Fellowship Report

Teak growth and carbon capture in Togo's teak plantations

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Plot measurement: A. Control teak plantation; B. Permanent plot; C. Marked tree; D. Applying flagging tape. *Photos: S. Ali (at right in photo D)*

The land area of private and state plantations in Togo is estimated today at over 40 000 ha (ITTO, 2005 and MERF/FAO, 2011), of which 70% is planted with teak (*Tectona grandis L.F.*). Teak is also gaining increasing interest among private plantation owners. Factors such as agroforestry conditions and the ability to adapt to the climates prevailing in most of the country explain teak's popularity in Togo.

However, volume parameters specific to Togo's teak plantations are not well known. General parameters published by technical organizations such as FAO, the Intergovernmental Panel on Climate Change (IPCC), or data specific to neighbouring countries such as the Côte d'Ivoire or Ghana, have often been used for estimating the standing volumes or the volume of carbon captured by teak. Whereas teak has colonized all ecological zones, it is quite common to observe growth variations in reforested areas or natural regeneration areas in the country.

This study on the dynamics of teak populations, which was financed by the ITTO Fellowship Programme as part of the author's doctoral research work at Bircham International University, is therefore justified in this context. In the study, the volume of carbon captured and the carbon emissions reduction potential of Togo's teak plantations were estimated, providing forest- and timber-related operators with specific local data for five sites located across the country's five Administrative Regions and distributed across three ecological zones in the country.

Objectives

The general objective of this study is to contribute to the sustainable management of Togo's forests through the provision of data in order to help enhance agroforestry with planted tree species with a view to increasing their production and provision of environmental services.

More specifically, the study aims to evaluate teak growth in Togo's ecological zones I, III and V, and to determine the potential of teak for the reduction of carbon dioxide (CO_2) in order to provide baseline data, which can be used afterwards for the monitoring and management of teak planting, and to determine local allometric equations (calculation of standing volume, carbon, etc.).

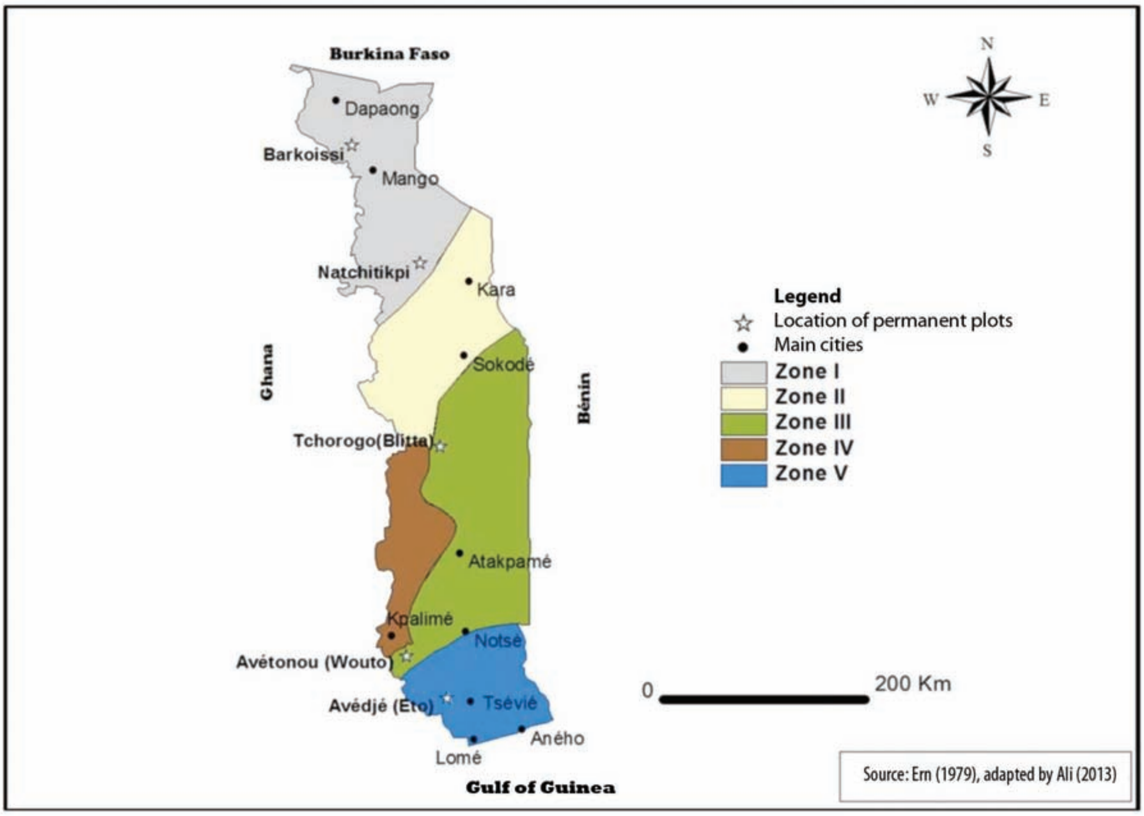
Methodology

Five reforestation sites were selected, i.e. one site per Administrative Region. From the viewpoint of the ecological zones, two sites are located in zone I, two in zone III and one in zone V (Table 1). Material used included a 20 m chain, a knife, masking tape, measuring tape (for forestry use), data collection sheets, Blum-Leiss dendrometer, pots of red paint, seals, brushes, flagging tape and GPS. In total, eighty-three 400 m² plots (20 m x 20 m) were established randomly in the five sites with a 0.21% sampling rate. Parameters measured include the diameter at a height of 1.30m above the ground, the total height and the bole height. For each plot, the mean density, mean diameter, mean height and dominant height, basal area and the spacing factor were calculated. Teak growth was then compared between all sites.

Table 1. Study sites and their ecological profiles

Sites	Administrative regions	Site location (ecological zone)	Description
Mango-Barkoissi	Savanes	Zone I	Lowland of northern Togo, Sudanese savanna vegetation, climate with one rainy season
Natchitikpi	Kara		
Tchorogo	Centrale	Zone III	Dry savanna forest with Guinean climate, one rainy season in the centre and two in the south of the country
Wouto	Plateaux		
Avédjé	Maritime	Zone V	Coastal Guinean climate, with two rainy seasons

Figure 1. Map of Togo with ecological zones and permanent plot locations



To estimate the live aboveground biomass (AGB) in plantations, the allometric equation developed by Sandra Brown (Pearson et al., 2005), which is appropriate to Togo's ecological conditions (dry tropical zone with a medium rainfall of between 900 and 1500mm), and to any diameter at breast height (DBH) of no more than 63 cm, was used. The equation is: $AGB = 0.2035 \times DBH^{2.3196}$.

Live belowground biomass (BGB) was determined by applying the ratio obtained from the default parameters of the IPCC to the aboveground biomass (R=0.27). **Dead wood biomass (DWB)**, which essentially comprises underground wood (stumps remaining after thinning), was estimated by multiplying the belowground biomass by a factor varying with age and therefore, with the number of thinnings: $DWB = (2^l - 1) \times BGB$ with l being the number of thinnings. The method assumes regular thinnings (one out of two trees removed) carried out at an average frequency of 8 to 10 years.

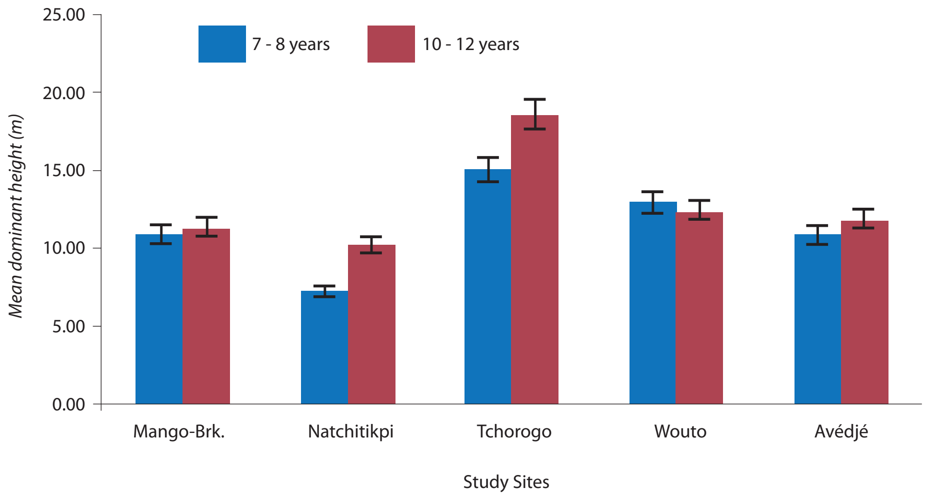
The **carbon content (C)** was deduced from the total biomass by multiplying by 0.5, followed by the CO_2 potential for teak per hectare by multiplying by the ratio 44/12 (3.67).

Results

The sites located in ecological zone III offer more benefits for teak agroforestry in Togo.

In the study sites, the main variation factor for density is the thinning conducted under management operations. The mean value for dominant height by age is also variable due to conditions specific to the ecological zones (soil, temperature, humidity, etc.). In fact, the analysis of mean dominant heights for two age groups (7-8 years and 10-12 years) between the study sites shows that the Tchorogo and Wouto sites, which are located in ecological zone III, are most appropriate for teak growth, followed by the Avédjé site in zone V and lastly, the Mango-Barkoissi and Natchitikpi sites in zone I (Figure 2).

Figure 2. Variation in dominant height per site and age group



An analysis of variance (ANOVA) and the Duncan significance test with a 5% threshold were conducted, and the Tchorogo site showed a significant difference compared to the other sites. The same can be said of the lowest value for the Natchitikpi site, which statistically differs from the lowest value observed in the other sites, except for the lowest value in the Mango-Barkoissi site. Between the two age groups, the difference is also significant (Table 2).

The sites in ecological zone III show the highest potential in carbon content

Looking at all plots, the mean values for the potential reduction of emissions were obtained as follows: 192 tCO_2/ha for the Mango-Barkoissi site, 256 tCO_2/ha for the Natchitikpi site, 498 tCO_2/ha for the Tchorogo site, 275 tCO_2/ha for for the Wouto site and 242 tCO_2/ha for the Avédjé site. Variation observed within the sites is linked not only to the biomass volume (which varies according to the stem basal diameter), but also to the density and the age of plantations. Plantation samples do not necessarily include all age groups in the sites. Between these sites, it clearly appears that in each age group at a 5-year interval, the Tchorogo site accumulates a higher potential CO_2 volume, followed by the Wouto site (in the higher age groups) or one of the other sites (in the lower age group), as shown in Figure 3.

Each site studied represents an administrative region. Based on the total land area of teak plantations in a given administrative region, including all age groups, the total carbon captured and the total potential in tons of CO_2 were determined and considered as a reference scenario at the end of 2012, as shown in Table 3 below. The Centrale Region shows the highest potential, followed by the Plateaux Region, the Maritime Region and the Kara Region. The Savanes Region shows the lowest value.

Conclusions

Currently, the 27 989 ha of teak plantations in Togo are absorbing 8960 $KtCO_2$ of emissions in total; this is the projection baseline data (static) for Togo's teak plantation at the end of 2012. Ecological zone III presents more favourable conditions for the success of teak with its two distinct seasons (dry and rainy) associated with the transition area between the Northern Sudanese climate and the Southern Guinean climate in Togo.

Table 2. Duncan significance test results

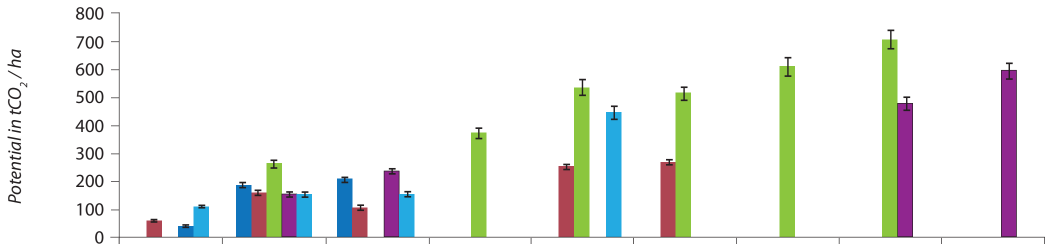
"Age" factor			"Site" factor		
Ages	**Mean height (m)**	**Significance**	**Site**	**Mean height (m)**	**Significance**
10-12	12.88 ± 3.17	a	Tchorogo	16.78 ± 2.06	a
7-8	11.38 ± 2.69	b	Wouto	12.69 ± 0.68	b
			Avédjé	11.34 ± 0.92	b
			Mango-Brk	11.13 ± 1.08	bc
			Natchitikpi	8.74 ± 2.04	c

Note: Different letters in the Significance column for one or more rows/factors indicate significant differences between the mean values of the factors.

Table 3. Captured carbon (C) and CO_2 potential in plantations, by region

Adm. region	Carbon mean value	State plantation	Private plantation	Total captured carbon	CO_2 potential
	tC/ha	tC	tC	KtC	$KtCO_2$
Maritime	66	143 204	269 327	413	1 513
Plateaux	75	317 523	601 682	919	3 370
Centrale	136	324 485	608 397	933	3 421
Kara	70	57 115	113 556	171	626
Savanes	52	2 755	5 610	8	31
Total		**845 082**	**1 598 572**	**2 444**	**8 960**

Figure 3. CO_2 potential variation in the 5 sites by age group



	[1-5]	[6-10]	[11-15]	[16-20]	[21-25]	[26-30]	[31-35]	[36-40]	[41-45]
Mango-Brk.	-	-	205	-	-	-	-	-	-
Natchitikpi	57	57	105	-	251	267	-	-	-
Tchorogo	-	-	-	371	533	513	608	704	-
Wouto	38	38	234	-	-	-	-	475	595
Avédjé	111	111	152	-	444	-	-	-	-

Age groups in plantations

The carbon baseline for teak in Togo was obtained using allometric equations developed in the course of research conducted in other countries. An allometric equation specific to Togo would provide more accurate estimations for carbon, and for the specific teak species used. For this reason, the plots established for this study will continue to be measured not only for monitoring growth change, but also for conducting tests to determine allometric equations specific to the study sites or ecological zones and to the species, in order to be able to quantify teak standing volume and carbon volume with better accuracy in Togo.

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ITTO Fellowship Program

ITTO offers fellowships through the Freezailah Fellowship Fund to promote human resource development and to strengthen professional tropical forestry and related expertise in member countries. The goal is to promote the sustainable management of tropical forests, the efficient use and processing of tropical timber, and better economic information about the international trade in tropical timber.

The next deadline for fellowship applications is 21 February 2014 for proposed activities starting later than 15 July 2014.

Please apply on-line at www.itto.int. Further details are available at www.itto.int or from Dr. Chisato Aoki, Fellowship Program, ITTO; fellowship@itto.int; Fax 81 45 223 1111 (see page 2 for ITTO's postal address).

ITTO fellow receives conservation award

On 20 August 2013, Mr. Constantino Aucca Chutas, a national of Peru, received the conservation award Carlos Ponce del Prado 2013, from the Minister of Environment of Peru, Mr. Manuel Pulgar Vidal for his work in the preservation of biodiversity in Peru. During an interview with the newspaper El Comercio, Mr. Aucca acknowledged the impact that the ITTO fellowship he received in 2008 had on his professional career and in getting a broader understanding of tropical forest management of the needs of the people who live in the forest. Mr. Aucca's fellowship work resulted in a manual on tree planting in community forests, which was subsequently described in TFU 21(1). Mr. Aucca's interview with El Comercio is available at: http://elcomercio.pe/actualidad/1615733/noticia-reconocen-cusqueno-como-artifice-conservacion-nuestro-pais. The ITTO Secretariat is developing a website for ITTO Fellows to share information and to better communicate achievements such as Mr. Aucca's; for more information contact aoki@itto.int.

Happy fellow: Mr. Aucca (left) receiving the Carlos Ponce Prado 2013 award from the Minister of Environment of Peru. *Photo: ECOAN*

India's arid-zone forest biodiversity at risk Cont'd from page 21

- Existing statutory rules and regulations governing the protection and management of *gauchars* and *orans* should be reviewed critically and, if required, amended to make them more stringent. The laws and rules governing the removal of unauthorized occupants from *gauchars* and *orans* should be made more effective.
- The Biological Diversity Act, 2002, provides for the conservation of biodiversity and the equitable sharing of benefits arising from the use of such biodiversity and associated traditional knowledge. Among other things, the Act established the National Biodiversity Authority, the functions of which include regulating access to biological resources and associated traditional knowledge on an equitable basis. Also under the Act, biodiversity management committees (BMCs) are to be set up to promote the conservation, sustainable use and documentation of biodiversity. In particular they are to prepare 'people's biodiversity registers' in consultation with local people, which would contain comprehensive information on the availability of and knowledge about local biological resources. It has been observed that no BMC has yet been constituted in most of the region, nor any such registers opened.

Conclusion

Gauchars and *orans* are like oases in arid ecosystems and they play crucial ecological roles. The Tanot Devi *Oran*, in Jaisalmer district, for example, provides (among other things) shelter for the *chinkara* (Indian gazelle) and *godavan* (great Indian bustard). Minor forest produce is collected by locals for self-consumption, and commercial use is banned. Local people abide by natural laws and have faith in the local god, and the *oran* is free from encroachment and unnecessary exploitation (Dagla et al. 2007).

Traditional approaches to biodiversity conservation and sustainable use should be recognized by policy-makers. In many parts of arid Rajasthan, *oran*-dependent communities still rely on local unwritten constitutions for managing their *orans*. A *maharaj* (guard) looks after the security of the *oran* and is regarded in the community as a religious teacher. In turn, the community provides the *maharaj* with respect, food and money. These traditional approaches must be integrated with wider policies to improve the management of biodiversity hotspots in consultation with local communities. Demarcating these areas on the ground, as well as on cadastral maps, is required. Keeping in mind the vast potential of these areas to sustain large-scale livestock farming for the overall economic well-being of the local people, there is an urgent need to restore degraded *gauchars* and *orans* in an inclusive and cost-effective manner.

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