How much carbon do Ghana's teak plantations sequester?

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Fellow at work: the author does some desk research.

FORESTS SERVE as a major reservoir of carbon, containing about 80% of all carbon stored in land vegetation. Large quantities of carbon may be emitted into the atmosphere during conversion from forest to another land-use, contributing to the increase of greenhouse gases in the atmosphere. The fast-dwindling nature of our forest estate is therefore alarming.

Many measures have been designed and put in place to encourage afforestation and reforestation. One of these is the Clean Development Mechanism of the Kyoto Protocol, under which afforestation-reforestation activities may qualify for carbon credits, which could lead to payments for carbon sequestration. Effective and accurate methods of accounting for carbon are needed to implement such sequestration projects.

The objective of my ITTO fellowship was, therefore, to acquire skills in and knowledge of the various modelling methods applied in carbon accounting. It was conducted at the Wageningen Agricultural University in the Netherlands under the supervision of Professor G. M. J. Mohren.

Ghana's plantation program

Ghana has a program to replant 20,000 hectares of its degraded forestlands each year with the aims of assisting economic development and providing new wood resources. The new plantations also act to sequester carbon.

Site characteristics

Table 1: General features of the sample plots

PARAMETER	SITE	
	TAMALE	BOLGATANGA
Area (hectares)	0.063	0.063
Height (m)	21.7	23.3
Basal area (m^2 per hectare)	26.5	32.4
VOLUME		
Stem (m^3 per hectare)	268	343
Foliage (m^3 per hectare)	19.6	21.4
Branches (m^3 per hectare)	171	211
Roots (m^3 per hectare)	105	111
TOTAL VOLUME *(m^3 per hectare)*	**564**	**686**

Teak (*Tectona grandis*) is one of the main hardwood species used in plantations in Ghana, having been planted for the first time in 1905 (Odoom & Varmola 2002). Teak grows very well in Ghana, with a mean annual increment of 8–10 m^3 per hectare (Bhat & Ma 2004). The systems used in plantation establishment are taungya and 'standard' monocropping.

Model description

The CO2FIX Version 3.1 simulation model (Masera et al.2001) is a user-friendly tool designed to quantify the carbon balance of both non-forested and forested ecosystems. It is a multi-cohort (see below), ecosystem-level model applicable to many situations, including afforestation projects, agroforestry and selective logging systems. It can be obtained for free from the internet at: http://www.efi.fi/projects/casfor/. The minimum requirements for installing the program on personal computers are: Intel 80386 processor, 4 MB RAM memory, 4 MB free space on the hard disk and any Win32 operating system previously installed.

A 'cohort' is defined in the model as a group of individual trees assumed to exhibit similar growth and which may be treated as a single entity within the model. Parameters to consider when running the model include initial biomass, growth and mortality of the cohort, and interactions between and within the cohort. The CO2FIX model has several components, described below.

Biomass and soil models

The model accounts for all carbon stock in the living biomass (above- and below-ground). The basic methods for modelling the growth of a forest are: (a) tree growth as a function of tree or cohort age; and (b) tree growth as a function of tree size (eg basal area, volume or biomass).

When the age of a cohort is known, biomass growth is often modelled as a function of time. On the other hand, biomass growth is modelled as a function of diameter increment when the cohort age is unknown. The mortality of each cohort can be described in two ways: mortality due to senescence and density-related competition, and mortality during and after logging.

Parameters for thinning and the final cut for each cohort must be defined. The required information for each cohort includes: age at which harvesting takes place; the intensity of the harvesting (fraction of cohort biomass removed); and the allocation of the biomass removed to the different raw-material classes of slash, logwood, poles and fuelwood.

The required inputs for the soil model are mean annual temperature, precipitation in the growing season, and potential evapotranspiration in the growing season for the study area.

Product model

The product model estimates the carbon stock in the product from harvesting to final decay. It takes into consideration the life span of the product, its purpose, and the portion it takes from the tree.

The bioenergy model calculates the effect of using wood or wood waste for the generation of energy. This emission avoidance can be expressed in terms of carbon and added to the total stock in the system to calculate the total effect of the modelled plantation on the atmosphere.

Data collection

To run the model, data were collected from two teak plantations at Bolgatanga (11°47N, 0°51W) and Tamale (9°25N, 0°51W) in northern Ghana. Temporary 25 m x 25 m sample plots were demarcated at the centres of the plantations; trees within the plots were counted to establish tree density. Height and diameter at breast height were measured for basal area and stem volume calculations. *Table 1* shows basic site data.

The soils at both sites are savanna ochrosols found on the Voltian sandstone. The topsoils are generally thin (<20 cm), greyish-brown sandy loam, and weakly granular and friable. The annual rainfall is 1000–1200 mm, with a peak around August-September. The mean annual temperature is 28°C (Boateng 1966).

Carbon accumulation

Table 2: Accumulated carbon stock in two teak plantations in Ghana

	TAMALE	BOLGATANGA
COMPONENT	**VOLUME** *(m^3 per hectare)*	
Stem	35.7	43.9
Foliage	4.72	5.16
Branches	40.9	50.7
Roots	25.3	26.6
	CARBON *(tonnes per hectare)*	
Biomass	107	126
Products	9.73	12.8
Soil	35.8	43.9
TOTAL	**165**	**191**

The model assumed a rotation length of 40 years, average wood density of 480 kg per m^3, and a mix of products (sawlogs, poles and fuelwood) harvested over the life of the plantation. *Table 2* summarises the outcomes of the modelling.

The net carbon that would be accumulated over the 40-year rotation is therefore estimated to be 165 tonnes per hectare at Tamale and 191 tonnes at Bolgatanga.

Conclusion

Further testing of the model parameters should be carried out in other teak plantations in Ghana. Many new things have been learned through this training program, and I hope that it will enhance my work and my contribution to the country's environmental management.

References

Bhat, K. & Ma, H.O. 2004. Teak growers unite! *TFU* 14/1.

Boateng, E. 1966. *Geography of Ghana*. Second edition. Cambridge University Press, Cambridge, UK.

Masera, O., Garza-Caligaris, J., Kanninen, M., Karjalainen, T., Liski, J., Nabuurs, G., De Jong, B. & Mohren, G. 2001. Modeling carbon sequestration in afforestation, agroforestry and forest management projects: the CO2FIX V.2 approach. *Ecological Modelling* 164: 177–199.

Odoom, F. & Varmola, M. 2002. *Hardwood plantations in Ghana.* FAO Working paper FD/24. FAO, Rome, Italy.

Fellowships awarded

Twenty-five fellowships worth a total of US$156 100 were awarded at the 39th session of the International Tropical Timber Council in November 2005. Awardees were:

Stephen Lartey Tekpetey (Ghana), to undertake a PhD in wood technology; **Bibi Pamela Mbohno** (Cameroon), to do a postgraduate diploma in tropical forest ecosystem management; **Qiao Chen** (China), to take a short training course on monitoring and managing tropical forests using remote sensing; **Fernando Fernández Méndez** and **Carolina Alcázar Caicedo**, both of Colombia, to undertake master's programs in the management and conservation of tropical forests and biodiversity; **Ripu Mardhan Kunwar** (Nepal), to prepare a technical document on non-timber forest products in Nepal; **Newton Jordao Zerbini** (Brazil), to do PhD research in Xingu, Para, Brazil; **Minlend Albert** (Cameroon), to participate in a short training course on sustainable natural resource management; **Vag-Lan Gomes Boges** (Brazil), to prepare a technical document on the economics of babassu trees products and derivatives in the Amazon; **Ganesh Bahadur Karki** and **Shiv Kumar Manjan**, both of Nepal, to undertake a master's program in watershed management; **Remy Shabantu Mukongo** (Democratic Republic of Congo), to attend a short training course on forest products; **Arsenio Bacerdo Ella** (Philippines), to publish manuals on Philippine woods; **Janice Monica Bollers** (Guyana), to do a master's program in environmental forestry; **Denis Ngatse** (Congo), to undertake training in improving transparency in the international trade of tropical timber; **María Soledad Bastidas Fegan** (Ecuador), to do a master's program in agroforestry; **Edouardo Zama** (Central African Republic), to do a master's program in the participatory management of forest resources; **Adje Oliver Ahimin** (Côte d'Ivoire), to conduct doctoral research on developing criteria to identify high conservation value forests and relevant silvicultural treatments in tropical forests; **Keassemon Herve Kone** (Côte d'Ivoire), to prepare a PhD thesis on reducing invasive species in teak plantations; and **Sadhna Tripathi** (India), to undertake a study tour.