)
T+Bg+Bt+L+B+S+Bd	12, 0.62	-	2	Fuwape, J. A., Onyekwelu, J. C., et al. (2001)
T+Bg+BT5+B+S	–	-	2	Mbaekwe, E. I. and Mackenzie, J. A. (2008)
T+Bg+Bt+L+B+S+Bd	38, 0.91	0	1	Hofstad, O. (2005)
T+Bg+Bt+L+B+S+Bd	41, 0.91	0	2	Hofstad, O. (2005)
T+Bg+Bt+L+B+S+Bd	27, 0.9	0	2	Hofstad, O. (2005)
T+Bg+Bt+L+B+S+Bd	50, 0.9	0	2	Hofstad, O. (2005)
T+B	40, 0.95	99	3	Manlay, R.J., Kairé, M., et al. (2002)
S	41, 0.86	93	2	Kaire, M. (1999)
S	41, 0.88	89	1	Manlay, R.J., Kairé, M., et al. (2002)
T+Bg+Bt+L+B+S+Bd	40, 0.97	90	1	Manlay, R.J., Kairé, M., et al. (2002)
L	40, 0.95	100	3	Manlay, R.J., Kairé, M., et al. (2002)
L	40, 0.94	99	3	Manlay, R.J., Kairé, M., et al. (2002)
Bg+Bt+Bd	40, 0.96	93	3	Manlay, R.J., Kairé, M., et al. (2002)
T+Bg+Bt+L+B+S+Bd	41, 0.97	100	3	Kaire, M. (1999)
L	41, 0.94	98	3	Manlay, R.J., Kairé, M., et al. (2002)
T+Bg+Bt+L+B+S+Bd	41, 0.98	83	1	Manlay, R.J., Kairé, M., et al. (2002)
Bg+Bt+Bd	41, 0.95	97	3	Manlay, R.J., Kairé, M., et al. (2002)
S	40, 0.81	89	1	Manlay, R.J., Kairé, M., et al. (2002)
T+B	41, 0.97	100	3	Manlay, R.J., Kairé, M., et al. (2002)
S	40, 0.8	91	2	Kaire, M. (1999)
T+Bg+Bt+L+B+S+Bd	33, 0.94	0	1	Hofstad, O. (2005)
T+Bg+Bt+B+S+Bd	84,–	100	2	Louppe, D., M'BlaKoua, et al. (1994)
T+Bg+Bt+B+S+Bd	84,–	0	1	Kaire, M. (1999)

ID	Tree species and location (annual rainfall)	Model Equations	Variables X (min, max), W, Z, U and V
542	*Piliostigma thonningii* in Saré Yorobana in Senegal (1022)	Y= 0.0554×(X^1.79)	D1.3 in cm (1, 200)**
543	-idem	Y= 0.0898×(X^2.29)	D1.3 in cm (1, 200)**
544	-idem	Y= 0.149×(X^1.66)	D1.3 in cm (1, 200)**
545	-idem	Y= 0.97×X^(1.66)	BD in cm (1, 225)**
546	-idem	Y= 0.157×(X^2.27)	D1.3 in cm (1, 20)*
547	-idem	Y= 0.0785×(X^1.99)	D1.3 in cm (1, 200)**
548	*Terminalia macroptera* in Saré Yorobana in Senegal (1022)	Y= 0.035×(X^2.02)	D1.3 in cm (1, 200)**
549	-idem	Y= 0.0966×(X^2.52)	D1.3 in cm (1, 200)**
550	-idem	Y= 0.0626×(X^2.38)	D1.3 in cm (1, 200)**
551	-idem	Y= 0.0507××^(1.97)	BD in cm (1, 225)**
552	-idem	Y= 0.155×(X^1.69)	D1.3 in cm (1, 200)**
553	-idem	Y= 0.0979×(X^2.4)	D1.3 in cm (1, 20)*
554	*Ziziphus mucronata* in Botswana	Y= 0.013×(X+W+Z)^(2.8625)	H in m, CD in m, CD in m (3, 54)**
INDIVIDUAL TREE IN TROPICAL MOIST DECIDUOUS FOREST (CLASSIFICATION PER GROUP OF TREE SPECIES)			
555	Group 24 in Saré Yorobana in Senegal (1022)	Y= 0.0965×(X^2.42)	Bd in cm (1, 25)*
556	-idem	Y= 0.172×(X^2.29)	D1.3 in cm (1, 20)*
557	-idem	Y= 0.0785×(X^2.17)	Bd in cm (1, 25)*
558	-idem	Y= 0.0566×(X^1.89)	Bd in cm (1, 25)*
559	-idem	Y= 0.171×(X^1.69)	D1.3 in cm (1, 200)**
GENERAL EQUATIONS FOR INDIVIDUAL TREE IN TROPICAL MOIST DECIDUOUS FOREST			
560	GeneralizeBd in Uganda	Y (fresh)= Exp (–1.198+1.556×LOG(X)+0.55× log10(W/100)+0.435× log10 (Z/100))	D1.3 in cm, H in m, CR in 100 (2, 200)**
561	-idem	Y (fresh)= 13.18334+0.06259×X^(2)×W/100	D1.3 in cm, H in m (1, 200)**
562	-idem	Y (fresh)= Exp(–0.89+2.053× log10 (X))	D1.3 in cm (2, 200)**
563	-idem	Y (fresh)= –4.22412+0.56×X^(2)	D1.3 in cm (3, 200)**
564	-in Zambia	Y= 23.34×X–218.34	D1.3 in cm (10, 30)
565	-idem	Y= 1.6×X–4	BD in cm (3, 10)*
566	-idem	logY= –0.739+0.89×LOG(X)+0.132×LOG(X^2)+ 0.913×LOG(W)–0.103×LOG(W^2)	D1.3 in cm, H in m (2, 70)
567	-idem	Y= 0.3623×X^(1.382)×W^(0.640)	D1.3 in cm, H in m (2, 70)
568	-idem	Y= X×exp(–1.499+(2.148×log(W))+ (0.207×(log(W))^2)–(0.0281×(log(W))^3))	WD in g.cm–3, D1.3 in cm (–, –)**
569	-idem	Y= exp(–2.134+2.530×log(X))	D1.3 in cm (1, 80)*
570	-idem	Y= EXP(–2.409+0.9522×LN((X^2)×W×Z))	D1.3 in cm, H in m, wd in g cm–3 (5, 148)
571	-idem	Y= 42.69–12.800×(X)+1.242×((X^2))	D1.3 in cm (5, 148)*
572	-idem	Y= exp(–2.977+log(X×W^2×Z))	WD in g.cm–3, D1.3 in cm, H in m (–, –)**
573	-idem	Y= exp(–3.1141+(0.9719×log((X^2)×W)))	D1.3 in cm, H in m (5, 148)

Tree components	n, ,R^2	Interval of possibility (%)	Quality	References
L	40, 0.88	99	3	Manlay, R.J., Kairé, M., et al. (2002)
T+B	40, 0.94	100	3	Manlay, R.J., Kairé, M., et al. (2002)
S	40, 0.89	95	3	Manlay, R.J., Kairé, M., et al. (2002)
S	40, 0.87	31	1	Kaire, M. (1999)
T+Bg+Bt+L+B+S+Bd	40, 0.97	100	3	Manlay, R.J., Kairé, M., et al. (2002)
Bg+Bt+Bd	40, 0.96	97	3	Manlay, R.J., Kairé, M., et al. (2002)
L	40, 0.88	99	3	Manlay, R.J., Kairé, M., et al. (2002)
T+B	40, 0.96	100	3	Manlay, R.J., Kairé, M., et al. (2002)
Bg+Bt+Bd	40, 0.97	97	3	Manlay, R.J., Kairé, M., et al. (2002)
S	40, 0.95	93	2	Kaire, M. (1999)
S	40, 0.92	95	3	Manlay, R.J., Kairé, M., et al. (2002)
T+Bg+Bt+L+B+S+Bd	40, 0.96	100	3	Manlay, R.J., Kairé, M., et al. (2002)
T+Bg+Bt+L+B+S+Bd	17, 0.96	0	2	Hofstad, O. (2005)
T+B	161, 0.95	100	3	Manlay, R.J., Kairé, M., et al. (2002)
T+Bg+Bt+L+B+S+Bd	161, 0.94	100	3	Manlay, R.J., Kairé, M., et al. (2002)
Bg+Bt+Bd	40, 0.98	100	3	Manlay, R.J., Kairé, M., et al. (2002)
L	40, 0.96	100	3	Manlay, R.J., Kairé, M., et al. (2002)
S	40, 0.8	93	3	Manlay, R.J., Kairé, M., et al. (2002)
T+Bg+Bt+L+B+S+Bd	1695, 0.88	100	2	Velle, K. (1995)
T+Bg+Bt+L+B+S+Bd	1695, 0.75	100	2	Velle, K. (1995)
T+Bg+Bt+L+B+S+Bd	1695, 0.81	100	2	Velle, K. (1995)
T+Bg+Bt+L+B+S+Bd	1695, 0.73	100	2	Velle, K. (1995)
T+Bg+Bt+L+B+S+Bd	20,–	0	2	Chimudayo, E. N. (1990)
T+Bg+Bt+L+B+S+Bd	7, 0.94	0	3	Chimudayo, E. N. (1990)
T+Bg+Bt+L+B+S+Bd	271, 0.72	0	3	Stromgaard, P. (1986)
T+Bg+Bt+L+B+S+Bd	271, 0.71	0	3	Stromgaard, P. (1986)
T+Bg+Bt+L+B+S+Bd	1349, 0.99	100	3	Chave, J., Andalo, C., et al. (2005)
T+Bg+Bt+L+B+S+Bd	–, 0.97	100	2	Ponce-Hernandez, R. (2004)
T+Bg+Bt+L+B+S+Bd	168, 0.99	100	3	Brown, S.A.J., Gillespie, J.R., et al. (1989)
T+Bg+Bt+L+B+S+Bd	170, 1*	100	3	Brown, S. (1997)
T+Bg+Bt+L+B+S+Bd	1349, 0.99	100	3	Chave, J., Andalo, C., et al. (2005)
T+Bg+Bt+L+B+S+Bd	168, 0.97	100	3	Brown, S.A.J., Gillespie, J.R., et al. (1989)

ID	Tree species and location (annual rainfall)	Model Equations	Variables X (min, max), W, Z, U and V
STAND IN TROPICAL TROPICAL MOIST DECIDUOUS FOREST			
574	GeneralizeBd in Boulandor in Senegal (1124)	Y(kg ha^{-1})= 24240×(1–exp(–2×5111×X/24240))^2	Yr in Yr
575	- in Guiro yorobocar in Senegal (1022)	Y(kg ha^{-1})= 39435×(1–exp(–2×6700×X/39435))^2	Yr in Yr
576	-in Saré Yorobana in Senegal (1022)	Y(kg ha^{-1})= 42353×(1–exp(–2×4364×X/42353))^2	Yr in Yr
INDIVIDUAL TREE IN TROPICAL DRY FOREST (CLASSIFICATION PER TREE SPECIES)			
577	*Acacia auriculiformis* in Loandjili in Congo (1208)	Y= 4.16×10^(–4)×X^(3)+11.22	C10 in cm (4, 653)**
578	-idem	Y= 2.02×10^(–5)×X^(3)+2.36	C10 in cm (4, 653)**
579	*Acacia laeta* in mare d'Oursi in Burkina Faso (846)	Y(g)= (142×X+216.6)×10^(–3)	D1.3 in cm (1, 200)**
580	*Acacia mangium* in Loandjili in Congo (1208)	Y= 2.69×10^(–5)×X^(3)+0.25	C10 in cm (4, 653)**
581	-in Pointe noire in Congo (1208)	Y= 3.57×10^(–4)×(X^3)+19.2	C10 in cm (4, 653)**
582	*Acacia senegal* in Boboyo in Cameroon (782)	Y= 443.929×(X^(2.3783))	Cb in m (0, 7)**
583	*Acacia tortillis* in mare d'Oursi in Burkina Faso (846)	Y(g)= (52.5×X–44.64)×10^(–3)	D1.3 in cm (1, 200)**
584	Colophospermum mopane in Dukwe in Botswana (351)	Y= 0.0644×(X^1.3341)	BA in cm2 (1, 39879)**
585	*Combretum aculeatum* in mare d'Oursi in Burkina Faso (846)	Y(g)= 60.57×X–17.66×10^(–3)	H in cm (292, 5369)**
586	*Combretum glutinosum* in Mali	Y= 2.8×10^(–3)×X^(2.3)	C in cm (3, 628)**
587	*Eucalyptus donai* in Evander in South Africa (748)	Y= –0.0582+0.0206×(X^2)	D1.3 in cm (3, 11)
588	-idem	Y= 0.0645+0.0223×(X^2)	D1.3 in cm (3, 11)
589	-idem	Y= –0.4104+0.0673×(X^2)	D1.3 in cm (3, 11)
590	-idem	Y= –0.1960+0.1072×(X^2)	D1.3 in cm (3, 11)
591	*Eucalyptus emithii* in Evander in South Africa (748)	Y= –0.4622+0.0445×(X^2)	D1.3 in cm (4, 11)*
592	-idem	Y= –0.0859+0.0239×(X^2)	D1.3 in cm (3, 11)
593	-idem	Y= –1.5351+0.1294×(X^2)	D1.3 in cm (4, 11)*
594	-idem	Y= –0.5217+0.1286×(X^2)	D1.3 in cm (3, 11)
595	*Eucalyptus globulus* in Evander in South Africa (748)	Y= –0.1459+0.0552×(X^2)	D1.3 in cm (3, 11)
596	-idem	Y= –1.1054+0.1924×(X^2)	D1.3 in cm (3, 11)
597	-idem	Y= 0.2839+0.0202×(X^2)	D1.3 in cm (3, 11)
598	-idem	Y= –0.6006+0.0588×(X^2)	D1.3 in cm (4, 11)*
599	*Eucalyptus nitens* in Evander in South Africa (748)	Y= –0.6819+0.077×(X^2)	D1.3 in cm (3, 11)
600	-idem	Y= –0.2147+0.0371×(X^2)	D1.3 in cm (3, 11)
601	-idem	Y= 0.0967+0.0248×(X^2)	D1.3 in cm (3, 11)
602	- idem	Y= –0.5847+0.1683×(X^2)	D1.3 in cm (3, 11)
603	*Eucalyptus sp* in Pointe noire in Congo (1208)	Y= 0.01×X+(11.67–0.084×X)×(W^2)×Z	Yr in Yr, D1.3 in m, H in m (–, –)

Tree components	n, ,R^2	Interval of possibility (%)	Quality	References
T+Bg+Bt+L+B+S+Bd	18,–	-	2	Manlay, R.J., Kairé, M., et al. (2002)
T+Bg+Bt+L+B+S+Bd	17,–	-	2	Manlay, R.J., Kairé, M., et al. (2002)
T+Bg+Bt+L+B+S+Bd	17,–	-	2	Manlay, R.J., Kairé, M., et al. (2002)
T+Bg+Bt+B+S+Bd	8, 0.96	63	1	Bernhard-Reversat, F., Dianganam, D., et al. (1993)
L	8, 0.8	97	2	Bernhard-Reversat, F., Dianganam, D., et al. (1993)
L	–	98	2	Bellefontaine, R., Gaston, A., et al. (1997)
L	8, 0.87	99	2	Bernhard-Reversat, F., Dianganam, D., et al. (1993)
T+Bg+Bt+B+S+Bd	–	96	2	Bernhard-Reversat, F., Dianganam, D., et al. (1993)
T+Bg+Bt+B+S+Bd	37, 0.86	98	2	Smektala, G., Hautdidier, B., et al. (2002)
L	–	100	2	Bellefontaine, R., Gaston, A., et al. (1997)
T+Bg+Bt+L+B+S+Bd	36, 0.95	100	2	Tietema, T. (1993)
L	–	86	1	Bellefontaine, R., Gaston, A., et al. (1997)
T+B	–	100	2	Alexandre, D.-Y., and Kaïré, M. (2001)
L	4, 0.92*	100	3	Schonau, A.P.G. and Boden, D.I. (1981)
B	4, 1*	89	1	Schonau, A.P.G. and Boden, D.I. (1981)
Bg+Bt	4, 0.99*	100	3	Schonau, A.P.G. and Boden, D.I. (1981)
T+B+S	4, 1*	100	3	Schonau, A.P.G. and Boden, D.I. (1981)
L	4, 0.89*	100	3	Schonau, A.P.G. and Boden, D.I. (1981)
B	4, 0.99*	100	3	Schonau, A.P.G. and Boden, D.I. (1981)
Bg+Bt	4, 0.94*	25	1	Schonau, A.P.G. and Boden, D.I. (1981)
T+B+S	4, 0.99*	100	3	Schonau, A.P.G. and Boden, D.I. (1981)
Bg+Bt	4, 0.96*	100	3	Schonau, A.P.G. and Boden, D.I. (1981)
T+B+S	4, 0.99*	100	3	Schonau, A.P.G. and Boden, D.I. (1981)
B	4, 0.9*	78	1	Schonau, A.P.G. and Boden, D.I. (1981)
L	4, 0.89*	100	3	Schonau, A.P.G. and Boden, D.I. (1981)
Bg+Bt	4, 0.85*	100	3	Schonau, A.P.G. and Boden, D.I. (1981)
L	4, 0.95*	100	3	Schonau, A.P.G. and Boden, D.I. (1981)
B	4, 1*	89	1	Schonau, A.P.G. and Boden, D.I. (1981)
T+B+S	4, 0.99*	100	3	Schonau, A.P.G. and Boden, D.I. (1981)
D	70, 0.22	-	3	Saint-André, L., M'Bou, A.T., et al. (2005)

ID	Tree species and location (annual rainfall)	Model Equations	Variables X (min, max), W, Z, U and V
604	-idem	Y= 1249.8×X^(2.52)	D1.3 in m (0, 2)**
605	-idem	Y= 1.4×(((X^2)×W)^0.46)	D1.3 in m, H in m (0, 2)**
606	-idem	Y= 5.06×(((X^2)×W)^0.3)	D1.3 in m, H in m (0, 2)**
607	-idem	Y= 5.37+235.2×(X^2)×W	D1.3 in m, H in m (0, 2)**
608	-idem	Y= 13.73×((X^2)×W)^0.7	D1.3 in m, H in m (0, 2)**
609	-idem	Y= 0.22+(132.4+0.27×X)×(W^2)×Z	Yr in Yr, D1.3 in m, H in m (–, –)
610	-idem	Y= (7.78+1224.1×exp(–0.18×X))×(W^2)×Z	Yr in Yr, D1.3 in m, H in m (–, –)
611	-idem	Y= 38.1×((X^2)×W)^0.62	D1.3 in m, H in m (0, 2)**
612	-idem	Y= 2.76+182.7×(X^2)×W	Yr in Yr, D1.3 in m (0, 2)**
613	-idem	Y= 1.507+0.0001109×(X^3)+ 0.00004832×(W^2)×(X^2)	C in cm, Yr in Yr (–, –)
614	-idem	Y= –2.443+2.805×W–0.143×(W^2)– (0.0185+0.0639×W)×X+(0.003357 +4.8391^(–5)×(W^2))×(X^2)	C in cm, Yr in Yr (–, –)
615	-idem	Y= –0.2051–0.8321×W+0.1729×X+ 0.00003008×(W^2)×(X^2)	C in cm, Yr in Yr (–, –)
616	-idem	Y= (–0.9335–0.5551×W+0.3147×(W^2))+ (0.3145–0.1059×W)×x+0.0007208×W×(X^2)	C in cm, Yr in Yr (–, –)
617	-idem	Y= 0.089+(0.001895+0.000113×W)×x	C in cm, Yr in Yr (–, –)
618	-idem	Y= 9.08×((X^2)×W)^0.72	D1.3 in m, H in m (0, 2)**
619	-idem	Y= 0.117–(0.02243×(W^2))×x+0.008852×(X^2)	C in cm, Yr in Yr (–, –)
620	-idem	Y= 0.6+(5.26–0.024×X+ 565.1×exp(–0.15×X)×(W^2)×Z)	Yr in Yr, D1.3 in m, H in m (–, –)
621	*Eucalyptus viminalis* in Evander in South Africa (748)	Y= –0914+0.1975×(X^2)	D1.3 in cm (3, 11)
622	-idem	Y= 0.4964+0.457×(X^2)	D1.3 in cm (3, 11)
623	-idem	Y= –0.1807+0.0343×(X^2)	D1.3 in cm (3, 11)
624	-idem	Y= –0.1508+0.0392×(X^2)	D1.3 in cm (3, 11)
625	*Faidherbia albida* in Mali	Y(g)= 98×10^(–6)×(X^2.77) ×10^(–3)	H in cm (292, 5369)**
626	-idem	Y(g)= (X^2.08) ×10^(–3)	C in cm (3, 628)**
627	-idem	Y(g)= 0.32×(X^1.26) ×10^(–3)	As in dm^2 (0, 224)**
628	*Guiera senegalensis* in Burkina Faso	Y= 0.39×x^(1.6)	D1.3 in cm (1, 200)**
629	*Vitellaria paradoxa* in Mafa Kilda in Cameroon (997)	Y= 0.080×(X^(2.46))	D1.3 in cm (15, 53)
STAND IN TROPICAL DRY FOREST			
630	GeneralizeBd in Sonkorong in Senegal (682)	Y(kg ha–1)= 33338×(1–exp(–2×2245×X/33338))^2	Yr in Yr
GENERAL EQUATIONS FOR INDIVIDUAL TREE IN TROPICAL DRY FOREST			
631	GeneralizeBd in Burkina Faso	Y(g)= 1.8×x^(2.5) ×10^(–3)	C in cm (6, 36)
632	-idem	Y= 0.1263+0.1006×X	BA in cm^2 (8, 560)
633	in Boucle du Mouhoun in Burkina Faso (796)	Y= –1.2286732+0.70230016×X+0.1049166×(X^3)	D1.3 in cm (2, 200)**
634	-in Mali	log10Y= –2.26+(2.4×log10(X^0.8))	D1.3 in cm (1, 200)**
635	-in Mozambique	Y= –41.077+2.816554×X+0.35657×(X^2)	D1.3 in cm (8, 200)**

Tree components	n, ,R^2	Interval of possibility (%)	Quality	References
Rb	18, 0.89	100	3	Saint-André, L., M'Bou, A.T., et al. (2005)
Rm	18, 0.84	99	3	Saint-André, L., M'Bou, A.T., et al. (2005)
Rf	18, 0.84	97	3	Saint-André, L., M'Bou, A.T., et al. (2005)
T+Bg+Bt+L+B+S+Bd+Rb+Rm+Rf	18, 0.84	98	3	Saint-André, L., M'Bou, A.T., et al. (2005)
S	29, 0.95	99	3	Saint-André, L., M'Bou, A.T., et al. (2005)
T	70, 0.99	-	3	Saint-André, L., M'Bou, A.T., et al. (2005)
Bg+Bt	70, 0.77	-	3	Saint-André, L., M'Bou, A.T., et al. (2005)
Rb	18, 0.98	93	3	Saint-André, L., M'Bou, A.T., et al. (2005)
T+Bg+Bt+L+B+S	70, 0.99	98	3	Saint-André, L., M'Bou, A.T., et al. (2005)
S+Rb	80, 0.97	-	2	Laclau, J.-P., Bouillet, J.-P., et al. (2000)
Rm	80, 0.69	-	2	Laclau, J.-P., Bouillet, J.-P., et al. (2000)
Bg+Bt	80, 0.71	-	2	Laclau, J.-P., Bouillet, J.-P., et al. (2000)
L	80, 0.88	-	2	Laclau, J.-P., Bouillet, J.-P., et al. (2000)
B	80, 0.98	-	2	Laclau, J.-P., Bouillet, J.-P., et al. (2000)
B	70, 0.98	99	3	Saint-André, L., M'Bou, A.T., et al. (2005)
T	80, 0.99	-	2	Laclau, J.-P., Bouillet, J.-P., et al. (2000)
L	70, 0.96	-	3	Saint-André, L., M'Bou, A.T., et al. (2005)
T+B+S	5, 0.98*	100	3	Schonau, A.P.G. and Boden, D.I. (1981)
Bg+Bt	5, 0.64*	0	1	Schonau, A.P.G. and Boden, D.I. (1981)
L	5, 0.98*	100	3	Schonau, A.P.G. and Boden, D.I. (1981)
B	5, 1*	100	3	Schonau, A.P.G. and Boden, D.I. (1981)
L	–, 0.95	86	1	CTFT (1988b)
L	–, 0.98	100	2	CTFT (1988b)
L	–, 0.96	100	2	CTFT (1988b)
T+Bg+Bt+B+S+Bd	–	99	2	Neya, B., Kaboré, C., et al. (1998)
T+Bg+Bt+L+B+S+Bd	8, 0.7*	100	3	Peltier, R., Njiti, C.F., et al. (2007)
T+Bg+Bt+L+B+S+Bd	15	-	2	Manlay, R.J., Kairé, M., et al. (2002)
T+Bg+Bt+L+B+S+Bd	–	100	2	Neya, B., Kaboré, C., et al. (1998)
T+Bg+Bt+B+L+S+Bd	825,–	100	2	Nouvellet, Y., Sawadogo, L. (1994)
T+Bg+B+S+Bd	118, 0.86*	1	1	Kaboré, C. (1992)
T+Bg+B+S+Bd	–, 0.91	100	2	Alexandre, D.-Y., and Kaïré, M. (2001)
T+Bg+Bt+L+B+S+Bd	290, 0.86	100	2	Sitoe, A. A. and Tchaúque, F. (2007)

ID	Tree species and location (annual rainfall)	Model Equations	Variables X (min, max), W, Z, U and V
636	-idem	Y= (X×(0.214×(W×3.1416)–0.113)^2)/10	H in m, D1.3 in cm (3, 54)**
637	-idem	Y(Mg)= 3.01×X–7.48	D1.3 in cm (3, 100)*
638	-idem	Y(Mg)= 20.02×X–203.37	D1.3 in cm (100, 200)*
639	-in Senegal	Y= 0.17×x^(2.6)	D1.3 in cm (1, 200)**
640	-idem	Y= exp(–2.289+(2.649×log(X))–(0.021×log((X^2))))	D1.3 in cm (1, 148)*
641	in Kitulangalo forest, Morogoro in Tanzania (935)	logY= 0.0625+2.553×log(X)	D1.3 in cm (2, 50)
642	- idem	logY= 0.0016+0.421×log(X)+3.712×log(W)	D1.3 in cm, H in m (2, 50)
643	-idem	logY= 0.0219+1.4498×log(X)+1.7907×log(W)	D1.3 in cm, H in m (1, 50)
644	-idem	logY= 0.0014+(0.898×log(X))+(3.09×log(W))	BD in cm, H in m (2, 50)
645	-idem	logY= 0.01559+2.796×log(X)	BD in cm (2, 50)
646	-idem	logY= 0.0139+(1.9037×log(X))+(0.327×log(W))	BD in cm, H in m (2, 50)
647	in Kitulanghalo forest reserce in Tanzania (956)	Y= 0.06×(X^(2.012))×(W^(0.7))	D1.3 in cm, H in m (1, 200)**
648	in Sengwa Wildlife Research area in Zimbabwe (688)	Y= 0.0549×(X^(2.5101))	BD in cm (6, 225)*
649	-idem	Y= 1.2102×(X^(0.9138))	CV in cm^3
650	-idem	Y= exp(–2.187+(0.916×log(X×W^2×Z)))	WD in g.cm^{-3}, D1.3 in cm, H in m (–, –)**
651	-idem	Y= X×exp(–0.667+(1.784×log(W))+ (0.207×(log(W))^2)–(0.0281×(log(W))^3))	WD in g.cm^{-3}, D1.3 in cm (–, –)**
652	-idem	Y= 34.4703–8.0671×X+0.6589×(X^2)	D1.3 in cm (6, 40)*
653	-idem	Y= exp(–1.996+2.32×log(X))	D1.3 in cm (1, 40)*
654	-idem	Y= 10^(–0.535+log$_{10}$(X))	BA in cm^2 (1, 707)*
INDIVIDUAL TREE IN TROPICAL SHRUBLAND (CLASSIFICATION PER TREE SPECIES)			
655	*Acacia albida* in Mali	Y(g)= X^(2.08)×10^(–3)	C in cm (5, 61)
656	-idem	Y(g)= 98×(10^(–6))×X^(2.77)×10^(–3)	H in cm (292, 5369)**
657	-idem	Y(g)= 0.32×(X^1.26)×10^(–3)	CA in dm^2 (78, 67214)**
658	*Acacia erioloba* in Modubwana in Botswana (471)	Y= 0.1376×(X^(1.2562))	BA in cm^2 (1, 39879)**
659	*Acacia erubescens* in Dikelestane in Botswana (471)	Y= 0.1507×(X^(1.2647))	BA in cm^2 (1, 39879)**
660	*Acacia karoo* in Dikelestane in Botswana (471)	Y= 0.7558×X	BA in cm^2 (1, 39879)**
661	-in Dikeletsane in Botswana (471)	Y= 0.2865×(X^(1.2082))	BA in cm^2 (1, 1500)*
662	*Acacia luederitzii* in Kang in Botswana (400)	Y= 0.1505×(X^(1.2835))	BA in cm^2 (1, 39879)**
663	*Acacia luederitzii* in Kang in Botswana (400)	Y= 0.9206×X	BA in cm^2 (1, 39879)**
664	*Acacia mellifera* in Molepole in Botswana (466)	Y= 0.2081×(X^(1.2193))	BA in cm^2 (1, 39879)**
665	*Acacia senegal* in Tongomayel in Burkina Faso (429)	log10Y(g)= (–0.12+(2.64×log(X)))×10^(–3)	D1.3 in cm (1, 200)**
666	-in Mali	Y(g)= 14.05×(X^(1.40))×10^(–3)	C in cm (3, 628)**
667	-in Fété Olé in Senegal (224)	Y= –8+0.57×X	R in n (18, 70)*
668	-idem	log10Y= –3.07+(2.86×log10(X))	Cb in cm (4, 708)**

Tree components	n, ,R^2	Interval of possibility (%)	Quality	References
T+Bg+Bt+L+B+S+Bd	–, 0.92adj	100	2	de Boer, W.F. (2000)
T+Bg+Bt5+B+S	–, 0.88	0	1	Williams, M., Ryan, C.M., et al. (2008)
T+Bg+Bt5+B+S	–, 0.95	0	1	Williams, M., Ryan, C.M., et al. (2008)
T+Bg+Bt+B+S+Bd	–	7	1	Kairé, M. (1998)
T+Bg+Bt+L+B+S+Bd	–, 0.95adj	100	2	Kaire, M. (1999)
T+Bg+Bt+L+B+S+Bd	30, 0.95adj	0	1	Chamshama, S.A.O., Mugasha, A.G., et al. (2004)
Bg+Bt+L+Bd	30, 0.93	0	1	Chamshama, S.A.O., Mugasha, A.G., et al. (2004)
T+B+S	30, 0.93adj	0	1	Chamshama, S.A.O., Mugasha, A.G., et al. (2004)
Bg+Bt+L+Bd	30, 0.93adj	0	1	Chamshama, S.A.O., Mugasha, A.G., et al. (2004)
T+B+S	30, 0.93adj	0	1	Chamshama, S.A.O., Mugasha, A.G., et al. (2004)
T+Bg+Bt+L+B+S+Bd	30, 0.93adj	0	1	Chamshama, S.A.O., Mugasha, A.G., et al. (2004)
T+Bg+Bt+B+S+Bd	17, 0.93adj	100	2	Luoga, E. L., Witkowski, E. T. F., et al. (2002)
T+Bg+Bt6+B+S	–	100	2	Guy, P. R. (1981)
T+Bg+Bt6+B+S	–	-	2	Guy, P. R. (1981)
T+Bg+Bt+L+B+S+Bd	316,–	100	3	Chave, J., Andalo, C., et al. (2005)
T+Bg+Bt+L+B+S+Bd	316,–	99	3	Chave, J., Andalo, C., et al. (2005)
T+Bg+Bt+L+B+S+Bd	32, 0.67*	100	3	Brown, S.A.J., Gillespie, J.R., et al. (1989)
T+Bg+Bt+L+B+S+Bd	28, 1*	100	3	Brown, S. (1997)
T+Bg+Bt+L+B+S+Bd	191, 1*	86	1	Brown, S. (1997)
L	50, 0.98	100	3	Cissé, M. I. (1980)
L	50, 0.95	86	1	Cissé, M. I. (1980)
L	50, 0.96	99	2	Cissé, M. I. (1980)
T+Bg+Bt+L+B+S+Bd	27, 0.92	100	2	Tietema, T. (1993)
T+Bg+Bt+L+B+S+Bd	88, 0.96	96	2	Tietema, T. (1993)
T+Bg+Bt+L+B+S+Bd	36, 0.98	91	2	Tietema, T. (1993)
T+Bg+Bt+L+B+S+Bd	36, 0.96	0	1	Tietema, T. (1993)
T+Bg+Bt+L+B+S+Bd	19, 0.90	0	1	Tietema, T. (1993)
T+Bg+Bt+L+B+S+Bd	19, 0.93	0	1	Tietema, T. (1993)
T+Bg+B+S	35, 0.96	34	1	Tietema, T. (1993)
L	16, 0.97	98	2	Sanon, H. O., Kaboré-Zoungrana, C., et al. (2007)
L	–, 0.72	99	2	Bellefontaine, R., Gaston, A., et al. (1997)
T+B+S	8, 0.69	64	1	Poupon, H. (1976)
T+Bg+Bt+B+S+Bd	21, 0.8	78	1	Poupon, H. (1979)

ID	Tree species and location (annual rainfall)	Model Equations	Variables X (min, max), W, Z, U and V
669	-idem	log10Y= –1.01+(1.56×log10(X))	Cb in cm (4, 708)**
670	-idem	Y= –19.2+1.11×X	R in n (18, 70)*
671	-idem	log10Y= –1.22+(1.88×log10(X))	Cb in cm (4, 708)**
672	-idem	Y= –18.2+1.32×X	R in n (18, 70)*
673	-idem	Y= 11.0463–2.0733×X+0.1067×X^2–0.0009×X^3	R in n (12, 63)*
674	-idem	log10Y= –1.55+(1.57×log10(X))	R in n (12, 70)*
675	-idem	Y= 0.2857–0.0863×X+0.0502×X^2–0.0001×X^3	R in n (12, 70)*
676	-idem	log10Y(g)= 2.8840315×(X^(1.40))×10^(–3)	C in cm (3, 628)**
677	-idem	log10Y= –3.45+(2.73×log10(X))	Cb in cm (4, 708)**
678	-in Somalia	Y= Exp(2.83568×log(X)–3.75637+0.043274)	D1.3 in cm (1, 200)**
679	*Acacia seyal* in Mali	Y(g)= 0.21×X^(1.22)×10^(–3)	CA in dm^2 (78, 67214)**
680	-idem	Y(g)= 20×(10^(–6))×X^(3.06)×10^(–3)	H in cm (292, 5369)**
681	-idem	Y(g)= 0.6×(X^2.25)×10^(–3)	C in cm (5, 61)
682	*Acacia tortillis* in Gaborone in Botswana (552)	Y(g)= 5.7696×10^(–9)×(X^(3.914))×10^(–3)	H in cm (292, 5369)**
683	-idem	Y= 0.5331×(X^(1.6488))	CA in m^2 (1, 672)**
684	-idem	Y= 0.1813×(X^(1.1504))	BA in cm^2 (1, 39879)**
685	*Acacia tortillis* in Morwa Hill in Botswana (471)	Y= 0.1975×(X^(1.1859))	BA in cm^2 (1, 39879)**
686	-in Chad	Y(g)= 0.5×(X^(2.35))×10^(–3)	C in cm (3, 628)**
687	*Balanites aegyptiaca* in Fété Olé in Senegal (224)	log10Y= –2.51+(2.6×log10(X))	Cb in cm (4, 708)**
688	-idem	log10Y= –3.19+(2.59×log10(X))	Cb in cm (4, 708)**
689	-idem	log10Y= –2.3+(2.25×log10(X))	Cb in cm (4, 708)**
690	-in Mali	Y(g)= 38×(10^(–6))×X^(2.97)×10^(–3)	H in cm (292, 5369)**
691	-idem	Y(g)= 6.46×(X^1.5)×10^(–3)	C in cm (5, 61)
692	*Beilschmiedia diversiflora* in Morwa hill in Botswana (471)	Y= 0.0871×(X^1.2286)	BA in cm^2 (1, 39879)**
693	*Boscia albitrunca* in Kang in Botswana (400)	Y= 0.2683×(X^1.0455)	BA in cm^2 (1, 39879)**
694	*idem*	Y= 0.3391×X+1.0192	BA in cm^2 (1, 39879)**
695	*Boscia senegalensis* in Mali	Y(g)= 2.34×(X^(1.88))×10^(–3)	C in cm (3, 628)**
696	in Fété Olé in Senegal (224)	log10Y= –2.75+(2.04×log10(X))	Cb in cm (4, 708)**
697	- idem	log10Y= –1.49+(1.81×log10(X))	Cb in cm (4, 708)**
698	-idem	log10Y= –1.44+(1.49×log10(X))	Cb in cm (4, 708)**
699	*Combretum aculeatum* in Mali	Y(g)= 3.09×(X^(2.33))×10^(–3)	C in cm (3, 628)**
700	*Combretum apiculatum* in Dikelestane in Botswana (471)	Y= 0.2232×(X^1.1001)	BA in cm^2 (1, 39879)**
701	-in Molepole in Botswana (466)	Y= 0.2232×(X^1.1001)	BA in cm^2 (1, 39879)**
702	*Combretum glutinosum* in Gouani in Mali (815)	Y(g)= 4.2597×(X^2.1415)×10^(–3)	Cb in cm (4, 708)**
703	*Combretum molle* Morwa hill in Botswana (471)	Y= 0.1529×(X^(1.1141))	BA in cm^2 (1, 39879)**

Tree components	n, ,R^2	Interval of possibility (%)	Quality	References
Rb+Rm+Rf	6,–	89	1	Poupon, H. (1979)
Bg	8, 0.99	0	1	Poupon, H. (1976)
T+Bg+Bt+B+S+Bd+Rb+Rm+Rf	6, 0.99	96	2	Poupon, H. (1979)
Rb+Rm+Rf	8, 0.99	0	1	Poupon, H. (1976)
T+Bg+Bt+B+S+Bd	8, 0.99	18	1	Poupon, H. (1976)
Bt	8, 0.99	0	1	Poupon, H. (1976)
T+Bg+Bt+L+B+S+Bd+Rb+Rm+Rf	8, 0.99	0	1	Poupon, H. (1976)
L	–, 0.99	22	1	Poupon, H. (1979)
T+B+S	21, 0.99	100	2	Poupon, H. (1979)
T+Bg+Bt5+B+S+Bd	34, 0.99	100	2	Bird, N. M. and Shepherd, G. (1989)
L	44, 0.93	99	2	Cissé, M. I. (1980)
L	44, 0.99	72	1	Cissé, M. I. (1980)
L	44, 0.76	100	3	Cissé, M. I. (1980)
T+Bg+Bt+L+B+S+Bd	62, 0.66*	100	2	Tietema, T. (1993)
T+Bg+Bt+L+B+S+Bd	62, 0.89*	99	2	Tietema, T. (1993)
T+Bg+B+S	62, 0.93adj	97	2	Tietema, T. (1993)
T+Bg+Bt+L+B+S+Bd	109, 0.93	97	2	Tietema, T. (1993)
L	–	100	2	Bellefontaine, R., Gaston, A., et al. (1997)
T+Bg+Bt+B+S+Bd+Rb+Rm+Rf	14, 0.99	100	2	Poupon, H. (1979)
T+B+S	–, 0.99	100	2	Poupon, H. (1979)
Rb+Rm+Rf	14, 0.98	88	1	Poupon, H. (1979)
L	50, 0.93	75	1	Cissé, M. I. (1980)
L	50,–	100	3	Cissé, M. I. (1980)
T+Bg+Bt+L+B+S+Bd	12, 0.97adj	100	2	Tietema, T. (1993)
T+Bg+Bt+L+B+S+Bd	23, 0.93	98	2	Tietema, T. (1993)
T+Bg+Bt+L+B+S+Bd	23, 0.9	98	2	Tietema, T. (1993)
L	–, 0.99	100	2	Bellefontaine, R., Gaston, A., et al. (1997)
T+B+S	20,–	100	2	Poupon, H. (1979)
T+Bg+Bt+B+S+Bd+Rb+Rm+Rf	5, 0.85	99	2	Poupon, H. (1979)
Rb+Rm+Rf	5, 0.93	97	2	Poupon, H. (1979)
L	–, 0.94	96	2	Bellefontaine, R., Gaston, A., et al. (1997)
T+Bg+Bt+L+B+S+Bd	58, 0.86	98	2	Tietema, T. (1993)
T+Bg+Bt+L+B+S+Bd	58, 0.86	98	2	Tietema, T. (1993)
T+Bg+Bt+L+B+S+Bd	100, 0.94	100	2	Bazile, D. (1998)
T+Bg+Bt+L+B+S+Bd	6, 0.98	99	2	Tietema, T. (1993)

ID	Tree species and location (annual rainfall)	Model Equations	Variables X (min, max), W, Z, U and V
704	*Combretum nigricans* in Gouani in Mali (815)	Y(g)= 4.3184×(X^2.0077)×10^(–3)	Cb in cm (4, 708)**
705	- in N'goukan in Mali (896)	Y(g)= 1.2289×(X^2.5806)×10^(–3)	Cb in cm (4, 708)**
706	*Commiphora africana* in Fété Olé in Senegal (224)	log10Y= –2.69+(2.6×log10(X))	Cb in cm (4, 708)**
707	-idem	log10Y= –4.96+(3.56×log10(X))	Cb in cm (4, 708)**
708	-idem	log10Y= –2.6+(2.37×log10(X))	Cb in cm (4, 708)**
709	-idem	log10Y= –3.43+(2.53×log10(X))	Cb in cm (4, 708)**
710	-in Mali	Y(g)= 1.51×(X^1.78)×10^(–3)	C in cm (5, 61)
711	-idem	Y(g)= 0.155×(10^(–6))×X^(3.21)×10^(–3)	H in cm (292, 5369)**
712	*Croton gratissimus* in Morwa hill in Botswana (471)	Y= 0.074×(X^1.2668)	BA in cm^2 (1, 39879)**
713	*Detarium microcarpum* in Gouani in Mali (815)	Y(g)= 2.0919×(X^2.3118)×10^(–3)	Cb in cm (4, 708)**
714	-in N'goukan in Mali (896)	Y(g)= 0.8133×(X^2.7108)×10^(–3)	Cb in cm (4, 708)**
715	Dichrostachys cinerea in Dikelestane in Botswana (471)	Y= 0.2787×(X^1.0337)	BA in cm^2 (1, 39879)**
716	in Gaborone in Morwa Hill (471)	Y= 0.2787×(X^(1.0337))	BA in cm^2 (1, 39879)**
717	*Excoecaria bussei* in Somalia	Y= Exp((4.05271×log(X)–4.16400)+0.11648)	CD in m (1, 29)**
718	Gardenia ternifolia in N'goukan in Mali (896)	Y(g)= 4.5738×(X^2.0836)×10^(–3)	Cb in cm (4, 708)**
719	*Grewia bicolor* in Fété Olé in Senegal (224)	log10Y= –3.27+(2.45×log10(X))	Cb in cm (4, 708)**
720	-idem	log10Y= –1.67+(1.77×log10(X))	Cb in cm (4, 708)**
721	-idem	log10Y= –1.81+(2.12×log10(X))	Cb in cm (4, 708)**
722	-in Serlo in Senegal (234)	Y(g)= 6.39×(X^1.53)×10^(–3)	C in cm (3, 628)**
723	-idem	Y(g)= 64.4×(X^1.68)×10^(–3)	H in m (3, 54)**
724	*Guiera senegalensis* in Tongomayel in Burkina Faso (429)	log10Y(g)= (0.55+(1.89×log(X)))×10^(–3)	D1.3 in cm (1, 200)**
725	-in Mali	Y(g)= 3.09×(X^(1.89))×10^(–3)	C in cm (3, 628)**
726	-in Fété Olé in Senegal (224)	log10Y= –2.18+(2.15×log10(X))	Cb in cm (4, 708)**
727	-idem	log10Y= –2.45+(1.93×log10(X))	Cb in cm (4, 708)**
728	-idem	log10Y= –2.54+(1.96×log10(X))	Cb in cm (4, 708)**
729	in Guesselbodi in Niger (555)	Y= 1.0806×exp(−2.241+1.8577×ln(X))	D1.3 in cm (1, 200)**
730	*Pterocarpus lucens* in Tongomayel in Burkina Faso (429)	logY(g)= (–0.4+(2.86×log(X)))×10^(–3)	D1.3 in cm (1, 200)**
731	-in Mali	Y(g)= 0.95×(X^(2.07))×10^(–3)	C in cm (3, 628)**
732	-idem	Y(g)= 65×(10^(–6))×X^(2.83)×10^(–3)	H in cm (292, 5369)**
733	-idem	Y(g)= 0.6×(X^1.22)×10^(–3)	CA in dm^2 (78, 67214)**
734	-idem	Y(g)= 93×X^(2.07)×10^(–3)	C in cm (5, 61)
735	-in Serlo in Senegal (234)	Y(g)= 49.2×(X^1.62)×10^(–3)	H in m (3, 54)**
736	-idem	Y(g)= 8.02×(X^1.54)×10^(–3)	C in cm (3, 628)**

Tree components	n, ,R^2	Interval of possibility (%)	Quality	References
T+Bg+Bt+L+B+S+Bd	100, 0.99	100	2	Bazile, D. (1998)
T+Bg+Bt+L+B+S+Bd	100, 1	100	2	Bazile, D. (1998)
T+Bg+Bt+B+S+Bd+Rb+Rm+Rf	9, 0.99	100	2	Poupon, H. (1979)
Bg	10, 0.99*	5	1	Poupon, H. (1979)
Rb+Rm+Rf	9, 0.97	95	2	Poupon, H. (1979)
T+B+S	15, 0.9	100	2	Poupon, H. (1979)
L	50, 0.85	100	3	Cissé, M. I. (1980)
L	50, 0.85*	100	2	Cissé, M. I. (1980)
T+Bg+Bt+L+B+S+Bd	34, 0.89	100	2	Tietema, T. (1993)
T+Bg+Bt+L+B+S+Bd	100, 0.97	100	2	Bazile, D. (1998)
T+Bg+Bt+L+B+S+Bd	100, 0.98	100	2	Bazile, D. (1998)
T+Bg+Bt+L+B+S+Bd	33, 0.88	98	2	Tietema, T. (1993)
T+Bg+Bt+L+B+S+Bd	33, 0.7	98	2	Tietema, T. (1993)
T+Bg+BT5+B+S+Bd	49,–	100	2	Bird, N. M. and Shepherd, G. (1989)
T+Bg+Bt+L+B+S+Bd	100, 0.68	100	2	Bazile, D. (1998)
T+B+S	16,–	100	2	Poupon, H. (1979)
Rb+Rm+Rf	10, 1	95	2	Poupon, H. (1979)
T+Bg+Bt+B+S+Bd+Rb+Rm+Rf	10, 0.99	99	2	Poupon, H. (1979)
L	–, 0.96	99	2	Ngom, D., Diatta, S., et al. (2009)
L	–, 0.96	97	2	Ngom, D., Diatta, S., et al. (2009)
L	20, 0.96	98	2	Sanon, H. O., Kaboré-Zoungrana, C., et al. (2007)
L	–, 0.6	100	2	Bellefontaine, R., Gaston, A., et al. (1997)
T+Bg+Bt+B+S+Bd+Rb+Rm+Rf	5, 0.84	100	2	Poupon, H. (1979)
Rb+Rm+Rf	5, 0.96	99	2	Poupon, H. (1979)
T+B+S	21,–	100	2	Poupon, H. (1979)
T+Bg+Bt+L+B+S+Bd	–, 0.98	100	2	Alegria, J., Heermans, J. G., et al. (1986)
L	–, 0.95	98	2	Sanon, H. O., Kaboré-Zoungrana, C., et al. (2007)
L	–, 0.9	100	2	Bellefontaine, R., Gaston, A., et al. (1997)
L	40,–	86	1	Cissé, M. I. (1980)
L	40, 0.8	99	2	Cissé, M. I. (1980)
L	40, 0.79adj	0	1	Cissé, M. I. (1980)
L	–	98	2	Ngom, D., Diatta, S., et al. (2009)
L	–	99	2	Ngom, D., Diatta, S., et al. (2009)

ID	Tree species and location (annual rainfall)	Model Equations	Variables X (min, max), W, Z, U and V
737	*Ziziphus mauritania* in Mali	Y(g)= 1.38×(X^(1.91))×10^(–3)	C in cm (3, 628)**
738	*Ziziphus mucronata* in Dikelestane in Botswana (471)	Y= 0.2772×(X^0.8914)	BA in cm^2 (1, 39879)**
739	in Gaborone in Botswana (552)	Y= 0.2772×(X^(0.8914))	BA in cm^2 (1, 39879)**
740	*Ziziphus mauritiana* in Mali	Y(g)= 1.38×(X^1.91)×10^(–3)	C in cm (5, 61)
741	-idem	Y(g)= 0.58×(X^1.1)×10^(–3)	CA in dm^2 (78, 67214)**
742	-idem	Y(g)= 3×(10^(–6))×X^(2.83)×10^(–3)	H in cm (292, 5369)**

GENERAL EQUATIONS FOR INDIVIDUAL TREE IN TROPICAL SHRUBLAND

ID	Tree species and location (annual rainfall)	Model Equations	Variables X (min, max), W, Z, U and V
743	GeneralizeBd in Gaborone in Botswana (552)	Y= 0.1936×(X^(1.1654))	As in cm^2 (1, 22432)**
744	-idem	Y= 9.92–3.77×X+0.468×(X^2)–0.01021×(X^3)	BD in cm (5, 24)**
745	-in Gouani in Mali (815)	Y(g)= 3.5057×(X^2.1094)×10^(–3)	Cb in cm (4, 708)**
746	-idem	Y(g)= 3.3724×(X^2.142)×10^(–3)	Cb in cm (4, 708)**
747	-in N'goukan in Mali (896)	Y(g)= 1.8412×(X^2.448)×10^(–3)	Cb in cm (4, 708)**
748	-idem	Y(g)= 2.5347×(X^2.359)×10^(–3)	Cb in cm (4, 708)**
749	-in Sudan	log10Y= 0.163+0.861×log(X^(2)×W)	D1.3 in cm, H in m (1, 200)**
750	-idem	Y= exp(–1.996+2.32×log(X))	D1.3 in cm (1, 40)*
751	-idem	Y= exp(–2.187+(0.916×log(X×W^2×Z)))	WD in $g.cm^{-3}$, D1.3 in cm, H in m (–, –)**
752	-idem	Y= 34.4703–8.0671×X+0.6589×(X^2)	D1.3 in cm (6, 40)*
753	-idem	Y= X×exp(–0.667+(1.784×log(W))+ (0.207×(log(W))^2)–(0.0281×(log(W))^3))	WD in $g.cm^{-3}$, D1.3 in cm (–, –)**

INDIVIDUAL TREE IN TROPICAL DESERT (CLASSIFICATION PER TREE SPECIES)

ID	Tree species and location (annual rainfall)	Model Equations	Variables X (min, max), W, Z, U and V
754	*Acacia erubescens* in Namibia	Y(g)= (5.719–(0.349×X)+(0.00719×X^2)– (0.0000173×X^3))×10^(–3)	D1.3 in cm (27, 200)**
755	*Acacia fleckii* in Namibia	Y(g)= (–0.946+(0.0712×X)+(0.000514×X^2)+ (0.00000609×x^3))×10^(–3)	D1.3 in cm (13, 200)**
756	*Acacia mellifera* in Namibia	Y(g)=(–10.970+0.768×X–(0.0124×X^2)+ (0.0000826×X^3))×10^(–3)	D1.3 in cm (20, 200)**
757	*Acacia reficiens* in Namibia	Y(g)=(5.093–(0.2567×x)+(0.0059×x^2)+ (0.0000116×x^3))×10^(–3)	D1.3 in cm (21, 200)**
758	*Colophospermum mopane* in Namibia	Y(g)=(42.119–0.068×x+(0.00275×x^2)+ (0.00000888×x^3))×10^(–3)	D1.3 in cm (12, 200)**
759	*Dichrostachys cinerea* in Namibia	Y(g)=(115–(0.0680×X)+(0.00275×X^2)+ (0.00000888×X^3))×10^(–3)	D1.3 in cm (12, 200)**
760	*Terminalia sericea* in Namibia	Y(g)=(26.866–(0.609×x)+(0.00463×x^2)+ (0.00000572×x^3))×10^(–3)	D1.3 in cm (59, 200)**

INDIVIDUAL TREE IN TROPICAL MOUNTAIN SYSTEM (CLASSIFICATION PER TREE SPECIES)

ID	Tree species and location (annual rainfall)	Model Equations	Variables X (min, max), W, Z, U and V
761	*Acacia drepanolobium* in Laikipia in Kenya (739)	Y= 3.7704×X+1.1682	BD in cm (1, 15)*
762	-idem	Y= 2.2949×X+4.7997	BD in cm (1, 15)*
763	-idem	Y= 2.9602×X+1.6034	BD in cm (1, 15)*
764	*Croton macrostachyus* in Kakamega forest in Kenya (2002)	log10Y= (1.62365×log10(X))+ (1.29091×log10(W))–2.25217	D1.3 in cm, CD in m (1, 200)**
765	*Eucalyptus Camadulensis* in Jufi in Ethiopia (1502)	Y= 0.0155×(X^(2.5823))	D1.3 in cm (1, 200)**

Tree components	n, ,R^2	Interval of possibility (%)	Quality	References
L	–	100	2	Bellefontaine, R., Gaston, A., et al. (1997)
T+Bg+Bt+L+B+S+Bd	30, 0.97	99	2	Tietema, T. (1993)
T+Bg+Bt+L+B+S+Bd	30, 0.99	99	2	Tietema, T. (1993)
L	46, 0.85adj	100	3	Cissé, M. I. (1980)
L	46, 0.85adj	99	2	Cissé, M. I. (1980)
L	46,–	100	2	Cissé, M. I. (1980)
T+Bg+Bt+L+B+S+Bd	512, 0.5*	100	2	Tietema, T. (1993)
T+Bg+Bt+L+B+S	–, 0.77	100	2	Mabowe, R. B. (2006)
T+Bg+Bt+L+B+S+Bd	100, 1adj	100	2	Bazile, D. (1998)
T+Bg+Bt+L+B+S+Bd	500, 0.91	100	2	Bazile, D. (1998)
T+Bg+Bt+L+B+S+Bd	500, 0.89	100	2	Bazile, D. (1998)
T+Bg+Bt+L+B+S+Bd	100,–	100	2	Bazile, D. (1998)
T+Bg+BT5+B+S+Bd	18, 0.92	0	1	Helldén, U. and Olsson, K. (1982)
T+Bg+Bt+L+B+S+Bd	28,–	100	3	Brown, S. (1997)
T+Bg+Bt+L+B+S+Bd	316,–	100	3	Chave, J., Andalo, C., et al. (2005)
T+Bg+Bt+L+B+S+Bd	32, 0.67	100	3	Brown, S.A.J., Gillespie, J.R., et al. (1989)
T+Bg+Bt+L+B+S+Bd	316,–	99	3	Chave, J., Andalo, C., et al. (2005)
T+Bg+Bt+L+B+S+Bd	–	100	2	de Klerk, J.N. (2002)
T+Bg+Bt+L+B+S+Bd	–	100	2	de Klerk, J.N. (2002)
T+Bg+Bt+L+B+S+Bd	–	100	2	de Klerk, J.N. (2002)
T+Bg+Bt+L+B+S+Bd	–	100	2	de Klerk, J.N. (2002)
T+Bg+Bt+L+B+S+Bd	–	100	2	de Klerk, J.N. (2002)
T+Bg+Bt+L+B+S+Bd	–	100	2	de Klerk, J.N. (2002)
T+Bg+Bt+L+B+S+Bd	–	100	2	de Klerk, J.N. (2002)
T+Bg+Bt+B+S+Bd	15, 0.96	27	1	Okello, B.D., O'Connora, T.G., et al. (2001)
T+Bg+Bt+L+B+S+Bd	15, 0.98*	45	1	Okello, B.D., O'Connora, T.G., et al. (2001)
Bt+L	15, 0.69	0	1	Okello, B.D., O'Connora, T.G., et al. (2001)
T+Bg+Bt+L+B+S+Bd	12, 0.98*	100	2	Bradley, P. N. and Kuyper, J.B.H. (1988)
B	9, 0.99	0	1	Hailu, Z. (2002)

ID	Tree species and location (annual rainfall)	Model Equations	Variables X (min, max), W, Z, U and V
766	-idem	Y= 0.0172×(X^(3.1543))	D1.3 in cm (1, 200)**
767	-idem	Y= 0.0414×(X^(2.7175))	D1.3 in cm (1, 200)**
768	-idem	Y= 0.026×(X^(1.949))	D1.3 in cm (1, 200)**
769	-idem	Y= 0.1935×(X^(1.0913))	D1.3 in cm (1, 200)**
770	-idem	Y= 0.0131×(X^(1.8648))	D1.3 in cm (1, 200)**
771	-idem	Y= 0.0256×(X^(2.3711))	D1.3 in cm (1, 200)**
772	-idem	Y= 0.0141×(X^(1.9239))	D1.3 in cm (1, 200)**
773	-in Ker Jarso in Ethiopia (1502)	Y= 0.0129×(X^(2.588))	D1.3 in cm (1, 200)**
774	-idem	Y= 0.0686×(X^(2.5549))	D1.3 in cm (1, 200)**
775	-idem	Y= 0.0123×(X^(2.0202))	D1.3 in cm (1, 200)**
776	-idem	Y= 0.0219×X^(3.0441)	D1.3 in cm (1, 200)**
777	-idem	Y= 0.005×(X^(2.3597))	D1.3 in cm (1, 200)**
778	-idem	Y= 0.3647×(X^(0.8741))	D1.3 in cm (1, 200)**
779	-idem	Y= 0.0517×(X^(1.8393))	D1.3 in cm (1, 200)**
780	-idem	Y= 0.0291×(X^(2.3233))	D1.3 in cm (1, 200)**
781	*Eucalyptus globulus* in Ethiopian Heritage Forestry Park in Ethiopia (1191)	Y= 1.92–1.48×X+0.22×(X^2)	H in m (5, 16)*
782	-idem	Y= 0.09×(X^1.9)	D1.3 in cm (1, 16)*
783	-idem	Y= 0.03×(X^(1.9))	D1.3 in cm (1, 16)*
784	-idem	Y= 0.27+0.1×(X^(2.39))	D1.3 in cm (1, 16)*
785	-idem	Y= 1.17+0.12×(X^(2.51))	D1.3 in cm (1, 16)*
786	-idem	Y= –0.93+0.17×(X^2)	H in m (3, 16)*
787	-idem	Y= 0.005×(X^(2.33))	H in m (3, 16)*
788	-idem	Y= 0.59+0.03×X×(W^2)	D1.3 in cm, H in m (1, 20)*
789	-idem	Y= 1.76–0.53×X+0.05×(X^2)	H in m (5, 16)*
790	-idem	Y= 0.19+7.17×10^(–6)×(X^(5.41))	D1.3 in cm (1, 16)*
791	-idem	Y= 4.15–2.46×X+0.36×(X^2)	H in m (3, 16)*
792	-idem	Y= 0.45×(X^(–2.01))×(W^(3.41))	D1.3 in cm, H in m (0, 20)
793	-idem	Y= 0.56×(X^(0.56))×(W^(1.45))	D1.3 in cm, H in m (1, 20)*
794	-idem	Y= 0.00002×(X^(0.29))×(W^(0.94))	D1.3 in cm, H in m (1, 20)*
795	-idem	Y= 0.01×(X^(0.58))×(W^(2.17))	D1.3 in cm, H in m (1, 20)*
796	-idem	Y= 0.05×(X^(0.93))×(W^(1.61))	D1.3 in cm, H in m (1, 20)*
797	-idem	Y= 0.12×(X^(0.39))×(W^(2.08))	D1.3 in cm, H in m (1, 20)*
798	-idem	Y(Mg ha^{-1})= –33.6+19.4×X	yr in yr
799	-idem	Y= 2.5–0.79×X+0.06×(X^2)	H in m (8, 16)*
800	-idem	Y= 0.11×(X^(2.3))	D1.3 in cm (1, 16)*
801	-in Weldeab Ager in Ethiopia (980)	Y= 0.0208×(X^(2.35))	D1.3 in cm (1, 200)**
802	-idem	Y= 0.0228×(X^(2.2829))	D1.3 in cm (1, 200)**
803	-idem	Y= 0.0205×(X^(2.1391))	D1.3 in cm (1, 200)**
804	-idem	Y= 0.1303×(X^(2.2418))	D1.3 in cm (1, 200)**
805	-idem	Y= 0.0334×(X^(2.1323))	D1.3 in cm (1, 200)**

Tree components	n, ,R^2	Interval of possibility (%)	Quality	References
T+Bg+Bt+B+S+Bd	9, 0.99	34	1	Hailu, Z. (2002)
T+Bg+Bt+B+S+Bd	9, 0.99	100	2	Hailu, Z. (2002)
Bt+L	9, 0.93	100	2	Hailu, Z. (2002)
Bt+L	9, 0.99	99	2	Hailu, Z. (2002)
L	9, 0.78	100	2	Hailu, Z. (2002)
B	9, 0.99	89	1	Hailu, Z. (2002)
L	9, 0.87	100	2	Hailu, Z. (2002)
B	9, 0.98	82	1	Hailu, Z. (2002)
T+Bg+Bt+B+S+Bd	9, 0.97	100	2	Hailu, Z. (2002)
L	9, 0.92	100	2	Hailu, Z. (2002)
T+Bg+Bt+B+S+Bd	9, 0.99	51	1	Hailu, Z. (2002)
L	9, 0.78	100	2	Hailu, Z. (2002)
Bt+L	9, 0.81	98	2	Hailu, Z. (2002)
Bt+L	9, 0.91	99	2	Hailu, Z. (2002)
B	9, 0.97	89	1	Hailu, Z. (2002)
T	79, 0.7	100	3	Zewdie, M., Olsson, M., et al. (2009)
L	83, 0.79	69	1	Zewdie, M., Olsson, M., et al. (2009)
BT	83, 0.58	69	1	Zewdie, M., Olsson, M., et al. (2009)
B	79, 0.74	0	1	Zewdie, M., Olsson, M., et al. (2009)
T+Bg+Bt+L+B+S+Bd	83, 0.86	88	1	Zewdie, M., Olsson, M., et al. (2009)
L	83, 0.54	25	1	Zewdie, M., Olsson, M., et al. (2009)
Bt	83, 0.53	80	1	Zewdie, M., Olsson, M., et al. (2009)
T+Bg+Bt+L+B+S+Bd	–, 0.86	90	1	Zewdie, M., Olsson, M., et al. (2009)
B	79, 0.77	94	3	Zewdie, M., Olsson, M., et al. (2009)
Bg	83, 0.94	81	1	Zewdie, M., Olsson, M., et al. (2009)
T+Bg+Bt+L+B+S+Bd	83, 0.76	100	3	Zewdie, M., Olsson, M., et al. (2009)
L	83, 0.93	45	1	Zewdie, M., Olsson, M., et al. (2009)
Bt	83, 0.75	0	1	Zewdie, M., Olsson, M., et al. (2009)
Bg	83, 0.94	100	3	Zewdie, M., Olsson, M., et al. (2009)
B	79, 0.94	35	1	Zewdie, M., Olsson, M., et al. (2009)
T	79, 0.84	85	1	Zewdie, M., Olsson, M., et al. (2009)
T+Bg+Bt+L+B+S+Bd	83, 0.91	75	1	Zewdie, M., Olsson, M., et al. (2009)
T+Bg+BT+L+B+S+Bd	10, 0.79	-	3	Zewdie, M., Olsson, M., et al. (2009)
Bg	83, 0.69	100	3	Zewdie, M., Olsson, M., et al. (2009)
T	80, 0.74	100	3	Zewdie, M., Olsson, M., et al. (2009)
Bt+L	9, 0.96	100	2	Hailu, Z. (2002)
L	9, 0.96	100	2	Hailu, Z. (2002)
Bt+L	9, 0.71	100	2	Hailu, Z. (2002)
T+Bg+Bt+B+S+Bd	9, 0.99	100	2	Hailu, Z. (2002)
B	9, 0.96	96	2	Hailu, Z. (2002)

ID	Tree species and location (annual rainfall)	Model Equations	Variables X (min, max), W, Z, U and V
806	-idem	Y= 0.0015×(X^(2.9242))	D1.3 in cm (1, 200)**
807	-idem	Y= 0.0256×(X^(2.2769))	D1.3 in cm (1, 200)**
808	-idem	Y= 0.0555×(X^(2.6725))	D1.3 in cm (1, 200)**
809	*Eucalyptus saligna* in Kakamega forest in Kenya (2002)	log10Y= (2.17679×log10(X))+ (0.25086×log10(W))–1.71514	D1.3 in cm, CD in m (1, 200)**
810	*Markhamia lutea* in Kakamega forest in Kenya (2002)	log10Y= (2.18435×log10(X))– (0.20922×log10(X))–1.13559	D1.3 in cm, CD in m (1, 200)**
811	*Psidium guajava* in Kakamega forest in Kenya (2002)	log10Y= (0.68554×log10(X))+ (1.3879×log10(W))–0.14022	D1.3 in cm, CD in m (1, 200)**
812	*Sesbania sesban* in Kakamega forest in Kenya (2002)	log10Y= (1.25037×log10(X))+ (0.20120×log10(W))+0.52873	D1.3 in cm, CD in m (1, 200)**
INDIVIDUAL TREE IN TROPICAL MOUNTAIN SYSTEM (CLASSIFICATION PER GROUP OF TREE SPECIES)			
813	Group 25 in Kakamega forest in Kenya (2002)	log10Y= (2.40225×log10(X))+ (0.09071×log10(W))–2.53516	D1.3 in cm, CD in m (1, 200)**
814	Group 26 in Kakamega forest in Kenya (2002)	log10Y= (2.88659×log10(X))+0.11409	D1.3 in cm (1, 200)**
SPROUT IN TROPICAL MOUNTAIN SYSTEM			
815	*Dichrostachys cinerea* in National Regional State of Tigray in Ethiopia (987)	Y(g)= 46.50×(X^(2.71))×10^(–3)	D30 in cm
816	-idem	Y(g)= 0.016×(X^(1.60))×10^(–3)	CD in m
817	-idem	Y(g)= 135.24×(X^(0.83))×10^(–3)	D30 in cm
818	-idem	Y(g)= 274.95×(X^(1.37))×10^(–3)	D30 in cm
819	- idem	Y(g)= 230.98×(X^(1.47))×10^(–3)	D30 in cm
820	*Euclea shimperi* in National Regional State of Tigray in Ethiopia (987)	Y(g)= 57.30×(X^(1.87))×10^(–3)	D30 in cm
821	-idem	Y(g)= 4.88×(X^(3.54))×10^(–3)	D30 in cm
822	-idem	Y(g)= 20.55×(X^(1.69))×10^(–3)	D30 in cm
823	-idem	Y(g)= 63.07×(X^(1.78))×10^(–3)	D30 in cm
824	-idem	Y(g)= 22.09×(X^(22.09))×10^(–3)	D30 in cm
825	*Grewia bicolor* in National Regional State of Tigray in Ethiopia (987)	Y(g)= 1.93×(X^(0.39))×10^(–3)	D30 in cm
826	-idem	Y(g)= 7.06×(X^(1.75))×10^(–3)	D30 in cm
827	-idem	Y(g)= 52.43×(X^(1.99))×10^(–3)	D30 in cm
828	-idem	Y(g)= 52.97×(X^(1.91))×10^(–3)	D30 in cm
829	*Otostegia integrifolia* in National Regional State of Tigray in Ethiopia (987)	Y(g)= 45.80×(X^(2.26))×10^(–3)	D30 in cm
830	-idem	Y(g)= 43.77×(X^(2.4))×10^(–3)	D30 in cm
831	-idem	Y(g)= 0.54×(X^(–0.09))×10^(–3)	D30 in cm
832	-idem	Y(g)= 14.20×(X^(2.50))×10^(–3)	D30 in cm

Tree components	n, ,R^2	Interval of possibility (%)	Quality	References
L	9, 0.81	100	2	Hailu, Z. (2002)
B	9, 0.87	96	2	Hailu, Z. (2002)
T+Bg+Bt+B+S+Bd	9, 0.98	100	2	Hailu, Z. (2002)
T+Bg+Bt+L+B+S+Bd	16, 0.74adj	100	2	Bradley, P. N. and Kuyper, J.B.H. (1988)
T+Bg+Bt+L+B+S+Bd	4,–	100	2	Bradley, P. N. and Kuyper, J.B.H. (1988)
T+Bg+Bt+L+B+S+Bd	10,–	99	2	Bradley, P. N. and Kuyper, J.B.H. (1988)
T+Bg+Bt+L+B+S+Bd	15,–	95	2	Bradley, P. N. and Kuyper, J.B.H. (1988)
T+Bg+Bt+L+B+S+Bd	11, 0.86*	100	2	Bradley, P. N. and Kuyper, J.B.H. (1988)
T+Bg+Bt+L+B+S+Bd	4,–	0	1	Bradley, P. N. and Kuyper, J.B.H. (1988)
T+Bg+Bt	5,–	-	2	Cleemput, S., Muys, B., et al. (2004)
L	5,–	-	2	Cleemput, S., Muys, B., et al. (2004)
T+Bg+Bt+B+S	5,–	-	2	Cleemput, S., Muys, B., et al. (2004)
T+B	5,–	-	2	Cleemput, S., Muys, B., et al. (2004)
T+Bg+Bt+L+B+S+Bd	5,–	-	2	Cleemput, S., Muys, B., et al. (2004)
T+Bg+Bt+B+S	7, 0.31	-	2	Cleemput, S., Muys, B., et al. (2004)
L	7, 0.67	-	2	Cleemput, S., Muys, B., et al. (2004)
T+B	7, 0.92	-	2	Cleemput, S., Muys, B., et al. (2004)
T+Bg+Bt+L+B+S+Bd	7, 0.95	-	2	Cleemput, S., Muys, B., et al. (2004)
T+Bg+Bt	7, 0.95	-	2	Cleemput, S., Muys, B., et al. (2004)
T+Bg+Bt	8, 0.77	-	2	Cleemput, S., Muys, B., et al. (2004)
L	8, 1adj	-	2	Cleemput, S., Muys, B., et al. (2004)
T+Bg+Bt+B+S	8, 2adj	-	2	Cleemput, S., Muys, B., et al. (2004)
T+Bg+Bt+L+B+S+Bd	8, 0.96	-	2	Cleemput, S., Muys, B., et al. (2004)
T+Bg+Bt+L+B+S+Bd	7, 0.99	-	2	Cleemput, S., Muys, B., et al. (2004)
T+Bg+Bt+B+S	7, 0.98	-	2	Cleemput, S., Muys, B., et al. (2004)
L	7, 0.94	-	2	Cleemput, S., Muys, B., et al. (2004)
T+Bg+Bt	7, 0.91	-	2	Cleemput, S., Muys, B., et al. (2004)

ID	Tree species and location (annual rainfall)	Model Equations	Variables X (min, max), W, Z, U and V
STAND IN TROPICAL MOUNTAIN SYSTEM			
833	*Eucalyptus globulus* in Adis abeba in Ethiopia (1191)	Y(Mg ha–1)= –33.6+19.4×X	yr in yr
STAND IN TROPICAL MOUNTAIN			
834	*Acacia karoo* in Crossroads village in South Africa (572)	log10Y= (3.062×log10(X))–0.304	C in cm (3, 628)**
835	*Coddia rudis* in Crossroads village in South Africa (572)	log10Y= (0.62×log10(X))+2.23	C in cm (3, 628)**
836	*Diospyros dichrophylla* in Crossroads village in South Africa (572)	log10Y= (1.09×log10(X))+1.93	C in cm (3, 628)**
837	*Olea europaea* in Crossroads village in South Africa (572)	log10Y= (2.82×log10(X))+0.16	C in cm (3, 628)**
838	*Ptaeroxylon obliquum* in Crossroads village in South Africa (572)	log10Y= (2.538×log10(X))+0.42	C in cm (3, 628)**
GENERAL EQUATIONS FOR INDIVIDUAL TREE IN SUBTROPICAL HUMID FOREST			
839	GeneralizeBd in Crossroads village in South Africa (572)	log10Y= (2.74×log10(X))+0.15	C in cm (3, 628)**
INDIVIDUAL TREE IN SUBTROPICAL DRY FOREST (CLASSIFICATION PER TREE SPECIES)			
840	*Protea neriifolia* in Jokershoek valley in South Africa (1069)	logY= –2.23+2.26×log(X)	D20 in cm (1, 191)**
841	-idem	logY= –2.23+2.12×LOG(X)	D20 in cm (1, 191)**
842	*Protea repens* in Jokershoek valley in South Africa (1069)	logY= –2.89+2.36×LOG(X)	D20 in cm (1, 191)**
843	-idem	logY= –2.7+2.46×LOG(X)	D20 in cm (1, 191)**
844	*Widdringtonia nodiflora* in Jokershoek valley in South Africa (1069)	logY= –2.82+2.34×LOG(X)	D20 in cm (1, 191)**
845	-idem	logY= 3.19+1.94×LOG(X)	D20 in cm (1, 191)**
INDIVIDUAL TREE IN SUBTROPICAL MOUNTAIN FOREST (CLASSIFICATION PER TREE SPECIES)			
846	*Pinus patula* in Kwazulu natal in South Africa (600)	Y= 4.57×0.028×X×W	D1.3 in cm, CH in m (1, 200)**
847	-idem	Y= –35.78+1.5×X	D1.3 in cm (24, 200)**
848	-idem	Y= 9.78+0.171×X×W	D1.3 in cm, CH in m (1, 200)**
849	-idem	Y= 50.782+0.104×(X×W)+0.0003×((X×W)^2)	D1.3 in cm, H in m (1, 200)**
850	-idem	Y= 2.75+0.0015×(X^2)×W	D1.3 in cm, H in m (1, 200)××

Tree components	n, ,R^2	Interval of possibility (%)	Quality	References
T+Bg+Bt+L+B+S+Bd	10, 0.79	-	2	Zewdie, M. (2008)
T+Bg+Bt+B+S+Bd	14, 0.79	0	1	Potea, J., Shackleton, C., et al. (2006)
T+Bg+Bt+B+S+Bd	20, 0.3	72	1	Potea, J., Shackleton, C., et al. (2006)
T+Bg+Bt+B+S+Bd	19, 0.36	13	1	Potea, J., Shackleton, C., et al. (2006)
T+Bg+Bt+B+S+Bd	14, 0.81	0	1	Potea, J., Shackleton, C., et al. (2006)
T+Bg+Bt+B+S+Bd	11, 0.38	0	1	Potea, J., Shackleton, C., et al. (2006)
T+Bg+Bt+B+S+Bd	39, 0.77	0		Potea, J., Shackleton, C., et al. (2006)
		0		
T+Bg+Bt+L+B+S+Bd	105, 0.91	100	2	Van Wilgen, B. W. (1982)
Bg+Bt+L+Bd	105, 0.87	96	2	Van Wilgen, B. W. (1982)
Bg+Bt+L+Bd	241, 0.84	99	2	Van Wilgen, B. W. (1982)
T+Bg+Bt+L+B+S+Bd	241, 0.92	99	2	Van Wilgen, B. W. (1982)
T+Bg+Bt+L+B+S+Bd	247, 0.97	100	2	Van Wilgen, B. W. (1982)
Bt<6	247, 0.94	0	1	Van Wilgen, B. W. (1982)
L	–	97	2	Dames, J. F., Scholes, M. C., et al. (2002)
B	–	100	2	Dames, J. F., Scholes, M. C., et al. (2002)
Bg+Bt+Bd	–	93	2	Dames, J. F., Scholes, M. C., et al. (2002)
T+B+S	–	94	2	Dames, J. F., Scholes, M. C., et al. (2002)
Rb+Rm+Rf	–	97	2	Dames, J. F., Scholes, M. C., et al. (2002)

Appendix D. List of references used in appendix A and B.

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