UN-REDD
PROGRAMME

Inventory of Tree Biomass and Volume Allometric Equations in Southeast Asia

UN-REDD PROGRAMME

June 2014
Kepong, Malaysia

UN-REDD Programme
MRV Report 19
2014

The UN-REDD Programme, implemented by FAO, UNDP and UNEP, has two components: (i) assisting developing countries prepare and implement national REDD strategies and mechanisms; (ii) supporting the development of normative solutions and standardized approaches based on sound science for a REDD instrument linked with the UNFCCC. The programme helps empower countries to manage their REDD processes and will facilitate access to financial and technical assistance tailored to the specific needs of the countries.

The application of UNDP, UNEP and FAO rights-based and participatory approaches will also help ensure the rights of indigenous and forest-dwelling people are protected and the active involvement of local communities and relevant stakeholders and institutions in the design and implementation of REDD plans.

The programme is implemented through the UN Joint Programmes modalities, enabling rapid initiation of programme implementation and channeling of funds for REDD efforts, building on the in-country presence of UN agencies as a crucial support structure for countries. The UN-REDD Programme encourage coordinated and collaborative UN support to countries, thus maximizing efficiencies and effectiveness of the organizations' collective input, consistent with the "One UN" approach advocated by UN members.

Contacts:

Abd Rahman Kassim
Geoinformation Programme
Forest Research Institute Malaysia
Email: rahmank@frim.gov.my

Matieu Henry
UN-REDD Programme
Food & Agriculture Organization of the United Nations (FAO)
Email: Matieu.Henry@fao.org

Disclaimer

Citation

Abd Rahman, K., Mohamad Danial, M. S., Muhammad Faiz, K., Birigazzi, L. 2014. Inventory of volume and biomass allometric equations for Southeast Asia. FRIM, Kepong, Food & Agriculture Organization of the United Nations, Rome, Italy

Photo credit

Niiyama K. Largest tree for development of root biomass allometric equation at Pasoh Forest Reserve, Malaysia.

Inventory of Tree Biomass and Volume Allometric Equations in Southeast Asia

Abd Rahman Kassim, Mohamad Danial Md Sabri, Muhammad Faiz Kamarudin, Luca Birigazzi

Acknowledgement

The authors would like to acknowledge the contributions of Dato' Dr. Abd. Latif Mohmod, Director General of FRIM for the permission to conduct this compilation. A special thanks to Dr. Ismail Harun, the Director of Natural Forest and Environment Division and Pn. Nor Azura Ahmad Murad, the legal advisor of FRIM, for their administrative support. We would like to extend our deepest gratitude to all contact persons in the Southeast Asia region (as listed in (Appendix 1.1)) who has provided the support to access many relevant published and unpublished documents for this compilation. In addition, we would like to extend our gratitude to Dr. Samsudin Musa, Head of Natural Forest Programme for having time to read and check the final report and Pn. Rodziah Hashim, for her assistance in preparing GIS maps. Last but not least, we would like to thank Food and Agriculture Organization of the United Nations (FAO) who supported this work through its National Forest Monitoring and Assessment (NFMA) programme.

Table of contents

List of figures

List of tables

List of appendices

1. Introduction

Sustainable tropical forest management has been a major agenda in the tropical region after the World Summit on sustainable development in 1992. The sustainable development initiative considers environmental and socio-economic factors in addition to timber out-turn in relation to forest management practices. For example, practices to reduce damage to un-harvested trees during timber harvesting whilst conserving genetic resources in managed tropical forest were introduced.

Tropical forests are facing new challenges in recent decades with climate change Tropical forests contribute to the mitigation of climate change by via sequestration of the greenhouse gas carbon dioxide in tree biomass. Tropical forests additionally mitigate warming through evaporative cooling and the albedo effect of cloud cover. According to (FAO, 2010), South and Southeast Asia have shown a decrease in biomass stock per hectare between 1990 to 2010 due to deforestation and forest degradation. This region contains tropical forest with forest covering about 35 percent of the land area . Efforts have been initiated to promote sustainable use and conservation of the tropical forest. REDD+ (Reducing Emissions from Deforestation and Forest Degradation) is a mechanism established under the United Nations Framework Convention on Climate Change (UNFCCC) to provide incentives for developing countries to protect and manage their forest resources, in line with the global effort to address climate change.

Tree allometric equations are important tools for quantifying forest resources, providing estimates of volume, biomass and carbon stocks. They are statistical models that can be used to express the relationship between the different components of a tree in terms of their relative sizes. They allow foresters to convert simple measurements of trees such as stem diameter to characteristics which are much more difficult/expensive/destructive to measure such as tree biomass or carbon stock.

The development and use of country, biome, climate and species-specific equations improves accuracy, minimises error propagation and reduces bias arising from generic models.

Allometric equations for tree volume and biomass estimation have been developed for Southeast Asia yet many remain unpublished or difficult to access in theses and reports. Hence, FRIM with the support of FAO has attempted to gather all the published and unpublished material on volume and biomass allometric equations, biomass expansion factors and tree height-diameter equations for 8 Southeast Asian countries (Cambodia, Laos, Myanmar, Thailand, Malaysia, Brunei, Philippines and Singapore) into a database that can be made available internationally. This report describes the database.

2. Objectives of the report

The objectives of this report are:

(a) to provide a regional overview on the status of tree biomass and volume allometric equations in Southeast Asia to support policies and measures and identify gaps.

3. Data compilation

3.1 Review of available literature

The database was compiled by collecting data from several secondary sources, visits and correspondence with various agencies within the region. Initially the Forest Research Institute of Malaysia's online literature collection was accessed which includes the databases to which the Institute subscribes such as ScienceDirect and Forest Science Database. We also searched FRIM library's Online Public Access Catalogue (OPAC)which includes various published and unpublished technical publications such as conference papers, monograph and thesis collections. An online literature search using Springerlink and Google Scholar with the selected keywords was used to identify individual researchers and institutes in the region. Contacts were established with several regional institutes based on experiences and recommendation by FAO and Letters and emails were sent to seek further guidance. (Appendix 1).

Visits to forestry research and educational institutions in Malaysia, the Philippines and Laos yielded hard copies of theses and internal-circulation research papers which contained some relevant works on the development of allometric equations in the region (Appendix 2). Publications/ documents of the Food and Agriculture Organization (FAO) also yielded many allometric equations in the database especially for Indonesia (Krisnawati *et al.*, (2012)).

Despite our extensive efforts we believe that the collection is not exhaustive.

3.2 Data organization

In the process of compiling the relevant information, a total of 133 documents were assessed. Among these documents, 121 were selected for compilation. These were digitised using the structure of the Globallometree database available at: www.globallometree.org. The database provides information on the type of population, ecosystem, bioclimatic zones, equation parameters, fit statistics and geographic location where the equations were developed or applied. The tutorial used for development of the database is available on the Globallometree website (Baldasso *et al.*, (2012).

Several equations in the database were found to contain some vaguely defined vegetative components (big and small roots, trunk, small and large branches, above ground biomass etc.). To standardize the data and for easy usage, the vegetative components were divided into 11 different compartments and defined (Figure 1).

The tree component classification used in the present work was based on Henry *et al.* (2011) Taxonomical hierarchy of the plant/ tree for which the equations were developed was described where possible up to family level (species, genus and family) in three different fields. Fit statistics for the entered equations were described in terms of R^2, adjusted R^2, bias correction, root mean square error (RMSE) and standard error of mean.

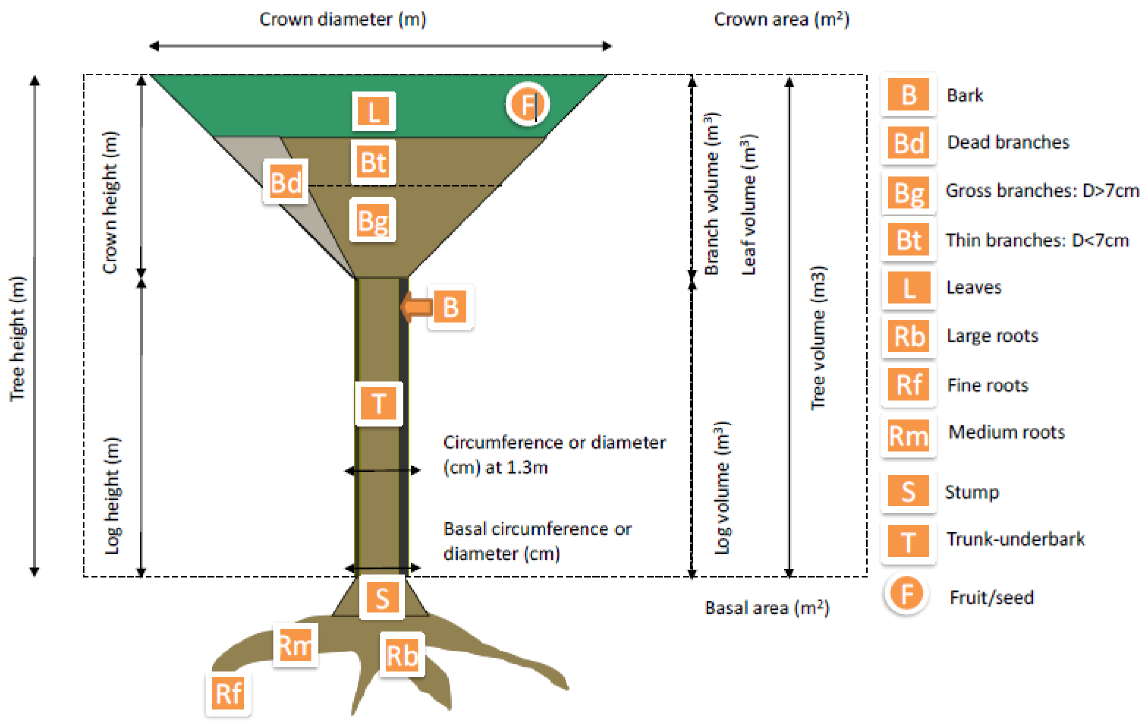


Figure 1. Tree components classification used in the present work (Henry *et al.*, 2011)

4. Data description and structure

The database consists of 74 variables grouped into 7 different categories:

1. Plant ecology (Population and Ecosystem)
2. Geographical location where the equation was developed or applied (Continent, Country, Biomes)
3. Equation parameters (variable characters and ranges)
4. Tree vegetation components (Bark, Root, Stump etc.)
5. Taxonomical description (Family, Genus, Species)
6. Statistical Information (R2, adjusted R2, bias correction, RMSE and standard error of mean)
7. Bibliography

4.1. Document status in the database

Table 1 shows the coverage of each Southeast Asian country in the available allometric equation literature. The differences in the literature coverage may not reflect the real amount of work conducted in developing biomass and volume allometric equations; as for example in certain countries the information had been compiled into a comprehensive national review while others had not done so. Equations for Vietnam (5178 equations), Cambodia (1102) and Indonesia (70) from the GlobAllomeTree database were included.

Table 1. Literature coverage in Southeast Asia per country.

COUNTRY	TOTAL DOCUMENTS COLLECTED		DOCUMENTS COVERED IN THE DATABASE		DOCUMENTS NOT COVERED FOR TECHNICAL REASONS	
	No.	**%**	**No.**	**%**	**No.**	**%**
Cambodia	8	4.13	6	2.75	2	16.67
Kiribati	-	-	-	-	-	-
Indonesia	15	10.74	12	9.17	3	25.00
Laos	3	2.48	2	1.83	1	8.33
Malaysia	64	52.89	61	55.96	3	25.00
Myanmar	1	0.83	1	0.92	0	0.00
Philippines	19	15.70	18	16.51	1	8.33
Singapore	1	0.83	1	0.92	0	0.00
Thailand	6	4.96	5	4.59	1	8.33
Vietnam	16	7.44	15	7.34	1	8.33
Total	**133**	**100**	**121**	**100**	**12**	**100**

4.2. Publication status of tree allometric equations per year

The earliest publication dated from 1962, dominated by the works on volume allometric equations in Malaysia. Intensification of volume and biomass allometric equation research can be observed in the period between 2006-2010 (Figure 2).

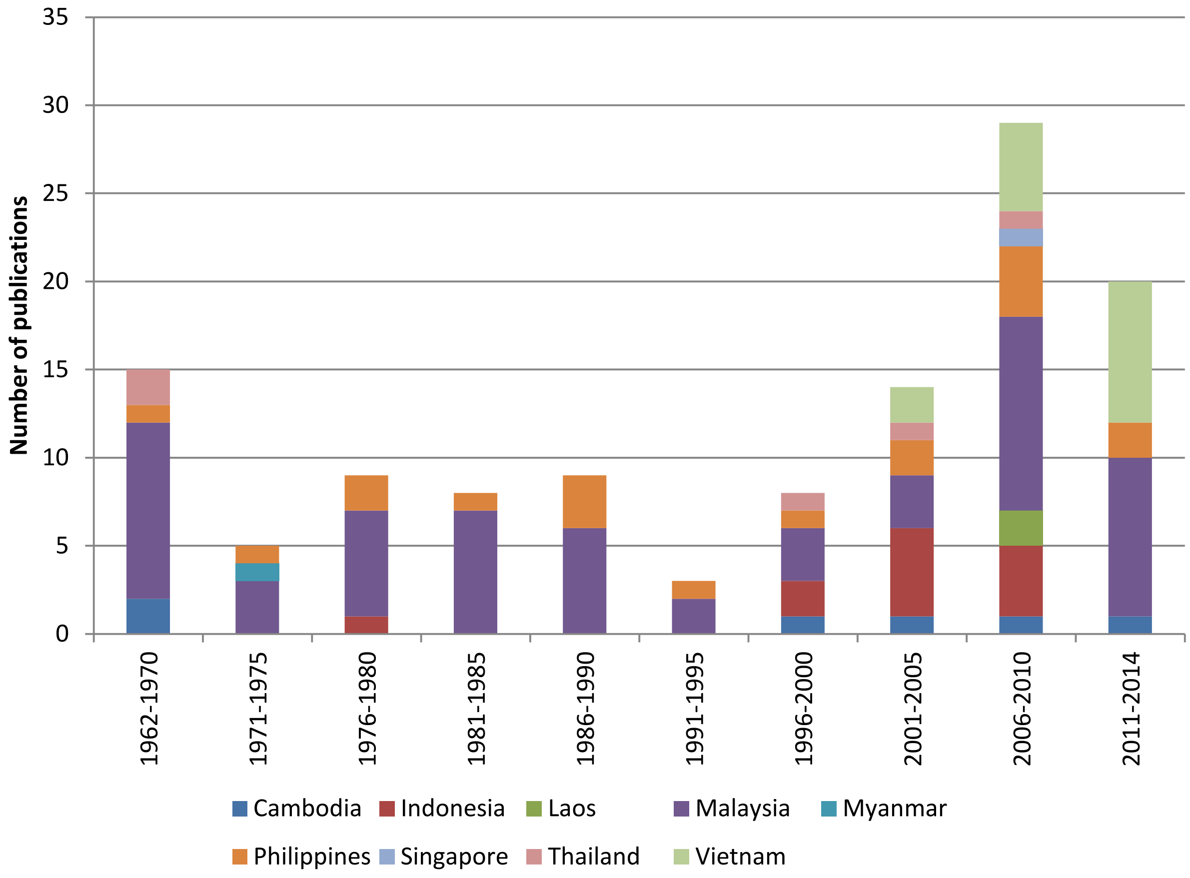


Figure 2. Number of published literature per year in Southeast Asia

4.3. Population and forest type's status in the database

The forest types in the database can be categorised into two groups, namely mangroves and terrestrial trees. 8.3 percent of publications collected cover mangroves, while the rest cover trees. Table 2 describes the number of publications for each country. The majority of the equations compiled are from the natural forest (2094 or 79 %) while the plantation forest was represented by 551 equations and urban forest by 1 equation from Singapore (Figure 3).

Table 2. Status of population in the literature covered

POPULATION	CAMBODIA		INDONESIA		LAOS		MALAYSIA		MYANMAR		PHILIPPINES		SINGAPORE		THAILAND		VIETNAM	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Mangroves	0	0.00	0	0.00	0	0.00	7	9.59	0	0.00	1	5.56	0	0.00	1	20.00	2	13.33
Tree	6	100.00	12	100.00	2	100.00	66	90.41	1	100.00	17	94.44	1	100.00	4	80.00	13	86.67
Total	6	100.00	12	100.00	2	100.00	73	100.00	1	100.00	18	100.00	1	100.00	5	100.00	15	100.00

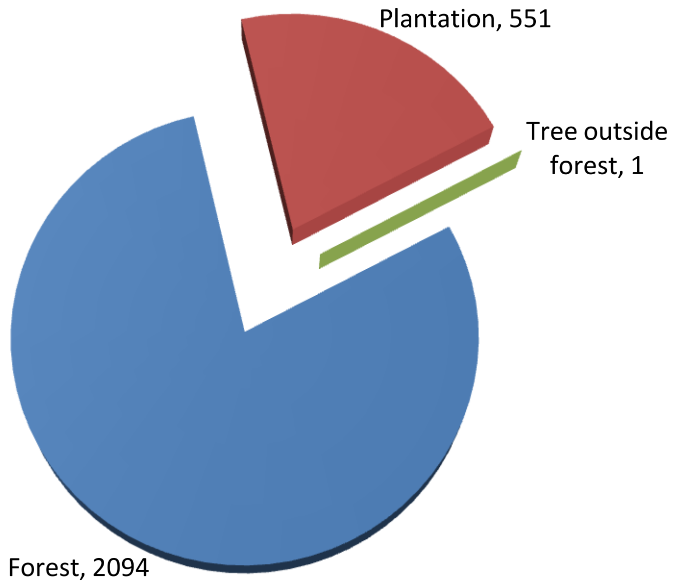


Figure 3. Number of published literature by forest types in Southeast Asia

4.4 Tree species status in the database

Indonesia yielded the largest number of allometric equations with 947, followed by Malaysia (769) and the Philippines (640). Indonesia also registered the highest number of both family and genus-specific equations. The Philippines and Vietnam have the same number of equations for family (23), while Vietnam has the second most equations for genus.

Table 3. Country-coverage of genera, family and equations in the database

COUNTRY	NUMBER			PERCENT		
	Family	Genus	Equations	Family	Genus	Equations
Cambodia	8	13	67	6.84	7.07	2.55
Indonesia	36	59	947	30.77	32.07	36.02
Laos	2	2	22	1.71	1.09	0.84
Malaysia	19	32	769	16.24	17.39	29.25
Myanmar	1	6	48	0.85	3.26	1.83
Philippines	23	30	640	19.66	16.30	24.34
Singapore	1	1	1	0.85	0.54	0.04
Thailand	4	4	24	3.42	2.17	0.91
Vietnam	23	37	111	19.66	20.11	4.22

In terms of species covered, Vietnam has the highest number of equations in the database. Indonesia and Malaysia were represented by approximately 19 and 15 percent respectively of the species allometric equation, followed by the Philippines.

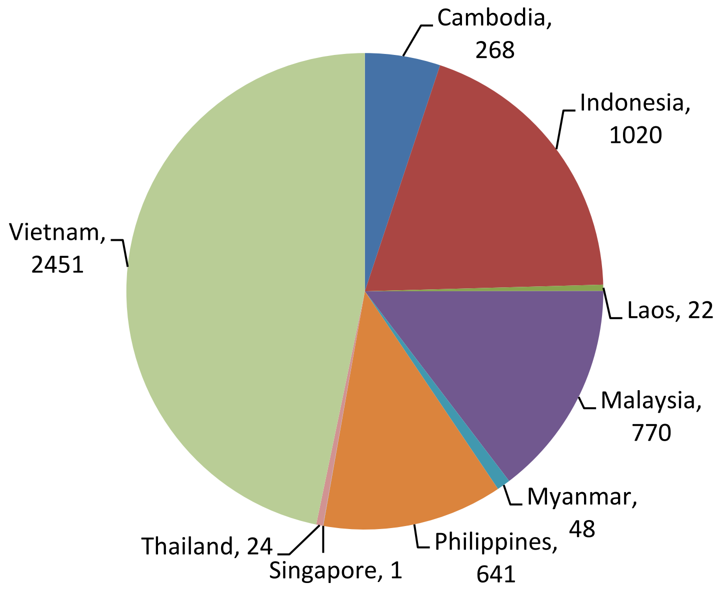


Figure 4. Country coverage of tree species in the database

4.4.1 Allometric equations per taxonomic rank

The information on the frequency of occurrence of taxonomic rank provides an insight on the importance of particular timber trees in the region. The most common tree allometric equation at family level is Leguminosae (657) followed by Dipterocarpaceae (579) and Rhizophoraceae (159) (Figure 4). The Leguminosae are mostly the plantation species, while the Dipterocarpaceae are commercial timber trees from the natural forest. The Rhizophoraceae are primarily the mangrove swamp forest species. See Appendices 4 and 4 for the species and genus-level allometric equations collected.

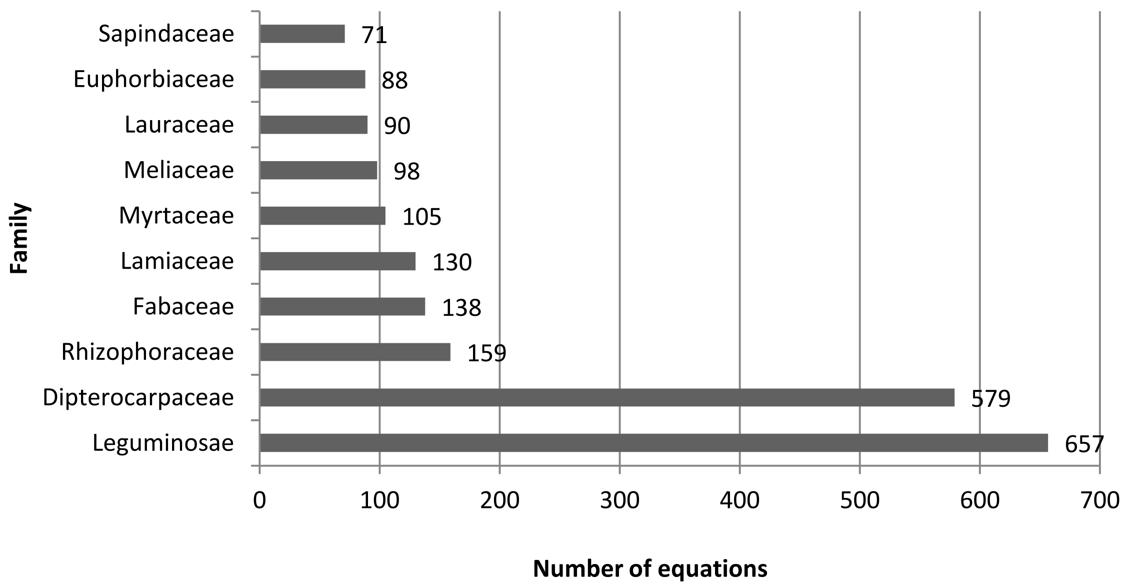


Figure 5. Ten most common families of the recorded allometric equations in SE Asia

At genus level, *Leucaena spp.* (434) was most frequently represented by the allometric equations followed by *Shorea spp.* (296) and *Acacia spp.* (209). (Figure 5). Both *Leucaena* and *Acacia* are genus from the Leguminosae family. *Shorea* and *Dipterocarpus* are the two common genus of Dipterocarpaceae. The *Rhizophora spp*. which is the fourth most common genus (n=82) represented the Rhizophoraceae family.

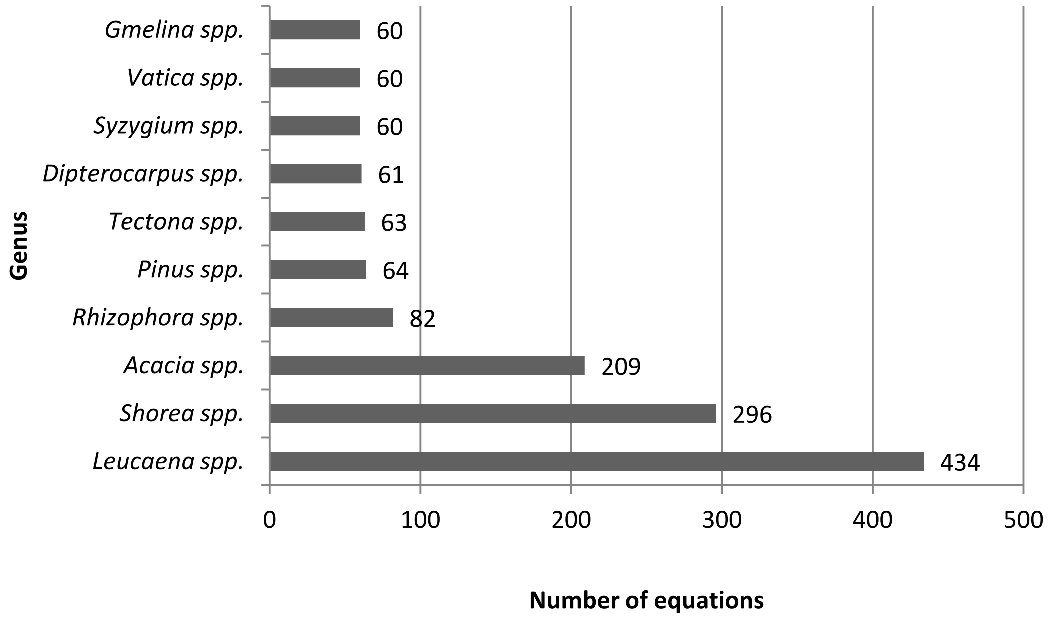


Figure 6. Ten most common genus of the recorded allometric equations in SE Asia

The ten most common species represented by the allometric equations are mainly the plantation species such as *Leucaena leucocephala* (434) and *Acacia mangium* (187), followed by natural forest species, *Shorea leprosula* (141). The dominant species of mangrove *Rhizophora apiculata* (55) was also listed among the ten most common species.

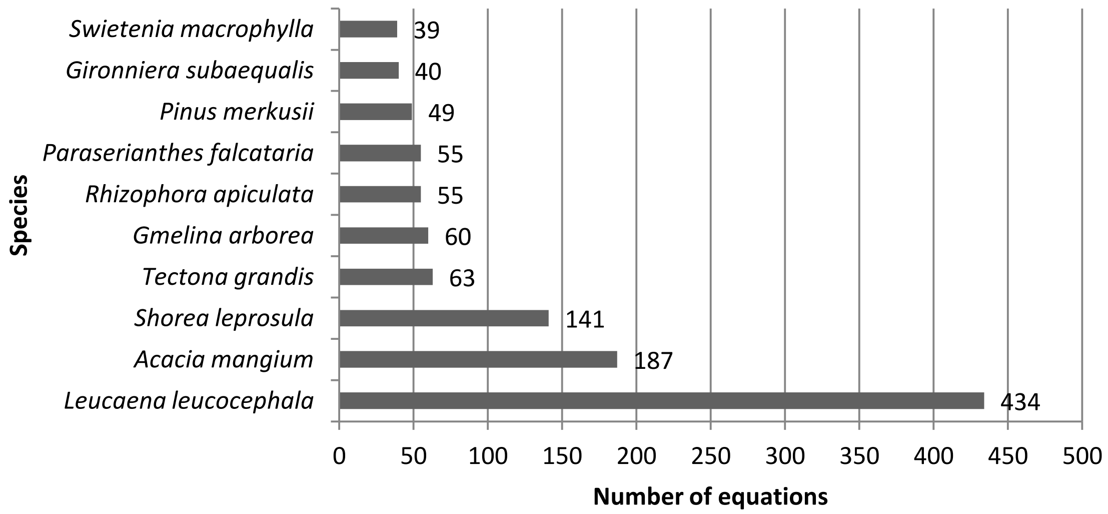


Figure 7. Ten most common species with the recorded allometric equations in the region

4.5. Categorization of allometric equations in the database

The equations were categorized into equations for volume, biomass, carbon stock and height. The biomass equations represented half of the total equations listed, followed by volume equations. The height~diameter equations were included as part of the assessment as the information is frequently referenced when calculating the tree volume and biomass.

The regional-level biomass equations comprised the highest number (1400) followed by volume (966) and height-diameter equations (250) (Figure 8). At country scale, in terms of volume equations, Indonesia contributed 440,Malaysia 303 and the Philippines 96. For biomass equations, the Philippines contributed 531 or 38% (mainly attributed to theses), Indonesia 507 and Malaysia 230. The height~diameter equations were only reported in three countries, Malaysia (236) or 94.4 percent of the total, followed by the Philippines (13) and Cambodia (1).

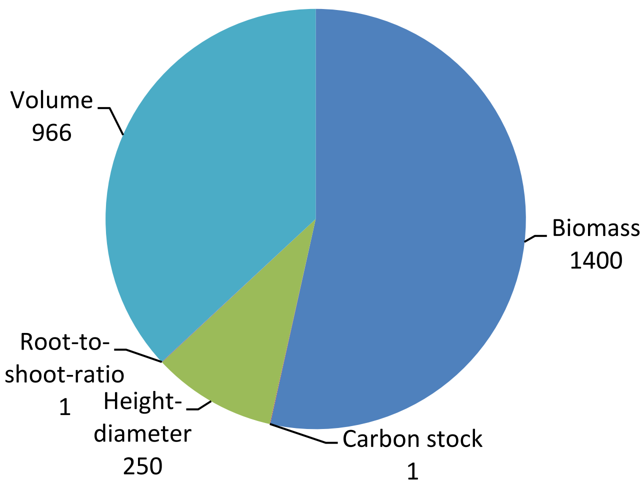


Figure 8. Number of allometric equations by type. Note that although the root to shoot ratio is not considered as an allometric equation, we have included it in the chart.

Table 4. Country contribution to the volume, biomass, carbon stock, height-diameter and root-to-shoot-ratio (RTSR) equations in database

COUNTRY	VOLUME		BIOMASS		CARBON STOCK		HEIGHT-DIAMETER		RTSR	
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Cambodia	44	4.55	22	1.56	0	0	1	0.40	0	0.00
Indonesia	440	45.55	507	35.93	0	0	0	0.00	0	0.00
Laos	21	2.17	1	0.07	0	0	0	0.00	0	0.00
Malaysia	303	31.37	230	16.30	0	0	236	94.40	0	0.00
Myanmar	48	4.97	0	0.00	0	0	0	0.00	0	0.00
Philippines	96	9.94	531	37.63	0	0	13	5.20	0	0.00
Singapore	0	0.00	0	0.00	0	0	0	0.00	1	100.00
Thailand	2	0.21	22	1.56	0	0	0	0.00	0	0.00
Vietnam	12	1.24	98	6.95	1	100	0	0.00	0	0.00
Total	966	100.00	1411	100.00	1	100	250	100.00	1	100.00

4.6. Representation of tree components in the database

Tree trunks were the most frequent tree component modelled by the equations collected, followed by total height, branches and leaves. The large number of trunk equations is due to the fact that the majority of volume equations refer to the trunk.

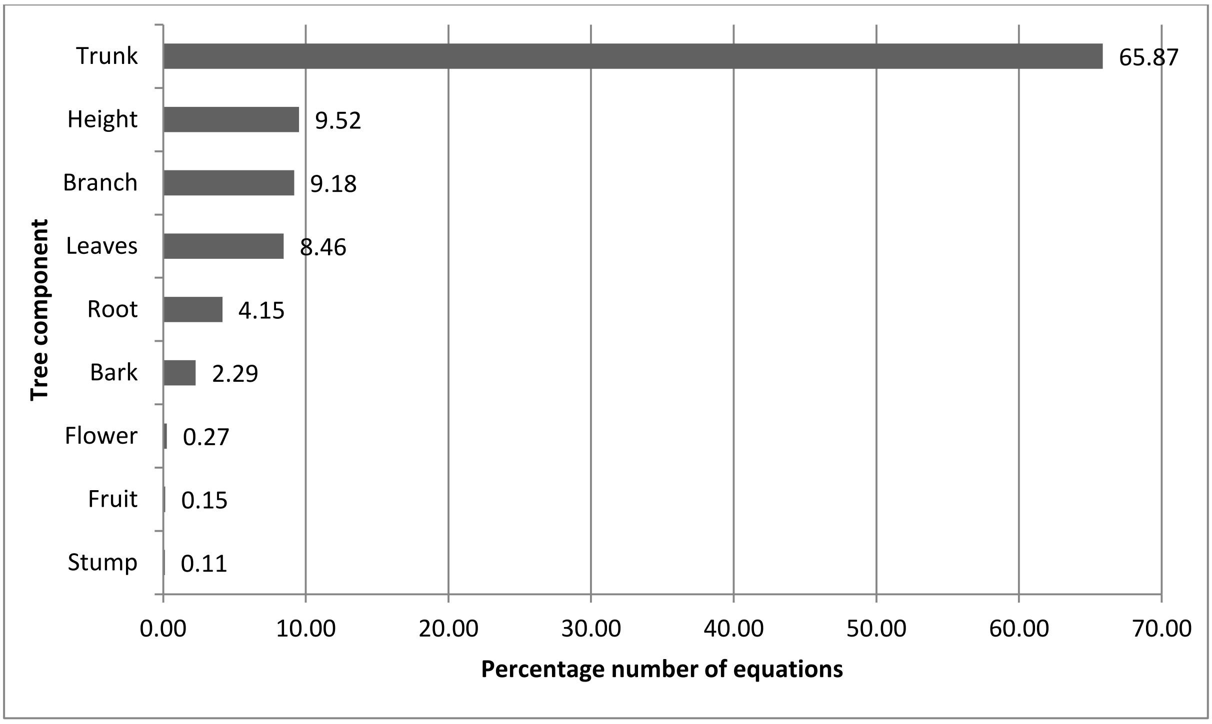


Figure 9. Percentage of allometric equations per tree component

4.7. Geographical distribution of the equations in Southeast Asia

With reference to the FAO Biomes, the information was collected from five biome types; (a) Subtropical humid forest, (b) Tropical dry forest, (c) Tropical moist deciduous forest, (d) Tropical mountain system, and (e) Tropical rainforest (Table 5, Figure 10). The majority of species-specific allometric equations found were for tropical rainforest (269 or 48.73%) followed by Tropical moist deciduous forest (26), tropical dry forest and tropical mountain forest. Considering all types of allometric equations, tropical rainforest covers 65.56% or 1833 equations followed by tropical moist deciduous forest (519) and tropical mountain forest (338). More work is required for the subtropical humid forest and also tropical dry forest as well as tropical mountain system. Distributions of tree allometric equations based on different biome categories is given in Appendix 5-9. Additionally, peat swamp is one the forest biomes which is under represented except in Indonesia.

Table 5. Coverage of tree allometric equations across different FAO biomes in Southeast Asia

FAO BIOMES	SPECIES-SPECIFIC EQUATIONS		ALLOMETRIC EQUATIONS	
	Number	%	Number	%
Subtropical humid forest	2	0.36	3	0.11
Tropical dry forest	34	6.16	103	3.68
Tropical moist deciduous forest	221	40.04	519	18.56
Tropical mountain system	26	4.71	338	12.09
Tropical rainforest	269	48.73	1833	65.56

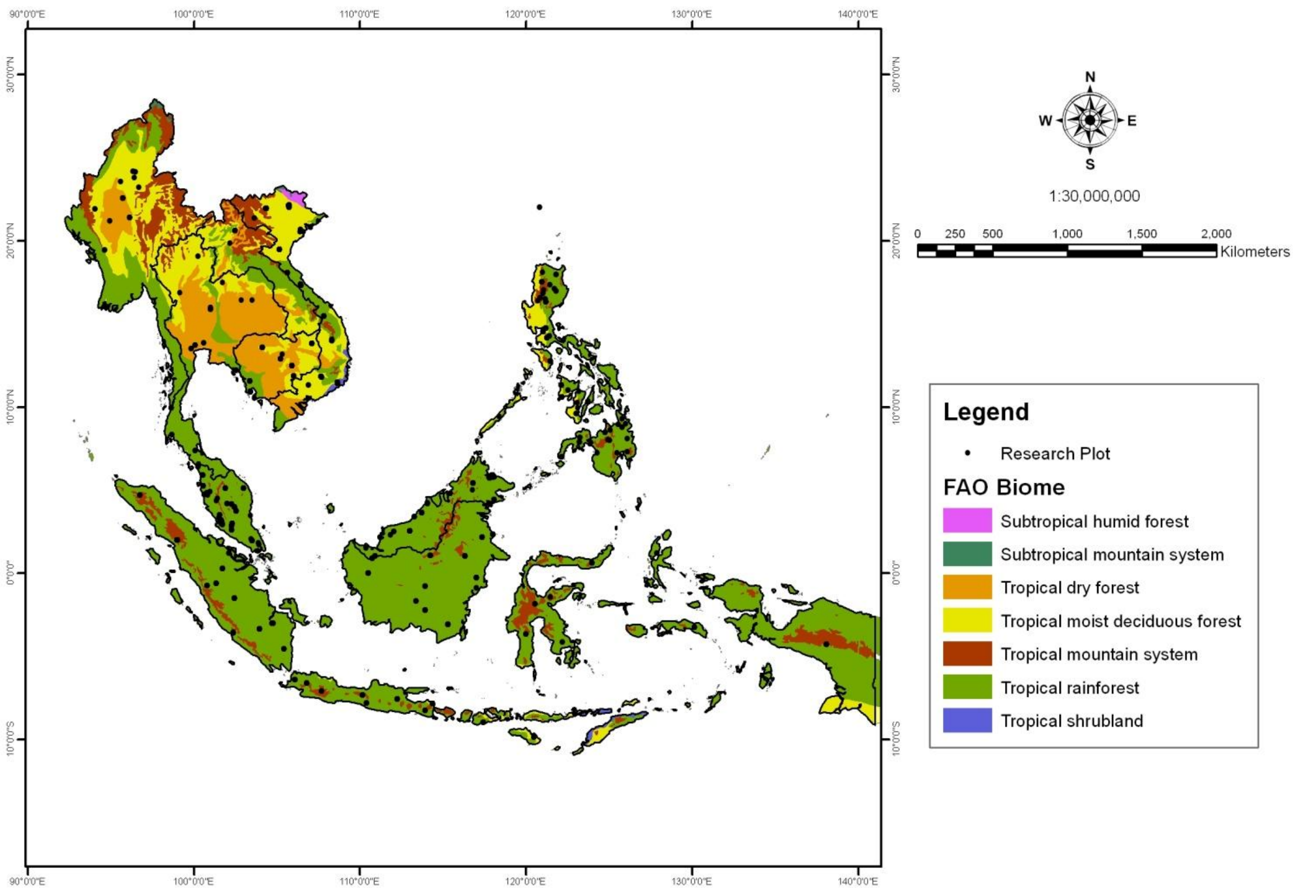


Figure 10. Geographical distribution of sample plots in FAO Biomes of Southeast Asia. The black dots represent the sample plots where equations were developed. The geographical distribution of sample plots of ecosystems under FAO, UDVARDY, Bailey and Holdridge biome classifications are given in Appendix 5-9).

5. Conclusions and recommendations

5.1 Conclusions

The inventory of tree biomass and volume allometric equations for Southeast Asia is timely to support better assessment of the forest resources in the region. As the development of such allometric equation requires intensive labour and resources, this compilation will support for researchers and managers in the region to estimate volume and biomass of trees in their respective countries, minimising the need for additional expensive and/or destructive measurements.

The database compiling the tree volume and biomass allometric equations collected from Malaysia, Indonesia, Thailand, Myanmar, the Philippines, Singapore, Brunei, Laos and Vietnam is presented. The list of allometric equations is far from exhaustive, as some of the papers were published in their native languages and thus require translation.

It is difficult to determine which genus, species or families are under-represented in the database as the region is very biodiverse, lying in the tropical zone. Many species are represented by only a few individuals and therefore any equations developed from these are statistically less reliable. Most species-specific equations (as well as total equations) came from tropical and tropical moist deciduous forest biomes.

The peat swamp area is one the forest biomes which is under represented except in Indonesia. In terms of the countries, in Laos for example, the effort to develop allometric equations particularly for biomass is at an early stage and little published material is available, but efforts to develop equations for Laos have been initiated recently, supported by an international project. In terms of forest biomes, subtropical humid forest, tropical dry forest and tropical mountain forests may need more future emphasis. Belowground biomass equations are lacking from the coverage of tree components, and require more work as do other vegetation types such as climbers, palms and bamboos which contribute significant biomass in natural forest. Getting access to internal and unpublished papers and extracting equations from publications in some of the national languages were obstacles to equation collection.. This can be rectified with good cooperation from the respective agencies within the country.

5.2 Recommendations

A substantial amount of data has been collected to develop the equation in SE Asia. It may be possible to develop a generalized allometric equation by reappraisal of the existing available data. Additionally efforts should be made to collect raw data in the region in order to develop a regional allometric equation, as has been done by Chave *et al.*, (2005). They conducted a critical reassessment of the quality and the robustness of the developed allometric models across tropical forest types, using a large dataset of 2,410 trees ≥ 5 cm diameter, directly harvested in 27 study sites across the tropics, and created a pan-tropical equation. Similarly a single equation may be able to be developed to represent the SE Asia region.

Development of volume equations is relevant for the sustainable forest management of both natural and plantation forests in the region. The challenge is to develop volume allometric equations per species as the tropical forest in the region contain multispecies stands with a limited number of samples per species. A mixed-effects model with species treated as random effects may be introduced as an alternative to modeling multispecies allometric equations ((Abdul Rahman & Hajar, 2013). Another approach is to group the species into categories such as demographic traits and plant functional traits of trees within the same ecological guilds (e.g. emergent, canopy, understorey etc.) that may share similar allometry properties. The approach will broadly categorise the allometric equations for large number of species in the tropical region.

In many countries in the region, resources to develop new equations may be limited, while the assessment is needed to assist in better country reports on carbon stock. Unlike the volume allometric equation which can be developed from non-destructive methods, the biomass allometric equation on the other hand requires weighing samples of a sufficient number of individuals from across the tree-size interval, therefore is destructive. However, a worldwide database on tree dbh and its biomass component has been initiated Instead of using species, the allometric equations use the wood specific gravity as surrogate for the species. Several papers were published using these allometric functions. However, very little work has been carried out to examine the below ground biomass allometric function. The pioneering work by (Niiyama *et al.*, 2010) provides a basis to estimate the below ground biomass for natural forest.

In the case of mangrove species in the region, an exemplary work of (Komiyama, Poungparn, & Kato, 2005) provides species-specific allometric equations for mangrove forest which allows for a comprehensive biomass estimation by species and subsequently expand its estimate to stand level. Comprehensive species lists should be developed for all forest types.

The application of allometric equations cannot be generalized without the knowledge of its site conditions where it was developed. For example, (Kenzo *et al.*, 2009) realized that the application of equations developed in primary forest stand may be overestimated when applied to degraded forest due to low wood density species dominating in the area. Thus, the compilation of the allometric equations also provide the gap analysis to examine the need to explore new models or utilize available alternatives to the most similar forest types relevant to the subject tree species or forest types.

Due to the time and resources needed to develop new allometric equations, we need to explore new techniques that may provide a simpler and non-destructive method while still producing reliable results. A Terrestrial LiDAR Scanner (TLS) can serve as an alternative option for volume and biomass estimation as TLS can be used to examine the actual shape and volume of the vegetation component (trunk and branch) and it may be possible to determine the biomass from TLS image. However, remote sensing results should be validated using field measurements.

Efforts should be intensified to create awareness to potential users such as researchers, academician and forest managers in the region on the availability of tree volume and biomass allometric equations in Southeast Asia. FAO may initiate regional workshops to promote the database, and provide guidance on the applications of the relevant allometric equation in the assessment of the volume, biomass and carbon stocks of both plantation and natural forest in the region. Such efforts may also encourage sharing of information on allometric equations among the various interested parties within the region.

6. References cited

Abd Rahman, K., & Hajar, Z. S. N. 2013. *Alternative Approach to Modelling Volume Equations for Multispecies Stand*. Paper presented at the 2nd International Symposium on Tropical Forest Ecosystem Science and Management: Challenges and Solutions, Universiti Putra Malaysia Bintulu Sarawak Campus.

Baldasso, M., Birigazzi, L., Trotta, C., & Henry, M. 2012. Tutorial for allometric equation database development. 27.

Chave, J., Andalo, C., Brown, S., Cairns, M. A., Chambers, J. Q., Eamus, D., Fölster, H., Fromard, F., Higuchi, N., Kira, T., Lescure, J. P., Nelson, B. W., Ogawa, H., Puig, H., Riéra, B., & Yamakura, T. 2005. Tree allometry and improved estimation of carbon stocks and balance in tropical forests. *Oecologia*, 145(1): 87-99.

FAO. 2010. Global Forest Resources Assessment 2010, *FAO Forestry Paper*. Rome.

Henry, M., Picard, N., Trotta, C., Manlay, R. J., Valentini, R., Bernoux, M., & Saint-André, L. 2011. Estimating Tree Biomass of Sub-Saharan African Forests: a Review of Available Allometric Equations. *Silva Fennica*, 45(3): 477 - 569.

Kenzo, T., Furutani, R., Hattori, D., Kendawang, J., Tanaka, S., Sakurai, K., & Ninomiya, I. 2009. Allometric equations for accurate estimation of above-ground biomass in logged-over tropical rainforests in Sarawak, Malaysia. *Journal of Forest Research*, 14(6): 365-372.

Komiyama, A., Poungparn, S., & Kato, S. 2005. Common allometric equations for estimating the tree weight of mangroves. *Journal of Tropical Ecology*, 21(04): 471-477.

Krisnawati, H., Adinugroho, W. C., & Imanuddin, R. 2012. Monograph Allometric Models for Estimating Tree Biomass at Various Forest Ecosystem Types in Indonesia. Bogor, Indonesia: Research and Development Center for Conservation and Rehabilitation, Forestry Research and Development Agency, Ministry of Forestry.

Muhammad-Zulkarnain, A. R. 2011. Estimation of Composite Hydrodynamic roughness over Land with High Density Airborne Laser Scanning. *PhD Thesis*. Delft University of Technology, the Netherlands

Niiyama, K., Kajimoto, T., Matsuura, Y., Yamashita, T., Matsuo, N., Yashiro, Y., Ripin, A., Kassim, A. R., & Noor, N. S. 2010. Estimation of root biomass based on excavation of individual root systems in a primary dipterocarp forest in Pasoh Forest Reserve, Peninsular Malaysia. *Journal of Tropical Ecology*, 26(03): 271-284.

7. References included in the database

Abd Rahman, K., & Hajar, Z. S. N. 2013. *Alternative Approach to Modelling Volume Equations for Multispecies Stand.* Paper presented at the 2nd International Symposium on Tropical Forest Ecosystem Science and Management: Challenges and Solutions, Universiti Putra Malaysia Bintulu Sarawak Campus.

Afzal-Ata, M., Noor, N. S. B. M., & Selvaraj, P. 1985. Local volume table for plantation Kapur (*Dryobalanops aromatica* Gaertn. f.) Sungai Puteh Forest Reserve (Federal Territory). *The Malaysian Forester*, 48(4): 276-287.

Appleton, N. S. 1980. Yield prediction models and economic rotations of unthinned (*Albizia falcataria* (Linn.) Fosb. plantation with different planting spacing. *Canopy International* , (January-February 1992): 4-8.

Ariffin, S. B. 2009. *Prediction model of Swietenia macrophylla Plantations survival and growth at Tawau Sabah.* Unpublished Thesis, Faculty of Forestry, Universiti Putra Malaysia.

Banaticla, M. R. N., Sales, R. F., & Lasco, R. D. 2007. Biomass equations for tropical tree plantation species using secondary data from the Philippines. *Annals of Tropical Research*, 29(3): 73-90.

Basuki, T. M., van Laake, P. E., Skidmore, A. K., & Hussin, Y. A. 2009. Allometric equations for estimating the above-ground biomass in tropical lowland Dipterocarp forests. *Forest Ecology and Management*, 257(8): 1684-1694.

Beadle, C. L., Trieu, D. T., & Harwood, C. E. 2013. Thinning increases saw-log values in fast-growing plantations of *Acacia* hybrid in Vietnam. *Journal of Tropical Forest Science*, 25(1): 42-51.

Bureau of Forest Development. 1987. Forest Resources of Region 2, *Philippine-German Forest Resources Inventory Project*: 86 p. Philippine-German: Department of Environment and Natural Resources.

Bureau of Forestry. 1963. Regional Volume Equations and Tables for Philippine Timber Species: 23 p.: U.S. Agency for International Development.

Cabral, D. E. 2007. *Non-linear height-diameter models for Yemane (Gmelina arborea Roxb.), Mangium (Acacia mangium Willd.), and Mahogany (Swietenia macrophylla King.) (in selected region in the Philippines.* Unpublished MSc Thesis, University of the Philippines Los Banos.

Cacanindin, D. C. 1982. *Tree volume, yield and economic rotation Kaatoan Bangkal Plantations in Agusan Del Norte*. Unpublished Thesis, University of the Philippines Los Banos.

Canonizado, J. A., & Buenaflor, V. D. 1977. Tree volume functions for the SJSB dipterocarp forest. *Working paper 1/77*. Forestry Department Headquarters, Peninsular Malaysia.

Chaiyo, U., Garivait, S., & Wanthongchai, K. 2011. Carbon storage in above-ground biomass of tropical deciduous forest in Ratchaburi Province, Thailand. *World Academy of Science, Engineering and Technology*, 58: 6.

Chandra, L. A., Seca, G., & Abu Hena, M. K. 2011. Aboveground biomass production of *Rhizophora apiculata* Blume in Sarawak mangrove forest. *American Journal of Agricultural and Biological Sciences*, 6(4): 469-474.

Chave, J., Andalo, C., Brown, S., Cairns, M. A., Chambers, J. Q., Eamus, D., Fölster, H., Fromard, F., Higuchi, N., Kira, T., Lescure, J. P., Nelson, B. W., Ogawa, H., Puig, H., Riéra, B., & Yamakura, T. 2005. Tree allometry and improved estimation of carbon stocks and balance in tropical forests. *Oecologia*, 145(1): 87-99.

Coulter, S., Duarte, C., & Tuan, M. 2001. Retrospective estimates of net leaf production in *Kandelia candel* mangrove forests. *Marine Ecology Progress Series*, vol. 221 117-124.

Cruz, V. C. d., & Bruzon, J. B. 2004. Volume equations/tables for falcata in Caraga Region. *Canopy International* (January- December 2014): 4-5.

Cuc, N., & Ninomiya, I. 2007. Allometric relations for young *Randella candel* (L.) Blanco lantation in Northern Vietnam. *Journal of Biological Sciences*, 7: 539-543.

Cuc, N. T. K., Ninomiya, I., Long, N. T., Nguyen Hoang Tri , Tuan, M. S., & Hong, P. N. 2009. Belowground carbon accumulation in young *Kandelia candel* (L.) Blanco plantations in Thai Binh river Mouth, Northern Vietnam. *International Journal of Ecology & Development*, Winter 2009; Vol. 12, No. W09 107-117.

Djailany, U. R. 1987. *Formation Vegetales Naturelles de Sumatra (Indonesie).Structure er Caracteristique Radiometrique*. Universite' Paul Sabatier de Toulouse.

FAO. 1971. Inventaire Forestier des Terres Basses du Versant Occidental des Monts Cardamome. Cambodge. Photo-Interpretation, Cartographie, Echantillonnage de Controle au Sol et Traitement des Donnees. Rome.

FAO. 1973. The Compilation of volume tables for the Mixed Dipterocarp Forest of Sarawak. Kuala Lumpur.

FAO. 1973. Forestry and forest industries development. Malaysia. A national forest inventory of West Malaysia, 1970-72., *DO/DP/MAL/72/009/TR5*: 259 p. Kuala Lumpur: FAO.

FAO. 1976. Advisory Services to Forest Industries Development of Kalimatan. Indonesia Forest Inventory Results. Jakarta.

FAO. 1998. Report on Establishment of a Forest Resources Inventory Process in Cambodia. Phnom Penh, Cambodia.

FAO. 2005. National forest assessment draft working paper. National Forest and Tree Resources Assessment 2003-2005. Manila: FAO-Forestry Department.

FAO & Ministry of Forestry Indonesia. 1996. National Forest Inventory of Indonesia. Final Forest Resources Statistics. Report, *FAO-FO-UTF/INS/066/INS. National Forest Inventory, Indonesia. Field document 55*. Jakarta.

Feldpausch, T. R., Banin, L., Phillips, O. L., Baker, T. R., Lewis, S. L., Quesada, C. A., Affum-Baffoe, K., Arets, E. J. M. M., Berry, N. J., Bird, M., Brondizio, E. S., de Camargo, P., Chave, J., Djagbletey, G., Domingues, T. F., Drescher, M., Fearnside, P. M., FranÃ§a, M. B., Fyllas, N. M., Lopez-Gonzalez, G., Hladik, A., Higuchi, N., Hunter, M. O., Iida, Y., Salim, K. A., Kassim, A. R., Keller, M., Kemp, J., King, D. A., Lovett, J. C., Marimon, B. S., Marimon-Junior, B. H., Lenza, E., Marshall, A. R., Metcalfe, D. J., Mitchard, E. T. A., Moran, E. F., Nelson, B. W., Nilus, R., Nogueira, E. M., Palace, M., PatiÃ±o, S., Peh, K. S.-H., Raventos, M. T., Reitsma, J. M., Saiz, G., Schrodt, F., SonkÃ©, B., Taedoumg, H. E., Tan, S., White, L., WÃ¶ll, H., & Lloyd, J. 2011. Height-diameter allometry of tropical forest trees. *Biogeosciences*, 8(5): 1081-1106.

Forest Department HQ. 1978. Mangrove poles volume study (to determine the appropriate conversion factor for Mangrove poles). Forestry Department Kuching, Sarawak.

Gartner, E. J. G., & Beuschel, G. K. 1963. Forest Inventory of the Northeastern Region, *Expanded Program of Technical Assistance*, Vol. Report No. 1692. Rome: FAO.

Hajar, Z. S. N., Shukri, W. A. W. M., Samsudin, M., Razali, W. M. W., & Ismail, H. 2010. Development of local volume table for second growth forests using standing tree measurements. *The Malaysian Forester*, 73(2): 163-170.

Halenda, C. J. 1988. The ecology of an *Acacia mangium* plantation established after shifting cultivation in Niah Forest Reserve. Forest Research Report. *F. Ecol. 1.* Forest Department Kuching Sarawak.

Halenda, C. J. 1988. The Ecology of a *Gmelina arborea* plantation established after shifting cultivation in Niah Forest Reserve. Forest Research Report. *F. Ecol. 2.* Forest Department Kuching Sarawak.

Halenda, C. J. 1988. The Ecology of a *Leucaena leucocephala* plantation established after shifting cultivation in Niah Forest Reserve. Forest Research Report. *F. Ecol. 3.* Forest Department Kuching Sarawak.

Hamzah, K. A., & Mohamed, A. H. 1994. Volume equations and tables for Teak (*Tectona grandis* linn) in Mata Ayer, Perlis, Malaysia *FRIM Reports No. 65*: 19-33: Forest Research Institute Malaysia.

Hashimoto, K. 1984. Interim tree volume tables for four plantation species in Sabah: 28. Sandakan, Sabah: Forest Research Centre, Forest Department Sabah.

Heineman, K. D., Jensen, E., Shapland, A., Bogenrief, B., Tan, S., Rebarber, R., & Russo, S. E. 2011. The effects of belowground resources on aboveground allometric growth in Bornean tree species. *Forest Ecology and Management*, 261(11): 1820-1832.

Heng, R. K. J., & Tsai, L. M. 1999. An Estimate of Forest Biomass in Ayer Hitam Forest Reserve. *Pertanika*, 22(2): 117-123.

Heriansyah, I., Abdul Hamid, H., Ainudin Nuruddin, A., Abdu, A., & Ibrahim, S. 2013. Measuring the Short-term Success of Hill Dipterocarp Forest Restoration: The Use of Organic Materials. *Journal of Agricultural Science*, 5(1): 230-240.

Hiratsuka, M., Toma, T., Mindawati, N., Heriansyah, I., & Morikawa, Y. 2005. Biomass of a man-made forest of timber tree species in the humid tropics of West Java, Indonesia. *Journal of Forest Research*, 10(6): 487-491.

Hoshizaki, K., Niiyama, K., Kimura, K., Yamashita, T., Bekku, Y., Okuda, T., Quah, E. S., & Noor, N. S. M. 2004. Temporal and spatial variation of forest biomass in relation to stand dynamics in a mature, lowland tropical rainforest, Malaysia. *Ecological Research*, 19(3): 357-363.

Hossain, M., Othman, S., Bujang, J. S., & Kusnan, M. 2008. Net primary productivity of *Bruguiera parviflora* (Wight & Arn.) dominated mangrove forest at Kuala Selangor, Malaysia. *Forest Ecology and Management*, 255(1): 179-182.

Hozumi, K., Yoda, K., Kokawa, S., & Kira, T. 1969. Production ecology of tropical rain forests in southwestern Cambodia in nature and life in Southeast Asia. *Production Ecology of Rain Forests in Cambodia 1*, 6: 1-51.

Huong, V. D., Tung, P. V., Dung, P. T., Phuc, H. V., Binh, N. T., Duc, H. M., & Tron, N. T. 2003. Site management and productivity of Acacia auriculariformis Ppantations in South Vietnam. Paper presented at the Site management and productivity in tropical plantation forests, Proceedings of workshops in Congo, July 2001 and China, February 2003.

Huong, V. D., Tung, P. V., Dung, P. T., Phuc, H. V., Binh, N. T., Duc, H. M., & Tron, N. T. 2003. *Site Management and Productivity of Acacia auriculiformis Plantations in South Vietnam*. In Nambiar, E.K.S., Ranger, J., Tiarks, A., & Toma, T. (Eds.), Site management and productivity in tropical plantation forests, Proceedings of workshops in Congo, July 2001 and China, February 2003.

Huy, B. 2010. CO_2 Sequestration Estimation for the Litsea-Cassava Agroforestry Model in Mang Yang District, Gia Lai Province in the Central Highlands of Vietnam, Vietnam Nework for Agroforestry Education – VNAFE.

Ibrahim, S. 1980. Construction of local volume table for Kembang Semangkok (*Scaphium spp*.). *Symposium on Mensurational Problems of Forest Inventory in Southeast Asia*, 26-28 June 1980, Bogor, Indonesia.

Istomo, Wibowo, C., & Wibisono, I. T. C. 2009. *Plant diversity and biomass content in relation to wise use of tyropical peat land*. Proceedings of Bogor Symposium and Workshop on Tropical Peatland Management, 14-15 July 2009, Wise Use of Tropical Peatland, Bogor, Indonesia

Itoh, A., Yamakura, T., & Lee, H. S. 1999. Effects of light intensity on the growth and allometry of two bornean Dyobalanops (Dipterocarpaceae) seedlings. *Journal of Tropical Forest Science*, 11(3): 610-618.

Jimin, D. 2002. *Local Volume Table for Mangrove Forest, Pantai Kelang Forest Reserve, Selangor*. Unpublished Thesis, Faculty of Forestry ,University Putra Malaysia.

Kamaruzaman Jusoff, H. 2008. Estimating *Acacia mangium* Plantation's Standing Timber Volume Using an Airborne Hyperspectral Imaging System. *The Open Forest Science Journal*, 1: 61-67.

Kasim, M. R. M., & Tee, W. P. 2009. Relationship between tree height and diameter at breast height for a 16-year old stand of *Hopea keranganensis* in Sarawak. *The Malaysian Forester*, 72(2): 261-264.

Kato, R., Tadaki, Y., & Ogawa, H. 1978. Plant biomass and growth increment studies in Pasoh Forest. *Malayan Nature Journal*, 30(2): 221-224.

Kendawang, J. J., Ninomiya, I., Tanaka, K., Ozawa, T., Hattori, D., Tanaka, S., & Sakurai, K. 2007. Effects of burning strength in shifting cultivation on the early stage of secondary succession in Sarawak, Malaysia. *Tropics*, 16(4): 309-321.

Kenzo, T., Furutani, R., Hattori, D., Kendawang, J., Tanaka, S., Sakurai, K., & Ninomiya, I. 2009. Allometric equations for accurate estimation of above-ground biomass in logged-over tropical rainforests in Sarawak, Malaysia. *Journal of Forest Research*, 14(6): 365-372.

Kenzo, T., Ichie, T., Hattori, D., Itioka, T., Handa, C., Ohkubo, T., Kendawang, J. J., Nakamura, M., Sakaguchi, M., Takahashi, N., Okamoto, M., Tanaka-Oda, A., Sakurai, K., & Ninomiya, I. 2009. Development of allometric relationships for accurate estimation of above- and below-ground biomass in tropical secondary forests in Sarawak, Malaysia. *Journal of Tropical Ecology*, 25(04): 371-386.

Ketterings, Q. M., Coe, R., van Noordwijk, M., Ambagau', Y., & Palm, C. A. 2001. Reducing uncertainty in the use of allometric biomass equations for predicting above-ground tree biomass in mixed secondary forests. *Forest Ecology and Management*, 146(1–3): 199-209.

Khalid, H., Zin, Z. Z., & Anderson, J. M. 1999. Quantification of oil palm biomass and nutrient value in a mature plantation. I, above-ground biomass. *Journal of Oil Palm Research*, 2(1): 23-32.

Kiyono, Y., Ochiai, Y., Chiba, Y., Asai, H., Saito, K., Shiraiwa, T., Horie, T., Songnoukhai, V., Navongxai, V., & Inoue, Y. 2007. Predicting chronosequential changes in carbon stocks of pachymorph bamboo communities in slash-and-burn agricultural fallow, northern Lao People's Democratic. *Canadian Journal of Forest Research*, 12: 371-383.

Komiyama, A., Havanond, S., Srisawatt, W., Mochida, Y., Fujimoto, K., Ohnishi, T., Ishihara, S., & Miyagi, T. 2000. Top/root biomass ratio of a secondary mangrove (*Ceriops tagal* (Perr.) C.B. Rob.) forest. *Forest Ecology and Management,* 139(1–3): 127-134.

Komiyama, A., Poungparn, S., & Kato, S. 2005. Common allometric equations for estimating the tree weight of mangroves. *Journal of Tropical Ecology*, 21(04): 471-477.

Krisnawati, H., Adinugroho, W. C., & Imanuddin, R. 2012. Monograph Allometric Models for Estimating Tree Biomass at Various Forest Ecosystem Types in Indonesia. Research and Development Center for Conservation and Rehabilitation, Forestry Research and Development Agency, Ministry of Forestry. Bogor, Indonesia

Kudus, K. A. 2006. *Survival Analysis Models for Interval Censored Data with Applications to an Acacia mangium Plantation Spacing Trial*. Unpublished PhD Thesis, School of Biological Sciences, The University of Reading, UK.

Kudus, K. A., Zainor, M. Z., Chia, F. R., Lapongan, J., & Pang, K. N. K. 2011. Modelling Growth of *Swietenia macrophylla* (Mahogany) Plantation at Kolapis, Sabah. *The Malaysian Forester*, 74(1): 69-78.

Kwan, W. Y. 1966. Possibility of using a multi-species local volume table to estimate the total volume in lowland dipterocarp forest. *The Malayan Forester*, 29(4): 259-267.

Lamwilai, W. 1973. *Volume equation and table of Rhizophora apiculata*. Unpublished MSc Thesis, University of the Philippines Los Banos.

Lapongan, J., Chia, F. R., & Pang, K. K. N. 2012. A local volume table for teak (*Tectona grandis*) planted at Segaliud Lokan Forest Plantation Research Station. In Forestry Department Sabah (Ed.), *Sepilok Bulletin*, Vol. 15&16: 37-46. Forestry Department Sabah.

Lasmarias, V. T. 1979. *Stem form, bark thickness, bark volume, total and merchantable volume of Benguet Pine trees*. Unpublished MSc Thesis, University of the Philippines Los Banos.

Lasmarias, V. T. 1979. Taper, bark thickness and merchantable volume of benguet pines. *Canopy International* , January-February 1992: 4-8.

Letourneau, L. R. 1976. Another method of determining the volume of logs. *The Malaysian Forester*, 39(2): 81-82.

Lim, M. T., & Jimbat, T. 1983. Biomass of understorey plants between 1.5 and 5.0m in a logged-over forest. *Pertanika*, 6(1): 1-7. Cek balik pertanika yang sebelum ini

Lindgren, O. 1983. Installation of FIDAPS in Malaysia (March/May 1983), *GCP/INT/311/SWE*. Rome: FAO.

Lumbres, R. I. C., Lee, Y. J., & Seo, Y. O. 2012. Development of height-dbh growth model and biomass estimation of *Pinus kesiya* Royle Ex Gordon in La Trinidad, Benguet, Philippines. *Asia Life Sciences* 21(1): 177-188.

Majid, N. K. S. A. 2012. *Aboveground Biomass and Carbon Stock Estimation in Logged-Over Tropical Lowland Forest*. Unpublished MSc Thesis, Faculty of Forestry, Universiti Putra Malaysia.

Manggil, P. 1982. Mangrove cordwood volume-weight conversion study: 19. Report No. U/14. Forest Department Headquarters, Kuching, Sarawak.

Manila, A. C. 1991. Mensurational studies of red lauan (*Shorea negronensis* Foxworthy). *Sylvatrop Tech. J.*, 1(2): 75-90.

Miyakuni, K., Heriansyah, I., Heriyanto, N. M., & Kiyono, Y. 2004. Allometric biomass equations, biomass expansion factors and root-to-shoot ratios of planted Acacia mangium Willd. Forests in West Java, Indonesia. *Japan Society of Forest Planning*, 10: 69-76.

Miyamoto, K., Rahajoe, J. S., Kohyama, T., & Mirmanto, E. 2007. Forest Structure and Primary Productivity in a Bornean Heath Forest. ***Biotropica***, 39(1): 35-42.

Mohd, W. R. W., Maidin, R., Sujan, M. A., & Zain, J. M. 1983. Double entry volume table equations for some RRIM 600 Series clones of *Hevea brasiliensis*. *The Malaysian Forester*, 46(1): 46-59.

Mohd, W. R. W., Hamzah, K. A., & Chew, T. K. 1989. A volume table for planted Acacia mangium in Peninsular Malaysia. *Journal of Tropical Forest Science*, 2(2): 110-121.

Muller-Landau, H. C., Condit, R. S., Chave, J., Thomas, S. C., Bohlman, S. A., Bunyavejchewin, S., Davies, S., Foster, R., Gunatilleke, S., Gunatilleke, N., Harms, K. E., Hart, T., Hubbell, S. P., Itoh, A., Kassim, A. R., LaFrankie, J. V., Lee, H. S., Losos, E., Makana, J.-R., Ohkubo, T., Sukumar, R., Sun, I. F., Nur Supardi, M. N., Tan, S., Thompson, J., Valencia, R., Muñoz, G. V., Wills, C., Yamakura, T., Chuyong, G., Dattaraja, H. S., Esufali, S., Hall, P., Hernandez, C., Kenfack, D., Kiratiprayoon, S., Suresh, H. S., Thomas, D., Vallejo, M. I., & Ashton, P. 2006. Testing metabolic ecology theory for allometric scaling of tree size, growth and mortality in tropical forests. *Ecology Letters*, 9(5): 575-588.

Ng, Y. M., Kudus, K. A., Chia, F. R., Lapongan, J., & Pang, K. N. K. 2009. Modelling Growth of *Swietenia macrophylla* (Mahogany) Plantation in Gum Gum Forest Reserve Sabah. *The Malaysian Forester*, 72(2): 209-218.

Niiyama, K., Kajimoto, T., Matsuura, Y., Yamashita, T., Matsuo, N., Yashiro, Y., Ripin, A., Kassim, A. R., & Noor, N. S. 2010. Estimation of root biomass based on excavation of individual root systems in a primary dipterocarp forest in Pasoh Forest Reserve, Peninsular Malaysia. *Journal of Tropical Ecology*, 26(03): 271-284.

Nivelle, J. L. 1975. Rapport sur l'Inventaire des Pinarais du Phou Ka Kwi: 56 p.: FAO.

Okuda, T., Suzuki, M., Numata, S., Yoshida, K., Nishimura, S., Adachi, N., Niiyama, K., Manokaran, N., & Hashim, M. 2004. Estimation of aboveground biomass in logged and primary lowland rainforests using 3-D photogrammetric analysis. *Forest Ecology and Management*, 203(1–3): 63-75.

Ong, J. E., Gong, W. K., & Wong, C. H. 2004. Allometry and partitioning of the mangrove, *Rhizophora apiculata*. *Forest Ecology and Management*, 188(1–3): 395-408.

Ounekham, K. 2009. *Developing volume and taper equations for Styrax tonkinensis in Laos*. Unpublished MFSc Thesis, University of Canterbury New Zealand.

Parlan, I., Kassim, A. R., Ahmad, W. M. S. W., Musa, S., & Osman, H. 2011. Development of a local volume table (LVT) for *Gonystylus bancanus* in Pekan Forest Reserve in technical information on optimum harvesting regimes of peat swamp forests in Peninsular Malaysia. *Technical Information on Optimum Harvesting Regimes of Peat Swamp Forests in Peninsular Malaysia*: 73-79.

Persad, V. 1991. Volume table of *Acacia mangium* and *Gmelina arborea*, *Project WB 3.5.* Tawau, Sabah: Sabah Softwoods Sdn. Bhd.

Revilla, A. V. J. 1982. Wood yield prediction models for *Leucaena* plantations in the Philippines. *Canopy International*. January-February 1992: 4-8.

Roland, K. J. H., Majid, N. M., Seca, G., & Ahmed, O. H. 2011. Total aboveground biomass of selected age stand of a rehabilitated forest. *Rehabilitation of Tropical Rainforest Ecosystems*(24-25 October 2011): 53-58.

Rollet, B. 1962. Inventaire Forestier de L'est du Mekong *Programme Elargi D'Assistance Technique Rapport No. 1500*. Rome: FAO.

Sabah-Malaysia, F. D. 2006. *Measurement of Timber for Royalti Assessment*. Sandakan, Sabah.

Sandrasegaran, K. 1966. A local volume table for Yemani (*Gmelina arborea* Roxb.). *The Malayan Forester*, 29(2): 97-101.

Sandrasegaran, K. 1966. A fuelwood volume table for *Eucalyptus robusta* Sm. *The Malayan Forester*, 29(2): 112-115.

Sandrasegaran, K. 1966. A local volume table for Tembusu (*Fagraea fragrans* Ridl.). *The Malayan Forester*, 29(1): 37-38.

Sandrasegaran, K. 1966. Provisional local volume tables for Teak (*Tectona grandis* Linn. F.). *The Malayan Forester*, 29(1): 39-40.

Sandrasegaran, K. 1967. A local volume table for *Eucalyptus grandis*. *The Malayan Forester*, 30(3): 207-211.

Sandrasegaran, K. 1968. A general volume table for *Pinus caribea* Mor. *The Malayan Forester*, 31(1): 20-27.

Sandrasegaran, K. 1969. A general volume table for *Tectona grandis* Linn. (Teak) grown in North-West Malaya. *The Malayan Forester*, 32(2): 187-200.

Sandrasegaran, K. 1970. A standard volume table for *Pinus merkusii* Jungh & de Vriese grown in the Forest Research Institute plantation in Malaya. *The Malayan Forester*, 33(1): 80-91.

Sandrasegaran, K. 1972. A general volume table for *Rhizophora apiculata* Bl. (Syn. *Rhizophora conjugata* Linn.) (Bakau minyak) in Matang Mangrove, Taiping, West Malaysia, incorporating a brief history of tree volume table construction in Malaya. *The Malayan Forester*, 34(1): 24-36.

Santos Martin, F., Navarro-Cerrillo, R. M., Mulia, R., & Noordwijk, M. 2010. Allometric equations based on a fractal branching model for estimating aboveground biomass of four native tree species in the Philippines. *Agroforestry Systems,* 78(3): 193-202.

Sarawak, F. D. 1978. Net Industrial Stemwood Volume for the Mixed Dipterocarp Forests of Sarawak. In M. a. P. O. Computing Section, Forest Department, Kuching (Ed.). Kuching, Sarawak: Forest Department Sarawak.

Tandug, L. M. 1986. *Biomass Prediction Equations for Giant Ipil-ipil (Leucaena leucocephala (Lam.) de Wit)*. Unpublished PhD Thesis, University of the Philippines Los Banos.

Tandug, L. M. 1992. Development of volume equations for the Philippine Forests. *Canopy International* (January-February 1992): 4-8.

Tandug, L. M., Lanting, M. V., Umali, P. A., & Lantican, N. L. M. 2010. Allometry of aboveground biomass and carbon content of forest tree species. *Canopy International*, 36(1-6): 2,10,12.

Terakunpisut, J., Gajaseni, N., & Ruankawe, N. 2007. Carbon sequestration potential in aboveground biomass of thong Pha Phum national forest, Thailand. *Applied ecology and environmental research*, 5(2): 93-102.

Thomas, S. C. 1993. *Interspecific Allometry in Malaysian Rain Forest Trees*. Published PhD Thesis, Harvard University.

Tin, M., Myint, T., Kyaw, S., & Thein, P. 1973. A Review of Forest Inventory in Burma (1963-1972): 1-109. Rangoon Myanmar: The Revolutionary Government of the Union of Burma.

Toma, T., Ishida, A., & Matius, P. 2005. Long-term monitoring of post-fire aboveground biomass recovery in a lowland dipterocarp forest in East Kalimantan, Indonesia. *Nutrient Cycling in Agroecosystems*, 71(1): 63-72.

Tomboc, C. C. 1976. Growth, yield and economic rotation of bagras pulp timber in the PICOP plantations. *Canopy International* , (January-February 1992): 4-8.

Tsai, L. M. 1986. Biomass and productivity of 4.5 year-old *Acacia mangium* in Sarawak. *Pertanika*, 9(1): 81-87.

Tsai, L. M., & Hamzah, M. B. 1985. Biomass accumulation in a naturally regenerating lowland secondary forest and an *Acacia mangium* stand in Sarawak. *Pertanika*, 8(2): 237-242.

USAID. 1962. Forest Inventory Manual.Techniques and Procedures for Cambodia.

Uriarte, M. T., & Pinol, A. A. 1996. Tree volume, yield prediction and economic rotation of *Albizia falcataria* in Mindanao, Philippines. *Journal of Tropical Forest Science*, 8(3): 289-299.

Van Do, T., Osawa, A., & Thang, N. T. 2010. Recovery process of a mountain forest after shifting cultivation in Northwestern Vietnam. *Forest Ecology and Management*, 259(8): 1650-1659.

Vincent, A. J., & Sandrasegaran, K. 1965. *Commercial General Volume Tables for the Commercially More Important Indigenous Forest Tree Species of Inland Forest, Malaya*. Malayan Forest Record No. 24. Forest Research Institute, Malaya.

Virtucio, F. D *et al.* 1984. Determination of taper, bark thickness and volume of commercial tree species. Terminal Report . Forest Research Institute, College, Laguna

Wilson, N. 2011. Biomass and Regeneration of Mangrove vegetation in Kien Giang Province, Vietnam. Conservation and Development of the Kien Giang Biosphere Reserve Project Report.

Yok, T. P., Yeo, B., Xi, Y. W., & Keong, L. H. 2009. *Carbon storage and sequestration by urban trees in Singapore*: Centre for Urban Greenery and Ecology (CUGE).

Yuan, C. T., Mahmud, N. A., & Nawi, S. 1997. Inventori Hutan Nasional Ketiga: Semenanjung Malaysia. 13-15. Jabatan Perhutanan Semenanjung Malaysia.

Yuliasmara, F., & Wibawa, A. 2007. Carbon Stock Measurement in Cocoa Plantation trough Plant Biomass Approach. *Warta Pusat Penelitían dan Kakao Indonesia*, 23(3): 149-158.

Zemek, O. J. 2009. *Biomass and Carbon Stocks Inventory of Perennial Vegetation in the Chieng Khoi Watershed, Nw Viet nam*. Unpublished MSc Thesis, University of Hohenheim, Stuttgart.

8. Appendices

Appendix 1. List of Contacts.

Country	Name	Institution	e-mail
Brunei	Kamariah Abu Salim	Universiti Brunei Darussalam	kamariah.salim@ubd.edu.bn
Laos	Silavanh Sawathvong	Department of Forestry (DOF)	Sawathvong@yahoo.com
Laos	Georg Buchholz	GIZ Climate Protection through Avoided Deforestation (CliPAD), Department of Forestry, Laos	georg.buchholz@giz.de
Laos	Tongyang Ardphasoukmoua	GIZ Climate Protection through Avoided Deforestation (CliPAD), Department of Forestry, Laos	tongyang.ardphasoukmoua@giz.de
Laos	Somsy Gnophanxay	National University of Laos	nhophanxays@yahoo.com
Laos	Savanh Chanthakoummane	REDD+ office and UN-REDD focal point	chanthakoummane_2012@yahoo.com
Malaysia	Noraishah Safee	Forest Research Institute Malaysia	noraishah@frim.gov.my
Malaysia	Nur Hajar Zamah Shari	Forest Research Institute Malaysia	hajar@frim.gov.my
Malaysia	Stephen Jilimin	Kumpulan Yayasan Sabah	sjilimin@icsb-sabah.com.my
Malaysia	Esther Dyi Ka Mei	Sabah Forestry Department	EstherDyiKa.Mei@sabah.gov.my
Malaysia	Jaffirin Lapongan	Sabah Forestry Department	Jaffirin.Lapongan@sabah.gov.my
Malaysia	James Josue	Sabah Forestry Department	James.Josue@sabah.gov.my
Malaysia	Jupiri Titin	Sabah Forestry Department	Jupiri.Titin@sabah.gov.my
Malaysia	Zamrie Imiyabir	Sabah Forestry Department	zamrie.imiyabir@sabah.gov.my
Malaysia	Malcom Demies	Sarawak Forestry Corporation	malcom@sarawakforestry.com
Malaysia	Zolkipli Mohamad Aton	Sarawak Forestry Corporation	zolaton@sarawakforestry.com
Malaysia	Normah Awang Besar@Raffie	Universiti Malaysia Sabah	normabr@ums.edu.my
Malaysia	Phua Mui How	Universiti Malaysia Sabah	pmh@ums.edu.my
Malaysia	Hazandy Abdul Hamid	Universiti Putra Malaysia	hazandy@upm.edu.my
Malaysia	Kamziah Abd. Kudus	Universiti Putra Malaysia	kamziah@upm.edu.my
Malaysia	Nur Kyariatul Syafinie Abdul Majid	Universiti Putra Malaysia	syafiniemajid25@gmail.com
Malaysia	Ong Kian Huat	Universiti Putra Malaysia	ong@btu.upm.edu.my

Malaysia	Nur Farika Zani	Universiti Teknologi Mara	ika_mim88@yahoo.com
Myanmar	Bui Thi Lan	FAO-Myanmar	BuiThi.Lan@FAO.ORG
Myanmar	Zan Rachelle	FAO-Myanmar	Rachelle.Zan@FAO.ORG
Myanmar	Zaw Win Myint	Forest Research Institute, Forest Department Yerin, Nay-Pyi-Taw, Myanmar	ap.zawm@gmail.com
Myanmar	Nyi Nyi Kyaw	Forest Research Institute, Myanmar	TEAKNET@mptmail.net.mm
Myanmar	Than Naing Win	Forest Research Institute, Myanmar	tnwin36@gmail.com
Myanmar	U Ohn	Forest Resource Environment Development And Conservation Association (FREDA)	freda@mptmail.net.mm
Myanmar	U Soe Win	Friends Of Rainforest Myanmar (FORM)	form@myanmar.com.mm
Myanmar	Nyein Chan	Kyoto University, Graduate School of Asian and African Area Studies	nchan08@gmail.com
Philippines	Genaro Castro	FAO-Philippines	genaro.castro@fao.org
Philippines	Joy L. Masongsong	FAO-Philippines	Joy.Masongsong@fao.org
Philippines	Toshihiro Tanaka	FAO-Philippines	FAO-PH@fao.org
Philippines	Ma. Dolores C. Tongco	Institute of Biology, University of the Philippines Diliman	mdctongco@gmail.com
Philippines	Sandra Yap	Institute of Biology, University of the Philippines Diliman	slimyap@gmail.com
Philippines	Perry Ong	Institute of Biology, University of the Philippines Diliman	ongperry@yahoo.com
Philippines	Annie Evangelista	University library, University of the Philippines Los Banos	agris_phils@yahoo.com.ph
Philippines	Leuvina M. Tandug	University of the Philippines Los Banos	lmtandug@yahoo.com
Philippines	Rodel D. Lasco	World Agroforestry Centre	r.lasco@cgiar.org
Singapore	Lum Shawn Kaihekulani Yamauchi	Natural Sciences & Science Education, Singapore	shawn.lum@nie.edu.sg
Thailand	Teerawong Laosuwan	Faculty of Science, Mahasarakham University	teerawong@msu.ac.th
Thailand	Ben Vickers	FAO Regional Office for Asia and the Pacific	ben.vickers@fao.org
Thailand	Khun Preecha	Thailand	preecha_ong@yahoo.com

Appendix 2. List of Institutes/Libraries that contributed documents to the database.

No.	Name of Department	Address	Tel. Number	Fax Number	Email
1.	Forest Research Institute Malaysia (FRIM)	Library, Forest Research Institute Malaysia (FRIM) 52109 Kepong Selangor Darul Ehsan, Malaysia	+603-62797497		feedback @frim.gov.my
2.	Universiti Putra Malaysia (UPM)	Resource Centre, Faculty of Forestry, Universiti Putra Malaysia 43400 UPM Serdang Malaysia	+603-89467171	+603-89432514	dean.forr@upm.my
3.	Forest Research Centre Sabah (FRC)	Library, Forest Research Centre Sabah (FRC) P.O. Box 1407, 90715 Sandakan, Sabah Malaysia	+60-89-531522/3/4	+60-89-531068	frcsabah@sabah.gov.my / frc@tm.net.my
4.	Sarawak Forestry Department	Library, Sarawak Forestry Department, 14th Floor, Wisma Sumber Alam, Jalan Stadium, Petra Jaya, 93660 Kuching, Sarawak Malaysia	+6082-31 9102	+6082-44 1377	
5.	Yayasan Sabah	Tun Haji Mohd. Fuad Stephens Borneo Research Library, Menara Tun Mustapha Yayasan Sabah Headquarters Complex Likas Bay P. O. Box 11201 88813 Kota Kinabalu, Sabah Malaysia	+6088-326300 / +6088-326489	+6088-326490 +6088 326424	library@ysnet.org.my
6.	Universiti Malaysia Sabah (UMS)	Resource Centre, School of International Tropical Forestry (SPTA), Universiti Malaysia Sabah, Jalan UMS, 88400, Kota Kinabalu, Sabah, Malaysia	+6088-320000 ext. 8772/8880/8583	+6088-320876	pejspta@ums.edu.my

7.	University of Philippines Los Banos	Library, College of Forestry and Natural Resources Tamesis Hall, Forestry Campus University of the Philippines Los Baños College, Laguna Philippines 4031	+63 (049) 536 3996	+63 (049) 536 2306	docfnr@uplb.edu.ph
8.	Office GIZ-Forestry Department Forestry of Laos	Climate Protection through Avoided Deforestation (CliPAD) Department of Forestry, Ministry of Agriculture and Forestry Laos	+856 21 254082		georg.buchholz@giz.de

Appendix 3. Information on species covered by the 4 types of allometric equations (and RTSR) available in the database.

No.	SPECIES	VOLUME		BIOMASS		CARBON STOCK		HEIGHT-DIAMETER		ROOT-TO-SHOOT-RATIO		TOTAL	
		Number	**%**	**Number**	**%**	**Number**	**%**	**Number**	**%**	**Number**	**%**	**Number**	**%**
1	*Acacia mangium*	0	0.00	1	0.08	0	0.00	0	0.00	0	0.00	1	0.04
2	*Acacia auriculiformis*	6	0.67	3	0.23	0	0.00	0	0.00	0	0.00	9	0.37
3	*Acacia crassicarpa*	0	0.00	7	0.54	0	0.00	0	0.00	0	0.00	7	0.29
4	*Acacia mangium*	66	7.36	114	8.73	0	0.00	6	2.40	0	0.00	186	7.58
5	*Acacia sp.*	1	0.11	0	0.00	0	0.00	0	0.00	0	0.00	1	0.04
6	*Agathis labillardieri*	2	0.22	0	0.00	0	0.00	0	0.00	0	0.00	2	0.08
7	*Agathis loranthifolia*	6	0.67	4	0.31	0	0.00	0	0.00	0	0.00	10	0.41
8	*Agathis sp.*	4	0.45	0	0.00	0	0.00	0	0.00	0	0.00	4	0.16
9	*Albizia falcataria*	6	0.67	0	0.00	0	0.00	0	0.00	0	0.00	6	0.24
10	*Alphitonia philippinensis*	1	0.11	0	0.00	0	0.00	0	0.00	0	0.00	1	0.04
11	*Alstonia scholaris*	6	0.67	0	0.00	0	0.00	0	0.00	0	0.00	6	0.24
12	*Alstonia sp.*	5	0.56	0	0.00	0	0.00	0	0.00	0	0.00	5	0.20
13	*Altingia excelsa*	9	1.00	0	0.00	0	0.00	0	0.00	0	0.00	9	0.37
14	*Anthocephalus chinensis*	3	0.33	0	0.00	0	0.00	0	0.00	0	0.00	3	0.12
15	*Aporusa aurea*	0	0.00	0	0.00	0	0.00	1	0.40	0	0.00	1	0.04
16	*Aporusa bracteosa*	0	0.00	0	0.00	0	0.00	1	0.40	0	0.00	1	0.04
17	*Aporusa falciflera*	0	0.00	0	0.00	0	0.00	1	0.40	0	0.00	1	0.04
18	*Aporusa globifera*	0	0.00	0	0.00	0	0.00	1	0.40	0	0.00	1	0.04
19	*Aporusa lunata*	0	0.00	0	0.00	0	0.00	1	0.40	0	0.00	1	0.04
20	*Aporusa microstachya*	0	0.00	0	0.00	0	0.00	1	0.40	0	0.00	1	0.04
21	*Aporusa nigricans*	0	0.00	0	0.00	0	0.00	1	0.40	0	0.00	1	0.04
22	*Aporusa prainiana*	0	0.00	0	0.00	0	0.00	1	0.40	0	0.00	1	0.04
23	*Aporusa sp. 1*	0	0.00	0	0.00	0	0.00	1	0.40	0	0.00	1	0.04
24	*Aporusa sp. 2*	0	0.00	0	0.00	0	0.00	1	0.40	0	0.00	1	0.04

25	*Aporusa symplocoides*	0	0.00	0	0.00	0	0.00	1	0.40	0	0.00	1	0.04
26	*Araucaria cunninghamii*	4	0.45	0	0.00	0	0.00	0	0.00	0	0.00	4	0.16
27	*Araucaria hunsteinii*	3	0.33	0	0.00	0	0.00	0	0.00	0	0.00	3	0.12
28	*Artocarpus heterophyllus*	0	0.00	3	0.23	0	0.00	0	0.00	0	0.00	3	0.12
29	*Avicennia marina*	0	0.00	3	0.23	0	0.00	0	0.00	0	0.00	3	0.12
30	*Avicennia sp.*	0	0.00	1	0.08	0	0.00	0	0.00	0	0.00	1	0.04
31	*Baccaurea gigantea*	0	0.00	0	0.00	0	0.00	1	0.40	0	0.00	1	0.04
32	*Baccaurea parviflora*	0	0.00	0	0.00	0	0.00	1	0.40	0	0.00	1	0.04
33	*Baccaurea racemosa*	0	0.00	0	0.00	0	0.00	1	0.40	0	0.00	1	0.04
34	*Baccaurea reticulata*	0	0.00	0	0.00	0	0.00	1	0.40	0	0.00	1	0.04
35	*Baccaurea sumatrana*	0	0.00	0	0.00	0	0.00	1	0.40	0	0.00	1	0.04
36	*Bischofia javanica*	1	0.11	0	0.00	0	0.00	0	0.00	0	0.00	1	0.04
37	*Bruguiera gymnorrhiza*	1	0.11	7	0.54	0	0.00	0	0.00	0	0.00	8	0.33
38	*Bruguiera parviflora*	0	0.00	19	1.45	0	0.00	0	0.00	0	0.00	19	0.77
39	*Bruguiera sexangula*	0	0.00	4	0.31	0	0.00	0	0.00	0	0.00	4	0.16
40	*Bruguiera sp.*	7	0.78	12	0.92	0	0.00	0	0.00	0	0.00	19	0.77
41	*Calophyllum sp.*	2	0.22	0	0.00	0	0.00	0	0.00	0	0.00	2	0.08
42	*Calopyllum sp.*	5	0.56	0	0.00	0	0.00	0	0.00	0	0.00	5	0.20
43	*Camnosperma sp.*	1	0.11	0	0.00	0	0.00	0	0.00	0	0.00	1	0.04
44	*Canarium sp.*	3	0.33	0	0.00	0	0.00	3	1.20	0	0.00	6	0.24
45	*Casuarina equisetifolia*	1	0.11	0	0.00	0	0.00	0	0.00	0	0.00	1	0.04
46	*Ceriops sp.*	0	0.00	1	0.08	0	0.00	0	0.00	0	0.00	1	0.04
47	*Ceriops tagal*	0	0.00	3	0.23	0	0.00	0	0.00	0	0.00	3	0.12
48	*Coffea sp.*	0	0.00	1	0.08	0	0.00	0	0.00	0	0.00	1	0.04
49	*Cotylelobium burckii*	0	0.00	4	0.31	0	0.00	0	0.00	0	0.00	4	0.16
50	*Dacrydium sp.*	0	0.00	3	0.23	0	0.00	0	0.00	0	0.00	3	0.12
51	*Dactylocladus stenostachys*	4	0.45	0	0.00	0	0.00	0	0.00	0	0.00	4	0.16
52	*Dalbergia latifolia*	7	0.78	1	0.08	0	0.00	0	0.00	0	0.00	8	0.33

53	*Dalbergia sisoides*	2	0.22	0	0.00	0	0.00	0	0.00	0	0.00	2	0.08
54	*Dehaasia triandra*	1	0.11	0	0.00	0	0.00	0	0.00	0	0.00	1	0.04
55	*Diospyros adenophora*	0	0.00	0	0.00	0	0.00	1	0.40	0	0.00	1	0.04
56	*Diospyros apiculata*	0	0.00	0	0.00	0	0.00	1	0.40	0	0.00	1	0.04
57	*Diospyros cauliflora*	0	0.00	0	0.00	0	0.00	1	0.40	0	0.00	1	0.04
58	*Diospyros celebica*	1	0.11	0	0.00	0	0.00	0	0.00	0	0.00	1	0.04
59	*Diospyros latisepala*	0	0.00	0	0.00	0	0.00	1	0.40	0	0.00	1	0.04
60	*Diospyros maingayi*	0	0.00	0	0.00	0	0.00	1	0.40	0	0.00	1	0.04
61	*Diospyros nutans*	0	0.00	0	0.00	0	0.00	1	0.40	0	0.00	1	0.04
62	*Diospyros pendula*	0	0.00	0	0.00	0	0.00	1	0.40	0	0.00	1	0.04
63	*Diospyros scortechinii*	0	0.00	0	0.00	0	0.00	1	0.40	0	0.00	1	0.04
64	*Diospyros wallichii*	0	0.00	0	0.00	0	0.00	1	0.40	0	0.00	1	0.04
65	*Dipterocarpus cornutus*	15	1.67	0	0.00	0	0.00	0	0.00	0	0.00	15	0.61
66	*Dipterocarpus kerrii*	0	0.00	4	0.31	0	0.00	0	0.00	0	0.00	4	0.16
67	*Dipterocarpus sp.*	5	0.56	3	0.23	0	0.00	0	0.00	0	0.00	8	0.33
68	*Dipterocarpus tuberculatus*	1	0.11	0	0.00	0	0.00	0	0.00	0	0.00	1	0.04
69	*Disoxylum molliscimim*	1	0.11	0	0.00	0	0.00	0	0.00	0	0.00	1	0.04
70	*Dryobalanops aromatica*	2	0.22	3	0.23	0	0.00	0	0.00	0	0.00	5	0.20
71	*Dryobalanops lanceolata*	4	0.45	3	0.23	0	0.00	0	0.00	0	0.00	7	0.29
72	*Dryobalanops sp.*	5	0.56	0	0.00	0	0.00	0	0.00	0	0.00	5	0.20
73	*Duabanga moluccana*	2	0.22	0	0.00	0	0.00	0	0.00	0	0.00	2	0.08
74	*Duabanga sp.*	2	0.22	0	0.00	0	0.00	0	0.00	0	0.00	2	0.08
75	*Durio zibethinus*	1	0.11	0	0.00	0	0.00	0	0.00	0	0.00	1	0.04
76	*Elaeis guineensis*	0	0.00	3	0.23	0	0.00	0	0.00	0	0.00	3	0.12
77	*Elmerrillia celebica*	0	0.00	16	1.23	0	0.00	0	0.00	0	0.00	16	0.65
78	*Endospermum peltatum*	2	0.22	0	0.00	0	0.00	0	0.00	0	0.00	2	0.08
79	*Engelhardia rigida*	1	0.11	0	0.00	0	0.00	0	0.00	0	0.00	1	0.04
80	*Eucalyptus robusta*	1	0.11	0	0.00	0	0.00	0	0.00	0	0.00	1	0.04

81	*Eucalyptus deglupta*	6	0.67	15	1.15	0	0.00	0	0.00	0	0.00	21	0.86
82	*Eucalyptus grandis*	8	0.89	10	0.77	0	0.00	0	0.00	0	0.00	18	0.73
83	*Eucalyptus sp.*	2	0.22	0	0.00	0	0.00	0	0.00	0	0.00	2	0.08
84	*Eucalyptus urophylla*	2	0.22	0	0.00	0	0.00	0	0.00	0	0.00	2	0.08
85	*Eusideroxylon zwageri*	8	0.89	0	0.00	0	0.00	9	3.60	0	0.00	17	0.69
86	*Fagraea fragrans*	1	0.11	0	0.00	0	0.00	0	0.00	0	0.00	1	0.04
87	*Ficus sp.*	0	0.00	1	0.08	0	0.00	0	0.00	0	0.00	1	0.04
88	*Garcinia bancana*	0	0.00	0	0.00	0	0.00	1	0.40	0	0.00	1	0.04
89	*Garcinia malaccensis*	0	0.00	0	0.00	0	0.00	1	0.40	0	0.00	1	0.04
90	*Garcinia nervosa*	0	0.00	0	0.00	0	0.00	1	0.40	0	0.00	1	0.04
91	*Garcinia scortechinii*	0	0.00	0	0.00	0	0.00	1	0.40	0	0.00	1	0.04
92	*Garcinia sp. 1*	0	0.00	0	0.00	0	0.00	1	0.40	0	0.00	1	0.04
93	*Garcinia sp. 2*	0	0.00	0	0.00	0	0.00	1	0.40	0	0.00	1	0.04
94	*Geunsia pentandra*	0	0.00	1	0.08	0	0.00	0	0.00	0	0.00	1	0.04
95	*Gmelina arborea*	23	2.56	26	1.99	0	0.00	4	1.60	0	0.00	53	2.16
96	*Gonystylus bancanus*	11	1.23	5	0.38	0	0.00	0	0.00	0	0.00	16	0.65
97	*Gonystylus sp.*	4	0.45	0	0.00	0	0.00	0	0.00	0	0.00	4	0.16
98	*Heritiera sp.*	1	0.11	0	0.00	0	0.00	0	0.00	0	0.00	1	0.04
99	*Hevea brasiliensis*	3	0.33	5	0.38	0	0.00	0	0.00	0	0.00	8	0.33
100	*Hopea bracteata*	3	0.33	0	0.00	0	0.00	0	0.00	0	0.00	3	0.12
101	*Hopea keranganensis*	0	0.00	0	0.00	0	0.00	5	2.00	0	0.00	5	0.20
102	*Hopea sp.*	2	0.22	3	0.23	0	0.00	0	0.00	0	0.00	5	0.20
103	*Igyin sp.*	2	0.22	0	0.00	0	0.00	0	0.00	0	0.00	2	0.08
104	*Intsia sp.*	3	0.33	1	0.08	0	0.00	0	0.00	0	0.00	4	0.16
105	*Ixora concinna*	0	0.00	0	0.00	0	0.00	1	0.40	0	0.00	1	0.04
106	*Ixora congesta*	0	0.00	0	0.00	0	0.00	1	0.40	0	0.00	1	0.04
107	*Ixora grandifolia*	0	0.00	0	0.00	0	0.00	1	0.40	0	0.00	1	0.04
108	*Ixora kingstonii*	0	0.00	0	0.00	0	0.00	1	0.40	0	0.00	1	0.04

109	*Ixora lobii*	0	0.00	0	0.00	0	0.00	1	0.40	0	0.00	1	0.04
110	*Ixora pendula*	0	0.00	0	0.00	0	0.00	1	0.40	0	0.00	1	0.04
111	*Ixora sp. 1*	0	0.00	0	0.00	0	0.00	1	0.40	0	0.00	1	0.04
112	*Kandelia candel*	0	0.00	6	0.46	1	100.00	0	0.00	0	0.00	7	0.29
113	*Koompassia excelsa*	3	0.33	0	0.00	0	0.00	3	1.20	0	0.00	6	0.24
114	*Koompassia malaccensis*	1	0.11	0	0.00	0	0.00	0	0.00	0	0.00	1	0.04
115	*Leucaena leucocephala*	9	1.00	423	32.39	0	0.00	1	0.40	0	0.00	433	17.64
116	*Litsea plutinosa*	2	0.22	10	0.77	0	0.00	0	0.00	0	0.00	12	0.49
117	*Lumnitzera sp.*	0	0.00	1	0.08	0	0.00	0	0.00	0	0.00	1	0.04
118	*Lunbo sp.*	1	0.11	0	0.00	0	0.00	0	0.00	0	0.00	1	0.04
119	*Macaranga sp.*	0	0.00	3	0.23	0	0.00	0	0.00	0	0.00	3	0.12
120	*Manilkara kauki*	2	0.22	0	0.00	0	0.00	0	0.00	0	0.00	2	0.08
121	*Melanorrhea wallichii*	1	0.11	0	0.00	0	0.00	0	0.00	0	0.00	1	0.04
122	*Octomeles sp.*	3	0.33	0	0.00	0	0.00	3	1.20	0	0.00	6	0.24
123	*Palaquium sp.*	3	0.33	3	0.23	0	0.00	0	0.00	0	0.00	6	0.24
124	*Paraserianthes falcataria*	15	1.67	38	2.91	0	0.00	0	0.00	0	0.00	53	2.16
125	*Parashorea malaanonan*	1	0.11	0	0.00	0	0.00	0	0.00	0	0.00	1	0.04
126	*Parashorea sp.*	1	0.11	0	0.00	0	0.00	0	0.00	0	0.00	1	0.04
127	*Peronema canescens*	2	0.22	0	0.00	0	0.00	0	0.00	0	0.00	2	0.08
128	*Pinus caribea*	3	0.33	0	0.00	0	0.00	0	0.00	0	0.00	3	0.12
129	*Pinus kesiya*	6	0.67	0	0.00	0	0.00	1	0.40	0	0.00	7	0.29
130	*Pinus merkusii*	26	2.90	22	1.68	0	0.00	0	0.00	0	0.00	48	1.96
131	*Pinus sp.*	3	0.33	0	0.00	0	0.00	0	0.00	0	0.00	3	0.12
132	*Piper aduncum*	0	0.00	1	0.08	0	0.00	0	0.00	0	0.00	1	0.04
133	*Podocarpus nerifolius*	2	0.22	0	0.00	0	0.00	0	0.00	0	0.00	2	0.08
134	*Podocarpus neriifolius*	2	0.22	0	0.00	0	0.00	0	0.00	0	0.00	2	0.08
135	*Polyscias nodosa*	0	0.00	14	1.07	0	0.00	0	0.00	0	0.00	14	0.57
136	*Pometia acuminata*	2	0.22	0	0.00	0	0.00	0	0.00	0	0.00	2	0.08

137	*Pometia pinnata*	1	0.11	0	0.00	0	0.00	0	0.00	0	0.00	1	0.04
138	*Pometia sp.*	0	0.00	1	0.08	0	0.00	0	0.00	0	0.00	1	0.04
139	*Pterocarpus indicus*	1	0.11	3	0.23	0	0.00	0	0.00	0	0.00	4	0.16
140	*Pterospermum diversifolium*	1	0.11	0	0.00	0	0.00	0	0.00	0	0.00	1	0.04
141	*Pterospermum javanicum*	3	0.33	0	0.00	0	0.00	0	0.00	0	0.00	3	0.12
142	*Quercus sp.*	2	0.22	0	0.00	0	0.00	0	0.00	0	0.00	2	0.08
143	*Rhizophora apiculata*	7	0.78	48	3.68	0	0.00	0	0.00	0	0.00	55	2.24
144	*Rhizophora conjungata*	3	0.33	0	0.00	0	0.00	0	0.00	0	0.00	3	0.12
145	*Rhizophora mucronata*	0	0.00	12	0.92	0	0.00	0	0.00	0	0.00	12	0.49
146	*Rhizophora sp.*	8	0.89	4	0.31	0	0.00	0	0.00	0	0.00	12	0.49
147	*Samanea saman*	1	0.11	0	0.00	0	0.00	0	0.00	0	0.00	1	0.04
148	*Scaphium sp.*	3	0.33	0	0.00	0	0.00	0	0.00	0	0.00	3	0.12
149	*Schima wallichii*	2	0.22	25	1.91	0	0.00	0	0.00	0	0.00	27	1.10
150	*Shorea agsaboinses*	1	0.11	0	0.00	0	0.00	0	0.00	0	0.00	1	0.04
151	*Shorea almon*	1	0.11	0	0.00	0	0.00	0	0.00	0	0.00	1	0.04
152	*Shorea negronensis*	1	0.11	0	0.00	0	0.00	0	0.00	0	0.00	1	0.04
153	*Shorea philippinensis*	1	0.11	0	0.00	0	0.00	0	0.00	0	0.00	1	0.04
154	*Shorea polysperma*	1	0.11	0	0.00	0	0.00	0	0.00	0	0.00	1	0.04
155	*Shorea squamata*	1	0.11	0	0.00	0	0.00	0	0.00	0	0.00	1	0.04
156	*Shorea acuminata*	1	0.11	0	0.00	0	0.00	0	0.00	0	0.00	1	0.04
157	*Shorea bracteolata*	3	0.33	0	0.00	0	0.00	0	0.00	0	0.00	3	0.12
158	*Shorea contorta*	0	0.00	3	0.23	0	0.00	0	0.00	0	0.00	3	0.12
159	*Shorea curtisii*	1	0.11	0	0.00	0	0.00	0	0.00	0	0.00	1	0.04
160	*Shorea hopeifolia*	2	0.22	0	0.00	0	0.00	0	0.00	0	0.00	2	0.08
161	*Shorea johorensis*	3	0.33	0	0.00	0	0.00	0	0.00	0	0.00	3	0.12
162	*Shorea leprosula*	13	1.45	128	9.80	0	0.00	0	0.00	0	0.00	141	5.74
163	*Shorea macroptera*	1	0.11	0	0.00	0	0.00	0	0.00	0	0.00	1	0.04
164	*Shorea negrosensis*	2	0.22	0	0.00	0	0.00	1	0.40	0	0.00	3	0.12

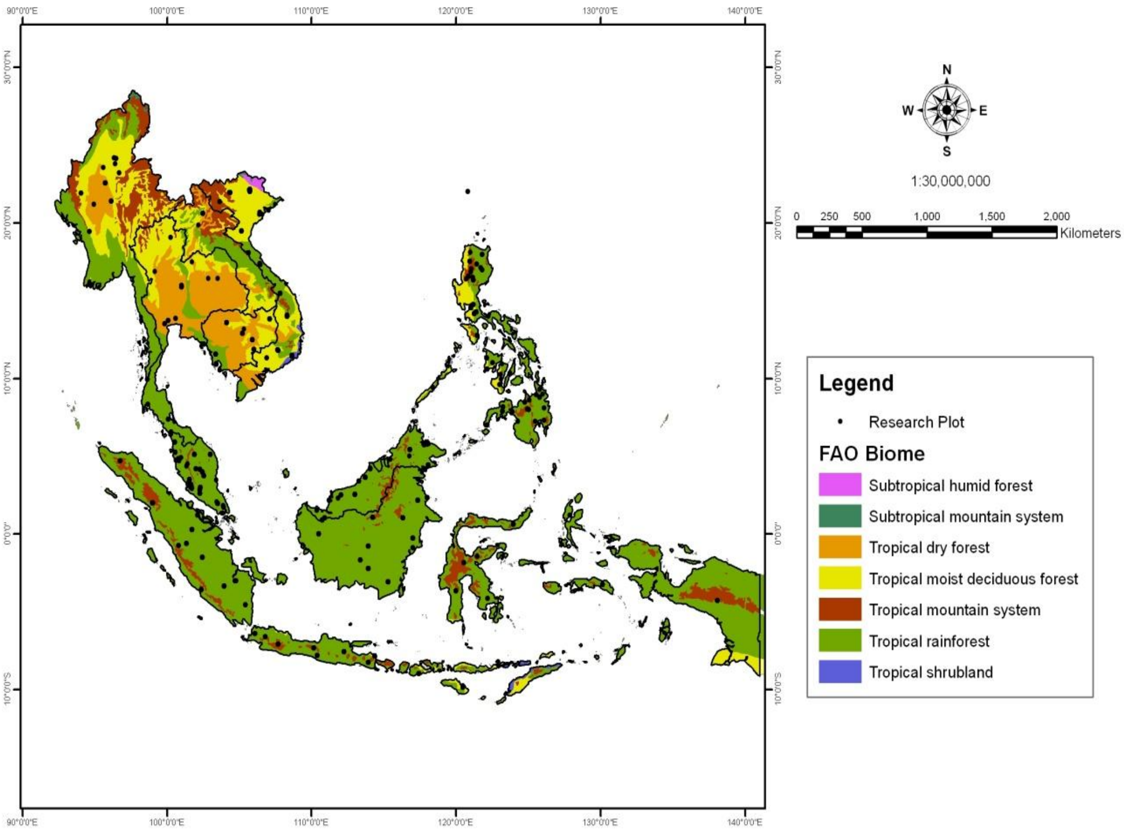
165	*Shorea parvifolia*	9	1.00	4	0.31	0	0.00	0	0.00	0	0.00	13	0.53
166	*Shorea pauciflora*	2	0.22	0	0.00	0	0.00	0	0.00	0	0.00	2	0.08
167	*Shorea sp.*	49	5.46	3	0.23	0	0.00	0	0.00	0	0.00	52	2.12
168	*Shorea sumatrana*	3	0.33	0	0.00	0	0.00	0	0.00	0	0.00	3	0.12
169	*Shorea xanthophylla*	3	0.33	0	0.00	0	0.00	21	8.40	0	0.00	24	0.98
170	*Styrax tonkinensis*	21	2.34	0	0.00	0	0.00	0	0.00	0	0.00	21	0.86
171	*Swietenia humilis*	1	0.11	0	0.00	0	0.00	0	0.00	0	0.00	1	0.04
172	*Swietenia macrophylla*	10	1.11	22	1.68	0	0.00	7	2.80	0	0.00	39	1.59
173	*Syzygium sp.*	2	0.22	0	0.00	0	0.00	0	0.00	0	0.00	2	0.08
174	*Taukkyan sp.*	2	0.22	0	0.00	0	0.00	0	0.00	0	0.00	2	0.08
175	*Tectona grandis*	43	4.79	20	1.53	0	0.00	0	0.00	0	0.00	63	2.57
176	*Theobroma cacao*	0	0.00	2	0.15	0	0.00	0	0.00	0	0.00	2	0.08
177	*Thitsi sp.*	2	0.22	0	0.00	0	0.00	0	0.00	0	0.00	2	0.08
178	*Thitya sp.*	4	0.45	0	0.00	0	0.00	0	0.00	0	0.00	4	0.16
179	*Timonius nitens*	3	0.33	0	0.00	0	0.00	0	0.00	0	0.00	3	0.12
180	*Toona sureni*	2	0.22	0	0.00	0	0.00	0	0.00	0	0.00	2	0.08
181	*Tristania sp.*	0	0.00	2	0.15	0	0.00	0	0.00	0	0.00	2	0.08
182	*Vatica celebensis*	5	0.56	0	0.00	0	0.00	0	0.00	0	0.00	5	0.20
183	*Vatica sp.*	5	0.56	0	0.00	0	0.00	0	0.00	0	0.00	5	0.20
184	*Vernonia vidalii*	1	0.11	0	0.00	0	0.00	0	0.00	0	0.00	1	0.04
185	*Vitex parviflora*	1	0.11	3	0.23	0	0.00	0	0.00	0	0.00	4	0.16
186	*Xylocarpus granatum*	0	0.00	5	0.38	0	0.00	0	0.00	0	0.00	5	0.20
187	*Xylocarpus sp.*	0	0.00	2	0.15	0	0.00	0	0.00	0	0.00	2	0.08
188	None	298	33.22	208	15.93	0	0.00	148	59.20	1	100.00	655	26.68
	Total	897	100.00	1306	100.00	1	100.00	250	100.00	1	100.00	2455	100.00

Appendix 4. Group distribution of different types of allometric equations available in the database. Some of the names are based on vernacular names.

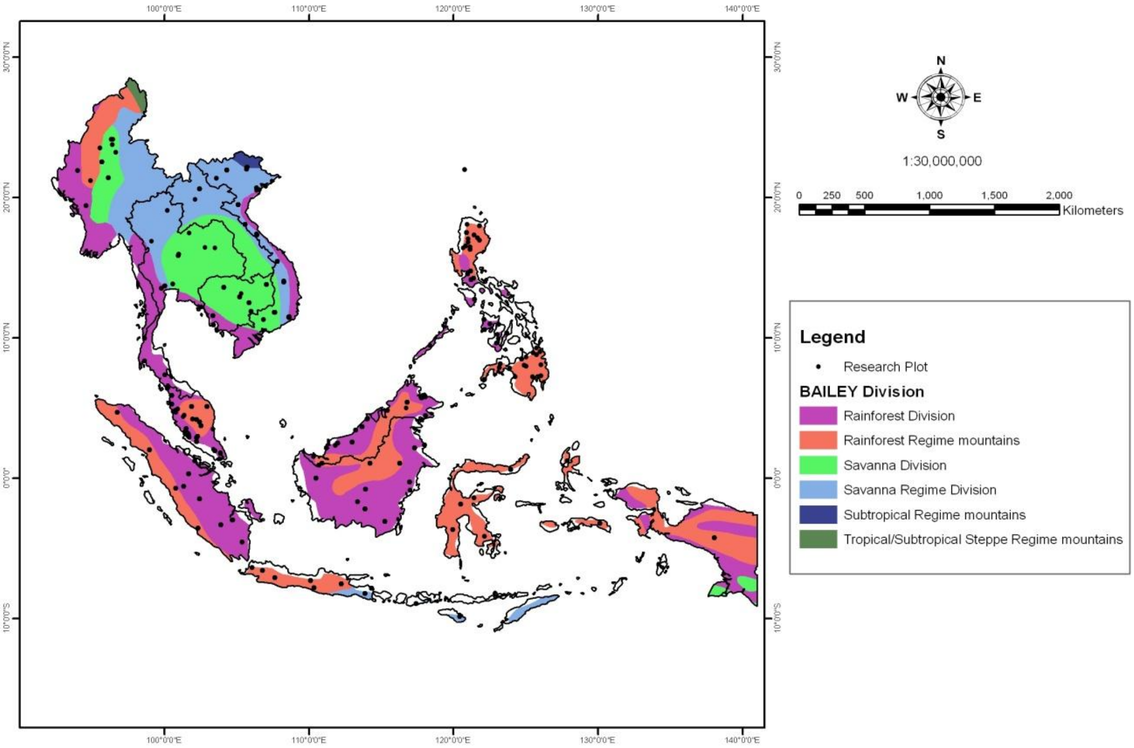
GROUP	SPECIES	VOLUME		BIOMASS		TOTAL	
		Number	**%**	**Number**	**%**	**Number**	**%**
1	*Shorea pauciflora*	1	3.70	0	0.00	1	2.22
	Parashorea lucida						
	Shorea dasyphylla						
	Shorea lepidota						
	Shorea ovalis						
	Shorea rugosa var. uliginosa						
2	*Dipterocarpus crinitus*	1	3.70	0	0.00	1	2.22
	Dipterocarpus cornutus						
	Dipterocarpus sublamellatus						
	Dipterocarpus appendiculatus						
	Dipterocarpus lowii						
	Dipterocarpus kerrii						
	Dipterocarpus costulatus						
	Dipterocarpus verrucosus						
	Dipterocarpus penangianus						
	Dipterocarpus fagineus						
	Dipterocarpus rotundifolius						
	Dipterocarpus kuntsleri						
	Dipterocarpus chartaceus						
	Dipterocarpus rigidus						
	Dipterocarpus gracilis						
	Dipterocarpus baudii						
	Dipterocarpus concavus						
	Dipterocarpus apterus						
3	*Shorea bracteolata*	1	3.70	0	0.00	1	2.22
	Bursereaceae						
	Lophopetalum sp.						
	Pentace sp.						
	Heritiera sp.						
	Palaquium sp.						
4	*Calophyllum sp.*	1	3.70	0	0.00	1	2.22
	Eugenia sp.						
	Elaeocarpus sp.						
	Lauraceae sp.						
	Myristicaceae sp.						
	Tetramerista glabra						
	Endospermum malaccense						
	Dillenia sp.						
5	*Ligth Hardwood, Shorea sp.*	1	3.70	0	0.00	1	2.22
	Anisoptera sp.						
	Dyera costulata						
	Sindora sp.						
6	*Shorea sp.* (Heavy Hardwood)	1	3.70	0	0.00	1	2.22
	Madhuca utilis						
	Neobalanocarpus hemii						
	Shorea kunstleri						
	Hopea nutans						
	Dialium sp.						
	Intsia palembanica						
	Vatica sp.						
7	*Bruguiera cylindrica*	0	0.00	4	22.22	4	26.67
	Bruguiera gymnorrhiza						
	Ceriops tagal						
	Rhizophora apiculata						
	Rhizophora mucronata						
	Avicennia alba						
	Sonneratia alba						
	Sonneratia caseolaris						
	Xylocarpus granatum						

	Xylocarpus moluccensis						
8	*Shorea leprosula*	0	0.00	12	66.67	12	26.67
	Pinus sp.						
9	*Shorea parvifolia*	4	14.81	0	0.00	4	26.67
	Shorea uliginosa						
10	*Shorea parvifolia*	4	14.81	0	0.00	4	26.67
	Shorea pauciflora						
	Shorea johoriensis						
11	*Shorea spp.*	3	11.11	0	0.00	3	6.67
	Dipterocarpus spp.						
12	Non dipterocarp	2	7.41	0	0.00	2	4.44
	Mersawa						
	Keruing						
13	Kapur	4	14.81	0	0.00	4	26.67
	White seraya						
	White meranti						
	Resak						
14	Other Red and dark Meranti	2	7.41	0	0.00	2	4.44
	Selangan batu						
15	Luis	2	7.41	0	0.00	2	4.44
	Hopea						
	Yellow meranti						
16	*Dryobalanops aromatica*	0	0.00	2	11.11	2	4.44
	Dryobalanops lanceolata						
	Total	27	100	18	100.00	45	100.00

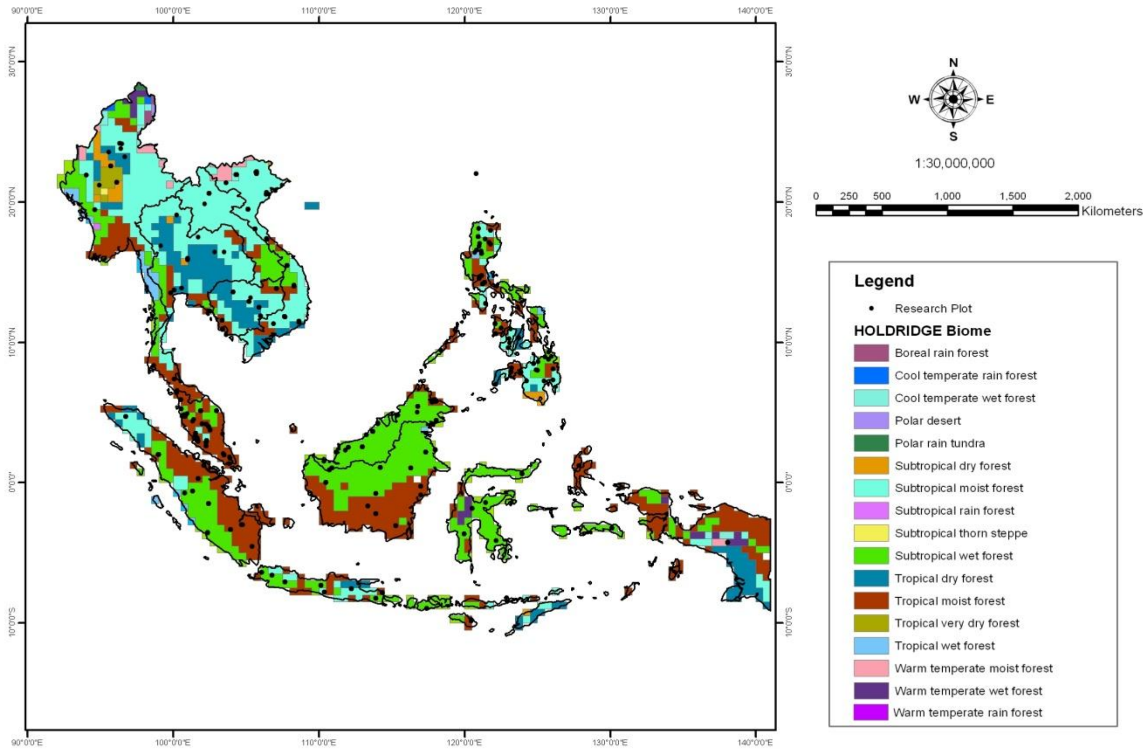
Appendix 5. Geographical distribution of sample plots with FAO Biomes of Southeast Asia. The black dots represent the sample plots where equations were developed.



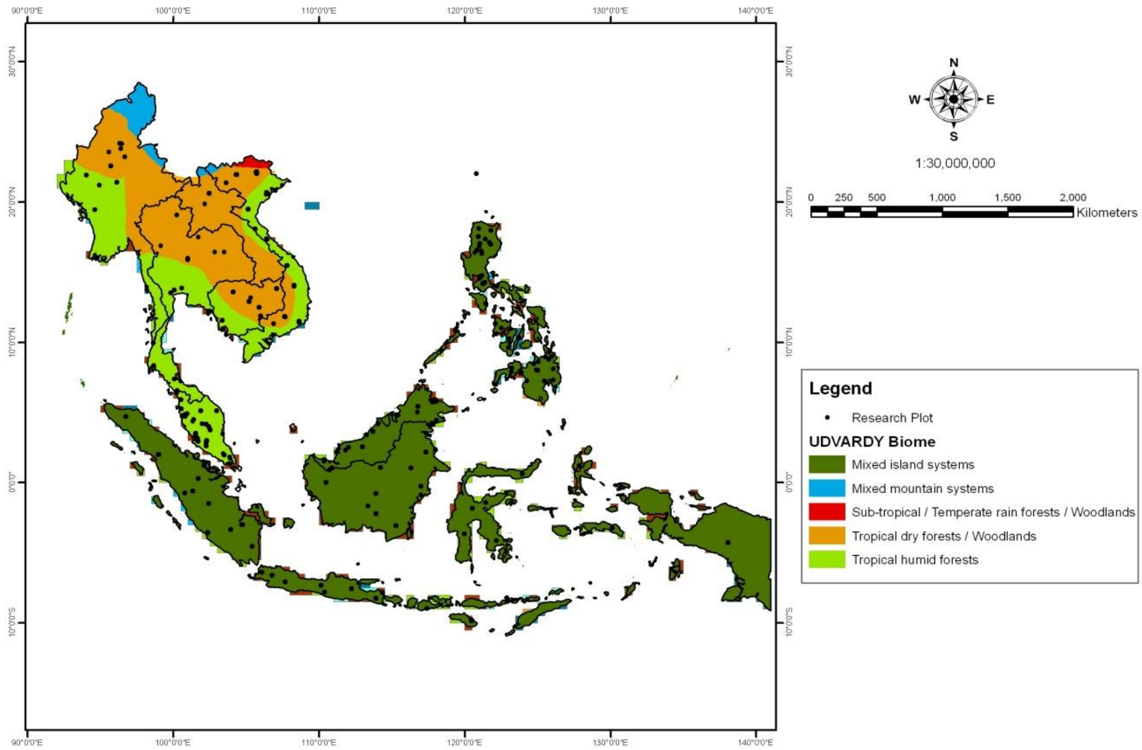
Appendix 6. Geographical distribution of sample plots with Bailey Divisions of Southeast Asia. The black dots represent the sites where equations were developed.



Appendix 7. Geographical distribution of sample plots of forest ecosystems in Holdrige Biome systems of Southeast Asia. The black dots represent the sites where equations were developed.



Appendix 8. Geographical distribution of sample plots of forest ecosystems in Udvardy Biome systems of Southeast Asia. The black dots represent the sites where equations were developed.



Appendix 9. Geographical distribution of sample plots of forest ecosystems in WWF Biome systems of Southeast Asia. The black dots represent the sites where equations were developed.