

Valuation of forest carbon stocks to estimate the potential for result-based payment under REDD+ in Cameroon

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SUMMARY

This study base on existing scientific literature makes an economic evaluation of carbon stocks gained under different deforestation and forest degradation scenarios (100, 50 and 25% avoided deforestation) during a 20 years period (2010–2030). It analyzes the associated financial commitments to achieve greenhouse gas emission reduction, and further discusses deforestation avoidance in the context of the 2035 emergence ambition of Cameroon. The Cumulative Stock of carbon potentially avoided during the period 2010–2030 for the 3 scenarios are 151.10 Mt, 75.55 Mt and 37.77 Mt respectively for 100%, 50% and 25% avoided deforestation. This can lead to an anticipated cumulative carbon revenue of 1 670 648 017. 37 US\$; 835 324 008. 69 US\$; and 417 662 004. 34 US\$ respectively for the 3 deforestation scenarios. Other services such as biodiversity are discussed as co-benefits that can be derived from forest management. The current study thus provides basic information which can help to enrich the debate on the feasibility of REDD+ implementation in Cameroon.

Keywords: Payment for Environmental Services (PES), REDD+, carbon stock, greenhouse gases, Cameroon

Donner une valeur aux stocks de carbone forestier pour estimer le potentiel de paiement basé sur les résultats dans le cadre de la REDD+ au Cameroun

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Cette étude se base sur la littérature scientifique existante pour faire une évaluation économique des stocks de carbone sauvée dans le cadre de différents scénarios de déforestation et de dégradation forestière (100, 50 et 25% de la déforestation évitée) pendant une période de 20 ans (2010–2030). L'étude analyse les engagements financiers pour atteindre les réductions des émissions des Gaz à Effet de Serre, et discute la déforestation évitée dans le contexte des ambitions d'émergence du Cameroun à l'horizon 2035. Les stocks cumulatifs de carbone potentiellement évités au cours de la période 2010–2030 pour les 3 scénarios sont 151,10 Mt, 75,55 Mt et 37,77 Mt respectivement pour 100%, 50% et 25% de la déforestation évitée. Cela peut conduire à un revenu carbone cumulatif de 1 670 648 017. 37 US \$; 835 324 008. 69 US \$; et 417 662 004. 34 US \$ respectivement pour les 3 scénarios de déforestation. D'autres services tels que la biodiversité sont discutés comme Co-bénéfices qui peuvent être tirés de la gestion des forêts. Cette étude fournit donc des informations de base qui peuvent aider à enrichir le débat sur la faisabilité de la mise en œuvre de la REDD+ au Cameroun.

Tasación de los stocks de carbono forestal para estimar el potencial de pago por resultados dentro de REDD+ en Camerún

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Este estudio hace una tasación económica de los sumideros de carbono obtenidos en diferentes escenarios de deforestación y degradación forestal (reducción de la de forestación del 100, 50 y 25%) durante un periodo de 20 años (2010–2030) en base a la bibliografía científica. Analiza los compromisos financieros asociados para alcanzar la reducción de gases de efecto invernadero, y trata además la reducción de la deforestación en el contexto del objetivo de "emergencia 2035" de Camerún. El stock de carbono acumulativo evitado potencialmente durante el período 2010–2030 para los 3 escenarios es de 151.10 Mt, 75.55 Mt and 37.77 Mt respectivamente para el 100%, 50% y 25% de deforestación evitada. Esto puede llevar a un ingreso previsto por acumulación de carbono de 1 670 648 017. 37 US\$; 835 324 008. 69 US\$; y 417 662 004. 34 US\$ respectivamente para los 3 escenarios de deforestación. Otros servicios como la biodiversidad también se discuten como co-beneficios que pueden derivar de la gestión forestal. El presente estudio ofrece así información básica que puede ayudar a enriquecer el debate sobre la viabilidad de REDD+ en Camerún.

INTRODUCTION

Putting an economic value on ecological services provided by forest is a major challenge in tropical forest management (Lescuyer 2000, Scherr *et al.* 2004, Bishop *et al.* 2009, Nlom 2011, Angelsen 2013). Several services provided by tropical forests fall under international/national public goods and services for which a financing mechanism needs to be sorted out (Cooper 2001). Carbon storage, water cycle regulation, soil erosion regulation, and biodiversity conservation are amongst the main ecosystem services provided by the tropical forests (Carpenter *et al.* 2006, Chomitz *et al.* 2007, Laurans *et al.* 2011, Scherr *et al.* 2004). Though biodiversity conservation has always taken central position in international discussions, forest carbon storage is increasing taking an important place in international agendas; especially within the context of the ongoing climate negotiations at the level of the United Nations Framework Convention on Climate Change (UNFCCC). Carbon emissions and the risk of emissions extension is thus ranked top on the list of globally important externalities (Chomitz 2007). Also, carbon storage in the context of the Clean Development Mechanism (CDM) and REDD+ (Reduced Emissions from Deforestation and Forest Degradation and conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries) process is attracting a lot of attention from the international community (Angelsen 2010, Kanninen *et al.* 2007). These processes have also been viewed as being able to help achieve biodiversity conservation; thus the link between the UNFCCC and the Convention on Biological Diversity (CBD). This inter-connectivity has thus lead some authors to come up with the idea of payment for multiple ecosystem services (Busch 2013).

Before the emergence of the current “era of REDD+”, biodiversity conservation has been more present in the forest agenda in Cameroon (Sonwa *et al.* 2011). A network of protected areas covering 10 437 336 Hectares (IUCN Category I to VI) has so far been established in Cameroon, in order to improve the conservation of the forests’ biological resources (Cerruti *et al.* 2010). The State of Cameroon is also taking measures in view of increasing biodiversity conservation and local forest governance. These measures are intended to reduce pressure on the forest habitat. COMIFAC (Central African Forests Commission), which is a regional organization working to harmonize forestry policies in Central Africa, is equally playing a major role in reinforcing these biodiversity conservation objectives of Central African countries.

Financing for the protected areas within the biodiversity conservation strategy has been mainly through public funding by the state, bilateral and multilateral cooperation, as well as private foundations through biodiversity conservation agencies such as WWF and WCS. From the different financial sources for biodiversity management, it is seen that there is not yet a properly established or formal framework for payment for ecosystem services (PES), which could participate in protected area financing (Blom 2004, Essama-Nssah and Gockowsky 2000); instead, considerable effort seems to be directed towards the improvement of forest habitats and

forest cover management (Essama-Nssah and Gockowsky 2000). This means that the efforts are focused mainly on improving forest management rather than on any particular quantifiable payment for biodiversity results. However, some private industries such as MTN-Cameroon (the Cameroon branch of Mobile Telecommunication Network, which is a South Africa-based multinational mobile telecommunications company) and Guinness-Cameroon (The Cameroon branch of a British multinational beverage company), through their CSR (Corporate Social Responsibility) have some ongoing tree planting initiatives that can be considered to support biodiversity management/conservation (Nembot Ndeffo 2009).

The regulation of the water cycle is another important service provided by Cameroon’s forest. Cameroon is covered by four main water basins: the Atlantic, Shanga, Benoue and Chad water basins. The first two fall within the Congo Basin rainforest so are dominated mainly by forest cover. Vegetation cover including forest is known to be an important regulator of the water regime within a watershed. As supported by Pokam *et al.* (2012), 70% of the precipitation in certain parts of the Congo Basin is due to evapotranspiration, mainly due to the presence of vegetation. Amongst other uses, Water is an important commodity for domestic uses (cooking, drinking, agriculture etc.) and also for industrial purposes (Brummet *et al.* 2009). Energy, water supply companies as well as some agro-industries are amongst the main users of water resources in Cameroon. Water is the principal input material in the process line of some of these industries. For example about 4 500 million Kilowatts of energy consumed annually in Cameroon is hydro-electricity power (Ongono 2009).

Carbon sequestration is another important ecosystem function of the forest. Through this process, carbon dioxide in the atmosphere is converted into solid carbon and stored in plant tissues. By so doing the forest contributes significantly in moderating global climatic conditions, hence the importance of the forest in global climate initiatives such as the UNFCCC’s CDM, and the recent REDD+ mechanism.

Despite this broad range of ecosystem services that come from the Cameroon forest, their contributions to the national economic development has been little investigated. Ruitenbeek (1990) and Yaron *et al.* (2001) made an assessment of the willingness to pay for water services provided by the forest in Cameroon but these results were hardly translated into a payment for ecosystem services (PES). Deforestation and forest degradation has an impact on the local hydrological service (Chomitz 2007). Thus, an understanding of the linkage between forest and the hydrological cycle can permit stakeholders in Cameroon both at local and national levels to negotiate the establishment of a PES for water in line with the example of Costa Rica. Such a system is a potential source of additional resources for forest and water management.

Going by the current situation in Cameroon, where forest, water, and energy are being managed by three different ministries, there is a slim chance that any legislation on water and electricity will have any forest management considerations (Sonwa *et al.* 2012). However, the situation is different for carbon stock and biodiversity conservation that can easily be linked to the internationally negotiated processes such as the

CDM and REDD+ mechanisms of the UNFCCC. The REDD+ initiative is a financial mechanism that is being designed to provide compensation for the efforts made by developing countries to avoid deforestation and forest degradation. That is to say the mechanism is designed to reward countries that prevent greenhouse gas (GHG) emissions into the atmosphere through the following activities: (1) Avoiding deforestation, (2) Avoiding forest degradation, (3) enhancing carbon stock, (4) conserving carbon stock, and (5) Sustainable Forest Management. Congo Basin countries appear to show a strong commitment to this process, probably due to the possibility it offers for Carbon trade or the willingness to pay for carbon services of the forest. Like in other countries of the Congo Basin, REDD+ is therefore perceived in Cameroon as an opportunity to compensate what could have been lost by putting the forest under sustainable management, sustainable agriculture, mining activities etc. (Cameroon REDD+ Document). Although REDD+ is still an emerging process, there seem to be an overwhelming interest around it, which makes it potentially capable of attracting international funding (Angelsen 2010, Chomitz 2007, Kanninen *et al.* 2007). There are already some established procedures, notably that emissions reductions in tropical forest countries shall be assessed at the national level based on a baseline scenario to which a project scenario will be compared (Angelsen 2013), and on the basis of which compensations shall be made (Chomitz 2007, Vatn and Anglesen 2009, Bush *et al.* 2012).

In this study, we evaluate the economic value of avoided emissions by examining the benefits that the country will derive from the carbon stocks that will be gained through the implementation of REDD+. The implementation of the REDD+ mechanism however, incurs different costs, notably those linked to the setting up and monitoring of REDD+ projects. Hence, the question this paper seeks answer is what a country like Cameroon stands to benefit in economic terms through the REDD+ mechanism.

In order to answer this question, it is imperative to have an understanding of: (i) the rate of Deforestation and forest degradation in Cameroon, (ii) the carbon stock that can be saved through the implementation of a REDD+ project, (iii) the investment, opportunity transaction costs related to the development of a REDD+ project (or developing a PES for the carbon), and (iv) the prize for a ton of carbon in the voluntary carbon market.

METHODOLOGY

The calculations and analysis carried out in this research are based on data gathered from available literature on the different themes analyzed in the study. Information used in the study were thus generated from studies carried at the global level with data on Cameroon. They can thus be considered as Tier 1 information. As a country, Cameroon will need to generate some data for REDD+ activities base on the requirement within UNFCCC or in voluntary markets. The country is still developing its REDD+ national strategy. We thus prefer to base the analysis on existing scientific literature or economic

data available in well-known public domains. The main focus of the study is to evaluate what the country can gain from efforts put in to reduce emission associated with deforestation/degradation. That is to say the gain from limiting deforestation and forest degradation. On an annual basis, such an income depends on the: (a) existing carbon stock, (b) deforestation rate, (c) Price of the carbon stock avoided, and (d) cost of implementation to reduce the emission. The linkage between the above are as follow:

$$(1) \text{ Emission avoided} = \text{Activity Data} * \text{Emission Factor}$$

In this study, we consider Activity data as Forest Carbon stock and Emission Factor as Deforestation rate, Thus on an annual basis,

$$\text{Forest Emission avoided} = \text{Forest carbon stock} * \text{deforestation rate}$$

$$(2) \text{ Annual Gross carbon income} = \text{Forest Emission avoided annually} * \$/\text{ton of Carbon}$$

$$(3) \text{ Annual Net Income from Forest Emission avoided} = \text{Gross Carbon income} - (\text{opportunity} + \text{transaction} + \text{investment cost})$$

The above calculations can either be done on an annual basis or for a certain propose period. For the current study, since the country wants to be an emergent economy by 2035, we choose to base our analysis for a 20 years period (2010–2030). This is also based on the time period covered by available data on Cameroon. The following sub-sections of the methodology provides some background details on the above elements and the source of data used in this study.

Determination of carbon stocks found in the forest of Cameroon

According to Nasi *et al.* (2009), the estimated average carbon stock in the Humid forest of Cameroon is 185 tons/ha. However, depending on the land cover type, the carbon stock is seen to vary between 45 tons and 192 tons/ha. Other studies have equally quantified the total carbon stocks in the Cameroonian forest. Nasi *et al.* (2009) estimated that the forests of Cameroon can store more than 5043 million tons of carbon, whereas Gaston *et al.* (1998) make an estimate of 3131 million tons. On the other hand, Gibbs *et al.* (2007) provided a more cautious estimation within a confidence interval of 3 454 and 6138 million tons of carbon. For this study since we want to put the information in the global context, we choose to use the figures that come from the global biomass map. The most regularly used global biomass maps are Saatchi *et al.* (2011) and Baccini *et al.* (2012). We choose to use Saatchi *et al.* (2011) because biomass values are provided according to the forest cover, which is one important parameter for defining forest in the REDD+ process. For Cameroon, Saatchi *et al.* (2011) has provided carbon stock values according to forest cover of 10, 25, and 30%. For this study we are using the carbon stock associated with a forest cover of 10% (Saatchi *et al.* 2011).

Determination of the rate of deforestation and forest degradation in Cameroon

Deforestation and forest degradation in Cameroon have been analysed for different time periods. Ernst *et al.* (2012) concluded that the rate of net deforestation between 1990 and 2000 was 0.08%, and 0.03% for the period 2000–2005. Forest degradation was observed to be relatively constant in these two periods; with rates of 0.06% and 0.07% respectively. Duveiller *et al.* (2008) published annual rates of deforestation and forest degradation of 0.14% and 0.01% respectively for the period 1990 to 2000. Meanwhile, another study by FAO in 2007, established that the annual rate of deforestation in Cameroon was 1%. Hansen *et al.* (2013) provided a high resolution global map of the 21st century forest cover change. Therefore in this study, we used the deforestation rate of 0.1% proposed by Hansen *et al.* 2013 following its global character.

Estimation of the carbon gained through REDD+ implementation

In order to estimate the potential carbon stock to be gained from REDD+ implementation, the carbon loss through deforestation and forest degradation is first determined. This calculation is based on total area. Carbon stock value of the entire Cameroon forest (using 10% forest cover) was used as the baseline. We then calculated the value of Carbon loss for the reference level using 0.1% deforestation rate (from Hansen *et al.* 2013) with an adjustment to 0.2% in 2019 and the rest of the study period. The carbon gain during the entire area is thus a 100% forest emission reduction during the period 2010–2030 considered in this study. The 100% can be considered as technical reduction if the country is targeting zero-deforestation.

Because of the macro-economic ambitions set by the Government of Cameroon, it is unlikely to expect that REDD+ implementation can lead to a 100% avoidance. For example, the average annual growth in agricultural production for the period 2010–2020 is projected at 5.3%, consumption of animal protein¹ is envisaged to attain the FAO standard of 42 kg/ha/year. In the forestry sector, more timber is expected to be recuperated following the construction of new dams and the implantation of processing plants. In addition to these, the forestry sector is expected to attain an average annual growth of 2.5% between 2010 and 2020 (MINEPAT 2009). Furthermore, several power plants for energy production are expected to go operational in this period e.g. the Kribi gas power plant in 2013, which is expected to generate 216 MW, the Lom Pangar in 2014; with an expected potential of 120 MW, the Nachtigal dam in 2014; expected to produce 330 MW, and the Memve'ele hydropower plant in 2016; with an anticipated energy potential of 201 MW. These energy

plants are expected to boost annual energy production from 2.9% between 2009 and 2011 to 13% for the period 2012–2020. An annual growth of about 8% is envisaged in the building and infrastructural development sub-sector. It is anticipated that the building and infrastructural development will raise the annual growth rate of this sub-sector to 8.8% over the period 2010–2020. Considering these macro-economic development goals, it was more plausible to assume that REDD+ implementation is likely to reduce deforestation by either 50% or 25%, justifying the consideration of these rates in calculating the potential carbon stock to be gained from REDD+ implementation. In summary, the calculation was done by making three different assumptions as follows: (i) that REDD+ implementation will completely avoid deforestation by 100% (ii) that only 50% of the deforestation will be avoided, and (iii) that only 25% of the deforestation will be avoided during 2010–2030 Period. The total carbon stock in 2010, was then used as the basis to calculate the potential carbon stock gained from REDD+ implementation.

Estimation of the potential economic benefits from REDD+ implementation

The potential economic benefits of REDD+ implementation were determined by calculating the following: (i) the annual net benefits of REDD+ and contribution to the Gross Domestic Product (GDP), and (ii) the projected cumulative revenue for the period 2010 to 2030.

Estimation of the potential gross revenue of carbon sequestration

Carbon negotiations' are still ongoing. The voluntary carbon market is currently one of the main framework within which carbon stock can be sold. However, due to the complex nature of the REDD+ process, it is still difficult to determine the exact price at which a ton of carbon will be sold. In the voluntary carbon market however, the price per ton of carbon ranged from 1.29 to \$ 4.40 USD² during the last quarter of 2012. The average price of a given ton of carbon is about \$ 2.845, i.e. about 1425 FCFA. Using the average market price of each year, we were able to calculate the gross revenue expected for the selling of 100, 50 and 25% of the Emission avoided during the period 2010–2030 in the voluntary market. The database contain the price from 2000 to 2014. For the future years, we used a discount factor of 3% for the period after 2015.

For this study, we used the cost provided by Ecosystem Market place. This voluntary carbon market place includes offsets that are purchased with the intent to re-sell or retire to meet carbon neutral or other environmental claims. It thus offer a good existing perspectives.

¹ It is currently 11 kg/per/year

² Unit price per carbon ton can be found from the following website: www.ecosystemmarketplace.com

Estimation of the annual net benefits of REDD+

The annual net benefits from REDD+ is calculated as the difference between the annual gross revenue and the total annual costs. The discount rate value is used in order to discount expected carbon prices and the costs associated with the implementation of REDD+. For the REDD+ mechanism to be profitable, the willingness by the beneficiaries to pay for efforts to avoided deforestation/degradation and/or to increase carbon stock in the forest must exceed the opportunity cost of the land users. What this means is that the gross annual revenue from REDD+ should be high enough to cover all the costs related to the implementation of the REDD+; which is relatively very high. As mentioned above, the net income is the difference between gross income and the implementing cost.

The costs of implementing REDD+

Three main types of costs are involved when implementing REDD+ either at the local or at the national level. These include: opportunity cost, transaction cost and investment cost.

The opportunity cost: According to Wilkie and Carpenter (2002), the opportunity cost of maintaining protected areas³ (i.e. indirectly by maintaining carbon stock and avoided deforestation/degradation) in Cameroon containing tree species with high commercial value amounted to US \$ 15/ha/year; approximately 7 500 XAF/ha/year. Ruitenbeek (1992) estimated the opportunity cost for creating the Korup National Park at 12.7 US\$/ha/year (approximately 6 250 XAF/ha/year); about 750 XAF/ha/year lower than that calculated by Wilkie and Carpenter (2002). Also, Karsenty (2006) estimated the opportunity cost for conserving the Ngoyla-Mintom forest massif (which is being proposed for conversion to conservation concessions) at 18 US\$/ha/year or 9 000 XAF/ha/year. Estimates of opportunity costs show that they are not constant but tend to increase over time; thus this variation must be taken into account when implementing any PES such as REDD+ (Tchiofo 2008;). One of the main challenges related to the opportunity cost is to know if what is paid is close to the alternative. In the case of REDD+, Gregersen *et al.* (2010) provides some reflection on this issue. Several studies are still necessary to be able to generate local/national rates that can be useful in making the calculation for the REDD+ process. In our case, the opportunity cost of 5.52 \$/tCO₂ base on Stern (2006) & Hatcher (2009) was used.

The transaction cost: Lescuyer *et al.* (2009) noted that the transaction cost for the establishment and operation of a PES scheme is a major obstacle in Central Africa. These costs are generally estimated between 5–25% of the operational budget and include: the cost of implementing the PES project, preliminary studies, monitoring and follow-up of contracts,

sanction mechanism, post evaluations etc. In addition to these project related costs, it is worthwhile including the potential costs associated to changes in land tenure, changes in agricultural practices, and overbidding by local communities during negotiations or in the course of executing the contract. Besides these, one should also include what is euphemistically called administrative costs, informal payments requested by local government officials or public authorities (which if not paid projects managers run the risk of encountering many hassles in the smooth running of their projects) (Green Synergies 2009). For the current study base on the existing literature and base on information available globally (Hatcher 2009), we assume Administrative, transaction and implementation costs of 0.72\$/tCO₂. This cost includes what could fall within the investment cost.

The investment costs: 32.847 million USD is required for the drawing up of the national REDD+ strategy for Cameroon, while the implementation of pilot projects in all agro-ecological zones require US \$ 60 million. In total, Cameroon needs about US \$ 92.847 million, approximately 46.42 billion FCFA to complete the preparatory phase of REDD+, which was supposed to run from 2012 to 2015. The REDD+ preparatory phase will therefore cost 11.6 billion FCFA on average (approximately 23 200 000 US\$ at an exchange rate of 500 FCFA per 1 US). However the country has requested US \$ 3.4 million from the FCPF (Forest Carbon Partnership Facility) for this activity. The extra funds needed will be sort from alternative sources. For example the PSFE (common fund of Multi-Donors for the Forest and Environment sector Program), IUCN⁴ mutual funds, Government of Cameroon, the Regional REDD+ Project of COMIFAC, etc. However, if the necessary funding is not secured in time, this would severely impede the process of implementing a REDD+ type PES scheme. For the current study, we assume that investment cost is part of what Hatcher (2009) put in “Administrative, transaction and implementation costs of 0.72\$/CO₂” (already considered above).

Projection of carbon revenue for the period 2010–2030

The carbon market is not yet in existence in Cameroon, however, we projected the value of carbon sequestration for the period 2010 to 2030 i.e. about 20 years period. This analysis is limited to 2030 because the year 2035 is set as a target by the government of Cameroon for the country to attain an emerging economy status. We assume that deforestation rate will double by 2020. i.e. from 0.1% to 0.2%. This assumption is based on the agriculture and livestock production intentions, as well as the infrastructural development plans set by the government of Cameroon. To arrive at these projections, we applied a discount rate of 3% (regularly used by BEAC) to calculate the cumulative annual revenue over this period.

³ Korup, Dja, Bayang Mbo and Campo-Ma'an

⁴ Through initiatives funded by DANIDA, CBFF, OIBT, ACDI, etc.

RESULTS

Carbon stocks gained from REDD+ implementation

The carbon stock gained due to REDD+ implementation calculated on the basis of 100%, 50%, and 25% of avoided deforestation in Cameroon stands at 151.10 tons, 75.55 tons, and 37.77 tons respectively for the three different scenarios assumed in the study (see table 1 below) for the period 2010–2030. Annually in 2010 the potential gain at 100, 50 and 25% reduction was 4.65; 2.33 and 1.16 Mt. This potential annual deforestation will be 9.20; 4.60 and 2.30 Mt in 2020 for the 3 scenarios. In 2030, it will be 9.02; 4.51 and 2.25 Mt respectively.

Potential economic benefits from REDD+ implementation*Potential Gross revenue of carbon sequestration in 2010*

The potential revenue from carbon sequestration obtained in 2010 was 92 337 273. 47 US \$; 46 168 636. 74 US\$ and 23 084 318. 37 US\$ respectively for 100, 50 and 25% of deforestation avoided (Data not present in the table).

Annual net benefits of REDD+ implementation

From the estimated annual revenue from the carbon saved through REDD+ and the different costs involved in REDD+ implementation, it is seen that in 2010 the country could had potentially generated an annual net benefit of 15 829 303. 35; 31 658 606. 71 and 63 317 213.41 US\$ respectively for 25, 50 and 100% of deforestation avoided.

Potential Contribution to the GDP of the national economy

Considering the Gross Domestic Product (GDP) of 23.7 Billion \$, the avoided deforestation net revenue were 0.067; 0.134 and 0.237% of the GDP in 2010 respectively for 25, 50 and 100% Deforestation. The contribution of avoided emission is seen to be very small (less than 1% of the GDP).

Projected cumulative revenue for the period 2010 to 2030

The anticipated cumulative carbon revenue for Cameroon for the period 2010–2030; calculated on the basis of three published carbon stock values for Cameroon, and considering a discount rate of 3% stood at 1 670 648 017. 37 US\$; 835 324 008. 69 US\$; and 417 662 004. 34) US\$ for 100%; 50% and 25% of avoided deforestation scenarios respectively.

DISCUSSIONS

Deforestation and development in Cameroon

The main deforestation periods is generally associated with the development phases of Cameroon (Defries *et al.* 2010, Mayaux *et al.* 2013, Megevand 2013, Mertens and Lambin 2000, Zhang *et al.* 2002, Wikie *et al.* 2000). Since independence, Cameroon went through 3 main development phases: a longer period with economic growth from 1950 to 1986; an economic crisis from 1987 to 1994; and a new economic ‘reprise’ since 1995 (Ongono 2009). During the first phase the oil boom had been associated with the creation of agricultural investments mostly in the humid forest zone (Ndoye and Kaimowitz 2000). The development of agro-industry in the South West region of Cameroon is observed to have affected areas that are very rich in biodiversity, and this has not only resulted in the alteration of biodiversity, but also in the loss of forest carbon stocks in this part of the country. The economic crisis caused several people to migrate to rural areas for agricultural purposes as the forest was perceived as a cheaper option to cope with the crisis. Deforestation and forest degradation tend to be on an increase during this period. Combining household data with remote sensing data, Mertens and Lambin (2000) observed that increase in deforestation during the economic crisis period had a direct link with population growth, increase marketing of food crops, modification of

TABLE 1 Carbon stock and CO₂ equivalent emission avoided and potential income for the period 2010–2030 in Cameroon

	Reduction of 100% deforestation	Reduction of 50% deforestation	Reduction of 25% deforestation
Initial carbon stock in 2010 (Mt C)	4 646	4 646	4 646
Cumulative Stok of carbon potentially avoided during the period 2010–2030 (Mt)	151.10	75.55	37.77
Cumulative of CO ₂ Equivalent potentially avoided during the period 2010–2030 (Mt)	554.52	277.26	138.63
Annual Potential Benefit from Emission avoided in 2010 (US \$)	63 317 213. 41	31 658 606. 71	15 829 303. 35
Annual Potential Benefit from Emission avoided in 2030 (US \$)	67 624 273.82	33 223 440. 96	16 906 068. 45
Potential Net Benefits from Emission avoided during the period 2010–2030 (US \$)	1 670 648 017.37	835 324 008.69	417 662 004. 34

farming systems, and colonization of new agricultural areas in remote forest zones. The factors of deforestation and forest degradation today are the same as those identified during the economic crisis period. For example, the expansion of agro industries such as oil palm potentially taking place in humid tropical rainforest areas (Hoyle and Levang 2012). The recent Herackles farms development is a tangible example. As already established, soils, climate, market and governance contribute in shaping the pressure on the forest (Chomitz 2007, Megevand 2013, Wikie *et al.* 2000).

Urbanization also results in increase level of fuel wood and illegal timber consumption that is collected from the wild (Nkamleu *et al.* 2002, Tollens 2010). As indicated by MINEPAT (2005), 70% of energy consumption in Cameroon is from traditional biomass. Access to rural electricity is currently estimated at 5% (Ongono 2009). This means that important proportion of the rural population does not have access to electricity and are thus using biomass as their main sources of energy. Road infrastructure development is usually associated with urbanization either for connecting the urban centers to each other or for connecting urban centers to rural areas. Road infrastructure development is seen as one of the key causes of forest fragmentation, which negatively affect biodiversity in central Africa (Wikie *et al.* 2000). Forest fragmentation has a direct implication on biodiversity and an indirect impact on carbon storage (Zhang *et al.* 2002). This means that maintenance of the habitat needs to be planned within the general development plan of the country as the maintenance of forest habitats cannot be separated from the development of the country (Essama-Nssah and Gockowsky 2007, Megevand 2013). Evaluating the situation in the Congo Basin, the World Bank concluded that future deforestation in the Congo basin will be more acute than in the past. This is due to the fact that certain prevailing conditions that slow deforestation are likely to change (Megevand 2013). For instance the region will become more attractive to agro-industrial investments and the urban demand for forest products will be higher. Gbetnkom (2008) concluded that the factors of deforestation in Cameroon are mainly from the non-forest sector and the solution to deforestation will depend on the design of non-forest sector policies.

Base on the findings of this study, using the current available global rate, payment for emission avoided will be contributing to less than 1% of the GDP of Cameroon. Cameroon is stressing that the fact that income from Emission avoided need to be seen as “Cherry over the Cake”; suggesting that what will be important is the development and modernization of land use and land planning through the adoption of good agriculture practices for example. Future research is needed to improve basic information and emission factor as well as real cost for investment in REDD+ process. This will probably help ameliorate the precision of the current findings, which is principally based on global/default factor.

Emission avoidance

Emission avoidance generally requires a combination of political and technical efforts. By adopting some efforts related to afforestation/reforestation, increasing area under

protection and adopting SFM (Sustainable Forest Management), Cameroon is making enormous effort to contribute to the protection of forest habitats (Essama-Nsah and Gockowsky 2007); thus indirectly contributing to avoid emissions. But the carbon implications of these efforts have been least documented. Emission avoidance is the result of a combination of several actions. Alongside economic considerations for emissions avoidance, there is a need to put emphasis on understanding the biophysical aspects related to ecosystem services (Guariguata and Balvanera 2009). Also, institutional and financial mechanisms are key elements to be put in place for any effort to reverse the trend of greenhouse gas emissions. This includes institutions at the national as well as the local level in accordance with what is expected from the international market (see Busch *et al.* 2012 for economic incentives necessary at national and local levels in Indonesia). Efforts for emissions reduction in Cameroon so far include: mangrove restoration, forest plantation projects in the North, West and North West regions (See the REDD-RPP of Cameroon). Some of these efforts have been unsuccessful; thus necessitating a potential need for improvement in order for forest sector related emission reductions to be successful in Cameroon. Agriculture is another untapped potential (Megevand 2013, Tollens 2010). Agricultural research activities in Cameroon up till now have focused on crop productivity and has suggested different methods for the improvement of crop yield. But due to the non-adoption of these improved methods, slash and burn agriculture has continued to be a common practice (Kotto-Nsame *et al.* 2000). As indicated in a recent publication of the World Bank (Megevand 2013), the Congo Basin is still endowed with non-forest land that is suitable for agriculture that has not yet been used up. If agricultural activities are concentrated in such areas, it will result in less emission as compared to agricultural activities in forest areas. Effort in reducing emission from forest lands can be found in the application of SFM. Current studies in Cameroon show that the adoption of SFM can lead to reduction of GHG; but as indicated by Gbetnkom (2008), the important effort to reduce deforestation will come from non-forest sectors such as agriculture, mining, etc. Thus a good inter-sector coordination is imperative for efforts to curb GHG emissions.

Co-benefits associated with emissions avoidance

According to Chomitz (2007), carbon storage and biodiversity conservation are forest services that attract a lot of global interest. Biodiversity conservation is thus one of the first service coming as co-benefit of emission avoidance from forest. But co-benefits from REDD+ for example will include local development and other ecological services associated with the presence of forest. By maintaining forest habitat through avoidance of deforestation and forest degradation, some important services that forest offer can be preserved (Sonwa *et al.* 2012). Environmental safeguards are in place to make sure that carbon storage or accumulation may not be at the expense of biodiversity conservation. Biodiversity conservation in Cameroon constitute a service that can be valorized. The country in the past had already received funding related

to the maintenance of its forest habitat or on the efforts to improve the management of the forest (Essama-Nsah and Gowkowsky 2007). It is established that the Congo Basin forest is playing an important role in hydrology cycling in sub-Saharan countries (Noggerotho *et al.* 2013). In the natural forest, keeping forest habitat also allows the potential for the maintenance of Bio prospection. A study in the south west Region of Cameroon stated the importance of forest for the provision water to agro-industry companies and puts a figure of 70 to 270 \$/Ha of forest that can be paid annually to maintain the forest (Ruitenbeek *et al.* 1990, Yaron 2001). However, the finding of this study was not supported by any concrete actions between the companies and the structure in charge of forest management, so it remained at the level of technical analysis.

At landscape level, forest is also observed to contribute to crop pollination as it is a habitat for pollinating agents. However, little or no information is known on the contribution of promoted pollination on small crop fields and/or industrial plantations. For example the value of bee pollination has been studied in Europe and America and lead to the recommendation that a minimum of forest trees should be kept within the landscape. In Cameroon, such pollination services are still perceived as free services. This means that there still exist some NTFPs and services obtained from the forest that can still be valued under the REDD+ initiative. We therefore observe that several benefits can be associated with emissions avoidance, which span from the rural economy to ecological benefits. For instance, socio-economic benefits such as NTFP collection from managed natural forest and forest plantations from the wild provide income that has not been considered in the analysis in this paper. Also, a full valorization of all the services discussed above is yet to be achieved.

Some authors for example Busch (2013) have raised the issue of payment for multiple ecosystem services. In the case of Cameroon, biodiversity can be a good example for multiple payments as international demand for biodiversity is high and it also falls within the recent Aichi CDB targets. Other co-benefits are valorized more within a national context based on the willingness of the country to make the forest sector received what it is contributing to the national economy. Considering the lack of a national willingness to locally valorize the forest sector and the absence of a clear payment mechanism for biodiversity, this study was focused on the benefits of sustainable forest management in reducing GHG emission.

Efforts and investment to valorize forest carbon storage

A country needs to make some minimum efforts and investments to be able to enjoy carbon benefits. Some of the efforts include: building a coherent and conducive environment at the national, local as well as project levels that can allow all the stakeholders to participate in the REDD+ process. For example a body was put in place to take charge of CDM project development and in the case of REDD+ a committee has been equally set up that includes several ministerial departments (Forestry, Agriculture, Planning and Regional Development etc. . .). Operationalization of REDD+ projects

also demands that a minimum number of institutions/bodies be put in place; including research and funding bodies. Therefore, good coordination amongst the different stakeholders is imperative for the success of the process.

In terms of investment in the REDD+ process, Cameroon has already received several supports. An important part of the money that has been invested so far has come from the International community through multi and bi lateral funding. All these funds were disbursed within the first 2 of the 3 REDD+ phases adopted by the UNFCCC. Besides national level investments to build the institutions, there is also need for local level investment for the operationalization of the REDD+ process.

For protected areas, Blom (2004) estimated that 21 \$/Km² is needed for the effective management of protected areas in the Gulf of Guinea. Wikie and Carpenter (2002) also estimated the opportunity cost for the management of protected areas at 15 US\$/ha/year. Ruitenbeek (1992) estimated the cost at 12.7 US\$/Ha/year for the Korup park, and Karsenty (2007) estimated 18\$/Ha/year while Lescuyer *et al.* (2009) estimated the opportunity cost related to the establishment and operationalization of PES in Central Africa to constitute a major constraint for PES in this region.

In the case of REDD+, a study by ONFI is the only available study that has provided an estimate for the cost of a REDD+ project at a local level (Calmel *et al.* 2010). This means that there is still scarcity of information on what it takes to implement REDD+. However, it is observed that investment cost is a key factor in determining the success of the REDD+ process.

CONCLUSION

PES may be one of the tools to be used to avoid deforestation and save the Cameroon forest so that it can continue to provide ecological services expected from it. For the time being, it appears that among the ecosystem services provided by the Cameroonian forest, biodiversity conservation and carbon storage seems to be those for which there is more willingness to pay. Biodiversity conservation has been supported by several conservation agencies that are present in the country. The PES of carbon storage can be developed rapidly and will help to generate some income for the country. This paper is based on information from available scientific literature, and has help to provide some ideas on what the country can expect from REDD+ under different scenarios. It is important to stress that the estimates produced in this study can act as a base for progressive improvement as more precise data at the national and sub-national levels become available.

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