



## Project Terminal Evaluation Report (Research Project)

Project Information		
Project title	To Demonstrate the Development and Application of Standing-Tree Carbon Equations to Improve the Accuracy of Forest-Cover Carbon Stock Estimates in Thailand [Project ID: 2015P6-THA]	
Supervisory agency	Royal Forest Department, Bangkok, Thailand	
Executing agency	Kasetsart University, Faculty of Forestry, Bangkok, Thailand	
Implementation partner(s)	-	
Implementation duration: 01/2017 to 12/2018, 24 months		
Total budget (USD) 253,354	APFNet grant (USD) 199,045	Counterpart contribution (USD) 54,300
Evaluation Results		
Rating scale (1-5)	1- Poor    2 – Fair    3 – Average    4 – Good    5 – Excellent	

Overall Evaluation Result	Rating: 4
<p>This project completed the expected outputs in a timely manner as outlined in the project completion report with presentations made during the Terminal Evaluation; namely, 1) Methodology to construct new tree carbon equations developed and pilot-tested; 2) Application of tree carbon equation to prepare a demonstration carbon cover map; 3) To prepare an Action Plan on the construction and promotion of national standing-tree carbon equations; and, 4) To disseminate project information and knowledge to stakeholders (KSU 2019a, b, c, d). This project has two distinct phases; namely, 1) Development of carbon equations; and, 2) Applying the developed equations to mapping forest carbon stocks. In Phase 1, carbon equations were developed by establishing sample plots in a systematic stratified manner in the Ngao Demonstration Forest in Lampang Province. Characteristics of identified trees were estimated, i.e., species, diameter, height and the basal area estimated into three forest classifications: a) Mixed Deciduous Forest (MDF); b) Dry Evergreen Forest (DEF); and, c) Dry Dipterocarp Forest (DDF). Wood samples were collected from select trees representing 24 major species by using an incremental borer and the carbon was estimated in the laboratory by using a carbon-nitrogen elemental analyser. Tree carbon equations were derived by contrasting the carbon content of the sample to the estimated characteristics of the trees. Equations with the best fit using regression analysis determined their applicability for use (KSU 2018a, b, c, d, e). The results were found to be acceptable with some caveats that should have been addressed by either the Executing Agency</p>	

(EA) or APFNet. In the first instance, the demonstration site is well researched. The TE was informed by the EA that they systematically stratified the forest because they viewed grouping the area by forest types challenging. However, the TE believes that the results should be aligned to known forest types. This is because forest classifications in Thailand already exist (FAO 2009). Secondly, inventory plots should follow the existing national forest inventory design (FAO 2007), such that results can be comparable to existing estimates. If the project was structured in this manner, scaling-up to the sub- or national-level will be straightforward and could be integrated into national level reporting to the United Nations Convention on Climate Change (UNFCCC). Carbon equations were compared to existing publications, yet all equations used to verify findings were over 36-years old, with the most recent publication dated 1983. More recent equations can be found in the literature and were not used, i.e., Chave (2014, 2005). This is significant oversight on behalf of the EA as variability of the equations may be higher and/or lower variability to more recent allometric model relationships. While this does not discount the results of the project, it also does not estimate the wider, more recent, applicability of the project. As this is a research project, a full literature review should have been completed.

The second phase of the project with regards to the verification of the equations was relatively straightforward. The methodology of sampling 3 km by 3 km grid was more suitable in this application for obvious spatial reasons. While the report did not specify the details of the results, i.e., full regression outputs including P-values, it did outline the goodness of fit, i.e., r-squared. The r-squared values were low indicating the fit of the regression equation was low. While the TE was informed during the Terminal Evaluation meeting that the regression was applied at the 95% confidence interval, no reference could be found in the report, and this is a glaring oversight. Presenting more details of the results can provide great insights into the actual applicability of the results of the project and their applicability to scale-up to the national level. While the project was successful in aligning carbon estimates with vegetative maps, work is needed before attempting to scale-up the work to the national level. That said, if this project is to be scaled-up, the TE recommends it to be done at the sub-national level and in-line with established national forest inventory procedures. The TE found some reporting inconsistencies, especially with regards to units of measurements but overall this project is acceptable, and no Activities were found to be outstanding.

1. Significance of the project	Rating: 4
<p>The significance of this project originates from work to fit carbon equations to specific wood densities of major species groups. With positive results, the possibility exists for this project to be replicated in other areas of Thailand. In many ways, this project was successful due to the focus of the work to tackle an important problem, i.e., tree volume taper equations. However, the work cannot be said to satisfy all conditions for scale-up. This is because the TE believes work is still required to better understand the relationship between the findings and more recent carbon equations. Should a supplementary project be developed, a full literature review and analysis is required to demonstrate the broader applicability of the established carbon equations. Secondly, the project demonstrates capacity at government institutions, including the ability to collaborate with select government agencies and technical partners. The future challenge will be the collaboration with national reporting agencies and conducting the work against the modalities of</p>	

the Intergovernmental Panel on Climate Change (IPCC) (GOFC-GOLD 2016).

<b>2. Scientific and technological excellence</b>	<b>Rating: 3</b>
<p>Many aspects of this project were completed to a high-level of accuracy and precision. Specifically, this relates to the collection and processing of field data, the creation and analysis of the carbon equations and the verification of the data against third-party obtained Landsat maps. However, there is room for improvement regarding the reporting and sharing of data, i.e., tabulating and sharing full regression outputs into an appendix as well as creating a technical annex on the development of the carbon equations, including the parameters used. Recalling this is a research project, all outputs should be able to be duplicated by any third-party for validation, verification and/or replication and as such, full transparency is required. While the verification of the equations relative to the carbon map was successful, the TE does not know how it could be otherwise, and it may be argued that recent Landsat and spot-imagery maps are more accurate than equations derived from traditional tree characteristics, i.e., DBH, height, species, etc. As this was a research project, a statistically significant sample of trees should have been felled for destructive sampling to verify the equations and increase their accuracy. This is despite the argument that ‘felling trees in Thailand is illegal’. As a research project, the TE is confident the EA would receive permission to do so. Carbon equations should have been analysed against recent carbon equations, i.e., Chave (2014, 2005). A comprehensive review of methods is required by APFNet prior to project acceptance.</p>	
<b>3. Innovation of the project</b>	<b>Rating: 3</b>
<p>The boring of core samples to determine the carbon content of identified species is aimed to avoid the need for destructive sampling, whereby trees are felled and weighed, and carbon is then estimated based on various factors, i.e., wood density, timber moisture, bark thickness, etc. The results indicate that this procedure is within the normal distribution and albeit slightly skewed, hence the low r-squared value. Nevertheless, the approach could be considered by the Ministry of Natural Resources and Environment (MONRE) for Thailand (KSU 2019e). One of the challenging components of this work is the time needed to collect the physical samples. While one of the aims of the project is the scaling-up to the national level, the TE is surprised the work did not follow existing national level inventory protocols or attempt to reduce the number of sample plots to streamline efficiency. Moreover, some destructive measurements would have likely increased the accuracy of the results. Nevertheless, the TE believes this project clearly satisfies some of the priorities of APFNet during the 2016-2020 period, namely; Priority 2) Promoting sustainable forest management to enhance ecological functions and ecosystem security of forests (APFNet 2016).</p>	

4. Quality and efficiency of the implementation and the management	Rating: 4
<p>The TE found this project to be adequately managed by the EA as all project documents, workshops, meetings and reports were completed in the proposed timeframe (KSU 2018e). The project budget outlined by the independent financial auditor indicates that it was based on the approved Annual Work Plan. The work was carried out against a plan and that the financial requirements as projected by the EA were fairly accurate.</p> <p>Regarding the project management team assembled by the EA, the TE met many of them during the Terminal Evaluation meeting on 4 April 2019. Headed by the Dean of the Faculty of Forestry, the team boasts an impressive skill-set with a great deal of experience. Overall, the EA did a good job matching experience with expectations. It would also be useful to the TE to better understand the project implementation schedule, i.e., to review mid-term reports and updates and assure any issues that may arise can be addressed immediately.</p> <p>A budget was proposed in the Project Concept Note and the TE found another in the Project Completion Report for which year 2 was verified in the Report of the Independent Auditor (KSU 2019c, d, KSU 2018e). The TE faced challenges when cross-referencing Annex B in the Project Completion Report and the Statement of Fund Balance from the Report of the Independent Auditor. This is because it is unclear to the TE how the money was spent and whether those expenses were justified. However, what was verified by the TE were the values of each row relative to the various Activities whereby the Activities and financial values tallied across the documents. This should not be understood as financial compliance rather it should be viewed as verification of the values in the Completion Report.</p>	

5. Quality of the project results/achievements	Rating: 4
<p>This project has the potential to be scaled-up to support a wider application in Thailand. Based on the Activity list outlined in Completion Report and the Terminal Evaluation, all Activities were completed in the allocated timeframe, i.e., two years (KSU 2019d). As stated above, the project can foster a new approach in the development of allometric equations beginning with the extraction of wood cores and analysing them in specialised equipment. Broadly, the results of this project justify the project-costs. However, there are many improvements that can be made to increase the effectiveness of the results, i.e., sample areas based on forest type stratification, optimise sampling by determining the least amount of sample plots to meet the desired levels of confidence, contrast the proposed equations against newer, peer-reviewed literature and equations, and include all results in the write-up such that experiments can be replicated and verified independently. Based on the documentation, it will be difficult to scale-up the experiments to the sub-national or national level and therefore, more emphasis should focus on reducing the number of sample plots, relative to the forest types. More efforts should be made to align the work to national carbon accounting practices such that approaches satisfy internationally recognised approaches (GOFC-GOLD 2016). As KSU is a government university, there should be no challenges with regards to intellectual property and ownership.</p>	

<b>6. Project (potential) impact through the development, dissemination and use of project results</b>	<b>Rating: 3</b>
<p>This project has the potential for replication, albeit, with more comprehensive and scientific approaches (as mentioned above and will not be repeated here). Importantly, the programme will require more frequent and clear reporting such that the work can be peer-reviewed and externally verified. Should an article get published in a peer-reviewed journal, this will greatly enhance the potential for replication and of course, the reputation of KSU. The TE further suggests enhancing the APFNet programme by instituting mandatory annual reviews on all projects, regardless of financial size of the project or the duration.</p>	

<p><b>7. Additional Comments, Recommendations and Lessons Learned</b></p> <p>The implementation of the various project Activities, how they were reported and the accuracy of those reports, including financial transparency in the delivery of the project could have been improved had better external monitoring taken place over the project period. APFNet as the grantor to the project, has institutional responsibility to assure funded projects meet the Mission, Principles, Values, Objectives and Key Priorities of the organisation, including the Monitoring and Evaluation System. The TE believes that more intensive monitoring of project activities and financial flows would have greatly improved the delivery of the project. Examples can be found in the delivery of reports as all reports were delivered in late 2018. The job of the TE is to ask questions. It became clear when reviewing the documents at the inception of this Terminal Evaluation that queries as to why those documents were outstanding could be answered by the lack of periodic monitoring. The TE believes the lack of regularly scheduled external documentation, progress and/or financial audits contributed to the challenges faced during the implementation of this project. This is because strict monitoring of compliance to the agreed timetables would place a 'safeguard' in the programme and/or flows of finance, which could be used by APFNet to ensure compliance to agreed programmes of work and/or modalities. A mandatory monitoring and compliance programme, either internally or externally, can greatly assist the effectiveness of project implementation, such as assuring project deliverables and reports are substantive and delivered on-time. Such measures could also be part of a larger internal quality assurance programme through the application of ISO quality management systems within the APFNet organisation itself. ISO 9001 is a quality management system that standardises documentation, work flows and coding such that all APFNet any member of staff can work on any project, at any time. This can greatly increase productivity and quality assurance. APFNet can change the guidelines to reflect this action whereby periodic and/or annual monitoring costs are the responsibility of project applicants.</p>
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**Evaluation Team:**

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Dr Theerapong Chumsangsri (Team member)

Dr Pongsak Hengniran (Team member)

**Signature and Date:**

11 June 2019

A handwritten signature in black ink, appearing to read 'M. Galante', written over a horizontal line.

Dr Michael Galante

Director

Climate Forestry Limited

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## List of Participants

The Terminal Evaluation Meeting of the Project “To Demonstrate the Development and Application of Standing-tree Carbon Equations to Improve the Accuracy of Forest-cover Carbon Stock Estimations in Thailand”, April 4th, 2019, at Meeting room 303, 3rd floor, 60<sup>th</sup> Anniversary Building Faculty of Forestry, Kasetsart University, Bangkok, Thailand.

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Photos and electronic information collected during the Terminal Evaluation has been sent to APFNet.