Proceedings of the training on tree allometric equation development and use

Bangladesh Forest Department
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The Forest Department of Bangladesh leads actions to improve forest management and conservation, adopting forward thinking, innovative approaches in its management of approximately 1.55 million hectares of land across the country.

In 2015, the Forest Department began a process to establish a National Forest Inventory and Satellite Land Monitoring System for improved forest and natural resource management. The process supports national objectives related to climate change mitigation and provides information in support of the UN-REDD programme aimed at Reducing Emissions from Deforestation and Forest Degradation (REDD+). The process also addresses domestic information needs and supports national policy processes related to forests and the multitude of interconnected human and environmental systems that forests support.

The activities implemented under the Bangladesh Forest Inventory process are collaboration between several national and international institutions and stakeholders. National partners from multiple government departments and agencies assist in providing a nationally coordinated approach to land management. International partners, including the United Stated Agency for International Development (USAID) and the Food and Agriculture Organization of the United Nations (FAO) are supporting the development of technical and financial resources that will assist in institutionalizing the process.

The results will allow the Forest Department to provide regular, updated information about the status of trees and forests for a multitude of purposes including for assessment of role of trees for firewood, medicines, timber, and climate change mitigation.

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Executive Summary

Estimating tree and forest biomass is a cornerstone of forest resource assessment. In addition to its application in forest-related commerce, forest resource assessment is becoming increasingly crucial in light of continued global deforestation and climate change. Developing a forest monitoring system is a comprehensive process that includes the collection, analysis and dissemination of forest-related data and the derivation of information and knowledge at regular intervals. It is only by having a comprehensive, reliable and transparent data collection and analysis process so that informed decisions can be made, communicated and defended on scientific grounds.

FAO is currently assisting Bangladesh Forest Department (BFD) to establish a national forest monitoring system. Strengthening national capacities and ownership on data management and analysis is essential to ensure the sustainability of the project. The amount of data collected on the status of forest resources is continuously increasing and improved data management tools are necessary. Such tools are fundamental to ensure the sustainability of the forest monitoring system, but also to ensure the transparency of the data analysis process and its improvement over time. Developing the capacity of BDF in statistical analysis with R software is therefore an important project activity.

Total eleven participants(nine male and two female)attended the training.

Contents

1.   Introduction

Theoretically, to determine the biomass or the carbon stock of tree, one must weigh all its compartments. These measurements become difficult or impossible to obtain at the forest scale for two reasons: (1) they are destructive and often prohibited on a large scale, and (2) the cost, time and labor are unrealistic. To measure the carbon content of tree roots, field work is even more tedious and is often replaced by the use of factors directly applied to the aboveground biomass.

I most of the cases, the assessment of tree volume, biomass or carbon stocks Another methodology to obtain an estimate of tree biomass is based on the relation between the diameter and biomass of a given tree. This is the stage at which allometric equations are used. Allometry refers to the statistical relation between two size characteristics of individuals in a population. Therefore a statistical relation can be developed between easy to measure tree characteristics (i.e. diameter, height or density) and difficult to measure variables such as biomass or volume. Consequently, costly and destructive measurements can be limited to a sample of trees and the results can be extrapolated to all trees in a given area.

As part of the UN-REDD Programme for Bangladesh, a series of capacity-building exercises are organized to enhance national capacity among national institutions on various elements of national forest monitoring. One key element of NFMS is the development of country-specific emissions factors for different land-uses types and forest classes, allowing country to report on carbon stocks changes. To develop country-specific emission factors, countries need to undertake field measurements and use collected forest data (DBH, height, wood density) to determine carbon stocks. Upon several repetitive measurements of these standards NFI parameters, countries are enabled to develop allometric equations to assess the carbon content of the measured biomass.

In 2015, two trainings will be implemented as part of the UN-REDD targeted support and will focus on strengthening capacities in data management and analysis and forestry statistics. The training on database management will aim at: (1) support the develop of data management system to strengthen the national forest monitoring in Bangladesh, (2) provide a training on data management and analysis for the NFI inventory data and for the support of a national tree biomass estimate, (3) develop an integrated approach to the management and analysis of forest data using calculation and data management tools developed by FAO teams and applicable in the context of REDD +, and (4) support the quality assurance and control of the data. The training on forestry statistics will aim at: (1) Introductory course to the R programming language as a statistical tool in forest biomass assessment, targeting national forestry staff, (2) Increased knowledge on statistical methods for biomass modelling based on the use of existing tree models in national forest inventory databases, (3) Enhanced knowledge on the analysis of the National Forest Assessment, and (4) Identification of gaps, needs and future steps regarding the improvement of forest biomass assessment.

The first national forest inventory for Bangladesh was implemented in the year 2005 with the support from FAO. The inventory was conducted using a systematic sampling design, based on measurement of 299 plots distributed across the entire country. As part of the previous support to Bangladesh on forest monitoring, several databases and documents have been compiled such as, an MRV action plan (Akhter 2012), a database on tree allometric equation (Akhter, Hossain et al. 2013), and a catalogue of data for land cover classification system (Akhter and Shaheduzzaman 2013). Several trainings were implemented such as on GHG inventory (Akhter and Shaheduzzaman 2012), Land Cover Classification System (Shaheduzzaman and Akhter 2013) etc.

Significant efforts have been made in FAO Forestry Department to strengthen capacities in forest modelling and forest biomass and carbon stocks and particularly on tree allometric equations (Picard, Saint André et al. 2012; Henry, Bombelli et al. 2013; Cifuentes Jara, Henry et al. 2014; Henry, Cifuentes Jara et al. 2014).

Based on the existing national forest assessment data, tree allometric equation database for Bangladesh and South Asia (Sandeep, Sivaram et al. 2013), previous trainings and additional accessible field inventory and model data, the aim of this training is to provide support on model fitting and development, and applicability of forestry models in the context of Bangladesh. The outputs of this training will particularly contribute to support the initial efforts to implement the second national forest inventory, and implementation of the national forest monitoring system.

2. Objectives

The general objective of the training was to strengthen the national capacities in developing and using tree allometric equations and to improve tree volume and biomass assessment in Bangladesh.

The sub-objectives were as follow:

- To assess the current status of ecological zones mapping and forest stratification of both countries, the status of allometric equations development and past experiences on biomass field measurement;
- To present the current and up-to-date knowledge for building allometric equations including courses on the related theory, field operations, fitting and use of the allometric equations,
- To propose technical exercises aiming at identifying gaps (knowledge, allometric equations and raw data) to report carbon stocks and carbon stock changes at the country level;
- To propose practical works on raw data to get familiar with the statistical software and to build allometric equations from their own data sets using open source and free softwares;
- To initiate building a network of experts on allometric equations.

3. Summary of the training

Welcome remarks were made by Md Mozarul Islam, CF and NPC. During the welcome remarks Md Mozarul Islam insisted on the need to use appropriate allometric equations for tree volume, biomass and carbon stock assessment. The objectives of the training were presented by Matieu Henry, CTA. He presented the context of forest resource assessment and the need to improve forest estimates to better guide decision making in the forestry sector. While a lots of efforts are being undertaken to improve forest estimates, various sources of errors affect the reliability of the estimates and the selection and the quality of the model used is one of the most important, as illustrated by concrete national case studies.

The training started with a particular focus on the state of the art in existing allometric equations and raw data for the national forest inventory and carbon stock assessment in the two countries were recent efforts were made to improve national forest estimates. The second day was dealing with exercises on graphical exploration and data quality check while courses were focusing on the determinants of biomass accumulation in trees and in stands as well as presenting some case studies for data collection, data entry and graphical exploration. The third and the fourth day were devoted to the practice (exercises, with restitution by the different groups) on the building allometric equations.

The detailed agenda and the related materials are given in the next section but they are also available on the training materials are available on the dropbox:

https://www.dropbox.com/sh/53khotbqqmr059d/AABstO1WlQ5H1eKojIkztbVOa?dl=0

4.   Recommendations for next steps

Despite long history in collecting volume and biomass data (more than 500 equations referenced), there are no available RAW data sets in the different institutions. Fortunately, we could work on data gathered on the publications by prof. Mahmood Hossain during the process of identifying available AE in Bangladesh. These data were concerning three species of the mangrove (one shrub and two tree species) and the database contained 107 trees. Practices have been done on this dataset (from quality check – exercise 3 to global models including wood density – exercise 7). However, those data remain limited and there is a clear need to improve the data collection for the destructive and semi-destructive tree biomass field measurements to be able to assess the reliability of available models and assess their accuracy.

Recommendation 1: improve the database for tree biomass estimates

Bangladesh being at the time of elaborating a new and sustainable NFI, it is crucial to identify needs and gaps regarding the AE development, considering available AE, the forest resources as described in the previous National Forest Inventory and the national land cover maps. This can be performed by working on the previous NFI (2005) and making a connection between the land-cover classification used at that time and the current land-cover classification that is planned to be applied in the next NFI. From that, it will be possible to identify for each strata, the main tree species as well as the range of dimension in diameter and height, to be compared to the database of existing AE in Bangladesh but also India (for the similar ecological zones). Once lacks are identified and from the available budget (do not reinvent the roll, if some equations are suitable for some species, it saves money and time), it will be possible to plan the collection of up-to-date volume, biomass and carbon data for the whole country.

Recommendation 2: link the NFA data, the proposed NFI forest stratification to be compared with available AE data.

FIGURE 1: DISTRIBUTION OF ALLOMETRIC EQUATIONS IN BANGLADESH ACCORDING TO THE NAITONAL FOREST LAND COVER MAP AND THE LOCATION OF THE NATIONAL FOREST INVENTORY PLOT
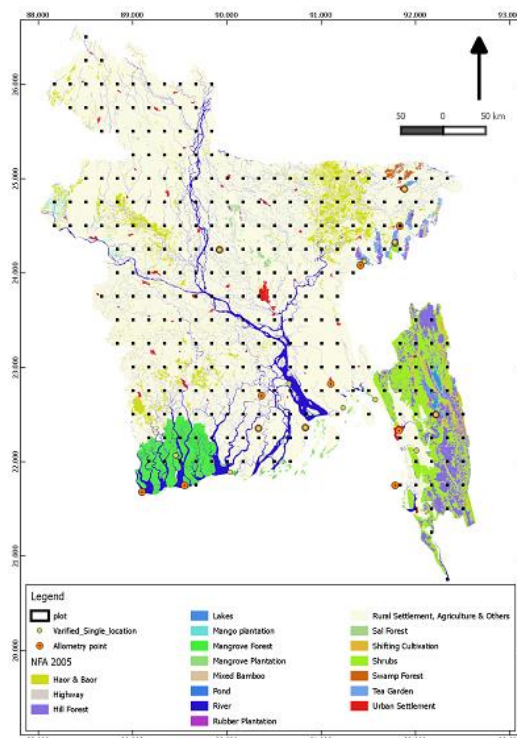
-The data gathered by prof. Hossain in several different publications can be revisited using the technics learnt during this training, and provide a first attempt of generalized equation for Mangroves in Bangladesh. This would require a small field campaign to collected samples for wood density analysis for the species considered. This field campaign can also be used to test the protocol of biomass measurement especially in zones were trees cannot be felled (see next point). In addition, performing the land cover map using the SPOT images and conducting field inventory data in the same area where the previous destructive measurements were performed would allow testing the method of integration of the destructive measurement until the land cover map development.

Recommendation 3: revisit the allometric equation analysis based on the data used during the training and, if possible, to link the AE development with forest inventory and land cover map development activities (depending on the geographic coordinates of the previous destructive measurements)

It would be necessary to provide support to students and field crews that will perform volume and the biomass measurements to achieve destructive measurements, maybe starting with forest plantations. In the case of natural forest and mangroves where tree felling is difficult but tree coring might be possible (non- to semi-destructive measurements), it is possible to explore the possibility to develop semi-destructive measurements.

Recommendation 4: to train students and field crews for allometric equation development once the manual for field measurement for the allometric equation development is operational.

The manual for tree volume and biomass allometric equation development in Bangladesh need to be improved taking into consideration the different procedures for plantations, natural forests and home gardens.

Recommendation 5: the manual should consider semi and non-destructive measurements for certain ecosystems where destructive measurements are not allowed.

There is a clear need expressed by the participants to benefit from additional trainings on R (use of the language) and background statistics (from the mean and variance to linear and non-linear models, including different statistical tests such as checking normality of distributions,…) that have not been covered by the present training.

Recommendation 6: additional trainings on basic forestry statistics and R are necessary.

Appendix 1.   Agenda

Day 1: 22 Feb 2016

Date	Topic	Speaker/facilitator
	Opening Session	
Session1: Welcome		
8:30	Registration	
9:30	Welcome Address	Mr Mozarul Islam
9:45	Context of AE development	Dr Matieu Henry
10:15		
Session 2: Overview on forest inventory and introduction to the statistical software		
10:45	Objectives of the training	Dr Matieu Henry
11:00	Introduction to forest types and ecological stratification of Bangladesh	Mr Zaheer Iqbal
11:30	National forest inventory in Bangladesh	Dr Mariam Akhter
12:00	Experiences from destructive field work in Bangladesh, the case of the Mangrove forest and the database of tree allometric equation in Bangladesh	Dr Mahmood Hossain
12:30	Lunch Break	
Session3: Introduction to the statistical software		
13:30	Using Allometric equations and field inventory data on xls	By group of 2 people per computer
14:00	Comapring the results from different tree allometric equations on R	By group of 2 people per computer
	Basic statistics	Prof. Laurent Saint-André
16:30	Round table	

Day 2: 23 Feb 2016

Session 4: Development of allometric equations "state of the art"		
9:30	Exercise: Quality control and graffic exploration	Prof. Laurent Saint-André
11:00	Break	
11:30	Complexity of tree growth and biomass allocation	Prof. Laurent Saint-André
13:30	Break	
14:30	Sampling strategy and stratification	Prof. Laurent Saint-André
16:00	Field experience on building tree allometric equation	Dr Matieu Henry
16:30	End	

Day 3: 24 Feb 2016

Session 4: Development of allometric equations "state of the art"		
9:30	Exercise: First glance at model fitting	Prof. Laurent Saint-

		André
11:00	Break	
11:30	Exercise: Linear, non-linear	Prof. Laurent Saint-André
13:30	Break	
13:30	Data entering, data management and QC	Dr Matieu Henry
14:30	Graphical analysis and first data interpretation	Dr Matieu Henry
16:00	Practical cases and issues related to model fitting	Prof. Laurent Saint-André
16:30	End	

Day 4: 25 Feb
2016

Session 4: Development of allometric equations "state of the art"		
9:30	Exercise: log-log model fitting and backtransformation	Prof. Laurent Saint-André
11:00	Break	
11:00	Exercise: tree species specific model development	Prof. Laurent Saint-André
13:30	Break	
14:30	Group presentation	By group of 2 people per computer
15:30	Integrating wood density factors	Prof. Laurent Saint-André
16:00	Model in use	Prof. Laurent Saint-André
16:30	Concluding words	
16:30	End	

Appendix 2.   Participant List

ID	Name	Gender	Organization	Designation	Phone no.	e-mail
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Appendix 3.   Evaluation

Responses were received from eight participants.

Male	5
Female	3

How often do you participate in training related to forest monitoring?

A professor/academic	3
A student	1
Forest Department staff	3
Government staff (outside Forest Department)	1

I would describe myself as?

Forester	5
GIS/RS	3
Statistics	1
Social survey/assessment	1
Economics	0
Natural Resource Management	3
Ecology	2
other	0

My professional background relates most closely to:

First time	2
1-3 every year	6
More than 3 per year	0
Regularly (approximately one per month)	0

My years of relevant experience is:

1-2 years	1
3-5 years	2
5-7 years	2
8-10 years	0
More than 10 years	3

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
The training was relevant to my daily work	5	3	0	0	0
I had enough previous knowledge to understand the content of the event	0	3	2	2	0
The training met my expectations in terms of the content and learning outcomes	3	3	2	0	0
The learning resources provided were adequate and useful	4	3	1	0	0
The resource person presented information in a way that i could understand and was easy to follow	2	6	0	0	0
I feel confident to be able to carry out the tasks described in the training without supervision.	1	3	2	2	0
I was pleased with the venue/meeting room/snack etc	4	4	0	0	0

Any other comments?

Obviously there's no shortcut in learning. So it would be great if such training can be extended for few more days or better, divided into couple of phases.
More emphasis is needed to be given in explanation of the statistical and mathematical affairs related to the allometric equation development. Exercise with data from other regions of Bangladesh is also needed. Developing allometric equation in other forms incorporating other variables i.e. height will also be helpful in future.
The trainers were very friendly and helpful,i learned so many things from them.
Need some training coarse about statistics program
Need some training on Basic Statistics and Allometric equation.