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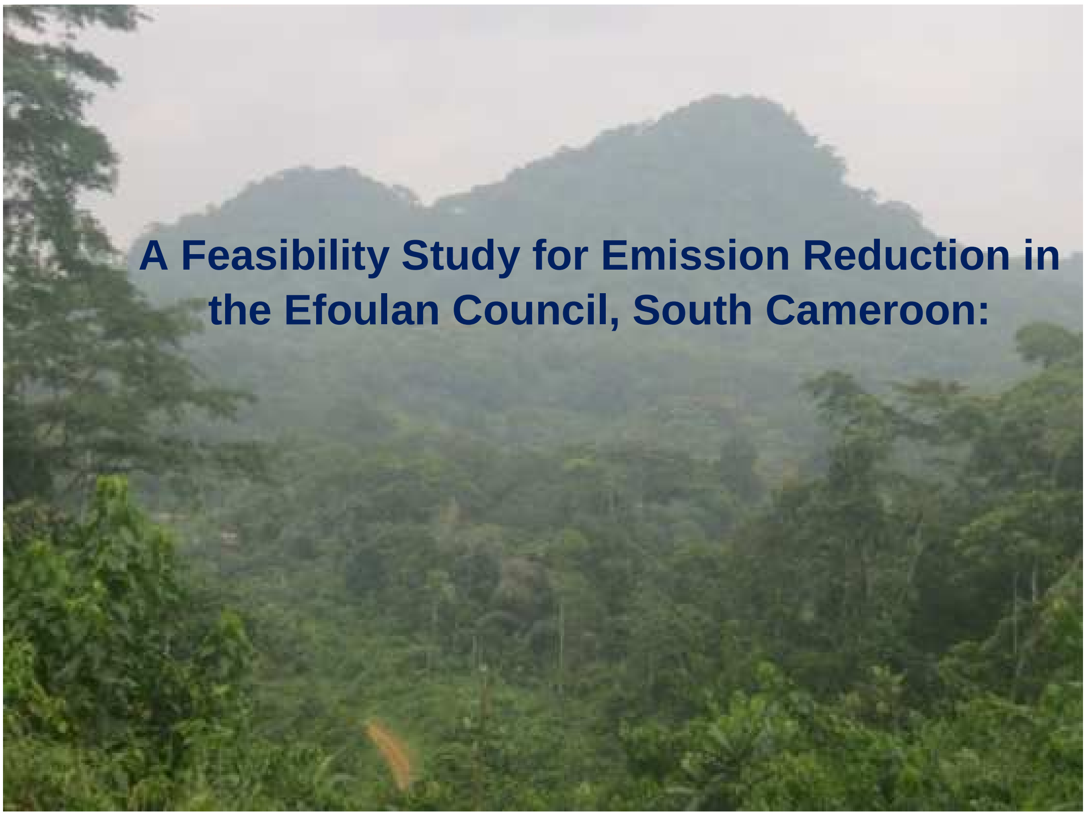
Reducing Emissions from All Land Uses-
REALU II- Cameroon Project



A Feasibility Study for Emission Reduction in the Efoulan Council, South Cameroon:

By:

Martin Yemefack and Dieudonne Alemagi (editors)

2013

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Partnership for the Tropical Forest Margins

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A Project Design Document (PDD)

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Martin Yemefack and Dieudonne Alemagi (editors)

2013

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TABLE OF CONTENT

LIST OF FIGURE

LIST OF TABLES

Acronyms

AFOLU	Agriculture and Forestry Land Uses
ASB	Alternative for Slash and Burn Partnership in the forest Tropic margins
CTFC	
COP	Conference Of Parties
HHS	Center for International Forestry Research
ICRAF	International Centre for Research in Agroforestry (The World Agroforestry Centre)
IFAD/FIDA	International Fund for Agricultural Development
IITA	International Institute for Tropical Agriculture
IRAD	Institut de Recherche Agricole pour le Développement
FCPF	Forest Carbon Partnership Facility
GEF	Global Environmental Facility
GHG	Green House Gas
GIS	Geographic Information System
GPS	Global Positioning System
MINEPDED	Ministry of Environment, Nature Protection and Sustainable Development
NGO	Non Governmental Organization
NRM	Natural Resource Management
REALU	Reducing Emissions from All Land Uses
REDD+	Reducing Emission from Deforestation, forest Degradation and recovery of carbon stocks
PDD	Project Design Document
PNDP	Programme National de Développement Participatif
PNUD	Programme des Nations Unies pour le Développement
UNFCC	United Nation Framework for Climate Change
UNEP	United Nation Environmental Program
UN-REDD	United Nation- Reducing Emissions from Deforestation and forest Degradation
RaTa	Rapid Tenure Assessment

Summary

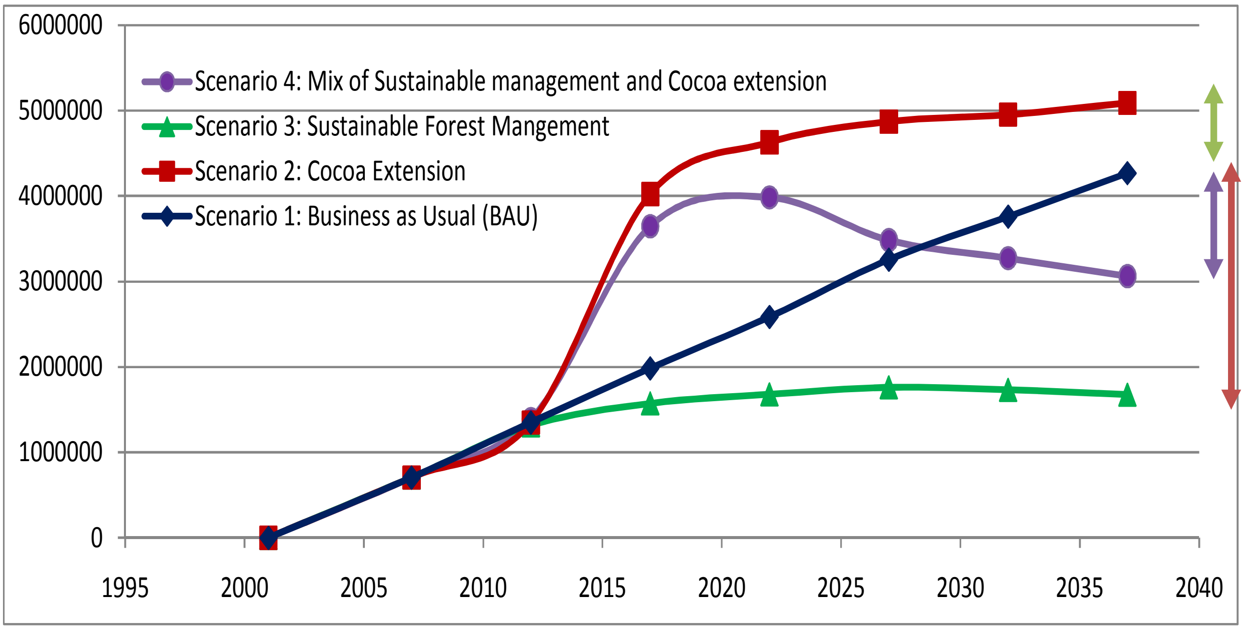
This document presents a study carried out within the REALU framework in Cameroon to assess the feasibility for greenhouse gases (GHG) emissions reduction or avoidance within the Efoulan Council, one of the poorest municipalities of southern Cameroon. This ecologically and economically valuable forest region is under serious threat of deforestation and forest degradation, caused by local people and others stakeholders through the establishment of food crops, cash crops (Cocoa and Oil palm plantations) and logging. Food crop production is based on shifting cultivation systems in which crop land shifts each season and each year from one land portion to another. Abandoned plots are left to fallow and reused after variable duration. Aboveground vegetation biomass in this system as compared to the primary forest with 232 ton of carbon stock per hectare is very dynamic and varies from 25 in cropland to 185 in old fallow plots. The perennials plantations of cocoa and oil palm are less dynamics and the carbon stocks of the vegetation biomass varies from 50 to 115 ton per hectare depending on the age of the plantation. Logging, although selective, contributes substantially to forest degradation, biomass damage and consequently to carbon emission in the area. However, some literatures argue that applying proper identification of the Minimum Felling Diameter (MFD) and other reducing impact techniques on logged species can avoid up to 35 ton of carbon loss per hectare. Beside these practices, the Cameroonian Government rural development strategy has clearly stated that the government will promote the extension of cocoa farms by more than 50 000 ha from 2010 to 2015, targeting forest zones in different municipalities.

The analysis of Carbon stocks in four major land uses (primary forest system - 311 TC/ha with almost 65% contained in tree biomass, jungle cocoa with 185 TC/ha, forest fallows – 163 TC/ha, and crop fields - 87 TC/ha) showed clearly that any development intervention that affects the three first land use types has a considerable impact on the loss of the carbon stock from the area. Analysis of land use changes between 2001 and 2007 showed a considerable decline in undisturbed forest area of around 194 ha/yr while there was an increase in cocoa plantations and crop fields by about 145 ha/yr and 45 ha/yr respectively. Logged forest area has also decreased (63 ha/yr). In sum, the observed land use changes in the municipality has resulted in diminishing carbon stock in the area as the major changes are happening in the land uses with high carbon stocks. Based on these baseline data, four key scenarios were developed to evaluate the feasibility of emission reduction or avoidance during the coming 30 years. Three of these scenarios which are strongly interlinked with greenhouse gases emission, were compared against the business as usual scenario in which no emergent intervention takes place to improve the GHG emission. In the three scenarios, most of the land use conversions are occurring due to the expansion of cocoa farms, with the assumption that one-tenth of the envisaged cocoa expansion in the country happens in the Efoulan municipality thus resulting in 5000 ha of cocoa farms creation by 2016. The baseline scenario based on the historical land use dynamic and forward looking change was considered the Business As Usual (BAU).

The scenario based on sustainable management of forest involving the implementation of good forest management strategies (like reforestation and reduce impact logging) in production forest, community forest and communal forest produces the best result in term of emission reduction and avoidance from the baseline, with 1 675 627 ton CO_2-eq emission in 2037 as compared to 4 267 938 ton CO_2-eq emission from the baseline (BAU). At the 30 year-period this scenario can reduce a total of about 3 000 000 ton CO_2-eq. The Cocoa Extension scenario reflecting the current interest of the government and the local population to increase cacao production by extending the cocoa farm in the area by 5000 ha in the coming 5 five years contributes the most on CO_2 emission, with 7 836 729 ton CO_2-eq emission above the baseline situation at the end of 30 years. However, the scenario involving cocoa extension and sustainable forest management practices application, was able to reduce CO_2 emission by 1 204 844 ton in 2037 as compared to BAU. The projections from these scenarios are summarized in the following figure.

The study has thus demonstrated that opportunities for reducing emission exist within various land use systems at the landscape level in the Efoulan municipality of South Cameroon. Any municipal plans formulated to reduce emission from the different land use systems must however, ensure that sustainable practices (intensification and diversification of cocoa agroforestry systems, suitable management of timber and other useful trees within cocoa agroforestry systems, reduced impact logging, afforestation and reforestation) that serve to improve the livelihoods

of forest-dependent communities are adopted and promoted. Such a bottom up approach should help to design realistic REDD+, NAMA and REL/RL that can be negotiated with national government; and offer an opportunity for synergies/ integration of REDD+, adaptation and or development plans at local level in a way that is cost effective. Our focus on this municipality was borne out of the consideration that with the effective completion of the decentralization process in Cameroon, the council administrative system would play a key role in the natural resource management framework as embedded in the municipality development plans.



Introduction: Opportunities and landscape approaches for Land Use based emission reduction

1.1- Background and concepts

REDD+ (Reducing Emission from Deforestation, forest Degradation and recovery of carbon stocks within forests) is a forest based mechanism set up for valuing the role of forest trees in stabilizing greenhouse gases concentration in the atmosphere for climate change mitigation (UNFCC, 2010). It is hypothesized that this REDD+ mechanism, if appropriately designed into well-developed projects, may emerge into a cost-effective approach that would help protect forests and mitigate climate change. In this context, the amount of emission reduction from a project depends upon the emissions that would have actually occurred without the project minus the emissions of the project. This hypothetical scenario is known as the Baseline of the project. However, according to Angelsen *et al*. (2012), an emerging problem for REDD+ is how to develop these reference levels, in order to provide a benchmark to measure the impact of the scheme in the form of reduced or avoided emissions. As from such benchmark, suitable projects are thus considered additional if they are different from the Baseline Scenario. This implies that something must happen that would not have happened without the project. On the guidelines developed by the UNFCCC, this additionality for an area can be described in a Project Design Document (PDD) prior to the implementation of the project in the area. This is a comprehensive document containing also a brief description of the anticipated positive or negative impacts associated with the project activity, the measures proposed to overcome the negative impacts and the reactions of stakeholders from various parties.

Such PDD have to be elaborated through an action research and a set of approaches to implement effective landscape-based strategies for REDD+ within a context of rural sustainable development, national sovereignty, respect for indigenous rights, and the integrity of a global greenhouse gas accounting system. Andelsen *et al*. (2012) have also recently, developed a stepwise approach to developing reference levels at the national level, in line with recent decisions by UNFCCC and building on the same logic as the tiered approach for emission factors. This stepwise approach can reflect different country circumstances and capacities and will certainly facilitate broad participation and early startup. The availability and quality of data should determine the methods used to develop reference levels. A condition with improved data availability (considering the drivers and activities that cause deforestation and forest degradation) will be important for adjusting reference levels with more accuracy.

Although the REDD+ can be a valid and viable mechanism for climate mitigation, it only addresses part of the total emissions from land-use change. It will be much more effective if constructed as part of a comprehensive architecture addressing all land use in developing countries. That is why the IPCC guidelines (IPCC, 2007) decided that methods of accounting should include all sources of carbon pools (Agriculture, Forestry and Other Land Uses (AFOLU)). A broad-based approach of Reducing Emissions from All Land Uses (REALU) was thus identified to be of a potential that can lead to greater emission reductions and larger benefits for local people. The REALU context aims to greatly increase the effectiveness of the REDD+ mechanisms by developing further methods and tools that include all transitions in land cover that affect carbon storage. In this concept, more attention is needed on the interactions between forest carbon stocks, other carbon stocks affected by land use, the major drivers of land use and forest change, and the livelihoods of the hundreds of millions of people whose actions shape those changes. Because, alone, REDD+ is likely to be hampered by methodological problems of leakage, unclear definition of forest, measurement methodology and equity issues between and within developed and developing countries with different agro-ecosystems.

1.2- The REALU concepts and framework

The ASB Partnership is now running Phase II of implementing REALU project which is a complimentary approach to understanding and dealing with drivers of deforestation within REDD. The southern region of Cameroon in the humid forest zone of the Congo basin is one of the major ASB benchmarks since the past 15 years. Several studies carried out since this date, have produced a considerable amount of information that can be useful for developing reference levels for the productive landscape of the area. The ASB REALU is a NORAD funded project of which, the first phase largely involved research and reviews on key areas that could enhance the understanding of landscape approaches to REDD and the implications for ongoing UNFCCC negotiations in five countries (Indonesia, Cameroon, Peru, Vietnam, and Nepal) across the humid and sub-humid tropics.

The project is based on the need to account for all sources of emissions to fulfill the mitigation and emission reduction targets. The real concern is on emission displacement across land categories, with substantial tree cover outside of conventional forest categories considered in the original concept of REDD. In its actual development, the REDD+ debate has developed in parallel to the NAMA (nationally appropriate mitigation actions) approach to deal with emissions at national scale through a combination of policy instruments. In this context, the ASB partnership created an initiative as an anticipation and response to such debates, in order to address the issues of land-use definition or boundaries within REDD. This initiative is based on Reducing Emissions from All Land Uses (REALU), a more holistic landscape approach to land-based emission reduction efforts (van Noordwijk et al., 2010; van Noordwijk et al., 2009). REALU also tries to ensure that NAMA's are based on Locally Appropriate Adaptation and Mitigation Actions (LAAMA) addressing real needs of the rural development and environmental targets.

Contributing to the REALU, Van Noordwijk et al (2009, 2010) provided evidence of the emission reduction achievable by inclusion or exclusion of various land-use types in policy instruments. In this regards, they believe that REALU objectives could be conducted through the promotion of high carbon-stock land uses supporting global climate goals as well as low-emission development goals at the local and subnational levels. As such, they defined three foundations aspects necessary to achieve REALU objectives: (1) Respect of the rights of indigenous people through free, prior and informed consent (FPIC); (2) Respect for national sovereignty within differentiated global responsibilities; and (3) Integrity of accounting systems based on AFOLU guidelines. Moreover, emission reduction and carbon enhancement in four different land use categories were laid out as the four pillars of REALU (Figure 1):

1. Reducing emissions from deforestation and forest degradation (REDD).
2. Reducing emissions through improved peatland management (REPeat).
3. Reducing emissions by carbon-stock enhancement (REStock).
4. Reducing emission from greenhouse gases owing to agricultural activities (REAgg).

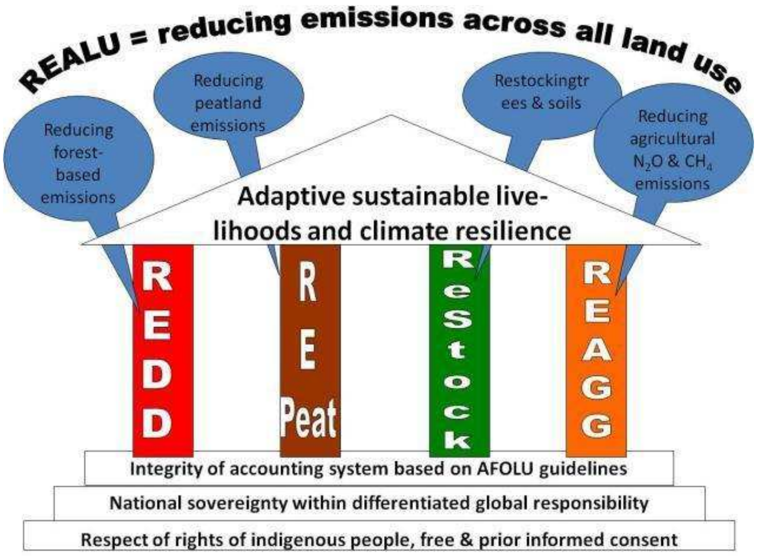


Figure 1. REALU foundation on three principles and architecture with four columns supporting the goal of adaptive sustainable livelihoods and climate resilience (After van Noordwijk et al, 2009)

About Emissions from peatland: RE peat

Peatlands are wetland ecosystems characterized by the accumulation of organic matter under cold and/or anaerobic conditions. These ecosystems are the largest terrestrial long-term sink of atmospheric carbon accounting for twice as much carbon as the biomass of the world's forests. They contain very high carbon stocks under natural conditions. However, the carbon stored is readily emitted when the vegetation is cleared and the soil is drained. In its natural condition and with good natural vegetation cover, peatlands serve as a sink for carbon that contributes to reducing greenhouse gases in the atmosphere, although the carbon accumulation process is very slow. Removing land cover and draining the peat soil will result in the oxidation of the carbon to CO_2 emitted in the atmosphere.

Peatlands ecosystems have been comprehensively investigated in boreal zones compared to tropical areas where very little data have been accumulated with respect to their ecological and socioeconomic aspects. Tropical forest peatlands are essential terrestrial carbon pools with diverse direct functions such as water regulation, protection from natural geomorphic processes, and mitigation from flood and macroclimate stabilization (Page, 2004; Page et al., 2006; Rieley et al., 2008). They also provide diversity in terms of plant communities, wildlife, hydrologic and many environmental other functions. These habitats have been estimated to represent about 11% of global peatland area, with the carbon pool accounting for between 17-19% of the global peat C pool (Immirzi et al., 1992). Since 1994, there has been a strong international effort to develop awareness of the importance and uses of peatland resources. Today with growing population and urbanization, these resources are endangered in front of expanding agricultural frontiers, illegal logging and poor management.

In Cameroon, some peat landscapes occurring in regions where topography and regional hydrology create impeded drainage, offer great opportunities with their luxuriant swampy vegetation and conditions for endemic plant species protection and environmental service enhancement. Peat C component there is an important C sink storing between 143.9 to 841.6 $MgC.ha^{-1}$. This represent between 2 and 5 times the amount C stored in well drained soils on an average basis. In contrario to Southeast Asian peatlands which are being rapidly converted into production systems for lucrative agribusiness purposes (Murdiyarso et al., 2010), peatlands in Cameroon are unused because of the low commercial value of their dominant forest species made mainly *Sterculia subviolacea* and *Raphia lookeri* and the low pressure of soil resources. However, controls and regulations on peat land resource have not yet been put in place due to the absence of essential information on their extension and characteristics. Their further detailed inventory and evaluation is essential for formulating a national peatland policy. Moreover, from soil management perspectives, information on the variety of properties and characteristics of peat is very important in developing strategies for peatlands management in order to reduce subsidence and potential CO_2 emissions, and achieve a sustainable agricultural system and economic benefits from peatland.

Forest and outside forest: Carbon Restocking

Within the forest transition gradient, land-cover changes serve as internal dynamics that lead to forest recovery (Figure 2). Large areas of the humid tropics are like mosaics, combining features of forests and agriculture and housing hundreds of millions of people. Land uses that store high quantities of carbon, such as agroforestry and other tree-based systems, make up a large part of those mosaic areas. Yet current discussions on REDD+ within the UNFCCC do not adequately address these land uses as part of a potential mitigation strategy, Minang et al. (2008) highlighted evidence showing the potential of such land uses for storing carbon, stabilizing forest resources and generating income. Policies and strategies that harness this potential can contribute to high carbon rural development in the humid tropics.

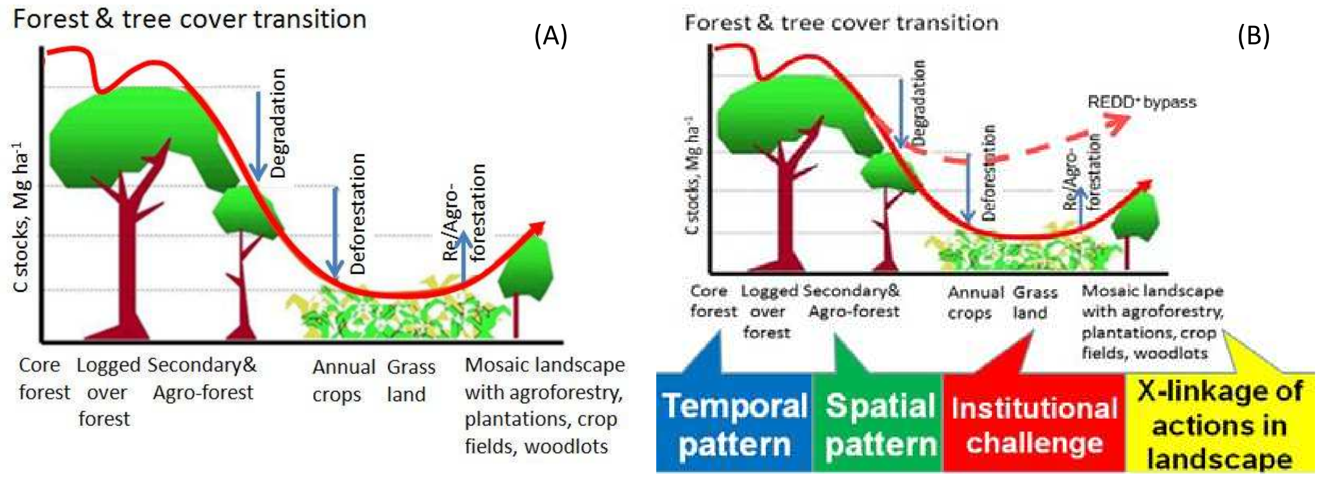


Figure 2. The suggested forest transition curve (A) with its temporal, spatial, and institutional interpretation and consequences for the linkages (B) across the landscape (Source: (van Noordwijk et al., 2009); modified by various subsequent authors)

Agricultural greenhouse gas emissions: REagg

Improvement of agricultural farming systems can lead to higher yields per unit land and reduce total land requirements to meet growing demand for food, feed, fibre and fuel. However, this may also increase emissions of nitrous oxide due to fertilizer use. Integrated ‘footprint’ calculations, as currently done for oil palm, include both costs and potential benefits (when expressed per unit product) of such farming systems. An intensively managed cocoa agroforest with fruit and timber trees is also an interesting model of carbon sequestration maintaining up to 53% of carbon contained in the initial forest system. However, the value and universal applicability of global default values of NO_3 emissions per unit fertilizer use are uncertain.

1.3-REDD+ and REALU in Cameroon

Falling within the Congo Basin forest, Cameroon has over 40% of forest cover. This forest is home to about 50,000 indigenous people whose livelihoods depend on the forest and on a combination of hunting, gathering, fishing and small-scale cultivation. Their customary use typically covers very large areas and requires unimpeded access (Tchoumba, 2005). In the Congo Basin, forest cover loss is estimated at about 0.16 % yearly (Eba’a et al, 2009) alongside the degradation rate of 0.09 % of dense forests (Duveiller et al., 2008). Between 1990 and 2005, the forest cover net loss was estimated to be 9.2%. Most studies (Dkamela, 2010 ; Robiglio et al., 2010), argued that the main driver of this deforestation is slash and burn agriculture and forest conversion into plantations among many other causes. Bellassen and Gitz (2008) even qualified Cameroon as “African deforestation in miniature” since the causes of deforestation in this country are diverse and complex, and could be considered as a summary of the problem in Central Africa.

Rural poverty and climate change have an increasing influence on forest edge community livelihoods and this has led to more anthropogenic activities resulting into increased carbon emissions in these landscapes. At continental level, vulnerability and risks are real in the various ecosystems and the impact of climate change may lead to more deforestation in Central Africa due to population growth. Specialists argue that this situation may become alarming in the Sub-Saharan Africa where the population is expected to increase from 133 million to 189 million in 2020 and probably reaching 307 million inhabitants in 2050 (PNUD, 2001 cited in (FIDA, 2001)).

Reducing Emission from Deforestation and forest Degradation with conservation and sustainable management of forest to enhance Carbon stocks is one of the mitigation and adaptation strategies for climate change (Cancun -UNCFCC, COP 16). This financial mechanism is foreseen to benefit biodiversity protection while maintaining and developing important ecological services provided by forest ecosystems. Therefore, understanding technical requirements and capacity building challenges at national level remains a relevant concern to research institutions in order to support national institutions in their efforts to deepen the state of arts on REDD and REALU frameworks. REDD mechanism is gaining the ground and it is gradually been recognized by many stakeholders (Skutch Marget McCall, 2011). In recent years, plans to establish mechanisms for REDD+ have become prominent in national forest policy-making and sub-national REDD projects are proliferating. In 2008, Cameroon submitted its concept note for national REDD readiness planning (known as a Readiness-Plan Idea Note – R-PIN) to the World Bank's Forest and Carbon Partnership Facility. At that time, there were two planned sub-national REDD projects, while in 2010 this review identified at least a further seven sub-national REDD projects.

There are two ministries in Cameroon with direct responsibility for REDD policy-making and related issues. The Ministry of the Environment, Nature Protection and Sustainable Development (MINEPDED) is overseeing climate change issues, while the Ministry of Forests and Wildlife (MINFOF) is responsible for protected areas and forests. With this regard, Cameroon, under the leadership of MINEPDED, is fully in the process of establishing a clear institutional framework to efficiently implement REDD+ in the country. Many actors are involved in REDD+ mechanism in Cameroon and climate change partners are particularly excitement towards this new funding mechanism. They are participating mostly at different levels depending on status and mission of their institutions. Most REDD actors' perception here is that national institutions have enough capacities to assume coordination with related policy, institutions, regulation and strategy to REDD+.

The climate change and REDD operational unit of MINEPDED, is very committed with the support of the World Bank through the Forest Carbon Partnership Facility (FCPF) and other international institutions, to mobilize national stakeholders in REDD+ piloting initiatives as they published their validated design of the Readiness Project Proposal (R-PP) for large funding in 2012. The government expectations on REDD+ funding mechanism are in line with sustainable development especially in its component of poverty alleviation and carbon stocks increase in the various productive landscapes. However, challenges still lay in terms of policy instruments to ease the implementation and ensure transparency in benefits sharing while developing capacity in carbons dynamics monitoring at forest ecosystems. In this regards, a report from Freudenthal et al. (2011) argues that national REDD readiness planning activities in Cameroon, still lack effective actions to ensure the participation of indigenous peoples and local communities, miss solid data on the drivers of deforestation and gloss over critical land tenure, carbon rights and benefit sharing issues.

That is why this project design document (PDD) of a case study taken from Efoulan municipality with climate change policy and mitigation/emission reduction perspective aims at (i) informing and sensitizing decision-making in the municipalities and (ii) contributing to REDD readiness in Cameroon, with fine resolution tools at landscape level, nested across the sub-national level. The focus is on land use changes trajectories and carbon stocks dynamics in landscapes of forest zones under the governance of municipality. In the forestry law currently under review, the permanent forest domain is classified in 5 legal categories: National parks, forest reserves, production forests, community forests and council forests. They all cover approximately 20 % of the national territory (FAO and MINFOF, 2007) and the last category is the one involving most communities and decentralized local administration. Outside forests, under non-permanent forest lands are made of agroforestry and agricultural lands with also a high potential to sequestrate carbon while having likelihood to increase pressure on the existing forest margins.

1.4-Objectives of the PDD

The project design in the Efoulan municipality is taking advantage on the emerging decentralization context in Cameroon started since about a decade (Law n°2004/017 of 22/07/2004 on decentralization and law n°2004/018 of 22/07/2004 on dispositions applicable to municipalities). The Project design document (PDD) tries to establish the basis in terms of all the envisaged emission reduction scenarios (especially building on any local/regional plans) and assess the feasibility of such scenarios including drivers/leakage analysis. Those expected to use and benefit from this analysis are mostly stakeholders concerned by the current debates on REDD+ within the United Nation Framework Convention on Climate Change (UNFCC). These include individuals, communities, NGOs, private carbon investors and donors collaborating with the local governments in the permanent struggle to reduce carbon emission from land use.

1.5-General methodological approach

The ASB platform in Cameroon including the world agroforestry Centre (ICRAF), the International Institute for Tropical Agriculture (IITA) and the Institute of Agricultural research for Development (IRAD) conducted a series of assessments a forest benchmarks area in the Southern region of Cameroon (Fig. 3). In this process, four councils (Ayos, Efoulan, Ebolowa II and Akonolinga) were candidate for the PDD development. But data collection and processing were proven to be too heavy, we opted to take Efoulan as a top priority for this phase in order to reduce uncertainty. Criteria used for this site selection were: (1) Satellite imagery coverage, (2) good forest cover, (3) active presence of key natural resource management bodies such as CTFC and PNDP, (4) existence of agri-business and forestry logging companies, (5) accessibility of the council, (6) availability of local authorities and their clear vision on natural resource management and (7) Availability of a local development Plan or in the process.

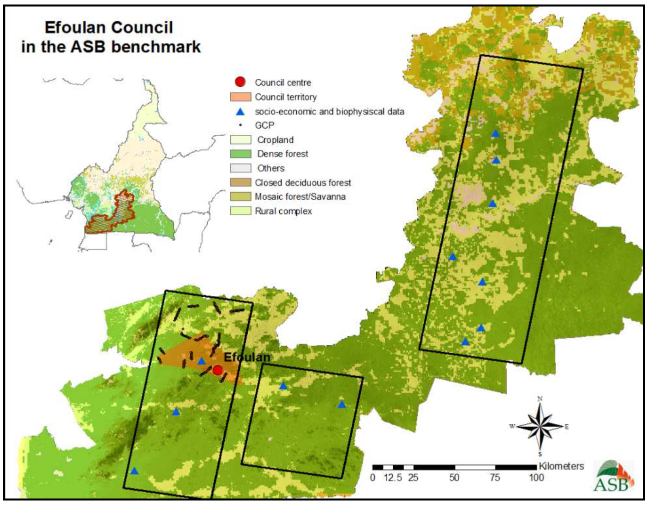


Figure 3. The ASB benchmark area and the Council of Efoulan. Land cover derived from Landsat and Aster satellite image coverage, for 2001 and 2007 respectively. Blue triangles indicate villages where socio-economic and biophysical data were collected. Small black dots indicate Ground Control Point data for RS derived maps validation.

The focus of the municipality planning is on the future implication of the decentralization laws on natural resources at landscape level (Law n°2004/017 of 22/07/2004 on decentralization and law n°2004/018 of 22/07/2004 on dispositions applicable to municipalities). It is anticipated that after effective completion of the ongoing decentralization process, council administrative systems would be key players and facilitators in natural resource management framework as this is to be embedded in the municipality development plans. In this regards, an early involvement/participation of these municipalities seems to be an appropriate entry point for REDD+/REALU development and implementation in Cameroon and the sub-region.

The approach used to achieve the goal of this PDD was based on key action research steps summarized in Fig.4: stakeholder identification and information workshops on climate change challenges, design of the assessment framework for socio-economic and institutional data collection as well as carbons-stocks and land uses changes analyses for scenarios development. Four research proposals were then developed and implemented in the benchmark area, comprising: (i) Household surveys for target villages, (ii) REALU-REDD Readiness, (iii) Land uses change analysis, (iv) Carbon assessment under various land uses.

The ASB research tools were used to assess above and below ground carbon stocks within the benchmark area. Data collection was on transects basis across village and surrounding forests. Socio-economic data, forest tenure systems (Rapid Tenure assessment) and governance issues were assessed and correlated with existing institutions and policy towards building incentive structures to reducing emissions from land uses. At the Efoulan council data collection focused on:

- household survey and forest tenure analysis within communities dwelling in the Efoulan forest landscapes,
- risks and safeguards study under REDD-REALU mechanisms in the context of Efoulan,
- Mapping out of institutions with potential to implement REDD/REALU piloting activities to enhance carbon stocks and reduce carbon emissions under current and future land uses.

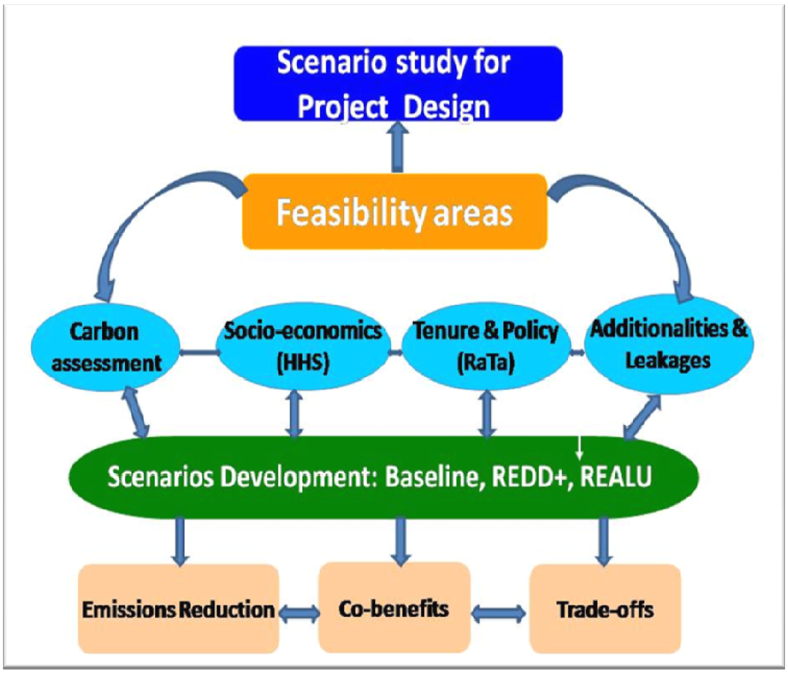


Figure 4. Feasibility study framework

Original conditions at Efoulan

2.1- Efoulan municipality and its governance

2.1.1- General information

The Efoulan council is located between 2°55’ -3°12’ N and 10°35’ - 11°2’ E, within the UTM projection zone 32 N, in the Mvila Division, South Region of Cameroon (Fig. 3). Efoulan locality is situated 32 km from Ebolowa and 43 Km to Lolodolf in the tropical humid forest zone. The administrative boundaries of Efoulan council cover about 830 km^2. This council was created in 2007 following the split of the Ebolowa Council into three different councils namely Ebolowa 1, Ebolowa 2 and Efoulan. For this reason, there is very little historical information and data available about the Efoulan Council. The Council government is made of an elected municipal council of 25 members and an executive body comprising an elected major and two vice-majors, assisted by a general secretary. The decision making team is extended to 12 elected councilors who seat on the major’s convocation to deliberate on the municipal affairs including political, cultural and land/forest resources issues.

The population is mostly rural and the average density is about 10 inhabitants /km^2. The population density within the settlement area of the villages is about 20 inhabitants per km^2, mostly along the two main roads (unpaved motorable public roads) crossing the municipality. Pathways are numerous throughout the forest, joining the villages to agricultural fields, and serving the hunters. This population depends on small scale traditional agriculture based on shifting cultivation, cocoa and oil palm plantations for their likelihood.

2.1.2- *Demography*

Efoulan council has a total population of about 28000 inhabitants distributed in 37 villages. This population is meanly distributed along the roadside (Fig. 5). Fig. 6 shows the distribution of this population in age (A) and its growth trend over time (B). Most of the Efoulan population is rural and depends on agricultural and forest activities for their livelihoods. Due to constant migration to urban areas, the population size may change from time to time. Jobless young people may come back to the village but often not for long due to social tensions.

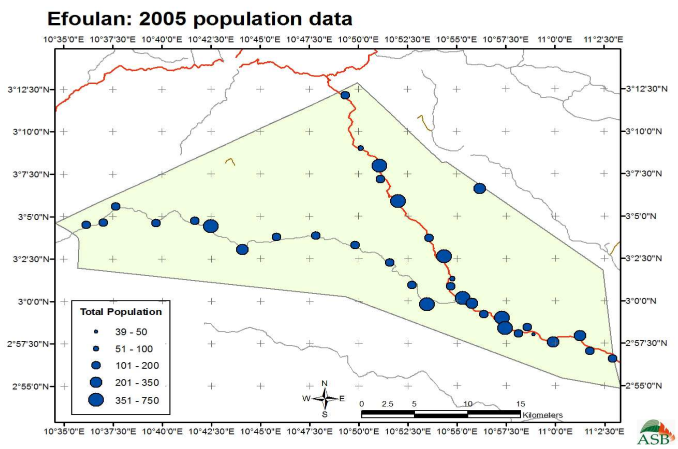


Figure 5: Spatial distribution of Efoulan Population

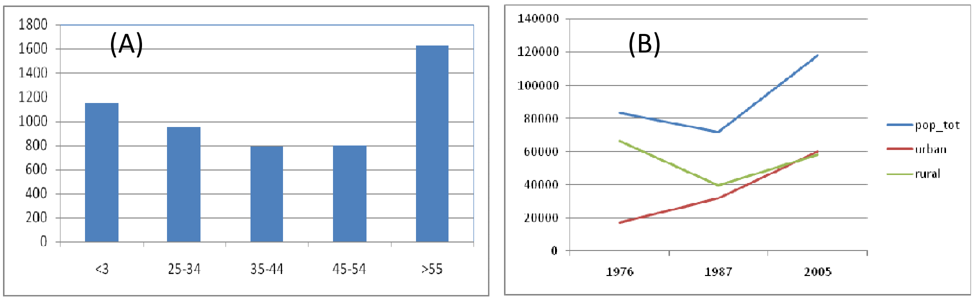


Figure 6: Population structure in Efoulan (A) and its growth trend over time (B) based on various census data of the Ebolowa council including Efoulan (BUCREP, 2010). Note an unbalanced distribution in favor of the over 55s = ageing population (probably due to migration of young people to urban centers).

2.1.3- Technical and Institutional Capacity

Table 1 summarizes the number and the type of institutions that are deploying efforts to strengthen the technical and institutional capacity of municipality in various domains including agriculture, health, husbandry and community forest management. These include Common Initiative Groups, social associations, NGOs, the government national program for participative development (PNDP), scientific research with ICRAF-ASB network.

Table 1: Institutions per legal status and main activity

	Activity/ Objective								
Legal status	Agriculture	Livestock	L.D.	Mutual help	Road Maintenance	Fishery	Politics	TMFU	Total
Association	27	3	1	17	1			19	68
CIG	70	16		5		4		13	108
Political Party							5		5
Union of CIG	2	1							3
Total	99	20	1	22	1	4	5	32	184

L.D. : Local Development ; TMFU : Traditional Microfinance Units; Source : PNDP 2011

2.1.4- Roads and communication facilities

Two main roads (unpaved motorable public roads) traverse the municipality from Ebolowa and splitting into Efoulan-Lolodorf and Efoulan-Bipindi (Fig.5). These main roads are very slippery during rainy seasons, rendering crops evacuation difficult during harvesting periods. The area is thus not easily accessible. Numerous pathways are in the forest, joining the villages to agricultural fields, and serving the hunters. Telephone systems operating in the area are CAMTEL and MTN networks. But, not the villages are covered these networks.

2.2- Biophysical setting of Efoulan municipality

2.2.1- Climate conditions

Efoulan territory is located within the agro-ecological zone with a bi-modal rainfall pattern (Fig. 7). The climate is characterized by four seasons: two rainy seasons (March-June and September-November) and two dry seasons. The average annual rainfall is around 2000 mm, with annual average temperature between 24°C and 25°C (Waterloo et al., 2000). The bi-modal rainfall pattern defines two growing seasons, each one fitting in one rainy season. However, irregularities are observed in local climate conditions in Efoulan and its surroundings (Ebolowa, and Lolodolf). An unevenly and strange changes in the rainfall patterns and in temperature rates are reported by elderly people interviewed during focus group discussions on climate change in Efoulan and Ebolowa. A summary of climatic data from selected meteorological stations surrounding the research area is given in Table 2.

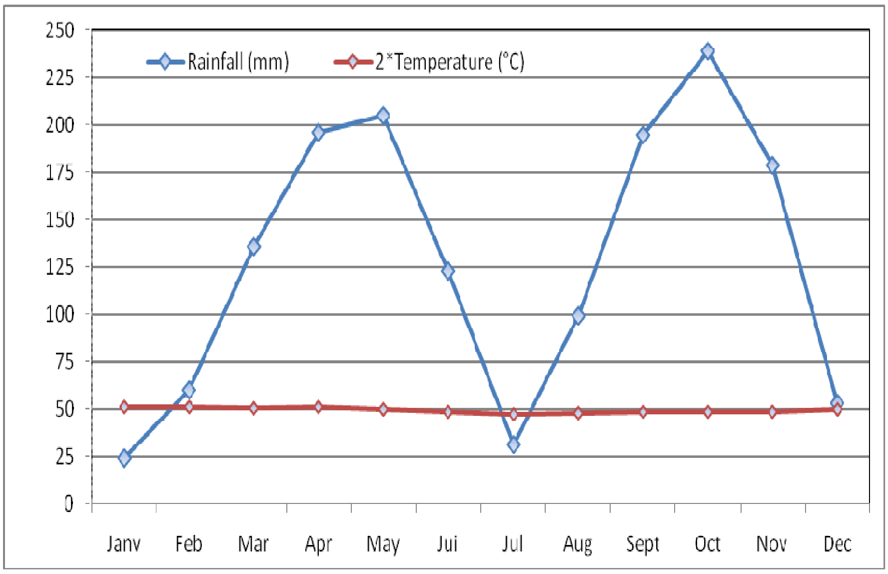


Figure 7: Rainfall pattern (mm) and temperature (°C) of Efoulan Area from A five-year average (2006-2010). Source : Ebolowa meteorological Station.

Table 2: Summary of climatic data from selected meteorological stations around Efoulan

Meteorological station	Lolodorf	Ebolowa
Altitude (m asl)	440	609
Mean annual temperature (°C)	24.6	24.0
Relative humidity (%)	84	83
Mean annual vapour pressure (mbar)	29.3	24.6
Mean annual rainfall (mm)	2096	1720
Mean wind direction	West	West

Lolodorf, n = 25 years; Ebolowa, n = 48 years. Source: Olivry (1986).

2.2.2- Geomorphology, Geology and Soils

The area belongs to the continental plateau of southern Cameroon, a tertiary erosional surface with an undulating to rolling hills alternating with some incised rivers and widely distributed swampy drainage ways. The northern and the eastern parts are underlain by the Precambrian Basement Complex (Champetier de Ribes and Aubague, 1956; Champetier de Ribes and Reyre, 1959) composed of acid metamorphic rocks with both felsic and mafic intrusions. The southern part is underlain by the Ntem Complex composed of leuco-mesocratic gneisses with intrusions of pyroxenic diorites and doloritic gabbros. Soils derived from these rocks are generally fertile for agriculture but loose rapidly their richness under annual agricultural use, pushing farmers to practice shifting cultivation and slash and burn agriculture.

Most of the upland soils (about 95%) are Ferralsols and Acrisols according to the World Reference Base (WRB) for Soil Resources classification system (FAO-ISRIC, 2006) and Kandiudox, Kandiudults, and Hapludults according to the USDA Soil Taxonomy (Soil Survey Staff, 1998). These are strongly-weathered soils in which edaphic constraints such as soil acidity, high exchangeable aluminum and low ratio of basic to total cations are the main limiting factors to permanent cropping systems (Bilong, 1993; Kauffman et al., 1998). These soils groups differ primarily by the presence of a strong textural contrast between topsoil and subsoil horizons in Acrisols and the dominance by sesquioxide clays in Ferralsols. Less developed poorly drained Fluvisols and Gleysols (WRB), equivalent to Fluvaquents and Endoaquents (Soil Taxonomy), occupy the swampy drainage ways (about 5%). Summary characteristics of two localities of the Efoulan municipalities is given in Table 3.

Table 3. Characteristics of the two localities situated west and East of the Efoulan Council.

	Locality	
Characteristics	Ebom	Efoulan
Location	3° 04' N	3° 00' N
	10° 42' E	10° 55' E
Elevation (m asl)	350-500	500-900
Landforms	-Dissected uplands	-Dissected uplands
	-Isolated hills	-Complex hills
	-Complex hills	-Mountains
Relief intensity (m)	30-80	120-250
Rainfall (mm / y)	2000	1900
Mean temp. (°C)	24.6	24
Geology	Migmatites, gneiss	Gneiss

	Ca-Mg complex	Ca-Mg complex
Dominant soils (WRB, 2006)	Well drained, Acrisols and Ferralsols	Well drained, Ferralsols
Ethnic group	Bulu	Bulu
Population*	1300	1095

2.2.3- Vegetation types and forest cover synopsis

According to Letouzey's classification in 1985 (Letouzey, 1985), the Efoulan forest massif is located in the evergreen humid dense forest, known as guineo-congolese forest with two districts: the Biafra Atlantic district made of Cesalpiniaceae and the Littoral Atlantic district made of *Lophira alata* (azobé) and *Sacoglottis gabonensis* (ozouga). Van Gemerden and Hazeu (1999) conducted a detailed vegetation study in the area including Efoulan landscape and reported 490 trees species belonging to 76 families. The most prominent families were Euphorbiaceae (47 species), Cesalpiniaceae (43 species), Rubiaceae (29 species) and Annonaceae (18 species); with about 114 endemic species (Tchouto, 2004). This forest is rich in plant species of which about 12% are restricted to the rain forests of Cameroon (Van Gemerden, 2004).

The vegetation composition changes with increasing altitude and decreasing rainfall from west to east. Characteristics species above 700 m asl are *Greewayodendron suavealens, Scaphopetalum blackii, Dialium spp*. Few emergent trees surpass 50-55 m height, while the closed canopy is at about 40 m. At elevation below 700 m asl, the dominant species are *Anisophyllea purpurascens, Maranthes glabra, Scorodophloeus zenkeri, Garcinia lucida* and *Diospyros hoyleana*. The canopy has an irregular height varying between 15-20 m, occasionally 35 m and is infested with climbers and the presence of epiphytic mosses is characteristic. This second type of forest land is the most commonly used for agriculture because it occurs on flat to gently sloping landforms. Wetland forests are mainly populated with *Rhizophora racemosa* and *Pandanus satabiei* alongside bambous species such as Phyllostachys *spp.* and raphia palms (*Raphia sp*.).

The area is home to a diversity of taxons: the *genus Cola* (Sterculiaceae), *Diosypyros* (Ebenaceae), *Garcinia* (Guttiferae) and *Dorstenia* (Moraceae). A large number of endemic species include: *Hymenostegia bakeri, Soyauxia talbotii, Deinbollia angustifolia, D. saligna, Camplysospemun dusenii, Eugenia dusenii, Ouratea dusenii* and *Medusandra richardsiana*. Several marketable trees for international and national trade are encountered in the Efoulan forest (see Annex 1).

Efoulan forest also provide home of relative safety to several key wildlife species of interest, including an average population of great apples (gorilla), buffalos and a few other notable species such as *Varanus ornatus*, african porc pine and a variety of birds (hornbills, toucans, guinea fowl, parrots, sparrows, turacos, swallows, hummingbirds, pigeons, partridges and hawks). River and wetland fauna include fish species (*Parachara obscura*), *Clarias sp*, *Oreochromis niloticus, Heterotis niloticus,Lutianus sp* and *Lates niloticus*) and crustacea and batracea.

This forest area, however, is under threats due to human influence and other anthropogenic activities such as slash and burn cropping systems and logging. The forest management status is presented in Fig. 10. The deforestation and degradation of this forest occurred as a result of illegal harvest for building poles and fuel wood as the only source of energy for the surrounding and adjacent community members. The resulting pattern of these land use systems in space is a landscape mosaic system (Forman, 1995), which is defined as a spatial and temporal heterogeneity of aggregated elements of distinct boundaries, where the mixed local ecosystems or land uses are repeated in similar form over a defined area. This leads to a dynamic process acting on the spatial pattern of Land Use/Land Cover (LULC) within the mosaic system. LULC types produce a spatial aggregation of various fallow types (Fig. 8), various food crop fields, various perennial plantation types, undisturbed forest, and settlement areas (Yemefack, 2005).

Figure 8. Degrading forest and secondary forest in Efoulan

2.3- Socio-economic setting

Selective industrial logging and extensive agriculture are the most important land use activities in the Efoulan area. Shifting cultivation and perennial plantations of cocoa and oil palm are the main land use systems practiced by small-scale farmers to ensure subsistence food crop production and a small income. Most agricultural farms are smallholdings but there are some larger plantations owned by local elites who are natives of a village, but who live in the cities and are employed in high-status occupations. Agricultural extension is rudimentary mainly due to lack of transportation for agents as well as farmers' limited resources for change.

2.3.1- Farming systems description

Farming systems in the Efoulan area as in most part of the moist evergreen rainforest area of Cameroon are related to five main components: household, cropping, animal husbandry, soil management and non-agricultural (hunting, fishing and other off-farm activities). The household component which contains the farmers is the locus of decision making and plays a central role in the functioning of other components. Cropping systems (first priority activity) based on shifting cultivation and perennial plantations are much more important than animal husbandry (second priority). Food crop production and cocoa perennial plantations are the most cropping activities. Vosti and Witcover (1996) argue that initiatives to better manage shifting agriculture and its alternatives must consider farm household behaviour. However, these are strongly influenced by endogenous and exogenous factors

Agricultural development faces several constraints: local agricultural markets are small, agricultural input markets are underdeveloped, and road infrastructure is poor and not maintained. However, increasing urbanization and consequent demand for food provides new income opportunities and encourages diversification. Policies to encourage agricultural intensification at the household level are then needed to overcome the divergence between the farmer's valuation of forest resource as agricultural land reserves and the societal value of a forest, e.g. timber revenues and environmental values. This can only be achieved, as suggested by Altieri (2002), with a research agenda that involves the full participation of farmers and other institutions serving a facilitating role, so that the constraints are removed or turned into incentives.

2.3.1.1- Social aspects of farming

There is a clear division of labour within the household. Women do the housework, tend the food crop fields, and help men harvest cocoa. Men do the heavy house repair and take care of cocoa and other plantations. Following the falling of cocoa price in the late 1980s, men were involved in the food crop production for cash in lieu of cocoa, clearing land and felling trees to open areas for cash crops. Women do the tilling, seeding, weeding, harvesting, and processing both for subsistence and cash crops. The use of hired labour is rare, mainly for tree felling during land preparation. Cooperative working groups are formed during periods of peak labour requirement. Children help their parents during school holidays, which fall during seeding and harvesting. Well-structured organizations are rare and limited to "tontine" (rotating credit) groups, work groups and community groups. Community groups are organized to facilitate access to government credit for the financing of small agricultural production projects. Groups are formed by affinity and their dissolution is often caused by mismanagement of funds.

Though most income is from agriculture, little is re-invested in agricultural production, occasionally to buy fungicides for cocoa. No chemical fertilizer is used in these farming systems. Cash is used chiefly for kerosene, soap, medicines, and school fees.

2.3.1.2- Cropping systems and cropping calendar

Agricultural land use is of three types: (i) home gardens near the home, (ii) perennial plantations (cocoa, oil palm) at a somewhat greater distance, and (iii) shifting cultivation fields away from the dwelling. It is common to find a forest patch between the home garden and the perennial plantations. This is the place where domestic animals, mainly pigs, stay. It is also used for firewood and material for building, repair and construction.

Table 4 shows the three cropping seasons used in the area and the sequences of farmers' activities. The first ("*Essep*"), running from December to July, is the most important because it spreads over more than four rainy months. Most bush fallow and forest lands are used during this season. The long dry season running from mid-November to the end of February allows the felling and drying of trees and branches from bush and forest fallow clearing. The second growing season ("*Oyon*"), from August to November, is less important because it is shorter than the first season; mostly Chromolaena (*Chromolaena odorata* (L.) RM King & H. Rob.) fallow is cleared; the preceding short dry season running from July to mid-August is not long enough to allow tree felling and drying. Arable swamps and valley bottom are cultivated between December and March ("*Assan*") for the off-season production of food crops by some households only.

Table 4. Cropping calendar and sequences of farmers' activities in various food crop fields

Field type	Cropping periods & Farm activities	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
First growing season ("essep")		X	X	X	X	X	X						X
Second growing season ("oyon")								X	X	X	X	X	
Off-season "assan" (valley bottom)		X	X									X	X
Forest Crop Field (FCF)	1- Clearing of undergrowth	X											X
	2- Planting of Plantain, cocoyam	X	X										
	3- Trees felling		X										
	4- Burning of dry biomass		X										
	5- Seeding cucumber, maize			X									
	6- Harvesting maize						X						
	7- Harvesting cucumber								X	X	X		
	8- Harvesting cocoyam, plantain	→	→	→	→	→	→					X	X
Annual mixed crop	1-Clearing of fallow	X						X					
	2- Burning of dry biomass		X					X	X				

field (CL)	3- Removing of unburned twigs			X					#				
	4- Tilling & seeding of all crops			X	X				#	#			
	5- First weeding				X	X					#		
	6- Harvesting groundnut, maize							X	X			#	#
	7- Second weeding							X	X			#	#
	8- Demsifying cassava							X	X			#	#
	9- Harvesting cocoyam, cassava	→	→	→	→	#	#	→	→	→	→	X	X
Assan	1- Clearing											■	■
(off-season wetland cropping)	2-Burning of dry biomass	■											
	3- Planting	■											
	4- Weeding		■	■									
	5- Harvesting				■	■							

Key: - - ▶: Harvesting continues onwards

Growing seasons

Forest Crop Field (FCF)

1st season of Food crop field (CL)

2nd season of food crop Field (CL)

Off-season crop field (“*Assan*”)

Land preparation is manual. The use of a chainsaw reduces labour only for forest crop field (FCF) preparation. Burning is an essential element of the system for all fallow types, as it is the only way to properly clear the ground of the large mass of slashed undergrowth and felled trees. Burning is also reported to kill weed seeds in the topsoil and stump sprouts that would shade out crop species, and to partially sterilize the soil (Nye and Greenland, 1960; Sanchez, 1976).

Within a typical sequence of cropping activities, a portion of primary forest (PF) or forest fallow (FF) is cleared and trees felled with chainsaw or axe and cutlass. FCF is established with the felled tree trunks left in the field, and crop seeds are planted directly in the topsoil with no tillage. After the FCF (one year later), the plot is cleared and burned to establish CL, and then a Chromolaena fallow follows two years later. Clearing this CF requires less labour, and only cutlass and hoe as tools. Therefore, women may do it by themselves. Dead bush is piled and burned in preparation for tillage, which is done manually with hoe. Tillage is generally shallow and without ridging because of the thin organic-rich topsoil (less than 10 cm) even from PF and due to the thick root layer in this topsoil. No chemical fertilizer or organic manure is applied. Most seed and cuttings are from the farmer’s own stock. Grains are stored in the house near the fireplace, where smoke hinders insect attacks. The heat may reduce germination and women often pre-germinate maize.

2.3.1.3- Home gardens

A home garden is a limited space around the compound with domesticated forest trees, local and introduced fruit trees, annual/biannual and perennial food crops, and managed by the whole family. In the northeast of the study area, Tchatat et al. (1996) reported the presence of 124 useful plant species in the home garden and we observed similar diversity here. Domestic animals are also part of the home garden: goats, pigs, chickens, sheep and ducks.

2.3.1.4- Trees and perennial plantations

Trees provide a considerable part of the production value. Despite market price fluctuation, cocoa is important cash even in remote villages. Fruit trees are planted in food crop fields and remain during the fallow periods. It is estimated that more than 30 tree species are planted or preserved for home use or market sale. The oil palm (*Elaeis guineensis Jacq*.) is of great importance, not only for palm oil but also as source of palm wine and as material for brooms, baskets and light construction. The Raphia palm (*Raphia monbuttorum* Drude) provides wine and materials for furniture and house construction; however these are not grown in plantations but rather exploited wild in the local swamps.

With the low and fluctuating price, new cocoa plantations are not being created, and old ones are not being well maintained. The bush-butter tree (*Dacryodes edulis* (G.Don) H.J. Lam) has gained an important economic role as one of the most important cash crops (Ndoye et al., 1997). Avocado pears (*Persea americana var. americana*) were introduced early in the colonial period and are both eaten and sold.

Semi-industrial plantations of oil palm are increasingly being established by local elites and international agri-business firms, mainly from primary forest land, avoiding conflicts with farmers who have customary rights over existing crop and fallow land. These elites are natives of the village and so by custom have the right to clear land, which no one else is using. These rights were established to allow growing families to expand their subsistence production (Diaw, 1997), but are now applied by the local elites for a completely different purpose. A study on six plantations of this type around the area showed that plot sizes ranged from 27 ha to 197 ha, with a total of 425 ha converted from PF.

Cocoa plantations that are created out of food crop fields and maintained with no input of chemical fertilizer behave like a fallow system, allowing rapid crown coverage and generating biomass and nutrient levels approaching those of the secondary forest after about 15 years.

2.3.2- Animal system

Animal husbandry is limited to the rearing of a few goats, fowl, pigs and sheep. It is practiced by nearly every family but without much attention. Constraints to its development are diseases, absence of technical knowledge, and limited use of breeding animals. By tradition, domestic animal consumption is reserved mainly for important social events. Bush meat is the most important source of proteins for this population. Van Dijk (1999) reported the hunting of about 40 wild species.

2.3.3- Non timber forest products (NTFP)

Other income generating activities in Efoulan area are NTFP from the forests and old fallows. This is an all year round activity with high potential to contribute to household income. Few of the Efoulan dweller are part time hunters and sell bush meats whenever possible and women are mostly involved in fishing, but solely for family consumption. Traditional grafting and petit trading are also providing additional options for house income though practiced at very small scale.

2.4- Forest governance and land tenure

In pre-colonial times, land was communal. The chief of the village granted temporary usufruct rights for agricultural production to kin groups or individuals. Colonial rule from the beginning of the 20th century had a profound effect on land tenure. Cocoa was introduced in smallholder production and its long productive cycle led to the establishment of permanent villages and land claims by kin group according to first clearing. Usufruct rights are not given outside the kin group. Even short-term users rights are not granted to migrants for fear of difficulties and disputes for future negotiations with the authorities of the expanding administrative settlements and industries (Nounamo and Yemefack, 2001). Following independence in 1960, Cameroon land policy was improved through the 1974 reform which instituted the principle of the national land domain, stipulating that the State is the keeper of all the lands and in that capacity can intervene in order to ensure a rational use that takes into account the imperatives of economic options of the nation. However, in spite of the compulsory aspect of land registration, the majority of farm lands remain under customary occupation (Bigombe Logo and Bikie, 1998). Customary land rights are usually based on lineage; the original rights to land being gained through settlement or clearing. It is critical to realise that women are rarely allocators of land rights. Their right to use land generally comes through men, either from a husband or from other male family members.

As another example, plots of land along the roadsides are preferred for farm establishment; this is the source of most of land conflicts since land tenure rights are based on first use and continuous occupancy. For this reason, road and logging tracks are often used by young farmers and migrants to gain access to new lands in primary forest, rather than providing incentives for transformation of local subsistence agriculture into market-oriented farming systems (Mertens and Lambin, 2000). Our results confirm those of Schuck *et al*. (2002) that the 'first use' land tenure system promotes shifting cultivation in preference to sedentary systems with higher investment.

Such socio-cultural issues as land tenure regime and property rights can have strong implications on land use and natural resource management. In order to slow down deforestation, well defined property rights are essential to provide private actors with the incentives to undertake investments in the most beneficial long term use. In case where the opportunity costs for forest conversion are high, conditional tenure could be formulated and used for payment for environmental services.

State forest reserves are poorly managed and open access resources are subject to predatory use (Agrawal and Ostrom, 2001) As such, they are potential areas for immense practice of slash and burn activities. Community forestry enterprises and small and medium–sized forest enterprises therefore represent more promising routes to sustainable forest management. Where the opportunity costs of foregoing forest conversion to other land uses are too high, a combination of policy options involving positive incentives and direct regulation will be necessary if deforestation is to be avoided.

The land use zoning and forest management units delineated in 2012 (Fig. 9) comprise (i) Five community forests for common Initiative Groups, (ii) one council forest, (iii) one forest management unit, (iii) one forest reserve and (iv) sales of standing volume. On the fringe of the Sangulo hills, Efoulan ranges from 193-1027 m elevation, which forms the remote but threatened forested landscape with eastern boundary to Biwong Bané.

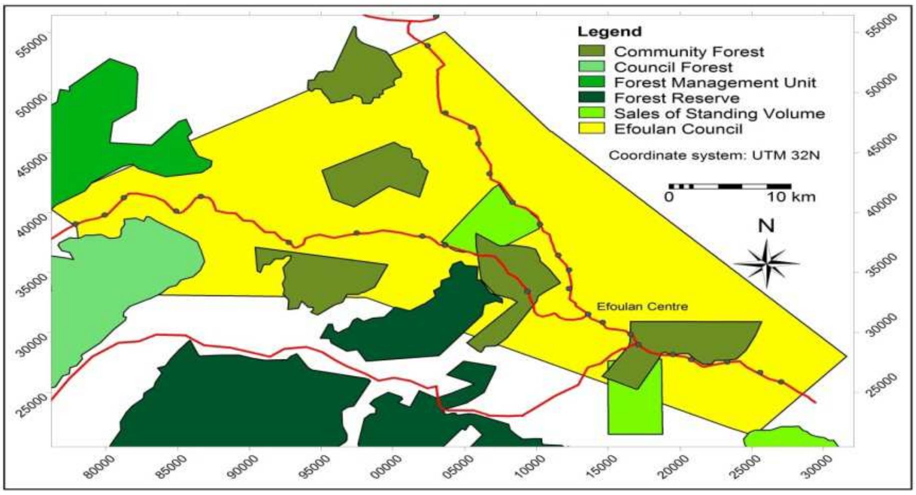


Figure 9. The 2012 Forest land use zoning and forest management plan in Efoulan

2.5- Land Use Dynamics

The cultivation of food crop fields (FCF and CL) shifts every season from one place to another by clearing a parcel of fallow land (FF, BF or CF) or a portion of primary forest (PF). The resulting spatial pattern is a landscape mosaic system in the sense of Forman (1995), composed of patches of primary forest, fallows, crop fields, perennial plantations, and settlements with their associated home gardens. Farming system studies in the area revealed five different cycles of shifting cultivation:

1. Crop lands with fallow (CF) of less than five years (FCF-CL-CF-CL-CF), here called the "rotational short fallow system" (RSFS).

2. As above, but allowed to reach BF before re-clearing (FCF-CL-CF-BF-CL-CF-BF): "Rotational long fallow system" (RLFS).
3. As above, but allowed to reach FF before re-clearing (FCF-CL-CF-BF-FF-FCF-CL-CF-BF-FF-FCF): "Rotational very long fallow system" (RVFS).
4. Agricultural fields expanding into primary forest lands (PF-FCF-CL-PP), the "forest conversion system" (FCS).
5. Once-used and then abandoned agricultural land, which may approach primary forest conditions (FCF/CL-CF-BF-FF-PF and FCF-CL-PP-PF); the land is removed from the management system.

The RSFS and RLFS are mainly practiced for mixed food crop fields, and the RVFS and FCS are practiced for cucumber production and for establishment of semi-industrial perennial plantations by non-peasant elites.

Agricultural statistics for the Mvila, including Efoulan, show an extension of the traditional cash food crop production such as plantain (*Musa sp*.) and melon (*Cucumber manii* and *Cucumeropsis sp)* that are farmed in the forest field right after clearing. Despite the increase of agricultural land extension, agricultural activities in the area have undergone very little innovation in the last 10 years. This can be explained most probably by the low population density, ageing of population, and difficult access to market due to the periodical bad conditions of the road network. The situation is expected to change once the main axis to Ebolowa will be paved, connecting through Lolodorf, Yaounde to the future Kribi deep seaport. The forest land of Efoulan, until now preserved by conditions that are unfavorable for agricultural development, might in the near future experience new threats both by the logging and the agricultural sector.

As previously indicated, selective industrial logging and extensive agriculture are the most important land use activities in the Efoulan area. Shifting cultivation and perennial plantations of cocoa and oil palm are the main land use systems practiced by small-scale farmers to ensure subsistence food crop production and a small income. Most agricultural farms are smallholdings but there are some larger plantations owned by local elites who are natives of a village, but who live in the cities and are employed in high-status occupations. Agricultural intensification is rudimentary mainly due to lack of transportation for agents as well as farmers' limited resources for change.

Table 5 shows the proportion of land utilisation (both area and households) within these. An average of 12% of the agricultural area was in the FCS cycle but this only occupied 5% of the population; this does not include the wealthier segment of the population with significant involvement by local elites. About half of the area and households were occupied with the traditional RLFS, but a significant proportion of both area (19%) and households (32%) with the RSFS. This trend towards shorter fallows (RSFS) is likely due to the limited labour to clear dense fallows (FF, BF), thus giving preference to clearing CF, and the limited availability of new land near roads.

Table 5: Proportion of actual land use within the agricultural production cycles at smallholders scale.

	Year 1		Year 2		Year 3		Average	
Production Cycles	% AA	% HH	% AA	% HH	% AA	% HH	% AA	% HH
RSFS	18	33	26	37	15	28	19.5	32
RLFS	52	51	46	49	55	56	51	52
RVLFS	20	11	15	10	17	11	17	11
FCS	11	5	13	5	14	5	12.5	5

Keys: %AA = percentage of total agricultural use area; HH = Percentage of total households in the four villages; RSFS= rotational short fallow system (less than 5 years); RLFS= rotational long fallow system (7-9 years); RVLFS= rotational very long fallow system (more than 15 years); FCS= agricultural fields expanding into primary forest lands, the forest contracting cycle (After Yemefack, 2005).

An important issue in the area is the net rate of deforestation for agricultural purpose. 88% of the area cleared for crop fields came from fallow lands and only 12% from primary forest (Table 5). With no estimate of the proportion of the food crop fields that are abandoned to secondary forest, as this is only apparent after at least 15 years. If this is 12% or more, the system does not require net conversion of forest under the present situation of slow population growth and weakly developed infrastructure and markets.

However, with the involvement of elites in agricultural plantations, net deforestation is probably occurring, because these plantations are only developed within the primary forest to avoid land-use conflicts. In addition, plantation plot sizes are far larger than those of small farmers.

In the study by Yemefack (2005) in the area including the Efoulan territory, 35 households cleared 95 ha in three years, of which only 12% was from PFFV (=PF); extrapolating this to 315 studied households this suggests that about 855 ha were cleared, of which about 102 ha from PF. By contrast, only six elites' plantations converted 425 ha, all from PF, during the same period. Thus, in the context of deforestation more attention should also be paid to the elites' agricultural activities. Because of the larger patches and limited species composition and pattern, these are probably more of a threat to biodiversity; in fact, Van Gemerden *et al.* (2003) argued that shifting cultivation has contributed to the actual high level of biodiversity of these rainforests.

Another major question is rotation length. In our study one fifth of food crop field plots were based on short rotational fallow cycles (RSFS), about half on long rotational fallow cycles (RLFS), one-fifth on very long fallow cycles (RVFS), and one-tenth on primary forest conversion (FCS). The systems in our study area include shorter rotational fallow cycles than reported for other areas (Nye and Greenland, 1960; Ruthenberg, 1976; Sanchez, 1977). These shorter fallows systems result mainly from the farmers' desire to replace cash income from cocoa with cash crops. If these shorter fallow cycles were sustainable, there would be benefits both ecologically (minimizing deforestation) and for the household (less labour). This may require intensification: tighter integration into the market economy and some purchased inputs, with special attention to nutrient cycling and soil management.

2.6- Divers of Land Use Changes

Four to five main periods can be considered of having great incidence on the historical development of farming systems in southern Cameroon (Table 6). These have shaped the economies of rural households as they are today. This historical development clearly indicates that households adjust to changes in their environment by changing their livelihood strategies. In this regards, a series of studies (Mertens et al., 2000; Ndoye and Kaimowitz, 2000; Sunderlin et al., 2000; Yemefack et al., 2006) on deforestation dynamics in Cameroon concluded that trends in land use change were related to how thousands of rural households react to the series of macroeconomic shocks, adapting their land use strategies.

Table 6: Summary of farming systems historical development (or drivers) and implications in southern Cameroon (Yemefack and Tchienkoua, 2010)

Period	Macroeconomic events	National/Immediate impacts	National adaptation	Regional adaptation
Before 1880	No great international influence	- Forest land cover exist in all the AEZs	- Subsistence agriculture	- Small plot of subsistence farming with extensively long fallow period - Hunting and fishing were other activities
1880-1930	German colonisation	- Initial stage into economical system - Introduction of new fruit trees and cash crops	- Creation of large agricultural plantation - Creation of road network - Manual railway construction	-Settling of indigenous population along the new roads and creation of villages in the forest area - Creation of most kingdoms (or fon-doms) in the western highlands
1930-1960	French and English colonisation	- Intensification of cash crop (cocoa, coffee, rubber) - Monetisation of rural economies	- Increasing roads construction - End of railway construction and end of forced labour - Development of cities - Subsidies and credit to encourage cocoa, coffee and rubber production	- Expansion of rural population - Adoption of cash crops (cocoa, and coffee for the forest zone and coffee for western Highlands) - Creation of periodic market in rural area - Sale of surpluses of food crop - Farmers engagement in commercial food crop production
1960-1990	Independence of Cameroon	- Initial industrialisation - Increasing export of agricultural products	- Economic growth - More government support to agriculture through para-statal companies	- Prosperity of villages - Creation of primary schools in rural areas

1990-till date	- Economic crisis - Devaluation of the CFA franc by 50%	- Price drop of export commodities - Increasing unemployment in town	- Liberalisation of the economy - Government removal of subsidies on fertilizers - Collapse of most agricultural enterprises -Many young people from town are back to villages for farming	- Farmers abandonment of cash crop for commercial food crops - Involvement of men in food crop production for more revenue -Creation of common initiative groups (CIG) for search of credit - Establishment of large food crop farms in the forest zone - Transformation of coffee plantations into commercial high value food crop in the western highlands - Less or no fertilizer use - Increasing pressure on the natural resource

2.7- Drivers of deforestation and forest degradation

Low national rates for deforestation and degradation set Cameroon and the other Central Africa countries apart from the intense deforestation dynamics in tropical countries of Latin America and South East Asia and make the understanding of past deforestation and dynamics crucial to traces future possible scenarios. Four of the 16 hotspot areas of deforestation in Central Africa assessed by the JRC in 1998 were located in Cameroon (TREES series 1998), suggesting that despite low national rates local dynamics of forest loss are intense. Deforestation is not a uniform process and depending on the way in which the direct and underlying factors that control land use change dynamics combine in a specific locality or region, dramatically different trends can be observed (see Mertens et al. 2000). In order to set up realistic reduction strategies and determine a level of accuracy that is requested for negotiation, forest dynamics have to be understood at the national and at the local level. A contextualized analysis of deforestation drivers and of the direct threats to forest cover is useful to set a sound baseline and identify future scenarios. Here, most of the changes in forest cover are the consequences of land use change. Therefore, to understand forest cover dynamics, it is important to understand the land use and resources management practices and anticipate their future dynamics. If this understanding is based on analysis of historic trends of deforestation and degradation, one should be aware that the same trends may not be indicative for the future.

The most extended land uses in the HFZ are logging, forest protection and agriculture. The spatial pattern of land uses conforms to the National Forest Zoning Plan elaborated in 1993 (Cote et al., 1993) by the Minister of Forestry and Environment, that separates the land into a Permanent Forest Domain (PFD) and a Non-Permanent Forest Domain (NPFD). NPFD is the land that may be converted to non-forest uses, such as industrial plantations, mining, hydrological power basin, or be re-classified as Permanent (for example once Council Forests are established on land that is not part of the Permanent Domain). It includes the zone “under human influence” that were identified by expanding the areas that were already under entropic pressure (agricultural and urban pressure) in 1993, delineated considering a scenario for population in 2020 and assigning to each person 3.6 ha of land.

Based on the ASB experience, observations gathered during the recent fieldwork, and the Strategic Plan of the Ministry of Agriculture, which indicates efforts to increase agricultural production for specific commodities, some major direct drivers of deforestation are identified and summarized in table 7 below. Logging in all forms (selective, illegal, and artisanal) is the main causes of forest degradation.

Table 7: Drivers and underlying factors of deforestation in Southern Cameroon

Direct Drivers of Deforestation in Southern Cameroon	
Main Drivers	***Secondary drivers***
Agricultural Expansion	*1) Shifting cultivation and fallow based rotational systems for food and cash crops as a consequence of a general increase of population density;* *2) Expansion of annual cash crops systems in the per-urban areas and bordering countries such as Gabon and Equatorial Guinea;* *3) Increase of small-scale plantations of oil palm;* *4) Increase of large scale semi-industrial plantations of oil palm, banana, etc;* *5) Practice of traditional forest crop fields for cucumber and plantain (*Essep Afan*);* *6) Adoption of full sun cocoa plantation versus traditional shaded low input agro-forests;* *7) Extension cocoa farmland to 50000ha between 2010 and 2015.*
Infrastructure Extension	*1) Improvement of national and regional transport network; increasing the access to land profitable for agricultural activities and expanding the influence of the urban markets;* *2) Intensification of the local fine grained accessibility pattern thanks to the impressive diffusion of motor bikes and small cars in rural areas;* *3) Development of mining projects;* *4) Development of hydrological power sector with the construction of Hydro-power stations and dams;* *5) Major infrastructural development associated to mining and hydro-power projects.*
Wood Extraction	*1) Illegal and un-planned logging, mostly in non-permanent forest domain;* *2) Fuelwood extraction associated to agricultural activities.*
Underlying causes of deforestation	
Main drivers	***Secondary drivers***
Demographic factors:	*1) Natural incremental population growth;* *2) Intra-regional migration following the creation of new opportunities;* *3) Intensification of urban/rural linkages with off-farm activities.*
Economic Factors	*1) Market growth for both export and domestic commodities;* *2) Welfare and increase of urban demand for timber and food commodities;* *3) Increase of cocoa price and of the certainty in the sector.*
Technological Factors:	*1) Increased accessibility to improved varieties and inputs for export crops such as cocoa;* *2) Increased accessibility to hand chainsaw in the villages.*

2.8- Gender issues: women, access to natural resources and income generating

The way people use and manage forests and land in Efoulan depends on socio-economic and socio-cultural factors, age and gender. The importance of gender depends on the extent to which it determines forest and land resource use, control patterns, decision making power and livelihood strategies. From the forest, women and men obtain different products and receive different benefits from forests. Women and men have different knowledge, access and control of forests. Forestry projects involve men and women in different ways. Women tend to be excluded. Both women and men contribute in different manners to forest conservation and management.

As summarized in table 7, women are the stewards of land and are in contact with the land on a daily basis. They face the greatest difficulties with land but cannot inherit because there no gender sensitive law on land and forest issues. They have limited access to trees (ownership and inheritance). On the basis of customary law which does not recognize women's rights and some social categories to enjoy forest and land resources, there is a critical issue of land tenure and decision making (notably in relation to forest resource management and of its revenues). The law should make a proposal of the customary law which will favour the involvement of women and other social categories in forest and land resource management.

The possibility to create a private forest is on the basis of land ownership. Women's access and ownership to land is extremely difficult, and so, women will be excluded from the process of creating and owning a forest.

Similarly, conditions to access exploitation licenses are out of reach to small exploiters. So, small farmers' groups, despite their proximity to the forest, they are unable to own forest exploitation licenses because the process is quite complicated.

Although women often dominate the collection and marketing of NTFPs they do not have security of access to these products or land and natural resources in general. Initiatives should critically address and integrate gender equality, women's land ownership, empower women and promote the advancement of women's rights. The law should make provisions of separating tree ownership from land ownership. This will give the possibility to a person who plants a tree to become an owner.

Table 8: Distribution of work and benefits/income between men and women in southern Cameroon

	Women	Men
Activities carried out by men and women in the forest	• Harvesting • Collection of fuel wood • Fishing • Wood exploitation for home & traditional uses • Collection of NTFP for • food & medication • Farming • Rituals • Water collection • Crafts and weaving	• Wood exploitation (building, sale) • Fishing • Cash crop production • Logging • Harvesting • Distraction • Rituals • Hunting • Collection of produce for medication
Resources obtained by men and women in the forest	Women use wild patches and marginal areas from which they collect: • NTFP • Fuel wood • Raw material for craft work & medicine • Food • Tree barks • Water • Small scale fishing & hunting • Food	• Men will cut down the trees to sell as firewood or to be used in construction • Industrial wood • Medicine • Raw material for craft work • Bigger animals from large scale hunting • Honey • Fish • Mineral resources
Benefits	Women typically gather forest products for fuel, fencing, food for the family, fodder for livestock and raw materials to produce natural medicines, all of which help to increase family income.	Men are more likely to be involved in extracting timber and non-timber forest products (NTFPs) for commercial purposes
Non cash benefits for men and women	• Food • Medicinal plants • Cosmetic products	• Health solutions • Food • Cultural enrichment • Emotional, psychological and spiritual

	• Cultural benefits • Good harmony with the nature	satisfaction
Cash benefits	• Sales of NTFP • Sales of food crops • Sales of crafts	• Sales of NTFP • Wood sales • Logging • Sales of hunting and fishing products • Food crops

Carbon stock in the current Land Use Systems

3.1- Introduction

Following the full description of land use systems in the previous sections, the current challenge lies in how to quantify and demonstrate the contributions of such land use systems in maintaining or increasing the supply of ecosystem services and producing, under changing climate, a continue support both to human needs and to the functioning of natural ecosystems. The study on carbon sequestration was therefore, conducted in Efoulan, with the following objectives: (i) to assess vegetative composition within the land use patterns; to quantify above and below ground carbon flux; and to establish the relationship between carbon stocks and land use patterns. This chapter presents the methodology used in this study (Hairiah et al., 2009) and reports on the results achieved on carbon stock in these systems.

3.2- Main types of Land use/Land cover types within the Efoulan area

As mentioned in section 2 above, the biophysical environment of Efoulan is characterized by the tropical humid jungle forest covering the whole territory of the municipality. However, due to human activities, the resulting spatial pattern of this forest jungle is a landscape mosaic system, composed of patches of primary forest, fallows, crop fields, perennial plantations, and settlements with their associated home gardens. Table 9 describes the most common land cover actually encountered in the area. These are defined based on the dominant land use or land cover, but they all comprise a diversity of indigenous and exotic fruit trees, medicinal species and any others useful species. These land use systems provide food to the households and generate substantial economic returns and acceptable levels of critical environmental services.

Table 9: Characteristics of different land cover types found in the agricultural landscapes in southern Cameroon (After Yemefack, 2005)

Treatments	Vegetation cover types (*Local name*) orncrop types
FCF (Forest Cropped Field)	Cucumber, plantain, cocoyam, maize (*Afub afan*)
CL (Cropped Land)	Groundnut, maize, cassava, cocoyam (*Afub wondo*)
CF (Chromolaena Fallow)	Shrub vegetation in which *Chromolaena odorata.* is the dominant species (*Ekotok ngoum ngoum*)
BF (Bush Fallow)	woody vegetation of pioneer species and young forest trees without trunks (*Nnom Ekotok*)

FF (Forest Fallow)	Woody vegetation with trunks and a closed canopy in which forest species of secondary forest are of dominant amount (*Afan*)
CP (Perennial Plantations)	- Cocoa, fruit trees, and woody vegetation (with trunks and a fairly closed canopy) of forest species. (*Afub caca*)
OP (Perennial Plantations)	- Or Oil palm with grass vegetation under palm trees (*Afub melen*).
HG (Home garden)	Domesticated forest trees, local and introduced fruit trees, annual/biannual and perennial food crops, managed around the compound.
FV or PF (Virgin Forest)	Tropical rainforest species (*Afan*)

3.3- Data collection, processing and analysis

Based on Hairiah *et al*. (2009), three types of nested sub-plots were set up in each sample plot area depending on vegetation: 40 m x 5 m sub-plot for counting trees and dead wood between 5 to 30 cm diameter; 100 m x 20 m plots for measuring trees and dead wood of more than 30 cm diameter; 5 quadrants of 2 x 2 m set up inside sub-plot used to count understory in secondary forest, mixed perennial systems, shrub grass, and food crop farms. All tree species were identified using local names and scientific names and their diameter at breast height (dbh) were measured. Destructive samples were taken from 2 x 2 m plots for shrub/grasses and food crops then weighed fresh and dry. In mixed perennial systems destructive samples were collected in 1 x 1 m plots.

Tree growth parameters (height and diameter at breast height (DBH)) were assessed for above ground biomass while litter and soil samples were collected for belowground biomass estimation. The composition of the vegetative cover was assessed and the species identified. Other dendometric parameters of live and dead trees as well as GPS position were also recorded. Plant and soil samples were analysed for carbon determination and all data entered into a database. Aboveground biomass was estimated using the function developed by Chave et al.(2005), a best allometric model for moist forest stands (Eq.1). Wood densities used in the study were from various sources in the literature (Djomo et al., 2010; Maniatis et al., 2011). Thereafter, potential carbon stocks were derived as 50% total Biomass estimated (Eq.2.).

$$AGB = EXP(-2977 + In(\rho D^2 H)\text{---------------}Eq.\ 1.$$

$$Potential\ C\text{-}stock = 50\% * AGB \text{----------}Eq.2.$$

where:

EXP =“e to the power of”

ln = natural logarithm

ρ = wood density (g m^{-3})

D = DBH = Diameter at Breast Height (cm)

H = Tree height (m)

AGB = aboveground biomass in Mg ha^{-1} of dry matter

= AGB_BT+ AGB_ST+ DB_BT+ DB_ST+ UDS_BIOM, with

AGB_BT = above ground biomass big trees (>30cm)

AGB_ST = above ground biomass small trees (5<dbh<=30cm)

DB_BT = above ground biomass Dead big trees;

DB_ST = above ground biomass dead small trees

UDS_BIOM = understory biomass

3.4- Above and belowground Carbon stocks assessment

According to the IPCC approach, emissions from forest land can be estimated from the following carbon pools: aboveground plant biomass (tree and understory), dead wood, litter and belowground (soil organic carbon and peat).

3.4.1- Aboveground carbon stock: Plant Carbon stock

Figure 10 shows the distribution of aboveground carbon stock in various biomass pools. The primary forest contains about 75% of carbon stock in the aboveground biomass (222 tC/ha). Old fallow and mid-fallow cover contains respectively 180 tC/ha and 75 tC/ha. A jungle cocoa plantation contains 60% of carbon stock in aboveground biomass with a total of 115 tC/ha. Cropland and young fallow contains in the aboveground biomass about 25 to 32 tC/ha.

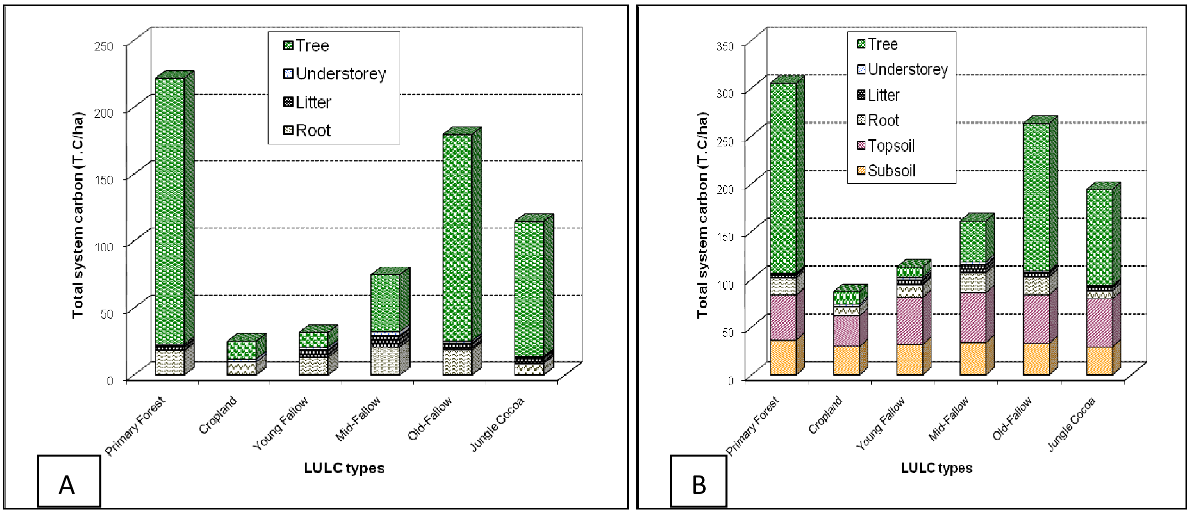


Figure 10. Aboveground carbon stock (A) and total carbon stock (B) in various land use types

3.4.2- Belowground carbon stock: Soil Carbon stock

The amount of soil carbon within the first 50 cm of the soil depth represents 26% of the total stock in the primary forest and is subject to very little variation within the shifting agricultural landscape. Other authors believe, however, that this variation in soil carbon, though insignificant compared to that for above-ground biomass, must not be neglected. This relative stability of soil carbon during forest conversion cannot, however, be used as an effective indicator for soil fertility in this region (Kotto-Same et al., 1997).

3.4.3- Total Carbon stock

The total carbon (in TC/ha) varies in the following decreasing order: VF (305), SF (251), OCP (184), FF (180), CF (101), and MC (67). Figure 10b shows the results for carbon stocks in various systems, as distributed between the trees, undergrowth, litter, roots and soil (in the 0-50 cm layer). Total carbon from the PF system amounts to an average of 311 TC/ha, with almost 65% contained in tree biomass. However, the average total carbon produced by the shifting agricultural landscape is only 157 TC/ha, which is half that stored in PF. This value obtained from agricultural systems in Efoulan remains slightly higher than that (140 TC/ha) reported by Brown (1997) for other tropical forests. This is justified by the fact that, based on the agricultural practices encountered in Southern Cameroon, many large trees are generally allowed to continue growing in agricultural fields.

Crop fields produce the lowest total quantity of carbon from the system (67 TC/ha), which is equivalent to a carbon stock loss of almost 80% due to the cultivation of forest land. The most vulnerable carbon pool in this conversion is the above-ground biomass. Kauffmann *et al.* (1995) reported a similar situation in parts of the Amazon rainforest that have been converted to pasture.

On average, the shifting agricultural systems found in Efoulan's humid forest region sequestrate half the total carbon produced by the primary forest. However, this value remains comparable to the quantity produced by some types of forest due to the presence in this agricultural system of large trees, which the farmers allow to continue growing in cultivated fields. Within the agricultural system, the organic carbon and nutrient stock are highly dynamic; it involves the highly significant changeover from forest to cultivated fields and vice versa during the fallow period.

Seventy-seven percent of the total carbon stock sequestered during the fallow period is a linear indication of the fallow age (p=0.001). When forests are converted into agricultural land, an enormous quantity of nutrients stored in the above-ground biomass is lost due to clearance and burning. The above-ground biomass is then rapidly rehabilitated during the fallow period and after 15 to 20 years, eighty percent of the total carbon stock is recovered from the fallow land compared to primary forest. This potential for carbon dynamics provides agricultural system with a major source of sequestered carbon. Fallowing and reconversion to Secondary Forest lead to a carbon re-accumulation of 3.9 TC/ha/year (r^2= 0.83, p= 0.001).

3.4.4- Plant growth and Carbon stock accumulation

During the fallow period, carbon accumulation is very rapid. Based on the estimate produced according to the age of various LUVC types, a mathematical regression model has been developed by correlating the fallow period and total system carbon. This regression shows that 77% of the total carbon stock variation could be explained by the fallow period duration. In these secondary forests, 85% of the total carbon stock is recovered. The old cocoa plantation, considered by Kotto-Same et al. (1995) to be the best alternative to slash-and-burn agriculture, produces 60% of total system carbon compared to primary forest. Biomass accumulation in such cocoa plantation with plant growth is explained by Fig. 11 below.

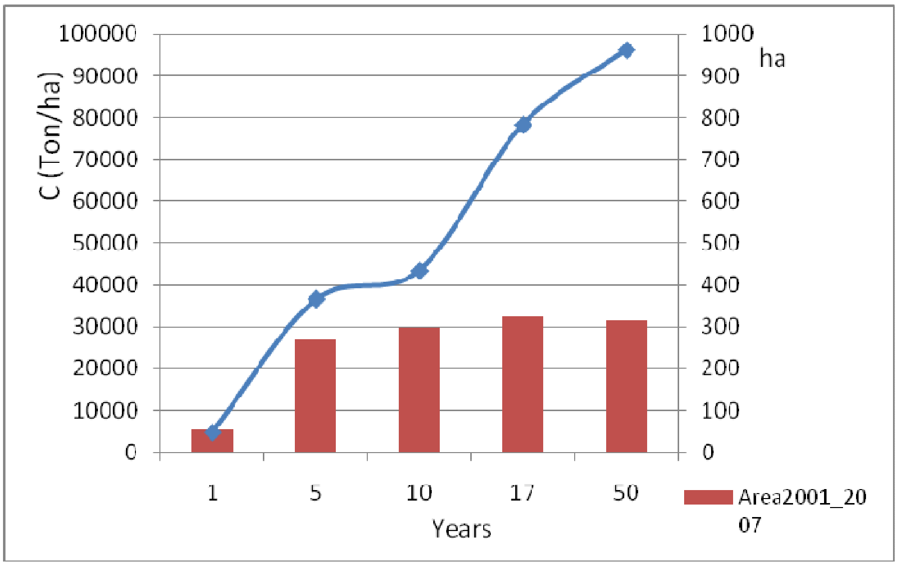


Figure 11: Carbon production (Ton/ha) with area extension (ha) aging of perennial plantation in Efoulan area.

3.5- Profitability of Land Use Systems: Case of cocoa agro-forests

3.5.1- Introduction

In southern Cameroon, cocoa is managed in complex agroforest systems (AFS) that includes annual crops, fruit and timber trees along with other remnant trees from the forest where the farm was first established. Traditional complex AFS are the outcome of an adaptation of local practices of trees resources management to changing socio-economic household needs and marketing opportunities. Their complex structure contributes to maintaining a large number of ecological characteristics of natural forests thus they play an important role for biodiversity conservation (Bissuela et al., 2009; Sonwa et al., 2009). However, despite the importance of cocoa as cash income source at a closer look, traditional AFS have not proven to be profitable due to their low productivity (Eboutou et al., 2010; Gockowski and Sonwa, 2010; Jagoret et al., 2011; Sonwa, 2004). Low yields are generally attributed to the senescence of cocoa farms (FAO, 2002; Jagoret et al., 2011). Neither fertilizers nor herbicides are used (Jagoret et al., 2011) and diseases such as black pod and capsid attacks remain a major challenge also when pesticides are applied.

In southern Cameroon, traditional cocoa AFS have been at the core of local smallholder livelihoods for more than 50 years. 40% of the existing farms are inherited and were planted before 1950; more than half of the plantation is older than 30 years (PNUE, 2009). Cocoa farms are managed with family labor and minimal maintenance level (FAO, 2002). Seeds used are called «german cocoa»[1]derived from the plots established during colonial time in the last century.
In the early1990s, due to the economic crisis that affected the cocoa sector, several farms were abandoned or set aside with minimum management. Only recently international price increase has led to a renewed interest for cocoa production in Cameroon. To boost national production the government supports system intensification through the use of improved planting material associated to a regular use of farm inputs (fertilizers and pesticides) as well as the establishment of new farms (SDSR, 2006).

Traditionally the expansion of cocoa farms has been done primarily on forests land (Gockowski and Sonwa, 2010). This originates major concerns due to the role further cocoa expansion might play in deforestation process and associated carbon emissions, in particular because Cameroon, as a REDD+ country is committing to a reduction of its anthropic based carbon emissions. The study here focusses in particular on (i) the assessment of the carbon stocked by various system components and (ii) the analysis of relationships between carbon stock, productivity and cocoa yield.

3.5.2- Characteristics of traditional cocoa farms

Basic descriptive statistics, analysis of variance (ANOVA) and means separations (Fisher tests) were applied to the data on cocoa yield, trees densities, carbon stock and income according to

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[1] German cocoa belongs to the Trinitario group coming from crosses between Criollo and Forastero

renovation practices in the farms. Correlations between variables were evaluated and tested at 5% and 1% limits. Particularly the relation between renovation practices and the other practices was considered, based on the assumptions that they reflect the general attitude of the farmers to invest/engage in intensification.

3.5.3.1- Traditional cocoa farms Management

Average of quantities of fertilizers and pesticides (fungicides and insecticides), yield, cost and incomes was calculated and used for comparison between traditional cocoa agroforests and intensified models. Main management practices reported for the traditional systems included renovation, weeding, fertilization and phytosanitary treatments. The frequency of each activity varied widely across farms.

Renovation practices: Renovation practice consists of adding new young cocoa trees plants in the existing farm. It can be done to density cocoa trees stand or to extend the farm size by adding some new cocoa plants. In this study, 35% of farmers applied the renovation practices in their farms with 14% through farm size expansion and 21% by replacing the senescent or died cocoa trees. In the first case, farm site is expended while in the second one, the surface of the farm remains the same. The two practices can occurred in the same farm. This practice of regeneration did not show a clear dependence on the age of cocoa farms or age of producers.

Weeding: A proportion of 54% cocoa producers weed their farm once a year as compared to 46% who did it twice or more. The first or unique weeding was done between March and June; and the second one between September and November. Weeding was manual using cutlass. Only 6% of producers reported to use herbicides one time a year.

Use of fertilizer and phytosanitary products: Farmers dis not use fertilizers but 82% reported to use pesticides (insecticides and fungicides). Three types of user were distinguished: 40% of farmers used only fungicides; 26% used only insecticides and 34 % used both insecticides and fungicides. Fungicides treatments were done on average 6 times a year and insecticides treatments 4 times. The type of pesticide used (Chi square=0.03), changed by renovation practices with fungicides most used in farms renovated by replacement.

3.5.3.2- Profitability of traditional cocoa farms

Profitability was estimate for 3 models of production: (i) a traditional one with no fertilizers, low management practices and differentiated according to renovation practices; (ii) new intensified model without fertilizers used but with good management practices applied and (iii) new intensified model with fertilizers used and good management practices. The Net present Value (NPV) was used as indicator of profitability and calculated based on the following assumptions:

- Discount rates of 5%, 10%, 15% and 20%. The poor farmers with limited resources tend to plan short-term horizons and discount rates are high and subjective;
- Time horizon production is 30 years to account for the shorter life cycle of intensified systems compared to local varieties;
- Cocoa is sold at stable price of 1000FCFA per kilogram.

Based on farmer declaration it was assumed that for traditional cocoa AFS production starts at the 7th year, as well as the one of associated planted fruit trees. Non Timber Forest Products are harvested as from the first year and contribute to the income during all the production horizon of the farm. Annual and biannual associated crops contribution to income is relevant during the first 4 years and decreases with the expansion of cocoa trees canopy. Farmers may continue to plant some of these crops in occasional gaps in the farm. Hunting contribution to income starts from the first year and continue along the whole horizon of production. Cocoa yield in the traditional systems was assumed to be stable during all the horizon of production because in the traditional systems no significant correlation exists between the declared age of a cocoa farm and yield (Jagoret, 2011).

In the intensified models designed by the Government, very few trees are left in the farm at the establishment time at low densities (35-40 trees per hectare)[2] to provide a minimum of shade. During the first three years, a plantain farm can be established. Cocoa production is expected to start at the end of the second year and behaves as follow (Table 10):

Table 10: cocoa productivity of some models designed by the Government[3]

		Years				
		1	**2**	**3**	**4**	**5 to 30***
Yields (kg/ha)	With fertilizers use	0	400	1000	1500	967
	No fertilizers use	0	200	400	1000	513

**Year 5 to 30 is an assumption based on the calculated averages*

Yields estimation: Cocoa yields were low (346 ± 202kg/ha) and are significantly influenced by the frequency of fungicides treatments: 255 ±199 kg/ha with less than six times treatments and about 500±213 Kg/ha above six treatments a year.

Costs and Incomes distribution: Average annual production and marketing cost summed up to about 460.000FCFA /Ha, including family labour. Total costs presented a high variability. Labour costs were the highest (75% of total annual costs) with family labour (generally internalized) amounting to more than the half (53%). The type of renovation applied by the household had a significant effect on the amount of internalized costs: very low (average 329 FCFA/ha) for no renovated cocoa farms, average 104 thousand FCFA/ha for farms where replacement was applied; 580 207 FCFA/ha for cocoa farms that had been expanded.

The average annual gross income (including sales and consumptions) was 475 thousand FCFA per hectare with a net income of 15700FCFA per hectare (if internalized costs are considered). In general gross income was composed by 88% of sales and 12% of consumption of products from associated systems.

[2] http://www.sodecao.cm/index.php/Cacaoculture/comment-creer-une-cacaoyere-moderne.html
[3] www.fertilizerscameroon.cm. Fiche Technico-Economique sur la fertilisation du Cacaoyer. 11pages.

Net Present Value (NPV) estimation: Average NPV values where positive for the traditional system. However if once the renovation method is considered, only the farms renovated by replacement had the positive NPV values (table 11);

Table 11: Net Present Value of each farm management type at various discount rates

Traditional cocoa farms	Net Present Value			
	Discount rates			
	20%	15%	10%	5%
All farms	23 200	69 558	159 524	358 661
No renovated farms	-167892	-170116	-168312	-153849
Renovated-expansion	-24 130	-20 236	-21 473	-39 607
Renovated-replacement	695882	1003992	1597014	2899171

3.5.4- Carbon sequestration in traditional cocoa agroforests

Average carbon stocked in the AFSs (including below and above ground) was 94.2± 42 T/ha. Above ground (living biomass) contributed to more than the 60% of the overall stock. In that above ground carbon, large trees (DBH > 30 cm) contributed for 84%, small tress (DBH < 30 cm) 9% and cocoa 7%. Large trees include commercial, Non Timber Forests Products (NTFP) and fruit trees species and other forest trees that according to farmers do not have any specific function. Carbon stock correlated significantly with the density of large trees (r=0.61, Fig.12). Commercial timber species were the most common with on average the 26% (±19%) of the trees, followed by the Non Timber Forest Products trees 15% (±18%) and the fruit trees 7% (±12%).

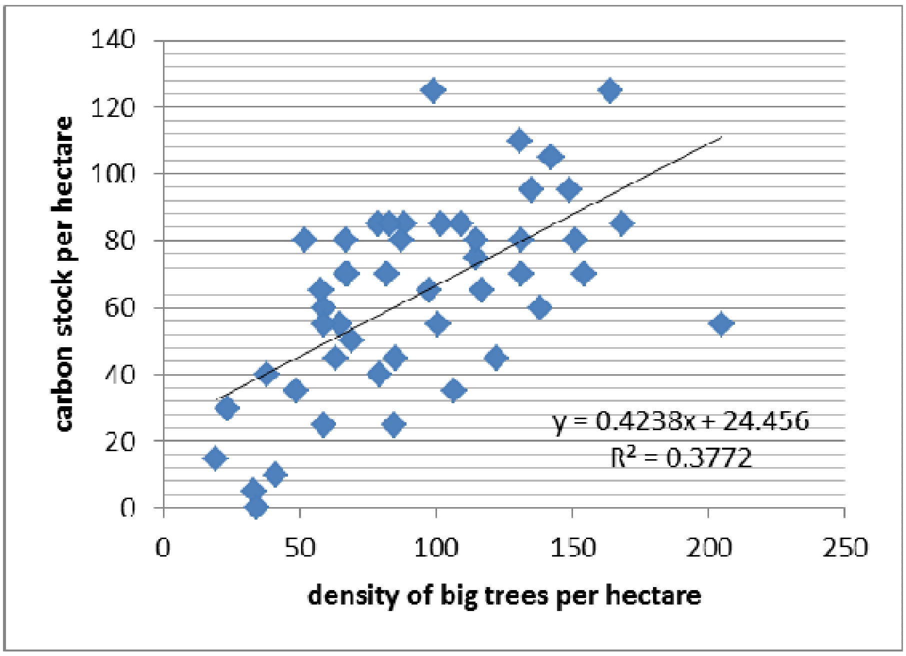

Figure 12: Relationship between Tree density and carbon stocks

3.5.5- Comparing the traditional cocoa agroforests and intensified models of cocoa production

Management: In traditional cocoa system, few farmers weed their farm twice a year as recommended for intensified models. As shown in the table 12, fertilizers are not used in traditional cocoa agroforests. Average declared quantity and frequency of use of pesticides (insecticides and fungicides) are the same that those of new intensified models but present a high variability.

Table 12: Quantities and frequency of fertilizer and pesticides used in various cocoa farms

		Cocoa farming systems		
		Traditional farming system	Intensified model without fertilizers	Intensified model with fertilizers
Fertilizers	**quantity**	-	-	Average 425kg*
	frequency	-	-	2 times a year
	Period/percentage	-	-	April and September
Insecticides	**quantity**	3liters (0.3-15liters)	3 liters	3 liters
	frequency	4 times a year	4times a year	4times a year
	Period/percentage		September to October	September to October
Fungicides	**quantity**	30 bags (7-88)of 60g each	30 bags of 60g each	30 bags of 60g each
	frequency	6 times a year	6-8 times a year	6-8 times a year
	percentage		At the beginning of raining season	At the beginning of raining season
Herbicides	**quantity**	5 liters (1.25-10liters)		-
	frequency	1 time a year		-
	percentage	6%		

*application is done in two times at April and September. For the first two years: 300kg per hectare per year with the rate of 250g per tree (125g at April and 125g at September); from the third year, 550 kg per hectare per year with the rate of 500g per tree (250g at April and 250 at September).

Profitability

Yields: New intensified models promoted by the Government have the higher yields averaging 967 kg/ha with fertilizer input and of 513 hg/ha without fertilizer showing a yield increase of 54% and 180% respectively, as compared to the average value in the traditional AFSs (346kg/ha).

Costs and Incomes distribution: Intensified model with no use of fertilizers presents lower annual costs (352 923 FCFA/ha), follow by the traditional farming system (459 131 FCFA/ha) and the intensified model with fertilizer (535 885 FCFA/ha). Labor represents the highest share of these costs, particularly in the traditional systems. Also, traditional cocoa agroforests present a lower level of expenses for purchasing cocoa seeds. However, it has very high costs of purchasing phytosanitary products.

It was estimated that traditional cocoa agroforests provided lower net income than new intensified models (table 13). However, its gross income was higher than that of new intensified model with no fertilizers use. Cocoa contributed for 80% to gross income and the other 20% was provided by associated products such fruits (Dacryodes edulis, Persea americana, Mangiferasp, citrus sp etc.), food crops (Musa s)p and cocoyam (xanthosoma sp), NTFPs (Irvingia gabonensis, Garcinia kola, Ricinidendron haleutii, Spondias dulcis, etc.) and occasional sale of timber/fire woods and hunting products. Dacryodes edulis was the most frequent and encountered tree species in all cocoa farms. The gross income in the new intensified models derived only from cocoa.

Table 13: Income distribution from various sources

Cocoa farming systems	Average gross income	Average net income	Income distribution (%)					
			Cocoa	Food crops	Fruits	NTFP	Hunting	Timber /wood
Traditional farming system	474790	15658	80	5	10	2	1	1
Intensified without fertilizers	400000	47077	100	0	0	0	0	0
Intensified withfertilizers	725000	189115	100	0	0	0	0	0

Net present value estimation of different farming systems: All farms systems showed positive NPV, and intensified systems the highest values at all discount rates (table 14). A 20% decrease in prices, would determine a negative NPV for the traditional systems at all discount rates; new intensified models with fertilizers still would have positive and higher NPV values than those with no fertilizers that have positive NPV values only at 10% and 5% discount rates.

Table 14: Net Present Value from each farming system at various discount rates

Cocoa farming systems	Net Present Value			
	Discount rates (%)			
	20	15	10	5
Traditional farming system	23 200	69 558	159 524	358 661
Intensified without fertilizers	263646	521153	986943	1949956
Intensified with fertilizers	1074093	1679086	2777728	5064111
	With 20% decreasing in prices			
Traditional farming system	-91 217	-122 921	-191 435	-353 875
Intensified without fertilizers	-152 114	-56 793	115 204	466 628
Intensified with fertilizers	295 855	597 857	1 146 332	2284 725

3.5.6- Tree densities and Carbon stocks

New intensified models had very little trees of DBH larger than 30cm and they store significantly less carbon (94.2 t/ha ± 42 t/ha) than traditional ones. In these systems *Musaceae*, oil palm and small trees lack as shown in table 15. In the traditional systems, the density of cocoa trees is highly variable (1170±544 plants per hectare). New intensified models stored little carbon (56.5t/ha) than traditional cocoa agroforests (94.2t/ha).

Table 15: Trees densities for some common species

Cocoa farming systems	Trees density (trees per ha)					
	Cocoa	Musaceae	Big Oil palm	Small oil palm	Big trees	Small trees
Traditional farming system	1170±544	30±71	5±9	5±15	64±29	120±148
Intensified without fertilizers	1111		0	0	35-40	0
Intensified with fertilizers	1111		0	0	35-40	0

3.5.7- Discussion and pathways for intensified cocoa agro-forests and C enhancement

Profitability

Results of the present study indicate that the profitability of traditional cocoa AFSs depends on management practices and that renovation practices are a good proxy for intensification with higher incomes. However net benefit exists only if costs of family labor are not accounted for and indeed the margin remains narrow because of overall low levels of productivity.

A big gap exists between traditional systems and the systems currently promoted by the government. A part from the quality of the variety used and of structural parameters (density of cacao plants, of associated trees) the use of fertilizers seems to be the major element in guaranteeing system productivity.

Estimates of the contribution of the traditional AFS to household annual gross income appeared to be very close to the results by Gockowski et al. (2010). Among the secondary products sold, *Dacryodes edulis* and oil palm nuts were the most important as well as non-timber forest products.

This study further confirmed how significantly diversification strategies contribute to farmer's income, along the line of studies like the one by Sonwa (2004), Jagoret et al.(2009) and Gockowski and al.(2010), making the overall system more profitable (Eboutou and al, 2010). Diversification also increases resilience to cocoa price fluctuations in the international market (Sonwa et al., 2001).

Technical recommendations for intensified cacao production systems should account for the tendency to diversification observed in the traditional systems and not only aim at designing of renovation strategies involving improved planting materials and the use of chemical inputs to maximize production with the elimination trees.

Carbon stocks

The study also confirms the important role of trees in the traditional systems in storing carbon. This is part of the ecosystem services, as well as biodiversity conservation that traditional systems provide (Kotto Same et *al*. 1997; ASB 2000; Nolte et *al.* 2001; Sonwa 2004; Gockowski and Sonwa, 2010) and that are condemned to be drastically reduced if intensified systems are adopted. In the present study the importance of large diameter trees was highlighted, as reported by other authors (Kotto-Same et *al.* 1997; Nolte et *al.* 2001 and Sonwa 2004). Current management of the tree components could be improved by reducing the number of trees that do not have any particular economic, cultural or ecological function and that may be substituted by useful species.

Relation between carbon stock, yields and incomes

In the present study the general relationship between carbon level and cocoa yield with yield decreasing in a non-linear way under increasing shade -and carbon level along with it, did not apply to the present case, most likely because a lack of consistency in management practices, that does not allow to separate the effect of single components and practices on productivity. The high diversity of the systems observed made it difficult to assess the existence of clear tradeoffs among carbon stocks, yield and incomes. The factors determining such variability in the systems has to be understood if a transition to more intensified systems has to be designed. For example among the trees associated to cocoa AFSs, the majority remain of limited use for farmers because, as per their declaration, they do not contribute to farm revenues. An assessment of their ecological and functional role per species should be conducted to promote the selection of useful species.

As suggested for Central American case studies, it is possible to design cocoa-based agroforest systems that provide both good yields (cocoa and shade canopy) and high carbon densities. However in the case of Southern Cameroon that would require a major shift in current trees management practices to include carbon content as a service acknowledged by the farmers and apply a completely new paradigm to systems that have resulted from a long term adaptation process. That would imply an intense learning process to capacitate farmers to spare standing tree species not only on the basis of commercial and socio-cultural considerations but actually on their agro-ecological contribution to systems efficiency both for carbon and cacao yield (stem parameters, foliage parameters, roots parameters and growth parameters. Similar strategy for trees association in cocoa farm was earlier suggested by Gockowski et *al.* (2010). Research should provide information on indigenous native species from primary and secondary forest that can provide those services to maintain the conservation and cultural value of traditional systems. Specific studies should be conducted to characterize tree species to be systematically used in the systems based on existing local ecological knowledge. Provision of tree planting material should be secured. Also costs for implementing and managing these systems should be estimated to assess their economical return under carbon credits payment scenarios. If Cameroon REDD+ strategy and "mechanism of benefits sharing" will be ready and operational, the sale of carbon stored in the cocoa AFSs could generate a modest income for cocoa farmers additionally to income derived from cocoa plantations (cocoa, fruits, timber).

Pathways for intensification of cocoa farming and enhancement of its emission reduction capacity

Increasing cocoa production through the intensification of smallholder traditional systems and expansion of the cultivated area is at the core of the government strategy for the cocoa sector in Cameroon. Intensification has to be based on the use of improved planting material associated to inputs (fertilizer and phytosanitary products). This study on the profitability of traditional cocoa agroforest have highlighted that cocoa agro-forests in southern Cameroon are still managed in a very traditional way with intensive use of family labor, low yield and profitability, high shade/high carbon stock levels, little attention on the quality of associated trees species and planting material, no use of fertilizers and irregular use of pesticides. Still, under current frequency of fungicides use and farm regeneration practices a positive significant effect on cocoa yield and on the returns was observed. Profitability analysis showed that farms regenerated by replacement were more profitable with high positive NVP at all discount rates. As compared to traditional farming system, the intensified cocoa systems promoted by the ministry of agriculture were more profitable at various discount rates. However they had a significantly lower carbon stock. To overcome the impact on emission in line with the engagement on REDD+, the importance of including associated trees, of their choice and spatial distribution has to be stressed.

Households' poverty is the major constrain to agricultural intensification and limits investments in chemical inputs use. In the absence of major intervention to support chemical inputs purchase, the design of intensification paths should be gradual and first target the improvement of management practices such as a better management of tree resources, improvement of maintenance and renovation practices by replacement. Where financial resources are scarce, only good management practices may help to increase yield and profitability of cocoa farms without fertilizers and maintaining a high level of carbon stock.

3.6- Opportunities cost of emissions caused by Land Use Changes

In Aloum village of the Efoulan council, 30 farmers were interviewed on the composition of their farms and sample farm units mapped with GPS. Land Use trajectories were then built based on the frequency of transitions between land uses. The budget for various land use types and the NPVs were calculated over 30 years for the most representative trajectories identified and at different discount rates to assess private profitability. Four main age-ranges of fallows were identified by the farmers using local classification systems. They summarized the age-ranges into 4 classes: young fallow (2-4 years, also called chromolaena fallow), medium fallow (4-7), old fallow (8-10, also called bush fallow) and very old fallow (10-35, also as secondary forest). Cultivated surfaces include a combination of annual/biannual (slash and burn systems) and perennial crops (Table 16).

Table 16. Proportion of agricultural land use mosaic covered by crops and field size (average)

	Perennial crops		Slash and Burn systems		
	Traditional Shaded Cocoa	Oil Palm-small scale	Forest fields (*Essep*)	Mixed Foodcrop	Monoculture Foodcrops
% of land	9.7	4.3	8.2	3.4	0.1
Area (ha)	0.6	3.4	0.6	0.13	0.19

Extensive Cocoa growth, with low input, low yield production system (highly shaded) is the main source of cash for households. Of the two other cropping systems based on slash and burn, the mixed food crop field is opened mainly in young to medium fallows and the *Essep* (melon seed-field) is from forest or old fallows of more than 15 - 20 years. According to farmers, very few innovations have been introduced in their farming practices in the last 30 years. This confirms the general stagnation in the agricultural sector already described as a general condition for the area of Efoulan. In general the changes reported refer to the expansion and increase in the number of mixed food crop fields and *Essep,* and oil palm.

Few farmers have expanded or renewed their cocoa farms in the last years. However they have not introduced the new cocoa hybrids nor adopted related techniques to manage their farms (reduced shade, increased plant density and use of chemical inputs). Cocoa farms are rarely established directly after forest clearing/thinning but are preceded by *Essep* farms or mixed food crops fields with a short fallow rotation in between.

More than the 75% of food crops production is for self-consumption. The *Essep* system is still very traditional and predominantly (80%) for the production of melon seeds, typical for areas with scarce market access. They associate a covering crop (*Cucumeropsis mannii*) to Plantain (*Musa sp*.), Macabo (cocoyam- *Xanthosoma sagittifolium*) and Cassava (*Manihot esculenta*). In areas with better market access *Essep* fields are dominated by the production of plantain.

Small-scale oil palm plantations are rare, but slowly spreading, according the farmers' description. Family consumption covers more than the 50% of the production. Oil palm farms are not directly established on forest soil but in general are created in young and medium fallows.

Changes in the surface of land use systems.

Estimated Land Use changes and Total Emission per Land Use change between 2001 and 2007 (Figure 13) showed no significant net carbon emissions. This can be explained by the stagnation in land use dynamics already described above.

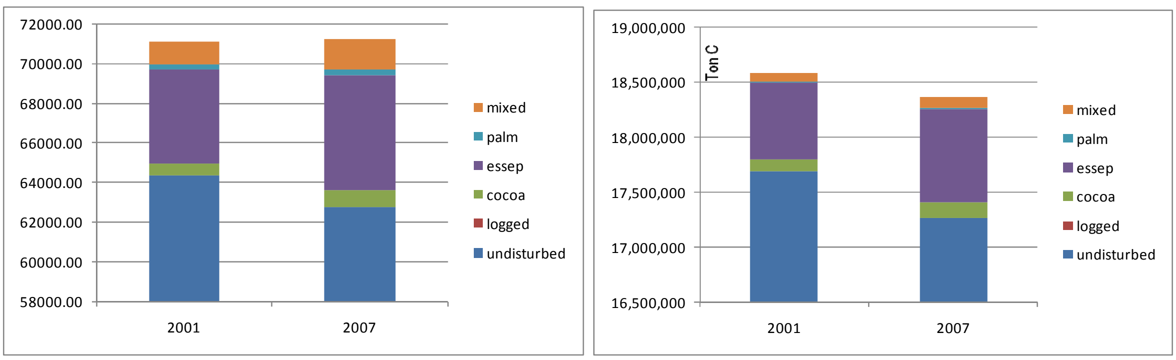

Figure 13: Estimated Land Use changes and Estimated Total Emission per Land Use change (based on Time Averaged Carbon per Land Use system) between 2001 and 2007

Since two of the systems are perennial, with yields varying as a function of age, profitability of land use systems was evaluated over a 30 year period using the discounted net present value (NPV) accounting approach with two different discount rates: 20, as the one practiced locally (derived from farmers declarations and information on monthly rates applied by local agencies) and 5. The NPV was calculated for the most representatives land use trajectories identified (Figure 14 and table 17).

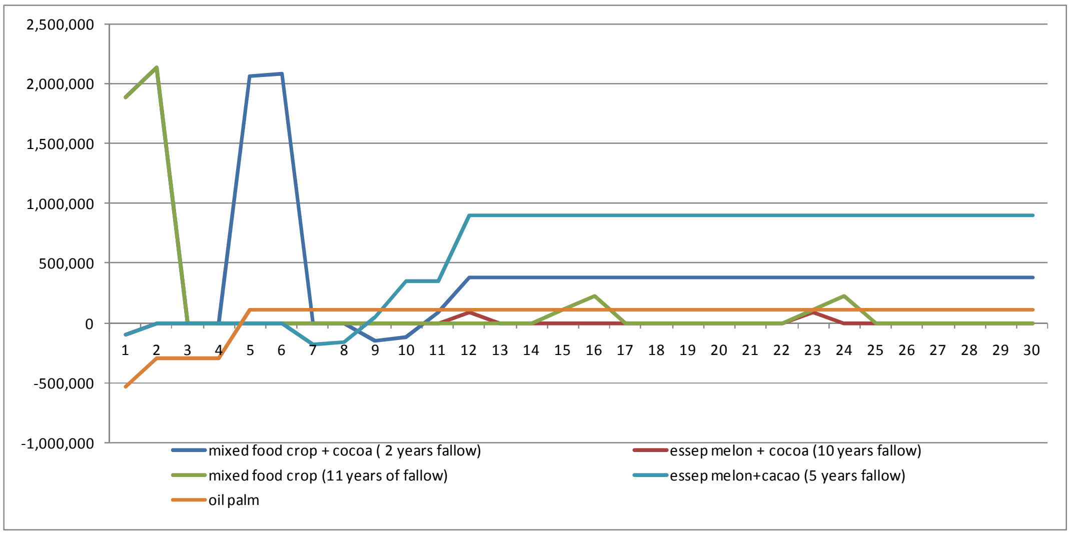

Figure 14. Typical land use system trajectories identified in Aloum. NPV by land use systems (returns to land in $ / ha per year over the time span considered).

Table 21. Profitability of selected land use systems

NPV 20 (USD/ha)	NPV 5(USD/ha)	Land Use System
209.781055	828.889843	**cocoa (mixed food crop + 2 years fallow)**
209.7798539	828.1865432	**mixed food crop (11 years of fallow)**
-10.38857167	-36.36171077	**essep melon**
-71.01929225	-269.448209	**oil palm**

The abatement cost curve for the land use systems changes described for 2001-2007 (Fig.15) shows an average emission of 12.84 Mg Co2-eq/Ha,Year. The average sequestration is 8.78 Mg Co2-eq/Ha,Year. The annual net emission that could be compensated with $5 carbon price is 10.83 Mg Co2-eq/Ha,Year,

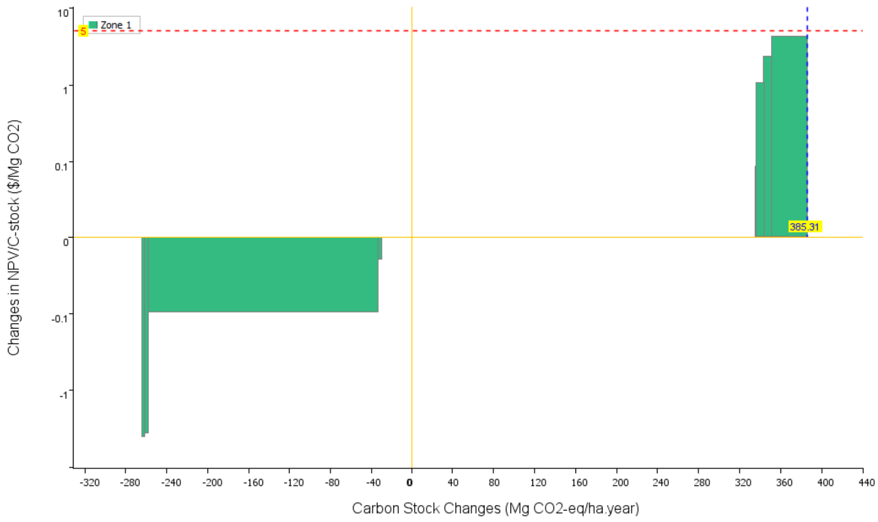

Figure 15.Abatement cost curve for the land use systems changes described for 2001-2007

All the emissions occurred in the time span considered, lead to less than 5 $ return per ton CO_2-eq . As expected this is due to the overall low profitability of the system related to the accessibility, the low population density and the lack of economic alternatives/opportunities.

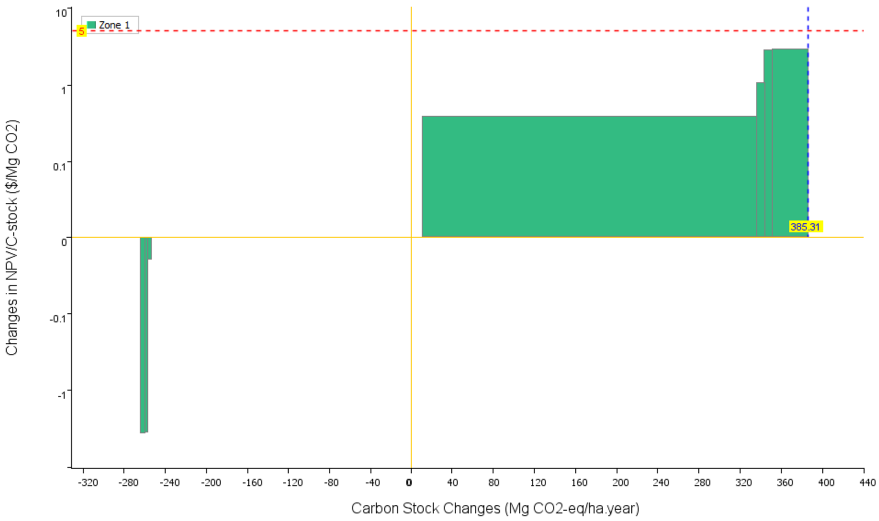

Figure 16. Abatement cost curve for the land use systems changes in a scenario with higher profitability for cocoa and essep.

A slightly better market accessibility would impulse the demand for plantain and or foodcrops and to cocoa production, with higher profitability for the *essep* (introduction of plantain with NPV 237.5 $/ha) and cocoa systems (NPV 1000 $/ha). However, as shown in Figure 31, the returns per ton CO2-eq would be equally lower than 5 $. From this information it appears that the area of Efoulan would be suitable for establishing a cost-effective REDD + program.

Emission reduction opportunities options under various scenarios

4.1- Introduction

Exploring subnational level development planning and emission reduction linkages is an important part of ensuring sustainable and climate smart development. Here, we analyse the feasibility of the development pathways within the land use sector to reduce emission in the Efoulan municipality. The majority of the 25000 people living in this municipality rely on small scale traditional agriculture based on shifting cultivation for food crop production, as well as cocoa, and oil production. The most important farming systems are food crop production and cocoa perennial agroforestry plantations. Growing fruit trees cocoa agroforestry systems and retaining useful trees within the crop fields are usual practices among the farmers in the area. It is estimated that around 30 tree species are planted or preserved for home use or market sale (Jagoret *et* al., 2011). Various reports indicate that cocoa production systems in the municipality are non- profitable, with a negative Net Profitability Value (NPV) of 250000[4] FCFA per year (Eboutou et al. 2010; Gockwoski et al. 2010). However, trees associated within this system improve the biophysical conditions, sequester carbon and could thus help in climate change mitigation while strengthening the overall resilience of the system (ASB, 2000). Semi-industrial oil palm plantations are increasingly being established by local elites in the municipality by converting primary forest land and thus, avoiding conflicts with farmers who have customary rights over existing fallow land.

The carbon stocks in four major land uses were analyzed: primary forest system - 311 TC/ha with almost 65% contained in tree biomass, fallows – 163 TC/ha, crop fields - 87 TC/ha and jungle cocoa with 185 TC/ha (Figure 10). Hence, there is a clear supremacy of the primary forest in the amount of carbon contained in this land use type. Figure 10 shows the partitioned carbon content of the biomass and the soil. Hence, any development intervention that affects the areas of the primary forest area, the fallows and the jungle cocoa has a considerable impact on the loss of the carbon stock from the land uses. Therefore, it is important to be vigilant about the activities being planned by municipal planners and provide such evidences so that informed decisions can be made in tackling the development needs, conservation values and climate change issues in the municipality and thus of the country.

4.2- Land cover dynamics

Table 18 shows the observed land use changes between 2001 and 2007 and the resulting loss of carbon stock from the municipality from within the land use sector alone. We found a considerable decline in undisturbed forest area of around 194 ha/yr while there was an increase in cocoa plantations and crop fields by about 145 ha/yr and 45 ha/yr respectively. Logged forest area has also decreased (63 ha/yr) which is indicative of forest degradation. In sum, the

[4] FCFA (Franc CFA) is the national currency of Cameroon and 250000 FCFA is almost equal to 500 USD.

observed land use changes in the municipality has resulted in diminishing carbon stock in the area as the major changes are happening in the land uses with high carbon stocks.

Table 18: Land use dynamics in Efoulan Municipality and the associated carbon losses

Land use type	Time average carbon stock (t C/ha)	Spatial coverage (ha)		Relative change (ha/yr)	Net impact of land use change on carbon sequestration (t)
		2001	2007		
Mixed crop field	87	1198	1512	44.86	27318
Crop field created by clearing primary forest	225	599	830	33.00	51975
Cocoa farms	156	4755	5771	145.14	158496
Oil palm plantation	136	268	338	10.00	9520
Young/bush fallow lands	142.5	2031	2199	24.00	23940
Logged forest	267	8126	7683	-63.29	-118281
Undisturbed forest	311	64136	62780	-193.71	-421716

Note: for merged land use types e.g. young fallow and bush fallow, the carbon content is computed by averaging the per hectare values of the two.

4.3- Simulation scenarios and Results

In order to evaluate the way forward in implementing emission reduction in the Efoulan area, four land use scenarios was developed for simulation (Table 19), three of which are strongly interlinked with greenhouse gases emission were compared against the business as usual scenario in which no emergent intervention takes place to improve the GHG emission.

- Scenario 1 Business As Usual (BAU): this scenario reflects the current trend from the historical baseline if no measures are taken to reduce emissions at the landscape level. Here it is assumed that the rate of forestland conversion to other land uses continues at a similar pace as in the past due to lack of interventions.
- Scenario 2 Cacao Extension: a scenario reflecting the current interest of the government and the local population to increase cacao production by extending the cocoa farm in the area. In the Cameroonian Government rural development strategy (SDSR, 2006), it is clearly stated that the government will promote the extension of cocoa farms by more than 50 000 ha from 2010 to 2015. Forest zones in different municipalities are the targets of this expansion plan.
- Scenario 3 Sustainable Forest Management: a scenario involving the implementation of good forest management strategies (like reforestation and reduce impact logging) in production forest, community forest and communal forest.

- Scenario 4 A Combination of Sustainable Forest Management and Cacao Extension: a scenario involving cocoa extension and sustainable forest management practices application whereby intensification using input and integration of timber and fruit trees are applied in the cacao plantations and afforestation/reforestation and reduced impact logging practices are applied in forested areas.

In most of the scenarios except the BAU, most of the land use conversions are occurring due to the expansion of cocoa farms. We assumed that one-tenth of the envisaged cocoa expansion in the country happens in the Efoulan municipality thus resulting in 5000 ha of cocoa farms creation by 2016.

Table 19. Interventions in the different mitigation scenarios in the Efoulan municipality

Planning Units	**Scenario 1:** Business as Usual (BAU)	**Scenario 2:** Cacao extension	**Scenario 3:** Sustainable Forest management	**Scenario 4:** Mix of sustainable forest Management and properly managed Cacao extension
Community Forest	No measures are taken to reduce emission	2000 ha of this unit are converted into cacao plantation	Good management measures are applied	- Good management measures are applied and - 2000 ha are converted into cacao farm with applicable intensification pathways
Communal Forest	Same as above	1000 ha of this unit are converted into cacao plantation	Good management measures are applied	- Good management measures are applied - 1000 ha are converted into cacao plantation with applicable intensification pathways
Concessions of Forest Production	Same as above	Only selective logging and no total conversion takes place here.	Good management measures are applied	- Good management measures are applied - Limited areas of concession forests converted into cacao plantation with applicable intensification pathways
Shifting Cultivation landscape	Same as above	2000 ha converted into cacao plantation	Good management measures are applied	- Good management measures are applied - 2000 ha converted into cacao plantation with applicable intensification pathways

Note: any land use conversion from one to the other was assumed to happen between 2012 to 2016.

The long-term emission analysis showed that the strongest potential for emission reduction happens when sustainable forest management scenario is implemented in the municipality (Table 20). This is mainly due to the fact that sustainable forest management practices such as reforestation and reduced impact logging both help in enhancing the carbon sequestration potential in the municipality. The fact that this scenario reduces emissions strongly as compared to other scenarios is that the highest carbon sequestration potential of the municipality is due to its forested areas.

Table 20: Simulation outputs of C stock sequestration under various scenarios

	Surface area of each land cover			C stock	C stocks		
Land Cover	2007	BAU 2037	Scenario 3 2037	TC/ha	2007	BAU 2037	Scenario 3 2037
PF	**56928**	**49101**	**55624**	305	17363040	14975805	16965320
DF	**8671**	10027	8897	263	2280473	2637101	2339911
Fa	**1677**	3204	1931	137	229749	438948	264547
CL	**5462**	10406	6286	87	475194	905322	546882
Total	72738	72738	72738		20348456	18957176	20116660
2037vs 2007						-1391280	-231796
Bau37vsScenario3 37							1159484

The envisaged development pathway through cacao extension is going to result in increased emission of greenhouse gasses in the municipality. One thing to note here is that the rate of emission along the years stabilizes when the cacao plants have grown up and begin to sequester carbon. Despite the emission stabilization over time, cacao extension occurs at the expense of converting forests and fallow lands that have highest sequestration potential and hence the cumulative effect of this development pathway is increases emission.

The development pathway which involves integrating cacao extension, intensification of cocoa farms, and sustainable forest management was the second strongest potential pathway for reducing emissions in the municipality (Figure 17 and Table 21). This mainly is due to the potential of the cacao plants to sequester carbon after growing, the sustainable intensification pathways within the cocoa plantation and the implementation of good management measures within the forest area such as reduced impact logging. The main reason why this development pathway does not exceed the sustainable forest management scenario is that there is growing emission in areas where cacao extension takes place, while in areas where intensification and sustainable forest management practices are applied, there is net sequestration. Hence, the net effect of these compositions i.e. cacao extension, intensification, and sustainable forest management development pathways is low relative to intensification and sustainable forest management where we only have sequestration potential alone. The simulation results show that doing nothing as an emission reduction effort will lead to an increase in emission in a linear manner across the years. However, despite the linear increment, the aggregate emission from this scenario in the 30 years analyzed was not as huge as that of the cacao extension. It should be noted that as we are analyzing possible development scenarios in the municipality which are also intended to supply products and services to the community, the interpretation of the emission scenario should not be seen separately from the potential economic or livelihood contribution of the scenario both in the short- and long-term. When such dimensions of economic and or livelihood contributions are accounted for, the cacao extension scenario exceeds the business as usual scenario considerably. This implies the opportunity cost of emission reduction in cacao extension scenario is much higher than that of the business as usual one.

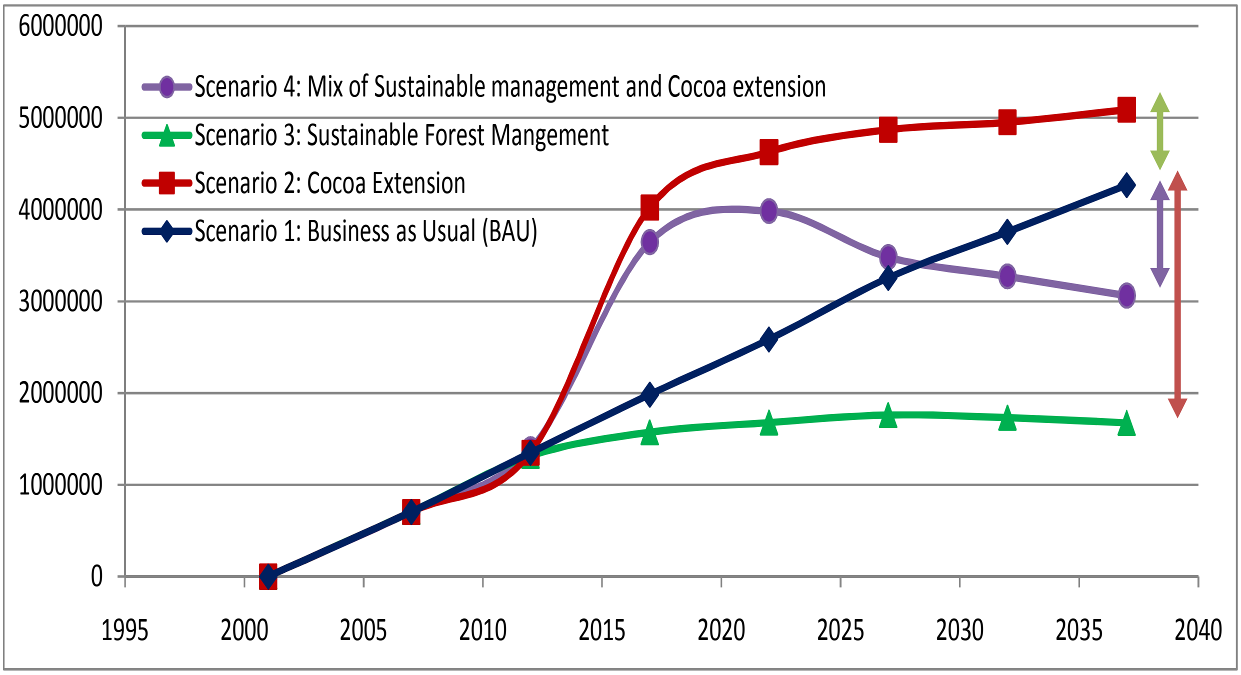

Figure 17. Greenhouse gases emission potentials (CO_2e) from the various development scenarios simulated over 30 years period

Table 21: Simulation outputs of C02 eq emission under various scenarios

	CO2 eq			
Year	**BAU**	**Scenario 3**	**Scenario 2**	**Scenario 4**
2007	245134	245134	245134	245134
2012	1049695	915601	1049695	1089305
2017	1854256	1273224	4022393	3645998
2022	2585675	1559323	4627842	3985009
2027	3256142	1661501	4870022	3482334
2032	3758993	1733026	4950749	3272715
2037	4267938	1675627	5088727	3063095
		2592312	-820788	1204844
	17017832	9063436	24854562	18783589

4.3- Options of low emissions strategies

4.4.1. Intensification of Cocoa agroforestry systems

Agro-ecosystems play a central role in the global carbon cycle and contain approximately 12% of the world terrestrial carbon (Dixon, 2005). With respect to climate change and carbon sequestration, agroforestry is important because the tree component has the capacity to fix and store carbon from the atmosphere for many years. Sonwa et al. (2009) found that in 60 cocoa plantations in southern Cameroon, an average cocoa farm stores 243 Mg per ha of carbon per year, with the amount of carbon sequestered largely depending on the agroforestry system put in place, the structure and function, tree species and the system management (Oke and Olatiilu, 2011).

Most cocoa farmers are not getting the full benefits from growing the crop. The low productivity of cocoa in this region is mainly associated to the old age of trees, widespread planting of traditional varieties, use of planting material of poor genetic quality, and small farm size due to fragmentation (Asare and David, 2010). To turn this situation around, farmers need to intensify cocoa agroforestry systems in the region.

The area has a strong potential for improving productivity of the existing farmlands of vast cocoa agroforestry landscape, through proper intensification approaches like agroforestry practices. For example, Gockowski and Sonwa (2011) found that if intensification of cocoa agroforestry systems through the use of inputs and the integration of timber producing trees in the Guinean rainforest of Central and West Africa (Cote D'Ivoire, Ghana, Nigeria, Cameroon) was practiced in the late 1960s, it could have spared about 21,000 km^2 of forests, thereby contributing to a reduction in emissions of about 1.4 billion tonnes of CO_2.

Despite such prominent potentials for sequestering carbon while providing other livelihood benefits, intensification of cocoa agroforestry systems is slow due to various technical and socioeconomic reasons. Although the suggestions for intensifications are increasing, no detailed account exists as to what is slowing down the move by smallholder farmers to such promising interventions. Besides, understanding the hurdles, there is a need to solicit how smallholder farmers could be motivated to implement intensification activities and well as identify the challenges that they faced as a result of intensifying their agroforestry systems.

Agricultural intensification as a whole is defined as a process of raising land productivity over time through increases in inputs on a per unit area basis within the context of the prevailing social and economic drivers (Juhrbandt, 2010). Cocoa intensification is a term used to describe a new vision of the cocoa investment whereby the crop is grown with the objective of increasing productivity while at the same time ensuring sustainability by protecting the environment (Asare and David, 2010). Intensification of cocoa production is an important objective to increase productivity and farm income; and the replacement of ageing tree stocks with improved planting material is a key element in this process (Edwin and Masters, 2005). Intensification of cocoa agroforestry systems by the use of improved planting material and inputs limit the rate of expansion into forest lands since productivity per unit hectare is improved (Gockowski and Sonwa, 2011).

4.4.2. Incentives for intensification of cocoa agroforestry system

According to Catacutan et al. (2012), incentives can either be moral (particular moves regarded as acceptable and results to increase self-esteem) or remunerative (financial or material rewards in exchange of acting in a particular way.

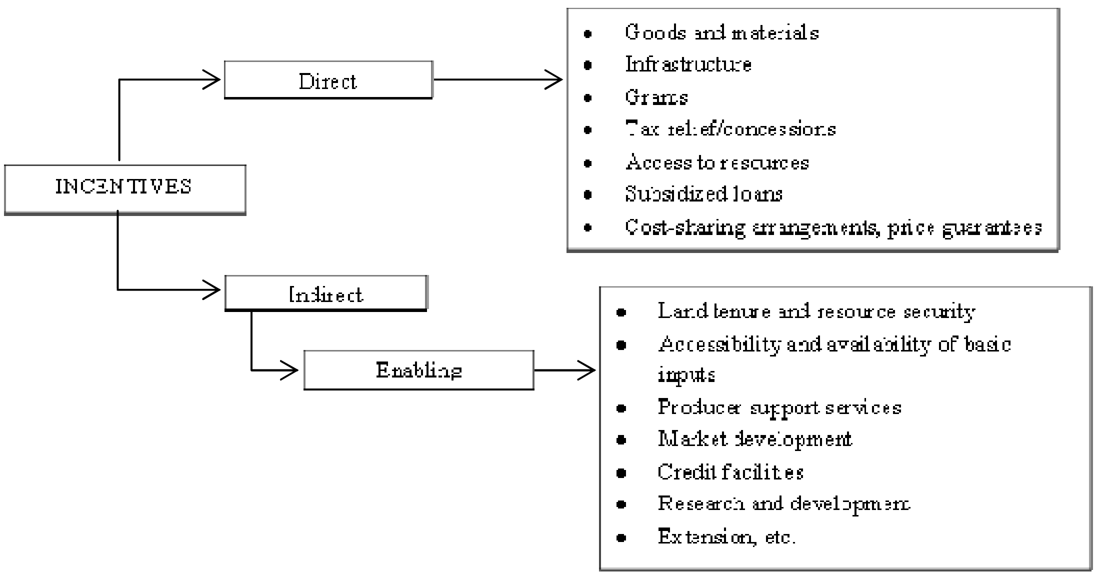

Figure 18. Types and examples of incentives that can stimulate adoption and investment for agroforestry development among smallholders (Adapted from Enters et al. 2004; and Cataculan et. Al. 2012)

The agricultural extension service of the Ministry of Agriculture and Rural Development in Cameroon provides extension workers who disseminate agricultural information and technologies to rural farmers in general including those involved in cocoa production. As Fonjong (2004) explains, some of this information has to do with how to apply fertilizers, insecticides and fungicides to crops, soil conservation, and seed multiplication techniques. The government also encourages the development of farmers' cooperative societies. The role of these cooperatives is to serve the interest of cocoa farmers and other farmers in general in as much as the acquisition of farm inputs and the commercialisation of their produce is concerned (Fonjong, 2004). While these cooperatives are generally organized and run by farmers themselves, government provides them with financial, technical, and material support through its decentralized units located at the sub-national level.
Agricultural credit assists cocoa farmers to procure basic tools, new seedlings, transport facilities, and crop preservation mechanisms, and inputs. In light of the fact that most small-scale cocoa farmers operating in rural areas of the country are poor, credit schemes are crucial to them and their activities. In fact, is has been documented that this was the fundamental rationale behind the early credit schemes that were developed by the government to target them (Fonjong, 2004). Many have asserted that right back from the 1960s, through the 1980s, government financed agriculture (including cocoa agroforestry systems) in Cameroon through the farmers' bank which was called FONADER and other affiliates (Fonjong, 2004; Websi, 2003). Today, sources of credit available to farmers include institutions like FIFFA, a private local micro-finance institute that also offers credit schemes to farmers.

In order to motivate farmers, the government organises agricultural shows in Cameroon. The first agricultural show was held in 1972 in Buea, the capital of the South Region of Cameroon. The last was held in 2011 in Ebolowa, the Capital of the South Region. Fonjong (2004) points out that this shows offer an ideal platform for farmers to display their best products, exchange ideas with other farmers and technicians operating in other parts of the country. Additionally, during this shows competitions are organised and prices are offered to the best agricultural producers as an incentive to motivate them.

Other efforts have been made by civil society to promote intensification of cocoa agroforestry systems in Cameroon. For example, sponsored by the U.S. Agency for International Development, the World Cocoa Foundation and Global Cocoa Industry, the U.S. Department of Agriculture, and the Food and Agricultural Organization (FAO), the Sustainable Tree Crops Program that was implemented (between 2007-2011) by the International Institute for Tropical Agriculture (IITA) provided training to cocoa farmers through the participatory Farmer Field School approach on topics related to integrated cocoa and pest management and the management of cocoa nurseries (IITA, 2012). With regards to the latter, the Program distributed improved planting materials to cocoa farmers, as well as cocoa pods to farmer's cooperatives to enable them develop their own nurseries. It should be noted that through participatory Farmer Field Schools, farmers also obtained knowledge on the aforementioned topics through farmer-to-farmer dissemination of information.

4.4.3- Analyzing incentives for cocoa intensification in Efoulan

A study showed that about 96% of the population of the Efoulan municipality are engaged in agriculture with cocoa being the main agricultural produce (Feudjio et al., 2012). However, information on the total quantity of cocoa produce on an annual basis is absent. The fundamental reason for selecting these communities was born out of the following considerations: First, unlike other communities in the municipality that are closer to the city of Ebolowa, they were located closer to the dense tropical rainforest of the Congo Basin. By being closer to this forest, they had more cocoa farmers who are engaged in the conversion of this forest into cocoa agroforestry systems. Finally, the selected communities also share the same cultural values and land use system. More specifically, shifting cultivation and perennial plantations of cocoa and oil palm are the main land use systems practiced by farmers in the area (Yemefack, 2005)

Since most adults in these communities are cocoa farmers, structured interviews were used on a random sample of 461 adult individuals from the population (Table 22). There is no non-response bias as all the approached adults were willing to participate in the interview. The questionnaire comprised both open ended and discrete categorical scale questions.

Table 22: Population, numbers of interviewees (cocoa farmers), and mean cocoa farm area in each of the ten case study communities

Community	**Population***		**Interviewees**	**Cocoa farm area (ha)**	
	Total population	Population of adults		Mean	Standard deviation
Ngonebok	4000	2200	156	2.92	2.22
Binyina	958	521	52	2.78	2.39
Adjap Essawoo	146	66	17	2.14	0.93
Mekalat	842	432	31	2.87	2.31
Nyazo'o	549	301	24	2.06	1.13
Bongolo	638	350	32	2.20	1.77

Mintô	367	200	32	3.53	3.15
Megale	618	339	52	1.98	1.18
Mebande	625	343	51	2.82	2.31
Minkane	185	84	14	3.04	2.49
Total	**8928**	**4836**	**461**	**2.71**	**2.17**

Results obtained from this study are presented below mostly in aggregate across all the case study communities with minimal reference to individual communities.

Respondents' experiences with tree planting and the use of inputs in cocoa agroforestry systems

Of the 461 respondents that took part in the interviews, 15% (68) noted that they have never planted trees in their cocoa farms while 85% (393) stated that they had. With regards to the use of inputs, 36% (164) of the respondents noted that they have never use inputs in their cocoa farms, while 64% (297) answered affirmatively. Of these latter respondents, 98% (290) indicated that they were using fungicides while only 2% (7) were using fertilizers and insecticides as the most common input in the cocoa farms. Among the fungicide used, Calomile (36%), Plantomile (24%), Ridomile (19%) and Nordox (10%) were the top four widely used ones. Market was the main source of fungicides and insecticides used in cocoa farms in the area. According to the respondents, fertilizers are solely outsourcing from assistances either from government or non-governmental organizations.

A synthesis of the comments given by farmers on the common inputs used in cocoa farms was done. For example, for the most widely used input, the fungicides, 43% of the respondents acknowledged that the input category is efficient but expensive. When we looked into the specific comments for the four widely used fungicides (Calomile, Nordox, Plantomile and Ridomile), it was observed that around half of the users commented that they were efficient but expensive.

Hurdles to tree planting and the use of inputs in cocoa agroforestry systems

Respondents that did not plant trees or use inputs in their cocoa farms were asked to rank a series of listed hurdles that impede them from adopting these practices from *1* to *3*, with *1* being the most important hurdle. Lack of awareness creation was also ranked as the most important hurdle affecting the use of inputs, followed by lack of financial support, and lack of technical support.

Tree species preference for planting in cocoa agroforestry systems

Respondents that planted trees in their cocoa farms were asked to rank the five most important tree species that are planted for their livelihood. However, most of the respondents' listed the planted species up to the third preference level only. For example the response rate was almost 50% and 20% only for the fourth and fifth most preferred species. As shown in table 23, the first and second preferences for tree species to be planted in cocoa farms were dominated by *Persea americana* and *Dacryodes edulis*.

Table 23. The top four species for the various levels of preferences for the widely planted tree species in cocoa farms in Efoulan municipality

First preference		Second preference		Third preference		Fourth preference	
*Species	Respondents (%) (n=393)	Species	Respondents (%) (n=382)	Species	Respondents (%) (n=340)	Species	Respondents (%) (n=240)
Persea americana	50.1	*Dacryodes edulis*	39.5	*Mangifera indica*	25.3	*Mangifera indica*	17.8
Dacryodes edulis	31.0	*Persea americana*	23.3	*Citrus sinensis*	17.1	*Irvingia gabonensis*	17.4
Mangifera indica	7.9	*Mangifera indica*	16.8	*Dacryodes edulis*	13.5	*Cola spp*	15.6
Irvingia gabonensis	4.5	*Citrus sinensis*	10.2	*Persea americana*	12.5	*Citrus sinensis*	14.8

Note: the species shown within each preference level are the top four selected by the respondents. The number of respondents corresponds to those who have listed tree species for a given preferences level.

Mangifera indica is the most prominent fruit tree species preferred by the study communities. The place of species like *Citrus sinensis* is not to be overlooked too as it appeared in many of the preference levels within the top four species (Table 23). Looking at the preferences patterns, the higher the preference level goes the percentage of respondents referring to the top four preferred species within each preference level decreases. For example, there is a very narrow gap among the top four species by the number of respondents choosing them as their preference for the fourth preference level (Table). The same is true for the fifth preference level (which is not shown here). This implies that the emphasis of most of the respondents is mainly on the first two or three level of preference and the higher it goes the evaluation becomes more diverse and lacks a defined pattern.

Factors motivating tree planting and use of inputs in cocoa agroforestry systems

Respondents were asked to rate the importance of a series of listed factors that motivate them to plant trees as well as use input using a 5-point Likert scale varying from *1= not at all important* to *5 = extremely important.* With respect to tree planting, respondents rated personal consumption of tree products, followed by the prevention of excessive sunlight on cocoa plants, and land ownership as the most important factors. Other important factors motivating farmers to plant trees were related to market and marketing issues e.g. demand for tree products, market access, authorization for selling tree products, access to market information and even the formation of cooperatives that helps them to make a good deal on prices of their products. At the other end of the spectrum, technical support was deemed to be the least important motivating factor for tree planting. The most important factor motivating the use of inputs included increase cocoa production, followed by cooperative and group formation, and land ownership while the least important factor was technical support.

Challenges associated with tree planting and the use of inputs in cocoa agroforestry systems

Finally, respondents were asked to rank a series of listed challenges that they encounter as a result of tree planting and the use of inputs from *1* to *3*, with *1* being the most important hurdle. For challenges affecting tree planting, limited access to credit facilities was ranked as the most important challenge, followed by inadequate infrastructural resources, and poor performance of planted trees. With respect to challenges associated with the use of inputs, limited access to credit facilities was again ranked as the most important challenge affecting the use of inputs, followed by limited financial assistance, and high cost of inputs.

Discussion on Impeding factors for promoting intensification of cocoa agroforestry systems

According to the farmers surveyed, major obstacles to tree planting were the lack of technical support, followed by the lack of awareness creation, and increased competition of non-cocoa trees with cocoa. Similarly, major hurdles to the use of inputs included the lack of awareness creation, the lack of technical support, and the lack of financial support. Three fundamental reasons were identified to explain these results. Firstly, there has been a drastic decline in agricultural support services provided by the government to cocoa farmers in Cameroon. As Fonjong (2004) explains, agriculture extension services of the Ministry of Agricultural and Rural Development (MINADER) provides extension workers who disseminate information about proper agricultural practices and technologies to rural farmers. Some of this information, Fonjong (2004) notes, has to do with how to apply inputs to plants, soil conservation, and seed multiplication. However, the author establishes that agriculture extension workers that provide extension services to farmers in Cameroon have not only decreased but the few who are available work under appalling conditions. Further, this author reports that most rural development agencies created by the State to provide inputs and other planting materials like cutlasses and improved seedlings to farmers have all collapsed. Secondly, respondents who rated increased competition as a major hurdle to tree planting were those respondents that inherited cocoa farms which were already saturated with trees from their predecessors. Thirdly, although the government provide financial support to farmers through cooperative societies (Fonjong, 2004), very few cooperative societies currently exist in Cameroon.

Persea americana, Dacryodes edulis, and *Mangifera indica* are the most important tree species that are planted in cocoa agroforestry systems for the livelihood of the surveyed respondents.

While the planting of more timber species in the cocoa farms could have contributed to the wood demands of households which in turn might have reduced the encroachment on forest lands for such wood products, timber species (like *Baillonella toxisperma, Guibourtia tessmannii and Triplochiton scleroxylon*) were not among the top most important trees species planted in cocoa agroforestry systems for the livelihood of respondents. One possible reason underpinning these results is that all naturally growing trees that have not been planted in Cameroon belong to the State as well as those planted on private land without a land title. This could have also contributed to the low level of intensification within these systems. Indeed, in April 2013, during field work for other relates studies, trees were counted on the farms of some previously interviewed respondents (34 in number). It was found that while these respondents planted mostly fruit producing trees in their farms, the overall level of intensification was really low as the average number of trees planted in their cocoa farms was only 16 trees per hectare.

Although farmers described personal consumption as the main underlying motivation for growing fruit trees, there seems to be a thin-line between growing or not growing as the cash income is another major push factor. Thus, it can be argued that fruit tree growing is often gauged by the presence of market for such products. For example, Ndoye (1995) found that between January and July 1995, the economic value of *Dacryodes edulis* that was traded within Cameroon was US $244,000. Besides, what makes market a crucial issue in growing of fruit trees is that with the fluctuating prices of cocoa on the market, fruit trees are becoming a backup mechanism to generate income from the cocoa farms for the households (Mbile et al., 2009). If market access is not there (and also demand is low), with the aforementioned limitation in user right for the timber species, the probability that cocoa farms may be mono-crop farms with limited shade trees is highly likely.

Intensification of cocoa agroforestry systems for reducing emissions from forests degradation

The widely used definition of forest by FAO states that for a vegetation to qualify as forest it has to have a minimum area of 0.05 ha, at least 2-5m tree height and a tree cover of at least 15%. Bisseleua et al (2009) showed that even in the least intensively managed cocoa agroforestry system in Southern Cameroon the tree cover, tree height, and cocoa tree density is about 87.8%, 55.5 meter and 1250 trees per hectare respectively. The result from our study shows that the average cocoa farm area is 2.71 ha. Therefore, cocoa agroforestry systems in Southern Cameroon qualify as a forest with no doubt even in some cases exceeding what is considered as forest in some forested areas. Therefore, theoretically, such land use systems can benefit from the widely used forest carbon payment schemes e.g. through REDD+ mechanism. For example, Sonwa et al. (2009) found that cocoa agroforestry systems in Southern Cameroon can sequester an average of 243 Mg per ha of carbon. If we take an average cocoa farm of 2.71 ha possession per household and an average carbon value of $9.2 USD per ton of carbon, this can generate additional $6058 USD per household which could be a great incentive for farm households. This gain from the carbon can even be higher than the cocoa yield for example in the least intensive old cocoa farms with an average net gain of $1218 USD per hectare according 2005 prices

(Bisselau et al 2009). Though such benefits from carbon sequestration in cocoa agroforestry systems are not yet realized, to help cocoa growing communities in Cameroon, the fact that cocoa agroforestry systems can conveniently qualify as a forest brings into light a great potential that can be exploited in order to maintain the current large areas of cocoa agroforestry that could be subjected to exploitation if the global market value of cocoa falls. The potential income from the carbon money can help farmers mitigate the possible yield losses of cocoa due to disease, unfavourable climatic conditions, and other possible damaging factors.

Motivations for tree planting within cocoa agroforestry systems

Respondent rated personal consumption of tree products, the prevention of excessive sunlight on cocoa plants, and land ownership as the most important factors that motivate them to plant trees. Three possible reasons could explain these findings. First, while some fruit trees (like *Dacryodes edulis, Irvingia gabonensis,* and *Persea americana)* produce fruits which are important cash earners, they are also major food products for the case study communities (Franzel et al., 2008). Moreover, unlike timber species, there is no concern for the aforementioned species regarding tree ownership issues. This may also motivate farmers to emphasize on such species for income generation and household consumption rather than dealing with the ownership challenges with the government as is the case with timber species. Second, cocoa plants need a minimum amount of sunlight for growth. As Mbile et al. (2009) explain, this could only be provided when indigenous trees that are greater than 20 meters in height are integrated into cocoa agricultural systems. Third, land ownership is a fundamental incentive for tree planting in agroforestry systems (Santos-Martin et al., 2011) as well as the use of inputs within these systems (Norton-Griffith, 2008). This further explains why land ownership was also an important motivation factor for input usage. However, it must be noted here that land ownership in this study was viewed mainly from a customary law perspective (especially through inheritance). The reason is rooted in the fact that due to the complex procedure involved in procuring a land certificate under the 1974 Land Ordinances of the Republic of Cameroon (ordinances N° 74-1 and N° 74-2 of the 6th of July 1974), many Cameroonians in rural areas have resorted to employing the customary system for land acquisition (van den Berg Biesbrouck, 2000).

Increasing cocoa production was the most important motivation behind the use of inputs in cocoa farms which is quite logical as these are cocoa farms and the main goal is to gain high cocoa yield. The motive behind increasing the production of cocoa is also associated with the rising global market demand of cocoa and hence, could be a very important source of income for farmers. Cooperative and group formation was also ranked as second most important factor motivating the use of inputs. At the very least, this is consistent with the literature supporting the importance of cooperative societies (Fonjong, 2004), Participatory Farmer Field Schools (PFFS), as well as educational farm visits as incentives for intensification of agroforestry systems (IITA, 2012; Thorlakson, 2011). On the other hand, it was observed that the least motivating factor for intensification of these systems was technical support. This observation is not particularly surprising. As stated earlier, it can be attributed to the reduction in support services that the State provides to farmers in the country.

The most important challenge associated to tree planting and the use of input in these systems was limited access to credit facilities. These results are a reflection of the few credit institutions that currently provide credit schemes to farmers in Cameroon. As of 2004, the World Bank supported FIMAC scheme was the only source of government credit available to smallholder farmers in Cameroon (Fonjong, 2004).

Another important challenge accompanying tree planting was inadequate infrastructural resources. This further confirms past observation that underscores the importance of rural infrastructure like good roads in the promotion of intensification pathways within agroforestry systems in the Philippines (Santos-martin et al. 2011). Poor performance of planted trees was rated as another challenge to tree planting perhaps because respondents are not aware that indigenous trees that grow below 20 meters easily compete for light with cocoa plants thereby affecting their growth performance. Limited financial assistance and high cost of inputs were also major challenges to the use of inputs and this could be ascribed to the limited cooperative societies that provide financial assistance to farmers and the lack of subsidies for inputs in the country.

4.5- Co-benefits feasibility analyses

4.5.1- Potentials of REDD+ Benefit-Sharing in Efoulan municipality

REDD+ projects in Agroforestry zones

The increase in cocoa production is an idea developed in the Efoulan municipality in response to the issue of sustainable forest management and improving the living conditions of the community. One of the options for farmers will be to plant fruit trees and other non-timber forest products for improving the quality of cocoa plants to increase carbon stocks in plantation, diversify and increase sources of household income and limit the occupation of existing forest areas. In order to move towards a system of payment for carbon credits from the project, who owns the carbon credits within the context of the Efoulan municipality?

The cocoa intensification project should be carried out in the farms of farmer, located in the agroforestry (ZA) zones of non-permanent forest estate. If the REDD+ mechanism depends on the existing land tenure systems, it may limit the participation of local communities in REDD+ mechanism (Costenbader, 2009), at the risk of encouraging deforestation. The population of the Efoulan municipality enjoy customary rights on land. Customary rights are recognized only as far as the enjoyment or use of the land is concerned, and gives no right of ownership to the beneficiary. It will be important to consider the existing customary rights on the use of land in determining access to REDD+ benefits. Within this context, profits from the sale of carbon credits will be used to compensate the efforts of farmers who helped in producing results. For communities living more or less close to the Efoulan community (proximity to the resource), land ownership will not be taken into account. This is the case of the Mount Elgon Regional Conservation Programme (MERCEP) in Kenya, were the benefits received by the communities are based on performance, measured by their contribution to improving tree planting in the forest (Mwayafu et al., 2011). Beneficiaries may also include those who have signed agreements with communities.

REDD Project in Communal Forests

Communal forests are considered as private estates of Councils. It is defined as any forest falling under a classification instrument on behalf of the council concerned or planted in this council area (Art 30, Law 1994). The classification instrument gives right to the establishment of a land title in the name of the council. By virtue of its status as permanent forest, the council is responsible for managing its forest cover and the income resulting thereof, but under State control. The Efoulan communal forest was classified by Decree N° 2010/2557/PM of 27 September to incorporate private estates of Akom II and Efoulan councils, a land with a surface area of 17 226 hectares of forest. However, it should be noted that the Efoulan communal forest is part of the –Akom II Efoulan block and represents 1/3 of the forest cover, with 2/3 of the forest cover representing 11 626 ha of the Akom II communal forest.

Concerning income management from the exploitation of communal forests, Article 4 of the Decree N° 076 notes that income from the exploitation of communal forests are shared to the tune of up to 30% with the local communities for the implementation of infrastructural development and 70% with the councils for the development of activities across its area of jurisdiction. The use and monitoring of income management intended for the community shall be provided by a communal committee, while 20% is intended to support the running of council, 80% at least is used for investment. This income is used as the basis of a five-year investment development plan to be implemented.

Within the framework of the implementation of a REDD+ project in the Efoulan communal forest, joint order N° 076MINATD/MINFI/MINFOF of 26 June 2012, takes into account any other income generated by the forests such as carbon credits. However, we should bear in mind that carbon credits are only available if there are results from activities related to reduction in emissions and increase in carbon stocks. Here, the issue of land ownership does not arise; the Efoulan municipality may have the communal forest ownership title. The beneficiaries are exclusively people of the Efoulan municipality, but it will be necessary to take into account those affected by the implementation of the project not only by making compensation for opportunity cost, but also by including those who took part in the signing of the agreements between stakeholders during the mounting of the project.

REDD Project in Community Forests

A community forest is a non-permanent forest estate not exceeding 5000 hectares, which is created through a management agreement between a village community and the Forests Authorities. The State remains the landowner, while communities have the right to management the resources under the supervision of the State.

The Efoulan municipality has three community forests that are being created but are not yet operational. They include the MINMVAN association community Forest, the DIMEJ I & II CIG Community Forest and the SANGULO community forest. According to Joint Order No. 076, income from the management of community forests are totally paid to the communities and managed by a legal entity in the name and on behalf of the local community concerned. The income is used to produce the annual action plan of projects in the area. This can be applicable within the context of a REDD+ community forest projects. In fact, although there is no land ownership evidenced by a land title, only those who produce results and enjoy customary land rights are considered as beneficiaries. This principle is encouraging in the current context of the REDD+ mechanism.

REDD Project in Forest management units (FMUs)

The Efoulan municipality has no forest management unit (FMU). During the creation of an FMU in future, the benefit sharing would follow the provisions of the Decree N° 076. FMUs will be created from the non-permanent forest estate. Thus, the question of ownership of land and resources does not arise here. It is up to the State to ensure that all Cameroonians benefit from the proceeds of the management of these resources. Within this context, all councils in Cameroon will benefit. The Efoulan council will receive 20% and the communities 10% of the income generated. However in the case of a REDD+ project in the FMUs, it would be important to consider, especially those whose customary rights are affected by the implementation of the project. Thus, it would be advisable to evaluate and compensate for the lost opportunity costs incurred by the communities.

4.5.2- Specificities of benefit-sharing in a REDD project in the Efoulan Municipality

Beneficiaries of current benefit-sharing mechanisms are primarily the local communities. The issue of land ownership is hardly taken into account in benefit sharing. However, it is up to the State to supervise the management of the activity and the income. In any case, the benefits are used for the development of public property on the basis of an initially prepared action plan. Although being beneficiaries, the current mechanisms do not allow households and individuals to receive money. However, REDD+ projects in Agro-forestry areas will provide opportunities for people to receive benefits at the level of each family/household that would be involved in the project of increasing their cocoa farms.

Income distribution under the current mechanism does not take into account a percentage to be paid at the national level for the running of management facilities of the process. It would be necessary to make provision for this. In fact, REDD+ intends to be national and should support activities for its implementation nationwide. The establishment of MRV technical committees or communal capacity-building committees and forest management at the level of the council is a very important factor in the monitoring and support of the MRV system as well as auditing at the national level. Order N° 076 identifies and distinguishes the roles of the various stakeholders involved in the management of income, in terms of powers and decision-making. However, it is necessary to develop and include these aspects in the roles and functions related to the implementation of REDD+ projects.

Conclusions: Feasibility and best options for emission reduction

In the PDD, we have demonstrated that opportunities for reducing emission exist within various land use systems at the landscape level in the Efoulan municipality of South Cameroon, and any municipal plans formulated to reduce emission from the different land use systems must ensure that sustainable livelihoods practices that serve to improve the livelihoods of forest-dependent communities are adopted and promoted. We focused here on intensification and diversification of cocoa agroforestry systems using such sustainable practices including suitable management of timber and other useful trees within cocoa agroforestry systems, reduced impact logging, afforestation and reforestation. Applying the current government strategy of cocoa farms extension for rural development in the Efoulan Municipality, 5000 ha of land that would consequently have been converted into cocoa farms by this population, can potentially increase the CO_2 emission between 2012 and 2016 by 4 million tons. Emission scenarios that lead to a win-win situation by reducing emission while addressing the livelihoods of forest dependent communities need to be at the core of the development plan of the municipality. Such a bottom up approach has to help designing realistic REDD+, NAMA and REL/RL that can be negotiated with national government; to offer an opportunity for synergies/ integration of REDD+, adaptation and/or development plans at local level in a cost effective way.

Despite the role played by cocoa agroforestry systems in reducing deforestation and forest degradation through sustainable intensification pathways at the margins of the tropical rainforest, its practitioners still faced a series of issues. Therefore, in an attempt to advance sustainable intensification pathways within these systems, policy makers are urged to consider the use of incentive mechanism including the provision of improved extension services from the government and NGOs, the creation of cooperative societies in rural areas, the facilitation of land tenure and resource security, the provision of tax reduction schemes and subsidies for inputs, the creation of adequate access to credit facilities, and the delivery of relevant sufficient infrastructural resources at the rural level.

Access to REDD+ benefits in Cameroon will depend primarily on the type of land use where the REDD+ action is conducted. The options used will guide the development of a benefit-sharing system. However, it should be noted that they are quite broad with the type of land use, which resources belong to the State and decentralized local communities. Cameroon needs to develop appropriate regulations for benefit-sharing, which are tailored to the local realities of each REDD+ project. Specifically, the project must recognize customary rights in order to encourage the involvement and participation local stakeholders. However, it should be borne in mind that REDD+ is based on the effectiveness of the carbon credit results. However, agreements between the parties concerned will present the specifics of each project.

It is important to note that while intensification of cocoa agroforestry systems plays a fundamental role in advancing the REDD+ mechanism, further research in this arena is warranted. For instance, little in the way of research has been conducted to ascertain optimal management of trees within cocoa agroforestry systems. Therefore, progress in this domain and the implementation of the aforementioned incentive mechanisms will help ensure that cocoa agroforestry landscapes continue to help in promoting REDD+ as an emission reduction strategy.

List of References

Agrawal, A., and Ostrom, E. (2001). Collective action, Property rights and Devolution of forest and protected area management., In R. Meinzen-Dick, et al., eds. Collective action, property rights and devolution of natural resource management: Exchange of knowledge and implications for policy. ZEl-DSE Ger.

Altieri, M. A. (2002). Agroecology: the science of natural resource management for poor farmers in marginal environments. *Agriculture, Ecosystems & Environment* **93**, 1-24.

Angelsen, A., Brockhaus, M., Sunderlin, W. D., and Verchot, L. V. (2012). Analysing REDD+: Challenges and choices. CIFOR, Bogor, Indonesia.

Asare, R., and David, S. (2010). Planting, replanting and tree diversification in cocoa systems. Learning about sustainable cocoa production: a guide for participatory farmer training. Manual No. 2. Development and Environment Series 13-2010. Forest & Landscape Denmark.

Ballassen, V., and Gitz, V. (2008). Reducing emissions from deforestation and degradation in Cameroon-assessing costs and benefits. *Ecological Economics* **68**, 336-344.

Bigombe Logo, P., and Bikie, E. H. (1998). Women and Land in Cameroon: Questioning women's land status and claims for change. *In* "The Women and Land Studies". School of Law, Emory University, Atlanta, Georgia, USA.

Bilong, P. (1993). Caractères des sols ferrallitiques à plinthite et à pétroplinthite développés sur roches acides dans la zone forestière du sud Cameroon. *Cahier de l'ORSTOM, Série Pédologie* **27**, 203-224.

Bissuela, D. H. B., Missoup, A. D., and S., V. (2009). Biodiversity conservation, Ecosystem Functioning, and Economic Incentives under Cocoa Agroforestry Intensification. Conservation Biology, Volume 23, No. 5, 1176–1184. .

Brown, S. (1997). "Estimating biomass and biomass change of tropical forests: A primer," FAO, Rome.

BUCREP (2010). Recensement général de la population et de l'habitat 2007. Volume 3: fichiers des villages et des quartiers de grandes villes. Ministère du Plan et de l'Administration Territoriale, Yaoundé, Cameroun.

Catacutan, D., Lasco, R. D., and Duque-Piñon, C. (2012). Incentive Mechanisms for Smallholder Agroforestry: Opportunities and Challenges in the Philippines. In: Nair PR and Garrity DP,(Eds). Agroforestry - The Future of Global Land Use. The Netherlands. Springer Science+Business Media Dordrecht. P. 497-514.

Champetier de Ribes, G., and Aubague, M. (1956). Carte géologiques de reconnaissance: Notice explicative sur la feuille Yaoundé-est. Direction des Mines et de la Géologie, Paris, France.

Champetier de Ribes, G., and Reyre, D. (1959). Carte géologiques de reconnaissance: Notice explicative sur la feuille Yaoundé-ouest. Direction des Mines et de la Géologie, Paris, France.

Chave, J., Andalo, C., Brown, S., Cairns, M. A., Chambers, J. Q., Eamus, D., Fölster, H., Fromard, N., Higuchi, T., Kira, J.-P., Lescure, H., Puig, B., Riéra, T., and Yamakura (2005). Tree allometry and improved estimation of carbon stocks and balance in tropical forests. . *Oecologia* **145**, 87- 99, DOI 10.1007/s00442-005-0100-x.

Costenbader, J. (2009). Legal Frameworks for REDD. Design and Implementation at the National Level. IUCN, Gland, Switzerland. 200 pp. .

Cote, S., Theriault, P., and et al. (1993). Plan de zonage du Cameroun forestier méridional: Objectifs, méthodologie, plan de zonage préliminaire, MINEF.

Diaw, M. C. (1997). Si, Nda et Ayang: Culture itinérante, occupation des sols et droits fonciers au Sud-Cameroun. *In* "Document du Réseau 21e" (Réseau forestière pour le développement rural, ed.). ODI, London.

Dixon, R. K. (2005). Agroforestry Systems: Sources of Sinks of Greenhouse Gases? Agroforestry Systems. 31 (2): 99-116.

Djomo, A. N., Ibrahima, A., Saborowski, J., and Gravenhort, G. (2010). Allometric equations for biomass estimations in Cameroon and pan moist tropical equations including biomass data from Africa. Forest Ecology and Management 260: 1873-1885. http://www.sciencedirect.com/science/article/pii/S0378112710004937.

Dkamela, G. P. (2010). The context of REDD+ in Cameroon: Drivers, agents and institutions. Occasional paper 57. CIFOR, Bogor, Indonesia.

Duveiller, G., Defourny, P., and et al. (2008). Deforestation in Central Africa: Estimates at regional, national and landscape levels by advanced processing of systematically-distributed Landsat extracts. Remote Sensing of Environment 112(5): 1969-1981.

Eba'a et al (2009). Etat des forest du bassin du Congo.

Eboutou, L. Y., Degrande, A., Jaza-Folefack, and Kamajou, F. (2010). More thanchocolate: Diversifyingcocoaagroforests for higherprofitability in Cameroon.World Agroforestry Centre. www.worldagroforestry.org/downloads/publications/PDFs?PO10198.PDF.

Edwin, J., and Masters, W. A. (2005). Genetic improvement and cocoa yields in Ghana. Experimental Agriculture 41:491-503.

FAO-ISRIC (2006). "World Reference Base for soil resources," FAO, Rome.

FAO (2002). Etude de cas d'aménagement forestier exemplaire en Afrique centrale: les systèmes agroforestiers cacaoyers, Cameroun. Par Denis J. Sonwa, octobre 2002. Document de travail FM/12F. Service de la mise en valeur des ressources forestières, Division des ressources forestières. FAO, Rome (non publié).

FAO, and MINFOF (2007). Evaluation des Ressources Forestieres Nationales du Cameroun 2003-2004. ROME, Food and Agriculture ORganization of the United Nations.

Feudjio, M., Magne, A. N., Alemagi, D., Robiglio, V., Ewane Nonga, N. E., Yemefack, M., Asaah, E., and Tchienkoua, M. (2012). Incentives measures for the REED+ mechanism and sustainable development in the Efoulan Municipality of the South Region of Cameroon. Alternative to Slash and Burn (ASB) Technical Report. ASB Partnership for the Tropical Forest Margins, Nairobi, Kenya.

FIDA (2001). Evaluation de la pauvreté rurale: Afrique de l'Ouest et du Centre, Rapport.113P, Rome, Italie.

Fonjong, L. (2004). Changing fortunes of government policies and its implications on the applicationsof agricultural innovations in Cameroon. Nordic Journal of African Studies 13 (1): 13-29. .

Forman, R. T. T. (1995). "Land mosaics: The ecology of landscapes and regions," Cambridge University Press, Cambridge, UK.

Franzel, F., Akinnifesi, F. K., and Ham, C. (2008). Setting priorities among indigenous fruit tree species in Africa. Examples from Southern, Eastern, and Western African Regions. In Akinnifesi FK, Leakey

RB, Ajayi OC, Sileshi G, Tchoundjeu Z, Matakala P, Kwesiga FR (Eds). Indigenous Fruit Trees in the Tropics: Domestication, Utilization and commercialization. CABI Publishing, Oxfordshire, UK.

Freudenthal, E., Nnah, S., and Kenrick, J. (2011). REDD and rights in Cameroon: A review of the treatment of indigenous peoples and local communities in policies and projects. Rights, Forests and Climate Briefing Series. Forest Peoples Programme.

Gockowski, J., and Sonwa, D. (2010). Cocoa Intensification Scenarios and Their Predicted Impact on CO2 Emissions, Biodiversity Conservation, and Rural Livelihoods in the Guinea Rain Forest of West Africa. Environmental Management. URL :http://www.springerlink.com/content/121xr71482210109/.

Hairiah, K., Dewi, S., Agus, F., Van Noordwijk, M., and Rahayu, S. (2009). Measuring Carbon Stocks Across Land Use Systems. A Manual. Bogor, Indonesia. Worlkd Agroforestry Centre (ICRAF), SEA Regional Office, Brwiijaya University and ICALRRD (Indonesian Center for Agriculture Land Resources Research and Development 127 p.

IITA (2012). Sustainable Tree Crops Program. International Institute for Tropical Agriculture. Yaoundé, Cameroon.

Immirzi, C. P., Maltby, E., and Clymo, R. S. (1992). The global status of peatlands and their role in carbon cycling, Report No. 11, Wetlands Research Group. Friends of the Earth, London.

IPCC (2007). Climate Change 2007: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change [Parry, Martin L., Canziani, Osvaldo F., Palutikof, Jean P., van der Linden, Paul J., and Hanson, Clair E. (eds.)].Cambridge University Press, Cambridge, United Kingdom, 1000 pp.

Jagoret, P., Michel-Dounias, I., and Malézieux, E. (2011). Long-term dynamics of cocoa agroforests: a case study in central Cameroon. AgroforestrySystems 81: 267-278.

Juhrbandt, J. (2010). Economic valuation of land use change - A case study on rainforest conversion and agroforestry intensification in Central Sulawesi, Indonesia. Dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy. Department of Agricultural Economics and Rural Development, Environmental and Resource Economics. Georg-August Universität Göttingen.

Kauffman, J. B., Cummings, D. L., Ward, D. E., and Babbit, R. (1995). Fire in the Brazilian Amazon: 1. Biomass, nutrient pools and losses in slashed forests. *Oecologia* **104**, 397-408.

Kauffman, S., Sombroek, W., and Mantel, S. (1998). Soils of rainforests: characterization and major constraints of dominant forest soils in the humid tropics. *In* "Soils of tropical forest ecosystems: characteristics, ecology and management" (A. Schute and D. Ruhiyat, eds.), pp. 9-20. Springer-Verlag, Berlin.

Kotto-Same, J., Woomer, P. L., Moukam, A., and Zapfack, L. (1997). Carbon dynamics in slash-and-burn agriculture and land use alternative of the humid forest zone in Cameroon. *Agriculture, Ecosystems & Environment* **65**, 245-256.

Letouzey, R. (1985). "Notice phytogéographique du Cameroun au 1:500000.," Intitut de la Carte Internationale de la végétation, Toulouse, France.

Maniatis, D., Malhi, Y., Saint Andre, L., Mollicone, D., Barbier, B., Saatchi, S., Henry, M., Tellier, L., Schwartzenberg, M., and LeeWhite (2011). Evaluating the Potential of Commercial Forest Inventory Data to Report on Forest Carbon Stock and Forest Carbon Stock Changes for REDD+ under the UNFCCC. *International Journal of Forestry Research* **xx:xx-xx. DOI:10.1155/2011/134526**.

Mbile, P., Ngaunkam, P., Besingi, M., Mfoumou, C., Degrande, A., Tsobeng, A., Sado, T., and Menimo, T. (2009). Farmer Management of Cocoa Agroforests in Cameroon: Impacts of Decision Scenarios on Structure and Biodiversity of Indigenous Tree Species'' Biodiversity 10(4) 2009: 12-19.

Mertens, B., and Lambin, E. F. (2000). Land-cover change trajectories in southern Cameroon. *Annals of the Association of American Geographers* **90**, 467-494.

Mertens, B., Sunderlin, W. D., Ndoye, O., and Lambin, E. F. (2000). Impact of macroeconomic change on deforestation in south Cameroon: Integration of household survey and remotely-sensed data. *World Development* **28**, 983-999.

Minang, P. A., Swallow, B., and Meadu, V. (2008). REDD Strategies for High-Carbon Rural Development. ASB PolicyBrief No. 11. ASB Partnership for the Tropical Forest Margins, Nairobi, Kenya.

Murdiyarso, D., Hergoualch, K., and Verchot, L. V. (2010). Opportunities for reducing greenhouse gas emissions in tropical peatlands. . *PNAS*

Mwayafu et al. (2011).

Ndoye, O., and Kaimowitz, D. (2000). Macro-economics, markets, and the humid forest cover of Cameroon, 1967-1997. *Journal of Modern African Studies*.

Norton-Griffith, M. (2008). Revitalizing African agriculture. PERC Reports 26 (3): 32-36.

Nounamo, L., and Yemefack, M. (2001). "Farming Systems in the evergreen forest of southern Cameroon: Shifting cultivation and soil degradation," The Tropenbos Foundation, Wageningen, The Netherlands.

Nye, P. H., and Greenland, D. J. (1960). "The soil under shifting cultivation," Commonwealth Bureau of Soils, Harpenden, UK.

Oke, D., and Olatiilu, A. (2011). Carbon Storage in Agroecosystems: A Case Study of the Cocoa Based Agroforestry in Ogbese Forest Reserve, Ekiti State, Nigeria. Journal of Environmental Protection 2, 1069-1075.

Olivry, J. C. (1986). Fleuves et Rivières du Cameroun. *Collection Monographies Hydrologiques d'ORSTOM N0 9. MESRES-ORSTOM, Paris, France*.

Page, S. E., R.A.J. Wüst, D. Weiss, J.O. Rieley, W. Shotyk, and S.H. Limin. (2004). A record of Late Pleistocene and Holocene carbon accumulation and climate change from an equatorial peat bog (Kalimantan, Indonesia): implications for past, present and future carbon dynamics. . *Journal of Quaternary Science* **19**, 625-635.

Page, S. E., Rieley, J. O., and Wüst, R. A. J. (2006). Lowland tropical peatlands of Southeast Asia, p. 145-172, In P. Martini, et al., eds. Peatlands: basin evolution and depository of records on global environmental and climatic changes. Elsevier (Developments in Earth Surface Processes series), Amsterdam.

PNUE (2009). Evaluation intégrée des politiques liées au commerce et les implications en termes de diversité biologique dans le secteur agricole en République du Cameroun : le secteur cacao.

Rieley, J. O., Wüst, R. A. J., Jauhiainen, J., Page, S. E., Wösten, H., Hooijer, A., Siegert, F., Limin, S. H., Vasander, H., and Stahlhut., M. (2008). Tropical peatlands, carbon stores, carbon gas emissions and contribution to climate change processes, p. 123-148, In Maria Strack, ed. Peatlands and climate change. International Peat Society.

Robiglio, V., Ngendakumana, S., Yemefack, M., Tchienkoua, M., Gockowski, J., Tchawa, P., and Tchoundjeu, Z. (2010). Options for Reducing emissions from all land uses in Cameroon, World Agroforestry Centre, 2010. 110P.

Ruthenberg, H. (1976). "Farming systems in the tropics," 2nd edition/Ed. Clarendon Press, Oxford.

Sanchez, P. A. (1976). "Properties and management of soils in the tropics," John Wiley & Sons, New York.

Sanchez, P. A. (1977). Soil management under shifting cultivation. *In* "A review of soils research in tropical Latin America" (P. A. Sanchez, ed.), Vol. Technical Bulletin 219. North Carolina State University, Raleigh, USA.

Santos-Martin, F., Bertomeu, M., van Noordwijk, M., and Navarro, R. (2011). Why smallholders plant native timber trees: lessons from the Philippines. Nairobi: ASB Partnership for the Tropical Forest Margins; Bogor, Indonesia: World Agroforestry Centre (ICRAF) Southeast Asia Program.

Schuck, E. C., Nganje, W., and Yantio, D. (2002). The role of land tenure and extension education in the adoption of slash-and-burn agriculture. *Ecological Economics* **43**, 61-70.

SDSR (2006). Stratégie de Développement du Secteur Rural (SDSR): Synthèse du volet Agriculture et Développement Rural. Ministère de l'Agriculture et du Développement Rural -MINADER Cameroun.

Skutch Marget McCall (2011). Community forest monitoring for carbon market: Opportunities under REDD. Earthscan Ltd, Dunstan House, London EC 1N 8XA, UK.

Soil Survey Staff (1998). "Keys to Soil Taxonomy," 5th edition/Ed. USDA, Blacksburg, Virginia, USA.

Sonwa, D. (2004). Biomass management and diversification within cocao agroforest in the humid forest zone of southern Cameroon [dissertation]. Faculty of Agriculture, University of Bonn, Germany, Cuvillier Verlag, Goettigen.

Sonwa, D. J., Weise, S. F., and Coulibaly, O. N. (2009). Contribution of traditional knowledge developed by farmers to control pests and diseases in cocoa agroforests in Southern Cameroon. IUFRO World Series 2009 Vol. 23 pp. 14-20.

Sonwa, D. J., Weise, S. F., Ndoye, O., and M.J.J., J. (2001). Initiatives endogènes d'intensification et de diversification à l'intérieur des agroforêts-cacao au Sud-Cameroun: leçons pour une foresterie participative dans les systèmes à base de cultures pérennes en Afrique centrale et de l'Ouest. Deuxième atelier international sur la foresterie participative en Afrique. Préparer l'avenir: des conditions de vie durables en milieu rural grâce à la gestion participative des ressources forestières. ftp://ftp.fao.org/docrep/FAO/006/y4807b/Y4807B42.pdf.

Sunderlin, W. D., Ndoye, O., Bikie, H., Laporte, Mertens, B., and Pokam, P. (2000). Economic crisis, smallscale agriculture and forest cover change in southern Cameroon. *Environmental Conservation* **29**, 84-290.

Tchatat, M., Puig, H., and Fabre, A. (1996). Genèse et organisation des jardins de case des zones forestières humides du Cameroun. *Révue Ecologique (Terre Vie)* **51**, 197-221.

Tchoumba, B. (2005). Indigenous and Tribal Peoples and Poverty Reduction Strategies in Cameroon (International Labour Organization, 2005), 13, http://www.ilo.org/indigenous/Activitiesbyregion /Africa/Cameroon/lang--en/index.htm; Minority Rights Group International, "World Directory of Minorities and Indigenous Peoples - Cameroon : Overview," 2007, http://www.unhcr.org/ refworld/docid/4954ce5f23.html.

Tchouto, M. G. P. (2004). Plant diversity in a Central African rainforest: Implication for biodiversity conservation in Cameroon. PhD Thesis, Wageningen University, The Netherlands.

Thorlakson, T. (2011). Reducing subsistence farmers' vulnerability to climate change: the potential contributions of agroforestry in western Kenya. ICRAF Occasional Paper 16. World Agroforestry Centre, Nairobi.

UNFCC (2010). COP 16 Cancun Report. United Nations Framework Convention on Climate Change. .

van den Berg Biesbrouck, K. (2000). The social dimensions of rainforest management in Cameroon: issues for co-management. Tropenbos-Cameroon series, Tropenbos cameroon. Kribi-Cameroon.

Van Dijk, J. F. W. (1999). "Non-timber forest products in the Bipindi-Akom II region, Cameroon: a socio-economic and ecological assessment," The Tropenbos Foundation, Wageningen, the Netherlands.

Van Gemerden, B. S. (2004). Disturbance, diversity and distributions in Central African rain forest. PhD thesis, Wageningen University, Wageningen, The Netherlands.

Van Gemerden, B. S., and Hazeu, G. W. (1999). "Landscape ecological survey (1:100 000) of the Bipindi-Akom II-Lolodorf region, Southwest Cameroon," The Tropenbos Foundation, Wageningen, The Netherlands.

Van Gemerden, B. S., Olff, H., Parren, M. P. E., and Bongers, F. (2003). The pristine rain forest? Remnants of historical human impacts on current tree species composition and diversity. *Journal of Biogeography* **30**, 1381-1390.

van Noordwijk, M., Agus, F., Dewi, S., Ekadinata, A., Tata, H. L., Suyanto, Galudra, G., and Pradhan, U. P. (2010). Opportunities for Reducing Emissions from All Land Uses in Indonesia: Policy Analysis and Case Studies. . *ASB Partnership for the Tropical Forest Margins. Nairobi, Kenya. http://worldagroforestry.org/sea/publications?do=view_pub_detail&pub_no=RP0265-10*.

van Noordwijk, M., Minang, P. A., Dewi, S., Hall, J., and Rantala, S. (2009). Reducing Emissions from All Land Uses (REALU): The Case for a whole landscape approach. . *ASB PolicyBrief 13. ASB Partnership for the Tropical Forest Margins, Nairobi, Kenya*.

Vosti, S. A., and Witcover, J. (1996). Slash-and-burn agriculture: household perspectives. *Agriculture, Ecosystems & Environment* **58**, 23-38.

Waterloo, M. J., Ntonga, J. C., Dolman, A. J., and Ayangma, A. B. (2000). "Impact of shifting cultivation and selective logging on the hydrology and erosion of rain forest land in south Cameroon," 2nd revised edition/Ed. The Tropenbos Foundation, Wageningen, The Netherlands.

Websi, S. (2003). Agriculture: Modernising agriculture in Camroon: prospects. CRTV Online at www.crtv.cm/actualite_det.php?code.

Yemefack, M. (2005). Modelling and monitoring soil and Land use dynamics within agricultural landscape mosaics systems in southern Cameroon. *In* "ITC Dissertation 121", pp. 196. ITC Enschede and Utrecht University, Enschede, The Netherlands.

Yemefack, M., Rossiter, D. G., and Jetten, V. G. (2006). Empirical modelling of soil dynamics along a chronosequence of shifting cultivation in southern Cameroon. *Geoderma* **133**, 380-397.

Yemefack, M., and Tchienkoua (2010). Review of shifting cultivation dynamics in southern Cameroon. ASB report, 62p.