TO DEMONSTRATE THE DEVELOPMENT AND APPLICATION OF STANDING-TREE CARBON EQUATIONS TO IMPORVE THE ACCURACY OF FOREST-COVER CARBON STOCK ESTIMATES IN THAILAND

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Problems to be Addressed

This project originates from the Kasetsart University, Faculty of Forestry (KUFF), Bangkok, Thailand. The rationale for this project is that there is uncertainty in the accuracy of national estimates of Thailand's forest-cover carbon stocks, incomplete reporting of carbon stocks and limited knowledge of the methods of carbon stocks assessment among the stakeholders. This, in turn, affects the national planning and other policy decisions that rely on information on national carbon stocks.

A new and novel approach has been developed at KUFF to estimate standing tree carbon content as a function of standing tree attributes (total height and DBH), using sample tree increment cores. Through this project, Thailand sought incremental financial assistance and limited technical support from Asia-Pacific Network for Sustainable Forest Management and Rehabilitation (APFNet) to demonstrate this new approach that could be used to develop new national standing-tree carbon equations. These equations could be used to estimate carbon stocks in Thailand's natural forests.

Goal and Objectives

The overall goal is to provide accurate information on national forest carbon stocks to support informed sustainable forest management policy decision-making and balanced public debate on the benefits of forests in climate change mitigation.

The specific objective is to pilot-test the development of accurate standing-tree carbon equations and their application to the preparation of a forest-cover carbon stock map in the Ngao Demonstration Forest, Lampang Province.

Project Site

The project target area for the demonstration project is the Mae Huad Sector, Ngao Demonstration Forest (NDF) locate in the north-west of Lampang Province in northern Thailand. The Mae Huad Sector covers an area of 43,431.75 hectares, including several forest types.

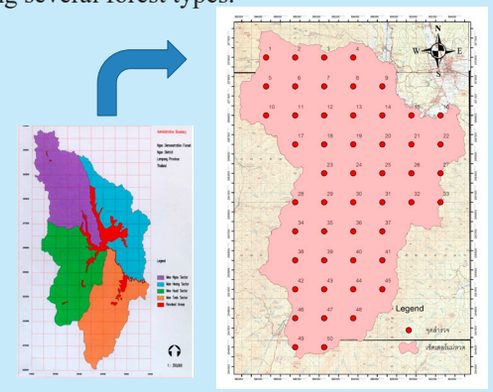

Figure 1 The area of Ngao Demonstration Forest (NDF) (left) and the layout and boundary of Mae Huad Sector (right)

Project Methodology and Results

1 Field sample tree data were collected using technique of Forest Inventory, Point sampling, Tree identification and Forest mensuration. The result found that the 45 tree species in 3 forest types are including the mixed deciduous forest (MDF), the dry evergreen forest (DEF) and the dry dipterocarp forest (DDF).

Figure 2 Field sample tree data collection

2 The groups of tree species were classified using the list of wood density and Importance Value Index (IVI) for 10 groups in each forest type, for a total of 30 groups.

3 Sample tree collections for tree volume and wood carbon fraction analysis were done by using the technique of Forest Inventory, Forest Mensuration and Dendrochronology. A total of 30 major tree species from 3 forest types (10 species each forest type) were selected. In each tree species, wood samples from 15 sample trees with small, medium and large size classes were collected using an increment borer.

Figure 3 Sample tree collections

4 Wood carbon fraction was analyzed using the Combustion Technique. The fresh and dry weights of wood samples were measured. These samples were pulverized to analyze the carbon fraction in the laboratory using the C/N analyzer. It was found that the average of carbon fraction in wood sample was 47.43 %.

Figure 4 Wood carbon fraction analysis

5 The standing tree bole carbon equations were constructed using the Regression Analysis as a function of total height and DBH. The resulting carbon equations were constructed by forest type: mixed deciduous forest (Table 1), dry dipterocarp forest (Table 2) and dry evergreen forest (Table 3). Additionally, the general tree carbon equation of the Mae Huad Sector is as follows:

$$C = 0.012348\ D^{2.1676}\ H^{0.6539}$$

Where: C = Carbon sequestration in stem bole, kg/tree
D = Diameter at breath height of the tree, cm
H = Total height of the tree, m

Table 1 The carbon equations classified by wood density of tree species in the mixed deciduous forest

No.	Sample Species	Carbon Equations	DBH Range (cm)
1	*Ficus var.pubescens* *Cananga latifolia* *Bombax insulare*	$C = 0.008730\ D^{2.335}\ H^{0.570}$	13.2-43
2	*Tetrameles nudiflora* *Elaeocarpus stipularis* *Croton roxburghii* *Grewia elastica* *Litsea glutinosa* *Sterculia pexa* *Ailanthus triphysa*	$C = 0.019454\ D^{2.335}\ H^{0.338}$	16.2-63
3	*Cleidion spiciflorum* *Lannea coromandelica* *Canarium subulatum* *Miliusa velutina*	$C = 0.001538\ D^{3.014}\ H^{0.475}$	11.8-58
4	*Radermachera pierrei* *Tectona grandis* *Lagerstroemia duperreana* *Terminalia nigrovenulosa*	$C = 0.018836\ D^{1.833}\ H^{0.848}$	8.7-71
5	*Buchanania latifolia* *Spondias bipinnata* *Dipterocarpus turbinatus* *Dipterocarpus costatus* *Albizia odoratissima* *Terminalia bellerica* *Lagerstroemia macrocarpa* *Dillenia obovata*	$C = 0.011350\ D^{2.043}\ H^{0.853}$	11.0-29
6	*Stereospermum neuranthum* *Anogeissus acuminata* *Terminalia nigrovenulosa* *Vitex canescens* *Chukrasia velutina* *Eugenia cumini* *Vitex peduncularis*	$C = 0.067764\ D^{2.011}\ H^{0.277}$	15-69
7	*Pterocarpus macrocarpus* *Madhuca thorelii* *Diospyros ehretioides*	$C = 0.014093\ D^{2.068}\ H^{0.723}$	11.5-61.5
8	*Xylia xylocarpa* *Millettia brandisiana* *Irvingia malayana* *Terminalia alata* *Schleichera oleosa*	$C = 0.011967\ D^{2.067}\ H^{0.791}$	13.2-68.8
9	*Butea monosperma* *Dalbergia oliveri*	$C = 0.017539\ D^{2.276}\ H^{0.547}$	11.1-42.8
10	*Quercus kerrii* *Terminalia corticosa* *Diospyros mollis*	$C = 0.005957\ D^{2.206}\ H^{0.819}$	13.2-66.5
11	General Equation for all species/wood density groups	$C = 0.018155\ D^{2.2204}\ H^{0.490}$	8.7-71

Table 2 The carbon equations classified by wood density of tree species in the dry dipterocarp forest

No.	Sample Species	Carbon Equations	DBH Range (cm)
1	*Mitragyna brunonis*	$C = 0.006353\ D^{2.227}\ H^{0.802}$	13-44.1
2	*Bridelia pierrei*	$C = 0.004887\ D^{2.618}\ H^{0.438}$	10-28.6
3	*Gardenia sootepensis*	$C = 0.020417\ D^{2.237}\ H^{0.696}$	11-2.4
4	*Haldina cordifolia* *Buchanania latifolia*	$C = 0.001928\ D^{2.664}\ H^{0.679}$	10.2-41.9
5	*Dipterocarpus obtusifolius.*	$C = 0.000975\ D^{2.389}\ H^{1.277}$	13.1-42.5
6	N/A		
7	*Dalbergia assamica* *Pterocarpus macrocarpus*	$C = 0.014093\ D^{2.068}\ H^{0.723}$	11.5-61.5
8	*Shorea siamensis* *Millettia brandisiana* *Shorea obtusa* *Terminalia alata* *Irvingia malayana* *Quercus kerrii*	$C = 0.022751\ D^{2.209}\ H^{0.458}$	11.2-58.2
9	*Xylia xylocarpa* *Dalbergia oliveri*	$C = 0.017539\ D^{2.276}\ H^{0.547}$	13.2-66.8
10	*Quercus SP.* *Terminalia corticosa*	$C = 0.005957\ D^{2.206}\ H^{0.819}$	13.2-66.5
11	General Equation for all species/ wood density groups	$C = 0.009462\ D^{2.328}\ H^{0.602}$	10-66.8

Table 3 The carbon equations classified by wood density of tree species in dry evergreen forest

No.	Sample Species	Carbon Equations	DBH Range (cm)
1	*Parkia leiophylla* *Tetrameles nudiflora* *Duabanga grandiflora .*	$C = 0.049317\ D^{1.997}\ H^{0.357}$	18-147
2	*Adenanthera pavonina* *Cleidion spiciflorum* *Croton roxburghii* *Podocarpus neriifolius* *Bischofia javanica*	$C = 0.019498\ D^{2.300}\ H^{0.300}$	12.5-42
3	*Lithocarpus annamensis* *Castanopsis acuminatissima* *Harpullia arborea* *Careya sphaerica*	$C = 0.012134\ D^{2.056}\ H^{0.668}$	12.0-3830
4	*Artocarpus lakoocha* *Terminalia nigrovenulosa* *Dipterocarpus costatus* *Eugenia aequea* *Lagerstroemia tomentosa*	$C = 0.001549\ D^{2.608}\ H^{0.854}$	11.10-47.30
5	*Dillenia obovata* *Cratoxylum formosum* *Hopea odorata* *Schima wallichii*	$C = 0.003192\ D^{2.374}\ H^{0.876}$	9.7-26.2
6	*Anogeissus acuminata*	$C = 0.015560\ D^{2.109}\ H^{0.625}$	18.6-71.7
7	*Pterocarpus macrocarpus*	$C = 0.014093\ D^{2.068}\ H^{0.723}$	11.5-61.5
8	*Terminalia alata*	$C = 0.002624\ D^{2.263}\ H^{1.086}$	12.8-52.7
9	*Xylia xylocarpa* *Dalbergia cultrata* *Dalbergia oliveri* *Terminalia nigrovenulosa*	$C = 0.049317\ D^{1.997}\ H^{0.357}$	13.2-66.8
10	*Quercus SP.* *Quercus lamellosa* *Quercus kerrii* *Terminalia corticosa*	$C = 0.006353\ D^{2.482}\ H^{0.609}$	10.9-43.7
11	General Equation for all species/ wood density groups	$C = 0.011803\ D^{2.1844}\ H^{0.617}$	9.7-147

6 The estimation of carbon sequestration in each sample point using the statistical analysis indicated carbon sequestration in Mae Huad Sector was 41.04 ton/ha.

7 The carbon stock map was constructed using the technique of Remote Sensing and Regression Analysis. The satellite data of two image bands (red and near-infrared bands) derived from Landsat 8 with a spatial resolution of 30 meters was used to generate the Normalized Difference Vegetation Index (NDVI). Carbon contents and the NDVI values in all sampling points were related by using Regression Analysis. The related pattern was applied to construct the carbon stock map. It was found that the total carbon stock in the form of living standing trees (boles) in the Mae Huad Sector, Ngao Demonstration Forest was estimated at 1,638,729 Tons.

8 The quality assessment (QA) of the carbon stock map using techniques of Land-use cartography, Forest Inventory, Forest Mensuration, Tree Identification, Remote Sensing and QA analysis indicated the relative difference of the carbon stock was only 11.40%.

Acknowledgement

The project was partly funded by a grant from the Asia-Pacific Network for Sustainable Forest Management and Rehabilitation (APFNet).

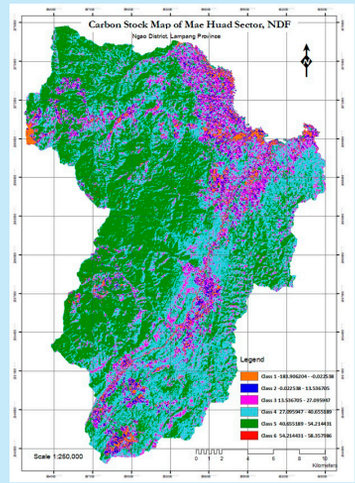

Figure 5 Carbon Stock Map of Mae Huad Sector, Ngao Demonstration Forest, Lampang Province