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Climate change commitments and agriculture sectoral strategies in Cameroon: Interplay and perspectives

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Abstract: Cameroon like other developing countries is developing approaches to respond to national and global climate change adaptation and mitigation commitments. Sufficient information on the interplay between sector policies and the causes, impacts and response to climate change is relevant for developing sustainable climate change response plans. Using the agriculture sector as a case, this paper examines this interplay in the context of the humid forest zone (HFZ) of Cameroon. Drawing on secondary information from agriculture sector strategies, forest cover change, climate vulnerability and agriculture systems in the HFZ, we found that: (i) the objectives of agriculture expansion and avoided deforestation and forest degradation are at cross-roads; (ii) agriculture as a livelihood strategy is vulnerable to climate variability and change; (iii) strengthening agriculture production systems technically, materially and financially are main suggestions for climate resilient and low carbon emission agriculture practices. We highlight barriers that need to be addressed for the agriculture intensification mechanism, i.e. the agriculture research and extension services in Cameroon to respond to the needs of adaptation and carbon emission reductions from avoided deforestation. These

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Eugene L Chia is a researcher/expert with an interdisciplinary background that cuts across environment and development issues. He has published extensively on climate change and has years of experience working on climate change mitigation and adaptation from the policy level to the project level in the Congo basin region. He is currently providing advisory services to the government of Cameroon on climate change response policies and actions related to adaptation and carbon emission reduction. This paper is part of his contribution to policy inputs (information and knowledge) and the debate in the climate change policy response process in Cameroon.

PUBLIC INTEREST STATEMENT

According to the framework convention on climate change, national development priorities need to align with climate change response commitments. This paper provides information to fuel the debate on the links between sectoral development vision and climate change mitigation and adaptation commitments in Cameroon. The agriculture sector is used here as a case study in Cameroon to demonstrate that on the one hand there is a serious need for enhancing adaptive capacity in the sector, and on the other hand agriculture expansion objectives will exacerbate emissions. Agriculture intensification is underscored as relevant for both adaptation and mitigation. But the existing system, i.e. the agriculture research and extension program, that intensification could build on need overhauling. In-depth evaluation of the system is required to identify the financial, technical and capacity building needs. This is relevant as the country is making efforts to mobilize resources for the design and implementation of climate compatible interventions.

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barriers and others would be addressed if their financial, technology and capacity building needs are carefully evaluated as Cameroon mobilizes resources for the implementation of its National Determined Contributions.

Subjects: Agriculture Development; Forest conservation; Climate Change; Development Policies; Adaptation; Mitigation; Agriculture Research

Keywords: agriculture systems; forestadaptation; mitigation; deforestation; extension; Congo basin

1. Introduction

Mitigation and adaptation are two climate change commitments of the international climate agreement to reduce the impacts of climate change on social and ecological systems. Mitigation is about reducing the long-term impacts of climate change through Greenhouse gases (GHGs) emission reduction or/and through their sequestration. Agriculture is one of the major drivers of deforestation and forest degradation (Hosonuma et al., 2012), and accounts for about 20% of GHGs emissions in developing countries (Angelsen, 2008). Offsetting these emissions by providing payments to countries, communities and individuals, for implementing forest management options that limit deforestation and forest degradation is one of the most cost-effective mitigation approaches (Angelsen, 2008; Stern, 2007). Adaptation to climate change targets the impacts of climate change by reducing vulnerability and/or enhancing resilience. Changes in the earth climate system have introduced new dynamics and uncertainties on agriculture systems, with increasing unevenness in inter-annual and seasonal climate patterns (Crane, Roncoli, & Hoogenboom, 2011). In this light, the adaptation of agricultural systems is necessary to reduce vulnerability and enhance adaptive capacities (Smit & Skinner, 2002). The adaptation of agricultural systems to climate change is a function of the type of climatic stimuli, location, farming characteristics, political, economic and institutional contexts in which policies are designed and implemented (Bryant et al., 2000).

Agriculture practices in forest areas are a component of the dynamics of forest management. It is argued that managing forest agricultural systems through intensification is an important opportunity to increase global food production with limited GHGs emissions, which results from land clearing for crop production. Intensification can lead to an increase in crop yields with limited cultivated areas (Rudel et al., 2009). In practice, intensification entails increasing production on abandoned and existing croplands, increasing productivity and frequency of cropping cycles, through technology transfer and improve agriculture practices (Tilman, Balzer, Hill, & Befort, 2011). These strategies involve technical, financial and managerial interventions, involving multiple stakeholders—governments, private sector and farmers. Nonetheless, to plan and implement these potential strategies requires a profile of the type of the activities, i.e. its feasibility, limitations, strengths and who will be involved in the facilitation, development and implementation (Bradshaw, Dolan, & Smit, 2004; Smit & Skinner, 2002). The agriculture research and extension services are vital in intensification initiatives. They are responsible for the design, testing and facilitation of all forms of context-specific intensification techniques and the propagation (demonstration, lectures and feedback interactions) of innovative practices to land users (Evenson, 2001). This is pertinent for agriculture in forest ecosystems, where poorly managed practices could exacerbate emissions from forest and land use practices; poorly managed forest carbon conservation and/or avoided deforestation initiatives, on the other hand, might have implications for subsistence agriculture systems (Bele, Tiani, Somorin, & Sonwa, 2013a; Chia, Somorin, Sonwa, & Tiani, 2013). This indicates that new ways of managing forest agriculture systems are important for the short-term (adaptation) and long-term (mitigation) abatement of climate change.

In Cameroon, forests cover about 17.5 million hectares (37%) of the total land area, with a high concentration in the Southern part of the national territory (World Resource Institute (WRI), 2011) (Figure 1). The vast dense HFZ makes Cameroon an important country for carbon emission

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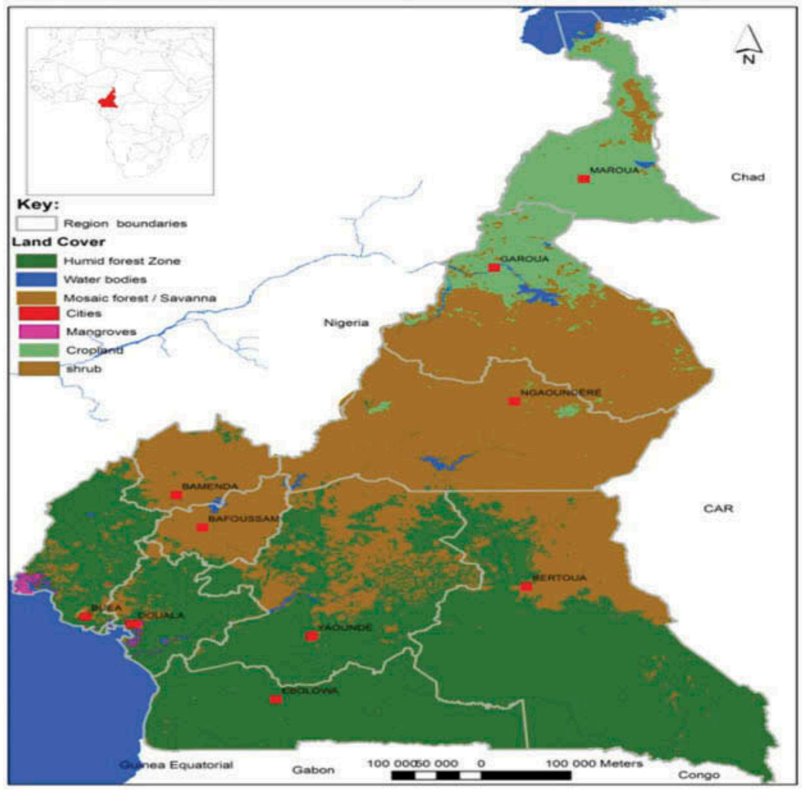

Figure 1. Map of the humid forest zone of Cameroon.

reduction through avoided deforestation (Robiglio et al., 2010)).). There is also a need for adaptation since the direct and indirect components of agricultural systems in the forest zones of Cameroon are vulnerable and impacted by climate variability (Tingem, Rivington, & Bellocchi, 2009; Yengoh, Tchuinte, Armah, & Odoi, 2010). To tackle these major challenges, the Government is committed through its Nationally Determined Contribution (NDC) to reduce emissions by 32% by 2035 from its projected baseline of 2010 emissions and to enhance the resilience of social and ecological systems. And agriculture is well represented in both the mitigation and adaptation commitments (Government of Cameroon [GoC], 2005).

As the government is planning and developing agriculture, forestry and other land use programs to respond to its climate commitments There is a need for more information on the interplay between climate change and the sectoral policies and processes, in terms of causes and/or drivers, impacts and response strategies. Using the agriculture sector as a case, this paper attempts to contribute to improve this reasoning by examining (i) the relationship between agriculture expansion and forest cover change, and agriculture and climate change vulnerability in the HFZ, (ii) the rationale for agriculture intensification for adaptation and avoided deforestation and forest degradation in the HFZ, (iii) the agriculture research and extension services program—which is the relevant agriculture intensification system in Cameroon. This will contribute to the debate related to the planning of the NDC implementation in terms of capacity and financial resource needs from sectoral perspectives.

2. Methodology

This paper builds on data collected from strategy and policy documents and literature. Strategy and policy documents were used to examine the government's position and vision on agriculture development and related policy processes and climate change in general. They include: (i) Second National Communication (NC2) (Ministry of Environment, Protection and Sustainable Development

[MINEPDED], 2015)—this is a national report submitted by the government of Cameroon to the United Nations Framework Convention for Climate Change (UNFCCC) which contains information on national situations, vulnerability assessments, education, technology transfer, financial resources and awareness on climate change; (ii) The National Strategy for reducing emissions from avoided deforestation and degradation (Ministry of Environment, Protection and Sustainable Development [MINEPDED], 2018)—provides orientations on the drivers of deforestation, sectoral interventions to offset drivers, governance and institutional arrangements, monitoring and evaluation, social and environmental safeguards, etc.; (iii) The Rural Sector Development Program (GoC, 2005) and the Growth and Employment Strategy Paper (GESP) (Government of Cameroon [GoC], 2009)—these documents contain information on the governments short and long-term vision and investment plan for agriculture and rural development; (iv) National Agriculture Research and Extension Program (NAREP) policy document (Ministry of Agriculture [MINAGRI], 2004)—this document outlines the rationale and the mode of operation of the NAREP from the national to the local level.

On agriculture and forest cover change, the literature search was guided by keywords such as agriculture and deforestation and forest degradation, conservation and carbon emissions, causes of deforestation and degradation, the reduced emission from deforestation and forest degradation mechanism, climate change mitigation, etc. This permitted the identification of possible agriculture management options that have implications on forest cover change in Cameroon. On adaptation, literature search, specifically from the HFZ of Cameroon was guided by keywords such as risks, vulnerability, impacts, resilience, adaptive capacity, coping strategies, adaptation strategies. To increase the chances of capturing hidden literature in terms of geographical setting, the search was widened to include the Congo basin, Central Africa and Cameroon, before being narrowed down to the HFZ. The main literature sources were Google scholar, Springer, Science direct and Web of science publications. It is possible that the literature search might not have captured all the relevant literature, but the search provided substantial information for the analysis.

In the identified literature, authors picked out the information on how climate change impacts agriculture and the proposed adaptation approaches on the one hand, and on the other hand, the links between agriculture and forest cover change and proposed methods for developing agriculture that will keep deforestation and carbon emissions at a low.

3. Climate change and agriculture in the HFZ of Cameroon

3.1. Impacts and coping strategies

3.1.1. Vulnerability and impacts on agricultural systems

The HFZ of Cameroon cuts across five regions—Centre, East, South, Littoral and Southwest Regions (Figure 1), and it is home to millions of people, who depend on forest ecosystem goods and services. Forest-dependent communities modify forest ecosystems to set up agriculture fields for subsistence and commercial purposes. Agricultural systems are multifaceted and dynamic systems facing frequent weather events, worsened by inter-seasonal and intra-seasonal climate variability (Jarvis et al., 2011). In Cameroon, the agriculture sector and other forest-related sectors (water, energy—fuelwood, and food—NTFPs) are vulnerable to climate variability and vulnerability is further exacerbated by land degradation, fragmentation and overexploitation of natural resources (MINEPDED, 2015; Sonwa, Somorin, Jum, Bele, & Nkem, 2012). Changing seasons and droughts represent the disturbances with major impacts (Pavageau, Locatelli,Tiani & Zida, 2013). Furthermore, torrential rains in rainy seasons lead to soil erosion and the rot of tuber crops like cassava (Bele et al., 2013a). Pockets of droughts and intense sunlight also caused rapid drying up of maize and groundnuts before maturity (Bele et al., 2013a; Chia et al., 2013). However, some disturbances (e.g. pockets of rain during dry seasons and droughts periods) favour some farm practices such as the production of off-season maize in dry swamps, growth and productivity of plantain and banana (Bele et al., 2013a; Yengoh et al., 2010).

Extreme and unexpected rainfall and sunshine influence planting and post-harvesting practices. Research based on crop and climate models indicates that climate variability and change are influencing the sowing dates and growing-season temperature, which have long-term effects on crop yields in the equatorial climate zone in Cameroon. For example, simulation results show that increased temperatures accelerate the phenological development of some important crops—e.g. maize, which gives less time for seed/grain formation and maturity (Tingem et al., 2009). The traditional post-harvest practice of preserving crops by leaving them in the farms for future home consumption and for favourable market conditions is becoming difficult, for example (Chia et al., 2013; Yengoh et al., 2010).

3.1.2. Possible adaptation/coping strategies

In Cameroon, agriculture communities in the HFZ respond to threats from climate change and variability through the expansion of agriculture lands into the virgin forest, at the expense of biodiversity and forest carbon conservation (Bele et al., 2013a; Chia et al., 2013; Epule & Bryant, 2016). Participatory and modelling research techniques have been used to identify agricultural practices that are relevant for agriculture systems to cushion the adverse effects of climate variability and change. Tingem et al. (2009) highlight that responding to increased temperature requires the development and subsequent replacement of existing cultivars with those having high thermal requirements to give opportunities for completion of phenological stages. In the same light, drought-resistant crop varieties, suitable planting methods and water conservation techniques have been proposed as relevant for agricultural systems to adjust to locally changing temperatures in the HFZ (Molua, 2006). In the Southwest Region, farmers rely on changing planting and harvesting dates, substituting crop varieties, e.g. varieties with shorter growing seasons and agroforestry to adjust to the changing climate (Epule &Bryant, 2016). Crop diversification to reduce climate risk and uncertainty on agricultural output and cocoa agroforestry were identified as adaptation strategies by local forest communities in the rainforest of Southern Cameroon (Chia et al., 2013; Yengoh et al., 2010). Yengoh, Hickler, and Tchuinte (2011) further noted that post-harvest food preservation techniques are also relevant for farmers who depend on traditional crop preservation methods, and suffer from post-harvest loss as a result of the changing seasons.

3.2. Agriculture and forest cover change in the HFZ of Cameroon

Agriculture is the backbone of the national economy and the livelihoods of rural populations in Cameroon (Molua, 2008). Agricultural expansion in the HFZ of Cameroon is the major driver of deforestation (MINEPDED, 2018; Robliglio et al., 2010; Kotto-Same, Woomer, Appolinaire & Zapfack 1997; Tegegne, Lindner, Fobissie, & Kanninen, 2016; Tchatchou, Sonwa, Ifo, & Tiani, 2015; Vermeulen, Gillet, Feintrenie, Dessard, & Garcia, 2016). Agriculture in the HFZ can be subdivided into different types, e.g., family or subsistence shifting cultivation, permanent crops or semi-permanent, whether family or agribusiness, and animal husbandry. Cropland expansion is related to different reasons such as: response to declining output as a result of climate change (Bele et al., 2013a; Chia et al., 2013), especially for subsistence-shifting cultivation systems; demographic pressure and increase in the demand for food, changing national and international macro policies (Tegegne et al., 2016; Vermeulen et al., 2016). Despite the changing situation of agriculture in terms of production, the surface area cultivated for some crops indicates that cultivation areas had a strong upward trend between 1990 and 2011 (FAOSTAT, 2014). For example, cocoa and cassava experienced an increase from 360,000 to more than 697,000 and from 96,000 to over 280,000 hectares, respectively. This is a trend which is likely to continue (Tchatchou et al., 2015).

3.2.1. Policy perspectives on agriculture crop expansion in the HFZ

The Government of Cameroon in 2005 put forward the Rural sector development strategy with the objectives to: (i) ensure food security and self-sufficiency of households and the nation; (ii) contribute to economic growth and in particular the growth of foreign trade and employment; (iii) increase the incomes of rural producers (farmers, ranchers, fishermen and local communities);

(iv) improve the quality of life of the rural populations; and (v) ensure the best use and sustainable management of the natural capital base for production (GoC 2005).

To achieve these objectives, the Government intends to increase yields and agricultural land to about 30% compared to the 2005 levels. As part of its agricultural strategy, the government is putting emphasis on enhancing the production of banana, plantain, sugar, palm oil, etc. This will involve the promotion of large-scale farms, the revitalization of agriculture cooperatives and youth empowerment (GoC, 2005). The agricultural development strategy through the increase of agricultural land will not happen without consequences on forest cover in the HFZ.

Cameroon will increase the agricultural area of more than 2.7 million hectares (30%) of 9.163 million hectares cultivated in 2005 (GoC, 2009). The impact of this strategy on forest cover is estimated at 1.025 million hectares, corresponding to 30% of cultivated area in the forest zone. This indicates that if measures are not taken, the development of Cameroon's agriculture by 2020 will cause a forest cover change estimated at about one million hectares, designating that 3.8% of the total forest cover will disappear in the next 10 years (Tchatchou et al., 2015).

3.2.2. Potential strategies to reduce agricultural pressure on forest cover change

Slash and burn shifting cultivation agricultural systems are responsible for a greater share of carbon emissions from forest cover change in the HFZ of Cameroon (Robiglio et al., 2010). Research has identified alternatives to slash and burn agriculture, which have a limited impact on biodiversity loss, improved livelihoods and reduced deforestation (Kotto-Same et al., 1997). Some of these alternatives include: (i) promotion of conservation-oriented land preparation which comprises soil fertility management, the protection of vital economic tree species and contour felling; (ii) increased large-scale production of valuable crops that do well in nutrient-depleted soils (abandoned fallows) such as cassava; and (iii) the promotion of agroforestry, which permits the cultivation of a complex mixture of trees, shrubs, herbaceous crops to provide for a mix of household and market demand (Kotto-Same et al., 1997; Sonwa et al., 2007). Cocoa production is a major source of livelihood for farmers in the HFZ (Sonwa, Coulibaly, Adesina, Weise, & Tchatat, 2002); and cocoa agroforestry has been identified in this area as the agricultural system that is superior to other alternative crop production land uses in terms of below and above ground biodiversity and carbon sequestration (Duguma, Gockowski, & Bakala, 2001). In this same viewpoint, research has shown that cocoa agroforestry systems in West and Central Africa would have saved 21,000 km^2 of forest and reduce emissions of nearly 1.4 billion tonnes of carbon dioxide if it was adopted in the early 1960s (Gockowski & Sonwa, 2010). It is important to note that limited studies have demonstrated how industrial agricultural expansion can be managed to benefit the reduction in forest loss and carbon emissions. However, some findings indicate that with proper management, oil palm expansion can be disconnected with deforestation and environmental degradation (Hoyle & Levang, 2012; Smit et al., 2013).

4. Adaptation and avoided deforestation commitments: Why the need for agricultural research and extension services

Several recommendations have been made on the need for agriculture research and extension in the context of climate change adaptation and avoided deforestation in the HFZ. On adaptation, there are a number of obstacles which have to be overcome for successful design and implementation of adaptation strategies. Some are: (i) limited availability and access to scientific information and innovation on climate change adaptation; (ii) lack of suitable agricultural outreach relevant for climate change adaptation; and (iii) insufficient financial resources (Bele, Sonwa, & Tiani, 2013b). Agriculture systems rely heavily on natural climatic cycles; however, the agricultural sector has inadequate information on agro-climatic dynamics and resources. This hampers the ability of farmers to make informed decisions and plan investment in their agricultural activities especially in the context of climate variability and change (Yengoh et al., 2011). Institutional arrangements, such as research, extension services, Non-Governmental Organisations (NGOs) and Community-based Organisations (CBOs) interventions, can support and facilitate the process of adapting agricultural systems to climate change (Bele et al., 2013b). Molua (2008) proposed that farm programs should be established to encourage farmers to use adaptive farm management approaches to adjust to climate change. Development of new crop varieties is frequently highlighted as an adaptation strategy for agriculture systems. However, developing a new crop variety takes a long time and entails a combination of new technologies such as genetic engineering and marker-assisted selection (Tingem et al., 2009). Thus, the need for enhanced research and extension services.

Tree-crop agroforestry systems have been noted to; be suitable for reducing forest cover change, increase carbon sequestration, reduce biodiversity loss and contribute to livelihoods (Mbow, Smith, Skole, Duguma, & Bustamante, 2014). However, there are major management conditions for cocoa and other crops to perform well in agroforestry systems such as shade control, weeding, pest, disease control and harvesting and processing. For example, Duguma et al. (2001) assert that shade management is important as it impacts several growth factors such as relative humidity, temperature, light intensity, which indirectly influences photosynthesis and the incidence of pest control. In this context, research needs to develop shade tolerant and disease resistant cocoa varieties, plant protection and disease control methods (Duguma et al., 2001). Gockowski & Sonwa (2010) affirm that seed-fertilizer technologies and the use of suitable timber species are important for improving the productivity of cocoa agroforestry systems. This aspect also requires research and extension interventions.

These different approaches for managing and improving forest agriculture systems for climate change adaptation and mitigation fit into the conceptualization of agriculture intensification. Agricultural intensification represents a multifaceted practice that attempts to halt the agricultural expansion, with an increase in outputs through an increase in inputs (Tilman et al., 2011). In this paper, our understanding is framed by the innovative aspects of intensification, which denote a change to a new technological and management approach, resulting in higher output per unit of input (Laney, 2002), be it the use of new cultivars, chemical fertilizers and pesticides and changes in local hydrology (Keys & Mcconnell, 2005; Matson, Parton, Power, & Swift, 1997); biodiversity conservation, hybridization of local seed varieties and the elimination of non-economic species (Mittermeier, Myers, Thomsen, Da Fonseca, & Olivieri, 1998). To overcome these challenges and to maximize opportunities in improving agricultural systems for adaptation and avoided deforestation, emphasis needs to be made on the agricultural research and extension program of the Ministry of Agriculture and Rural Development (MINADER) in Cameroon.

5. Agriculture research and extension program in Cameroon: Objectives and implementation barriers

The extension (training and visit) program started in Cameroon in 1987 as the National Agriculture Extension Program (NAEP), which later on evolved to the National Agriculture Extension and Research Program (NAERP) in 1998. The recent program has a combination of research and extension services across different research and ministerial departments mandated to: (i) improve agricultural productivity and the income of rural agricultural communities especially poor farmers and women, through the transfer and education of farmers on new farming techniques with evolving ecological and socio-economic changes; (ii) improve research on new seed/crop varieties and other new farming methods adapted to changing environments; (iii) improve collaboration and coordination between research and extension services (iv) and create an enabling environment for private enterprises and producer associations to get involved in agricultural activities (Bila, 2005; Ministry of Agriculture [MINAGRI], 2002). In theory, the objectives of the NAREP have potentials to respond to the expectations of agriculture intensification. However, years of practice of the NAREP in Cameroon indicate that more effort is needed to overcome the many barriers plaguing the research and extension services in terms of effectiveness and efficiency. Some of the barriers include (Antholt, 1998; FAO, 2008; Findings, 1998; MINAGRI, 1997, 2004):

(i) Financial, i.e. high cost of inputs, operation and implementation, insufficient financing, limited support from the state and high dependence on external funding, donor fatigue and withdrawal of investments;

(ii) Inadequate material and logistics support;

(iii) Knowledge capacity and information, i.e. low educational level and competence of extension agents, limited period of intervention and poor feedback mechanism, strictly top-down approach and limited frequency of visits to farms, more emphasis on training extension agents than farmers, limited period of intervention with priority given to big farmers;

(iv) Social and cultural issues, i.e. inadequate literacy level of farmers, methods and tools often challenged by farmers, gender biased;

(v) Inappropriate technologies, i.e. imported models that were not rooted in local realities;

(vi) Governance issues, i.e. corruption, inadequate coordination, accountability and transparency;

6. Discussion

6.1. Intensification of forest-based agriculture systems in Cameroon

In Cameroon as in other tropical forest countries, climate change is an emerging challenge for the management of agricultural systems. On the one hand, there is a need to adapt agricultural systems to climate variability and change. On the other hand, proper management of agriculture in forest zones is required to reduce deforestation and forest degradation. These double management objectives of agricultural systems are presently conceptualized as "climate-smart agriculture", and the ingredients for designing and implementing climate-smart agriculture are rooted in the requirements for agricultural intensification (Gockowski & Asten, 2012; Harvey et al., 2013), i.e. farming techniques that increase yields, reduce vulnerability to climate change and reduce emissions (Kaczan, Arslan, & Lipper, 2013). In the HFZ of Cameroon, agricultural expansion for food security and livelihoods is experiencing an increasing rate at the expense of conserving forest cover. There is no defined national strategy to reconcile the agricultural expansion policy and forest and biodiversity conservation in the HFZ. However, the ongoing national land use planning process provides the basis for such a strategy. It is argued that sustainable agricultural intensification can enable agriculture to adjust to the changing climate and also reduce emissions from forest conversion (Tilman et al., 2011). A study across 20 countries in Africa shows that sustainable intensification through crop improvement, agroforestry, soil conservation and integrated pest management resulted in an increase in food output (Pretty, Toulmin, & Williams, 2011).

In the HFZ, agricultural intensification through improved technology and better ex-ante and ex-post farm management have been underscored as relevant for farming systems to adjust to climate variability and change. However, research is needed to better understand the potential links between agricultural intensification and climate change and on how intensification practices may provide agro-ecological resilience to climate variability. In addition, traditional agricultural systems appear to show potentials for adapting to the changing climatic conditions (Lin, Perfecto, & Vandermeer, 2008); thus traditional agriculture in the HFZ should be an integral part of the intensification practice. This is necessary for cocoa production, which is identified as an important crop for agroforestry systems and a major crop that provides for the livelihoods of households in the HFZ. It is important to select tree-crop combinations that offer better livelihood opportunities and at the same time reduce forest degradation. In this light, more research is needed to identify other tree-crop agroforestry combinations suitable for the HFZ. In other tropical countries, components of tree-crop species mixture of coffee, fruits and nuts species have contributed to biomass conservation and improved livelihoods (Soto-Pinto, Anzueto, Mendoza, Ferrer, & De Jong, 2010). Intensification through sustainable agroforestry practices can help achieve adaptation and reduce carbon emissions (Albrecht & Kandji, 2003; Koohafkan, Altieri, & Gimenez, 2012; Mbow et al., 2014; Verchot et al., 2007).

Despite the fact that intensification was recognized as important for agriculture in the context of climate change adaptation and avoided deforestation, There is limited understanding on the dynamics of scaling up agricultural intensification to meet the large-scale framework of climate change adaptation and mitigation, in addition to food security and biodiversity conservation in the HFZ. Pretty et al. (2011) and Tegegne et al. (2016) noted that countries can scale up agriculture intensification through huge investments, renovation and infrastructure support, research and capacity building of extension agents and farmers, micro-credits support, private sector involvement, modern capacity building and communication techniques and tools, and improve tenure arrangements.

Nevertheless, agricultural intensification should have a sustainability face. Intensification can alter biotic interactions, the hydrological system, soil conditions such as erosion, nutrient depletion, and the application of agrochemicals may have implications on the cycles of biogeochemical elements such as carbon, nitrogen and phosphorous, which can have serious consequences on local and regional environmental conditions (Keys & Mcconnell, 2005; Matson et al., 1997). Agricultural intensification has been proposed in many forest carbon emission reduction countries as a strategy to off-set slash and burn extensive cultivation systems. However, research indicates that intensification may succeed in some contexts, while on the other hand, it might increase agricultural land rents as outputs per unit area increase, thereby creating new incentives for agricultural expansion and deforestation (Phelps, Carrasco, Webb, Koh, & Pascual, 2013).

In Cameroon, despite the repeated call for improving agriculture systems in the context of climate change response, there is limited information on the type of agriculture system (i.e. subsistence or small-scale versus large-scale) that needs to be improved to avoid deforestation and improve resilience to climate change. With the emergence of biofuel crop expansion, e.g. oil palm, in Cameroon and the Congo basin in general, experts are proposing that expansion should be directed to degraded areas to avoid forest cover and biodiversity loss (Hoyle & Levang, 2012; Tegegne et al., 2016). However, there is limited information on the financial, ecological and technological challenges involved in carrying out agriculture investments in degraded lands. This is a critical area for research to generate information to inform decision-makers, investors, land use managers and communities.

6.2. Agriculture research and extension services in the context of climate change: What does it take?

Climate change is an emerging task for agricultural research and extension systems that requires improve performance as well as the need to re-organize systems for future challenges. This task is more complex for a case like Cameroon, for example, where limited experience exists on the planning, implementation and the outcome of research and extension systems in the context of climate change adaptation and mitigation. According to Oladele and Sakagami (2004), a good situational analysis of extension systems enables decision-makers and extension program managers to reflect on designing effective and sustainable research and extension systems, adaptable to environmental changes such as climate change. Farmers need to connect directly with policies and programs that can provide them with suitable incentives to adopt new practices. For example, improving agricultural systems through agroforestry for climate change response requires research, learning of some advanced cultivation methods and technologies, and some service delivery and support to ensure swift adoption (Coe, Sinclair, & Barrios, 2014; Matocha, Schroth, Hills, & Hole, 2012). The study by Pretty et al. (2011) also affirms that research and extension services are vital for intensification to contribute to its intended goals. Nevertheless, policy reforms need to accompany research, system analysis and capacity building (Howden et al., 2007; Wall & Smit, 2005).

In the context of Cameroon, large-scale agricultural intensification can only be guaranteed by the NAREP. However, the program has technical and financial challenges on one hand, and on the other hand, farmers encounter financial and technical hitches to adopt improved agricultural management systems; this might hinder its potentials for a successful support to large-scale climate-friendly agriculture intensification. It is argued that for climate-friendly agriculture to go through as a strategy for adaptation and avoided deforestation, means must be put in place to enable farmers to have the necessary financial resources and technical capacity and sufficient agricultural training and visits; supported by investments in sustainable agricultural research, development and extension (Beddington et al., 2012). In a study in Awae and Akok in the HFZ of Cameroon, access to extension services personnel was identified as one of the challenges faced by smallholder farmers for their possible engagement in avoided deforestation initiatives (Cerbu, Sonwa, & Pokorny, 2013). This finding supports an earlier finding, still in the HFZ, which indicated that cocoa farmers received limited support from the agriculture and forestry departments, with about 85% of farmers in the study areas declaring to have no contact with extension personnel (Sonwa et al., 2001). Intensive research is required in terms of time, finance and expertise to develop the recommended crop/seed varieties relevant for increase productivity (Tingem et al., 2009). It has also been identified that persistent unavailability and high cost of inputs for local farmers and the limited capacity of government extension agencies are challenges which need to be overcome for research and extension to contribute to increased crop production per unit area (Padoch & Sunderland, 2014). The challenges identified in Cameroon are similar to experiences reported in Asia (Japan, Thailand) and other African countries (Nigeria, Ghana and Ivory Coast) (Oladele & Sakagami, 2004).

In developing countries, women are more involved in traditional subsistence agricultural systems which are vulnerable to climate variability; and the shifting slash and burn agricultural systems they practice contribute to deforestation. This implies that they constitute an important group in which agricultural research and extension need to target to make intensification respond to its objectives. This is, however, contrary to the context of extension services in Cameroon and in other developing countries where the involvement of women has been very low (Wakhungu & Bunyasi 2010). According to FAO (2005), women engagement and benefits from agricultural extension are as low as 5% in Africa. In Nigeria, despite the fact that women are highly involved in agriculture, education, skills and technology for effective farm management decisions target mostly men (Anugwom, 2009; Aja-Okorie, 2013). Promising solutions to climate change are technologically driven and are often developed without gender and social disparities (Beuchelt & Badstue, 2013). This is a trend which has to be reversed for better uptake and adoption of potential farming climate-friendly techniques.

Despite the numerous challenges, the report of the NAREP support project of the World Bank in Cameroon indicates that due to increased support of research and extension, farmers and farming communities targeted for technical, management and material support, recorded an increase in crop yields throughout the national territory (World Bank, 2006). Agricultural research was a policy reform for agricultural development across Africa; and findings show that research spurred up the discovery of new crop varieties and management techniques, which resulted in an increase in food production and poverty reduction in Africa (Masters, Bedingar, & Oehmke, 1998). However, for this research to realize its objectives, investments in extension services, credits and input supply systems are important (Alene & Coulibaly, 2009).

7. Conclusion

This paper has highlighted the rationale for implicating the agriculture sectoral policies and programs in the planning of climate change adaptation and mitigation policy design and implementation in Cameroon. This is shown by the strong mutually supportive link between agricultural expansion, intensification and climate change response. In the HFZ of Cameroon, agricultural systems are vulnerable and sensitive to climate variability and change; and farmers are already experiencing changes in the agriculture seasonal calendar, which is impacting growth cycles of crops, thus threatens food security and livelihoods. On the other hand, poor farming practices in the HFZ are responsible for forest cover and biodiversity loss and carbon emissions. Intensifying agricultural systems in the HFZ have been clamoured for by researchers as relevant for; reducing agricultural expansion and deforestation, maintaining the integrity of biodiversity and contributing to better livelihoods. In the same vein, the intensification of agricultural systems in the HFZ is also important for enabling farmers to adjust their farming methods to climate variability and change. Nevertheless, agricultural intensification is characterized by improved technology and farm management options. This requires research, in addition to efficient extension services responsible for educating local farmers and producers with research outcomes on improved farming techniques. In Cameroon, intensification hugely depends on the NAREP, a program that has potentials to improve agricultural systems, though presently plagued by financial, human resource and technical challenges. Nevertheless, the NAREP has opportunities which can be exploited and transformed to make the NAREP more sustainable and responsive to the conditions and economic productive capacities of farmers who are trapped between the impacts of climate change and their capacity to reduce forest cover loss from agricultural expansion. In this same logic, agricultural intensification is an opportunity to link adaptation and mitigation. However, such opportunities can only be exploited if the agriculture, forestry and the environment sectors cease to design policies and strategies in silos, and engage in better cross-sectoral collaboration and coordination.

Currently, a detailed analysis of the financial, technological, and capacity building needs for intensifying agriculture systems in Cameroon is lacking. The national agriculture research and extension initiative should be revised taking into consideration the emission reduction expectations from agriculture, forestry and land use activities, and the impacts of climate change. This is relevant for Cameroon to respond to its post-2020 global mitigation and adaptation commitments, where agriculture intensification is highlighted as an important approach to reduce emissions and to increase resilience to climate change through financial, technological, and capacity building support.

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